DOE/CF-0173
Volume 3 Part 1

Department of Energy
FY 2022 Congressional Budget Request

Electricity
Cybersecurity, Energy Security, and Emergency Response
Naval Petroleum and Oil Shale Reserves
Strategic Petroleum Reserve
Northeast Home Heating Oil Reserve
Energy Efficiency and Renewable Energy
Southeastern Power Administration
Southwestern Power Administration
Western Area Power Administration
Bonneville Power Administration

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Table of Contents

DEPARTMENT OF ENERGY
Appropriation Summary
FY 2022
(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs. FY 2021 Enacted $	FY 2022 Request vs. FY 2021 Enacted %
Department of Energy Budget by Appropriation					
Energy Efficiency and Renewable Energy	2,777,277	2,861,760	4,732,000	+1,870,240	+65.35%
Electricity	190,000	211,720	327,000	+115,280	+54.45%
Cybersecurity, Energy Security and Emergency Response	156,000	156,000	201,000	+45,000	+28.85%
Strategic Petroleum Reserve	195,000	188,000	197,000	+9,000	+4.79%
Naval Petroleum and Oil Shale Reserve	14,000	13,006	13,650	+644	+4.95%
Strategic Petroleum Reserve Petroleum Account	10,000	1,000	7,350	+6,350	+635.00%
Northeast Home Heating Oil Reserve	10,000	6,500	0	-6,500	-100.00%
Total, Petroleum Reserve Accounts	229,000	208,506	218,000	+9,494	+4.55%
Total, Cybersecurity, Energy Security, and Emergency Response	385,000	364,506	419,000	+54,494	+14.95%
Nuclear Energy (270)	1,340,000	1,357,800	1,700,700	+342,900	+25.25%
Fossil Energy and Carbon Management	750,000	750,000	890,000	+140,000	+18.67%
Uranium Enrichment Decontamination and Decommissioning (D&D) Fund	881,000	841,000	831,340	-9,660	-1.15%
Energy Information Administration	126,800	126,800	126,800	+0	+0.00%
Non-Defense Environmental Cleanup	319,200	319,200	338,860	+19,660	+6.16%
Science	7,000,000	7,026,000	7,440,000	+414,000	+5.89%
Office of Technology Transitions (OTT)	0	0	19,470	+19,470	N/A
Office of Clean Energy Demonstration (OCED)	0	0	400,000	+400,000	N/A
Advanced Research Projects Agency - Energy	425,000	427,000	500,000	+73,000	+17.10%
Advanced Research Projects Agency - Climate	0	0	200,000	+200,000	N/A
Nuclear Waste Disposal	0	27,500	7,500	-20,000	-72.73%
Departmental Administration	161,000	166,000	321,760	+155,760	+93.83%
Indian Energy Policy and Programs	22,000	22,000	122,000	+100,000	+454.55%
Inspector General	54,215	57,739	78,000	+20,261	+35.09%
Title 17 Innovative Technology Loan Guarantee Program	29,000	-363,000	179,000	+542,000	-149.31%
Advanced Technology Vehicles Manufacturing Loan Program	5,000	-1,903,000	5,000	+1,908,000	-100.26%
Tribal Energy Loan Guarantee Program	2,000	2,000	2,000	+0	+0.00%
Total, Credit Programs	**36,000**	**-2,264,000**	**186,000**	**2,450,000**	**-108.22%**
Total, Energy Programs	**14,467,492**	**12,295,025**	**18,640,430**	**6,345,405**	**+51.61%**
Federal Salaries and Expenses	434,699	443,200	464,000	+20,800	+4.69%
Weapons Activities	12,457,097	15,345,000	15,484,295	+139,295	+0.91%
Defense Nuclear Nonproliferation	2,164,400	2,260,000	1,934,000	-326,000	-14.42%
Naval Reactors	1,648,396	1,684,000	1,860,705	+176,705	+10.49%
Total, National Nuclear Security Administration	**16,704,592**	**19,732,200**	**19,743,000**	**10,800**	**+0.05%**
Defense Environmental Cleanup	6,255,000	6,426,000	6,841,670	+415,670	+6.47%
Other Defense Activities	906,000	920,000	1,170,000	+250,000	+27.17%
Total, Environmental and Other Defense Activities	**7,161,000**	**7,346,000**	**8,011,670**	**665,670**	**+9.06%**
Nuclear Energy (050)	153,408	149,800	149,800	+0	+0.00%
Total, Atomic Energy Defense Activities	**24,019,000**	**27,228,000**	**27,904,470**	**676,470**	**+2.48%**
Southeastern Power Administration (SEPA)	0	0	0	+0	+0.00%
Southwestern Power Administration (SWPA)	10,400	10,400	10,400	+0	+0.00%
Western Area Power Administration	89,196	89,372	90,772	+1,400	+1.57%
Falcon and Amistad Operating and Maintenance Fund	228	228	228	+0	+0.00%
Colorado River Basins Power Marketing Fund *	-21,400	-21,400	-21,400	+0	+0.00%
Total, Power Marketing Administrations	**78,424**	**78,600**	**80,000**	**1,400**	**+1.78%**
Federal Energy Regulatory Commission	0	0	0	+0	+0.00%
Total, Energy and Water Development and Related Agencies	**38,564,916**	**39,601,625**	**46,624,900**	**7,023,275**	**+17.73%**
Excess Fees and Recoveries, FERC	-16,000	-9,000	-9,000	+0	+0.00%
Title XVII Loan Guar. Prog Section 1703 Negative Credit Subsidy Receipt	-15,000	0	-10,800	-10,800	N/A
UED&D Fund Offset	0	0	-415,670	-415,670	N/A
Discretionary Funding by Appropriation	**38,533,916**	**39,592,625**	**46,189,430**	**+6,596,805**	**+16.66%**
DOE Budget Function	**38,533,916**	**39,592,625**	**46,189,430**	**+6,596,805**	**+16.66%**
NNSA Defense (050) Total	16,704,592	19,732,200	19,743,000	+10,800	+0.05%
Non-NNSA Defense (050) Total	7,314,408	7,495,800	8,161,470	+665,670	+8.88%
Defense (050)	*24,019,000*	*27,228,000*	*27,904,470*	*676,470*	*2.48%*
Science (250)	7,000,000	7,026,000	7,440,000	+414,000	+5.89%
Energy (270)	7,514,916	5,338,625	10,844,960	+5,506,335	+103.14%
Non-Defense (Non-050)	*14,514,916*	*12,364,625*	*18,284,960*	*5,920,335*	*47.88%*

* Amount has been adjusted per Section 127 of Public Law 116-159, Continuing Appropriations Act, 2021 and Other Extensions Act.

Electricity

Electricity

Electricity

Table of Contents

Electricity
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for electricity activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, **[**$211,720,000**]** *$327,000,000*, to remain available until expended: *Provided*, That of such amount, **[**$18,000,000**]** *$20,000,000* shall be available until September 30, **[**2022**]** *2023*, for program direction. *(Energy and Water Development and Related Agencies Appropriations Act, 2021)*

Public Law Authorizations

- Public Law 95–91, "Department of Energy Organization Act", 1977
- Public Law 109-58, "Energy Policy Act of 2005"
- Public Law 110-140, "Energy Independence and Security Act, 2007"
- Public Law 114-94, "Fixing America's Surface Transportation Act", 2015
- Public Law 116-260, Division Z, "Energy Act of 2020"

Electricity
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
190,000	211,720	327,000

Overview

Grid modernization is critical to achieving public policy and national security objectives, sustaining economic growth, supporting environmental stewardship, promoting energy justice, and mitigating risks to secure the Nation. The Office of Electricity (OE) leads the Department's efforts to strengthen, transform, and improve energy infrastructure so consumers have access to resilient, secure, and clean sources of electricity. OE provides solutions to market, institutional, and operational failures that go beyond any one utility's ability to solve.[a] To accomplish this critical mission, OE works with private industry and Federal, State, Tribal, territorial, and regional governments on a variety of initiatives to modernize the electric grid.

Proactive, coordinated, and innovative steps are needed to lay the foundation for economic growth and the creation of good-paying jobs and to ensure benefits accrue to marginalized and overburdened communities while addressing four critical challenges:

- Increasing threats and risks to the security of energy infrastructure
- Changes in demand driven by population growth, adoption of more energy efficient technologies, dynamic economic conditions, and broader electrification
- Changes in the supply mix and location (centralized, distributed, and offshore) of the Nation's generation portfolio
- Increasing variability and uncertainty from both supply and demand, including integration of variable renewables, more active consumer participation, and accommodating new technologies and techniques

Due to the critical role the electric grid plays across Federal, State, Tribal, territorial, and regional jurisdictions, OE programs work in an integrated manner in partnership with industry and other stakeholders, as well as other DOE offices, to enhance key characteristics of the U.S. electric transmission and distribution systems:

- Resilience—the ability to withstand and quickly recover from disruptions and maintain critical function
- Security—the ability to protect system assets and critical functions from unauthorized and undesirable actors
- Reliability—consistent and dependable delivery of high-quality power
- Flexibility—the ability to accommodate changing supply and demand patterns and new technologies
- Affordability—more optimal deployment of assets to meet system needs and minimize costs
- Efficiency—low losses in electricity delivery and more optimal use of system assets
- Environmental Justice—addressing disproportionately high and adverse human health, environmental, climate-related, economic, and other cumulative impacts on disadvantaged and energy communities

Within the Request, OE funds:

- Research and Development (R&D)—pursuing research for technologies to improve grid reliability, resilience, efficiency, flexibility, and functionality
- Cybersecurity R&D—design next-generation systems that are built from inception to automatically detect, reject, and withstand cyber incidents, regardless of the threat to the electricity delivery system
- Modeling and Analytics—developing core analytic, assessment, and engineering capabilities that can evolve as the technology and policy needs mature to support decision making within the Department and for stakeholders; analyses explore complex interdependencies among energy infrastructure systems, such as between electricity and natural gas systems

[a] Examples include wide-area visibility, identified from the 2003 Northeast blackout, and faster modeling and analysis, identified in the 2011 Southwest blackout.

- Data Platforms and advanced communications/control designs—pursuing national-scale sensor, data, and communication architecture platforms to mitigate risk and improve the economic efficiency of grid operations such as improved asset management
- Grid Storage Launchpad—final year of funding for construction of the facility and associated infrastructure to consolidate existing materials research and new characterization and testing capabilities focused on grid scale energy storage research
- Institutional Support and Technical Assistance—building capacity in the industry and convening stakeholders to coordinate efforts to transform the electric grid; providing technical assistance to Federal, State, Tribal, territorial, and regional entities to improve policies, utility incentives, State laws, and programs that facilitate the modernization of the electric infrastructure while also incorporating energy justice principles
- Coordination of Federal Transmission Permits and Transmission Planning —streamlining permits, special use authorizations, and other approvals required under Federal law to site electric transmission facilities
- Coordination with the Power Marketing Administrations to implement R&D solutions

The proposed investment continues to support OE's mission of security and resilience through five key priorities:

- North American Energy Resilience Model: Using the integrated North American Energy Resilience Model (NAERM) developed from 2019–2021 in partnership with the national laboratories and relevant stakeholders, conduct energy planning, transmission planning, and contingency analyses to drive infrastructure investment in the North American energy system
- Grid flexibility through Megawatt-Scale Grid Storage: pursue megawatt-scale storage capable of supporting voltage and frequency regulation, ramping, and energy management for bulk and distribution power systems
- Deep Learning via Sensing Technology Utilization: pursue integration of high-fidelity sensing technology for predictive and correlation modeling for electricity and interdependencies with oil and natural gas (ONG) systems
- Expanding Transmission Capacity and Advanced Grid Architectures: pursue electricity-related policy issues by carrying out statutory and executive requirements, while also providing policy design and analysis expertise to Federal, State, Tribal, territorial, and regional entities
- Building in Cybersecurity as a Standard: Accelerate and expand cybersecurity efforts to strengthen electricity infrastructure against cyber threats while mitigating vulnerabilities

OE's FY 2022 Budget Request will extend the impact of our research, development, demonstration, and deployment (RDD&D) funding by leveraging creative funding mechanisms—such as prizes, competitions, technical assistance, and programs targeted to small businesses. The goal is to enable the commercialization of climate change and clean energy innovations that will activate job creation, expand other public impact outcomes, and yield a more geographically diverse and impactful research portfolio.

Energy Storage Grand Challenge (ESGC): DOE is taking a holistic approach to accelerate the development, commercialization, and utilization of next-generation energy storage technologies. The ESGC will deploy the Department's extensive resources and expertise to address technology development, commercialization, manufacturing, valuation, and workforce challenges. The vision for the ESGC is to create and sustain global leadership in energy storage utilization and exports, with a secure domestic manufacturing supply chain that is independent of foreign sources of critical materials, by 2030.

OE's Energy Storage program's request supports grid-related ESGC objectives and other OE R&D efforts are also complementary to ESGC goals.

Grid Modernization Initiative and Grid Modernization Laboratory Consortium: The Grid Modernization Laboratory Consortium (GMLC) is a crosscutting strategic partnership between DOE and the national laboratories to bring together leading experts, technologies, and resources to collaborate on the goal of modernizing the Nation's grid. The benefits of the GMLC include more efficient use of resources; shared networks; improving learning and preservation of knowledge; enhanced lab coordination and collaboration; and regional perspective and relationships with local stakeholders and

industry. One of the main components of the GMI portfolio has been multiple Grid Modernization Lab Calls, which are a comprehensive effort between the multiple DOE applied energy offices and the national laboratories.[a]

Highlights and Major Changes in the FY 2022 Budget Request

Transmission Reliability and Resilience ($37,000,000; -$11,220,000) is focused on ensuring the reliability and resilience of the U.S. electric grid through R&D on measurement and control of the electricity system, assessing evolving system needs, identifying pathways to achieve an equitable transition to decarbonization and electrification, and risk assessment to address challenges across integrated energy systems. Funding decreases due to the FY 2021 completion of funding for NAERM Phase II development, as well as for fully funded FY 2021 congressionally directed projects for sensors and analytics technologies, a composite utility pole assessment, and the Grid Research Integration and Demo Center, not only account for the overall funding decrease in FY 2022 but also offset growth in Transmission Reliability and Renewable Integration and Advanced Grid Modeling. NAERM operations and maintenance transitions to the Energy Delivery Grid Operations Technology (EDGOT) program in FY 2022.

Resilient Distribution Systems ($50,000,000; $0) develops transformative technologies, tools, and techniques to enable industry to modernize the distribution portion of the electric delivery system. The FY 2022 request supports a competitive award process to harness emerging sources of energy for balance, reliability, and control: EVs, connected homes and buildings, increasing distributed solar, and energy storage. Situational Awareness Network (SAN) activities, which relate to operational support, maintenance, and expansion, transition to EDGOT.

Energy Storage ($119,000,000; +$39,000,000) is designed to develop new and advanced technologies that will ensure the stability, reliability, and resilience of electricity infrastructure. The request supports technology development of novel materials and system components, building a safety and reliability knowledge base for energy storage systems and components, and developing open-source analytic tools to address issues such as energy storage planning, sizing, placement, valuation, and societal and environmental impacts. The OE Grid Storage Launchpad (GSL) project, which is aimed at accelerating materials development, testing, and independent evaluation of battery materials and battery systems for grid applications, is fully funded in FY 2022 through the completion of construction and commissioning of the facility.

Cyber R&D ($25,000,000; +$25,000,000) is a new activity for OE in FY 2022 that was previously supported by the Office of Cybersecurity, Energy Security, and Emergency Response (CESER). It addresses R&D for energy sector cybersecurity associated with electricity delivery systems. Cyber R&D will focus on data and physics to redesign grid architecture that exposes the electricity system to cyber threats and will pursue coordinated engagement with DOE's other cyber-related activities, including in CESER and the Office of Intelligence and Counterintelligence. An important part of the Cyber R&D portfolio will be academic R&D for technology-focused activities that, in combination with industry guidance, result in impactful real-world solutions while helping train and develop the next generation of cybersecurity specialists.

Transformer Resilience and Advanced Components ($22,500,000; +$15,000,000) develops innovations for grid hardware that carries, controls, and converts electricity, helping achieve decarbonization goals, ensure reliability and resilience of electric infrastructure, adapt the electricity delivery system to the evolution of the electric power grid, and provide the foundation to invigorate domestic transformer manufacturing. The FY 2022 request accelerates the timeline for field validation of innovative, flexible, and adaptable prototypes for large power transformers (LPTs), which will promote greater standardization to increase grid resilience. Integrating of sensors and data analytics (such as for health monitoring) can further enhance the flexibility and adaptability of LPTs. TRAC will also address critical research needs for solid-state power substations (SSPS) with an emphasis on advanced materials, embedded intelligence for equipment monitoring, and validation of prototype converter building blocks.

Energy Delivery Grid Operations Technology ($43,500,000; +$43,500,000) is a new program in OE in FY 2022 that includes operations and maintenance for NAERM, which was developed by Transmission Reliability and Resilience (TRR), as well as the Post-Event Analysis Coordination (PEAC) network and Situational Awareness Network (SAN), which were previously supported by TRR and Resilient Distribution Systems, respectively. EDGOT will support a public–private partnership to develop national-scale energy planning and real-time situational awareness capabilities by focusing on developing large, networked communication and data infrastructures across multiple utility boundaries. The core of the EDGOT portfolio is

[a] https://www.energy.gov/grid-modernization-initiative

NAERM, which will help us transition from the current reactive state-of-practice to a new energy planning, investment, and operations paradigm in which we proactively develop infrastructure investment strategies. The EDGOT technology portfolio will enable assessment of risks and uncertainty, evaluation and identification of effective mitigation strategies, and support of more informed infrastructure planning and investment decisions by both public and private sectors, thereby enhancing U.S. energy and economic security. In FY 2022, leveraging NAERM capabilities, EDGOT will develop the framework and layers for an EDS infrastructure grid planning tool for transmission and distribution level networks supporting short- and long-term planning of grid activities.

Defense Critical Electric Infrastructure (DCEI) Energy Mission Assurance ($0; -$1,000,000) was established in FY 2021 to identify, evaluate, prioritize, and assist in developing executable strategies to ensure that critical national defense and security missions have reliable access to power as energy supply disruptions threaten the civilian grid due to intensifying cybersecurity threats as well as other hazards. In FY 2022, DOE is proposing to integrate the functions of the DCEI Energy Mission Assurance program into CESER's suite of activities partnering with, supporting, and sharing information with the electric utility industry to enhance energy resilience through its energy assurance planning efforts.

Transmission Permitting and Technical Assistance ($10,000,000; +$3,000,000) works with electricity system partners and stakeholders to modernize the grid and ensure equitable and adequate transmission capacity across the United States. The FY 2022 request expands TPTA's outreach and support activities with Federal, State, and industry partners to address the climate crisis by decarbonizing the electricity sector, supporting transmission planning, and maximizing cost-effective demand-side resources and solutions to achieve 100% carbon-free electricity by 2035.

FY 2020 Key Accomplishments

RAPID Toolkit Expands to Canada: OE, with the assistance of staff at Natural Resources Canada, expanded the Regulatory and Permitting Information Desktop Toolkit to include bulk electric transmission line permitting regulations at the Canadian federal and provincial levels. The expanded toolkit streamlines coordination with Canada as a crucial energy trading partner, increasing transparency and collaboration among electricity stakeholders and further prioritizing electricity resilience and reliability across the United States and Canada.[a]

Modeling and Simulation: OE's HELICS+ project enhanced the HELICS co-simulation platform (the primary simulation platform of all national laboratory modeling efforts on transmission system planning, resilience and interdependency analytics and extreme event modeling) to improve user interfaces and software integrations with commercial tools.

Grid Architectures: The GMLC Grid Architecture team delivered 5 reference architectures spanning the priority power system futures central to delivering resilient, clean power.

Validating Resilient Distribution Approaches: OE delivered a valuation framework for enhancing the national efforts to validate new approaches to resilient distribution systems.

Distribution Planning Workshops: OE delivered structured training workshops for state and industry staff on integrated distribution system planning accounting for new technologies and architectures inherent in the emerging clean, resilient distribution systems. The effort provided 25 states with tailored training on distribution system modernization issues relevant at the state and regional levels.

Modeling Extreme Events: OE delivered extreme event modeling tools with advanced solvers to analyze complex transmission planning contingencies that are relevant to both enhanced system resilience and the need to accommodate increased grid system dynamics as renewable generation gains an increased share of the Nation's generation capacity.

Potential Benefits of High-Power High-Capacity Batteries: This OE report outlines opportunities for high-power, high-capacity batteries to increase the resilience of the U.S. electric power system and help integrate higher levels of variable renewable energy. By describing the opportunities in terms of grid services and dimensional requirements, the report aims to align system needs with the storage options best suited to fill those needs.[b]

[a] https://www.energy.gov/oe/articles/innovative-tool-electricity-infrastructure-permitting-expands-canada
[b] https://www.energy.gov/oe/articles/oe-sets-stage-energy-storage-advances

Solid State Power Substation Technology Roadmap: This OE report examines the future of substation technology and grid power electronics advancements. The roadmap highlights the potential benefits of broader utilization of solid state power substation (SSPS) converters, documents a technology adoption trajectory that minimizes risks and costs, and identifies several R&D challenges and critical gaps that must be addressed to realize the SSPS vision presented as well as technical and institutional activities needed to address near-, mid-, and long-term gaps.[a]

CEII Final Rule: The Critical Electric Infrastructure Information (CEII) Final Rule went into effect on May 15, 2020. In the rule, DOE established administrative procedures for DOE's designation, protection, and sharing of CEII and provides procedures for DOE coordination with Federal and industry partners to facilitate mutual understanding and information sharing related to CEII. CEII designation protects and secures critical information about the Nation's electric infrastructure as part of DOE's commitment to improve energy security while ensuring a reliable and resilient flow of energy to America's communities and businesses.[b]

Bulk Power System Executive Order: On May 1, 2020, the President signed Executive Order (EO) 13920, "Securing the United States Bulk-Power System," which authorizes the Secretary of Energy to work with Federal partners and the energy industry to secure America's Bulk-Power System (BPS). OE issued a Request for Information (RFI) on July 8 seeking stakeholder input and recommendations, including from industry and the public, regarding the supply chain and economic analysis related to the executive order.[c]

NARUC-NASEO Task Force on Comprehensive Electricity System Planning: OE provided technical and capacity support to a national, two-year initiative hosted by the National Association of Regulatory Utility Commissioners and the National Association of State Energy Officials to advance the state-of-the-art in electricity system planning to reliably and affordably meet current and emerging needs, including grid stability, resilience and increased flexibility and optimization for all types of resources. On February 11, 2021, the Task Force released a blueprint for state action and five planning roadmaps, and announced actions by twelve states to apply the principles and strategies developed by the Task Force.

[a] https://www.energy.gov/oe/articles/oe-report-solid-state-power-substation-technology-roadmap
[b] https://www.energy.gov/oe/activities/critical-electric-infrastructure-information
[c] https://www.energy.gov/oe/bulkpowersystemexecutiveorder and https://www.energy.gov/oe/articles/doe-office-electricity-issues-request-information-bulk-power-system-executive-order

Electricity
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Transmission Reliability and Resilience	57,000	48,220	37,000	-11,220	-23.3%
Resilient Distribution Systems	45,000	50,000	50,000	…	…
Energy Storage					
Research	55,000[a]	57,000	72,000	+15,000	+26.3%
Construction: 20-OE-100 Grid Storage Launchpad	1,000[a]	23,000	47,000	+24,000	+104.3%
Total, Energy Storage	56,000	80,000	119,000	+39,000	+48.8%
Cyber R&D	…	…	25,000	+25,000	N/A
Transformer Resilience and Advanced Components	7,000	7,500	22,500	+15,000	+200.0%
Energy Delivery Grid Operations Technology	…	…	43,500	+43,500	N/A
DCEI Energy Mission Assurance	…	1,000	…	-1,000	-100.0%
Transmission Permitting and Technical Assistance	7,000	7,000	10,000	+3,000	+42.9%
Program Direction	18,000	18,000	20,000	+2,000	+11.1%
Total, Electricity	**190,000**	**211,720**	**327,000**	**+115,280**	**+54.4%**
Federal Full Time Equivalent Employees (FTEs)	**62**	**63**	**68**	**+5**	**+7.9%**
Additional FE FTEs at NETL supporting OE[b]	12	11	11	…	…
Total OE-funded FTEs	74	74	79	+5	+6.8%

SBIR/STTR:
FY 2020 Enacted: SBIR/STTR: $4,931
FY 2021 Enacted: SBIR/STTR: $4,646
FY 2022 Request: SBIR/STTR: $6,133

[a] $4,000,000 was reprogrammed into the 20-OE-100 Grid Storage Launchpad in FY 2020, bringing the total funding to $5,000,000. The sources for the reprogramming were $3,592,000 from Energy Storage Research, bringing total funding to $51,480,000, and $408,000 from prior year balances.
[b] OE funds FTEs at FE's National Energy Technology Laboratory who are FE employees, but support OE activities. The FTEs are included in FE's FTE totals and not in the OE FTE totals shown on the "Federal Full Time Equivalent Employees (FTEs)" line.

Transmission Reliability and Resilience

Overview

The Transmission Reliability and Resilience (TRR) program provides the electric sector with the necessary tools and analyses to assess risks, inform decisions, and improve power system planning and performance including mitigating the risks of large-scale blackouts and adapting to evolving system needs. TRR focuses on:

- Ensuring the reliability and resilience of the U.S. electric grid through research and development (R&D) concentrated on measurement and control of the electricity system
- Developing and validating models to assess evolving system needs and identify pathways for achieving an equitable energy transition towards decarbonization and electrification
- Mitigating risks across integrated energy systems

TRR brings together energy stakeholders from government, industry, and academia to generate ideas and develop solutions to the Nation's energy infrastructure challenges.

Transmission Reliability and Renewable Integration (TRRI) is developing transmission system tools and data analytics to inform planning and operational decisions that maintain and improve system reliability while accelerating the integration of renewable energy for the electricity industry. Advances in data analytics ensure utilities are getting the full value from new and existing sensors and enable inference of complex underlying dynamics and diagnosis of system behavior and abnormalities, while providing situational awareness for operators to make informed and equitable decisions. TRRI is developing tools that help system operators understand and adapt to changes in supply and load, including expanded growth in clean generation, access to distributed energy resources, and increased electrification. TRRI is modernizing transmission system tools through human factor and cognitive science research for system operations to allow for more timely mitigation of reliability events, such as blackouts, and allow for the development of training simulators for operator workforce development. TRRI R&D will enable determining the state of the power system with the greater speed, accuracy, and precision that are required to manage the increasing complexity of grid operations and assets and to monitor and manage the interconnected and interdependent effects among the Nation's critical infrastructures.

Advanced Grid Modeling (AGM) supports building the capacity and capability within the electric sector to analyze the electricity delivery system using Big Data, advanced mathematical theory, and high-performance computing to assess the current state of the grid, mitigate reliability risks, and understand future needs. AGM aims to lead the research activities in better understanding the issues surrounding the current and future electric power grid and developing robust model-based solutions that result in new software, analytical toolsets for operators and planners. Successful research in this area will enable grid operators and planners to optimize their decision-making, giving the electric industry sophisticated tools to dramatically improve electric delivery system efficiency, reliability, resilience, and security.

In achieving this vision, TRRI and AGM foster strategic, university-based power system research. Building and maintaining effective public-private partnerships is one of the key strategies for these programs. Such partnerships facilitate innovations in R&D and enable industry (and ultimately consumers) to capitalize on the outcomes. TRRI will continue work to develop research datasets and data platforms that reduce utility burden from data requests and facilitate tool development with real data. This will set the groundwork for catalyzing artificial intelligence and machine learning in the transmission system. Advancing analytics to be capable of fully capturing and understanding new system dynamics from the integration of renewable energy, inverter-based technologies, and advanced transmission control schemes (such as dynamic line rating and transmission topology control) will further develop the electricity system as a resource.

Protective relaying is required at all levels of the electric grid to detect problems in the earliest stages and then act by isolating the problems to prevent or reduce damage to equipment and potential resulting injuries to utility personnel and the public. The protective relaying program was developed to advance research flexibility and adaptability to changing power flows, improve detection methods, and lead to overall faster response times. Protective relaying complexity varies by function and vendor and, with many senior technicians and engineers retiring, the burden on the remaining workforce is increasing. The relaying program will develop guidelines, best practices, and toolsets to support workforce development of relaying professionals across the Nation.

TRR began development in FY 2019 of the North American Energy Resiliency Model (NAERM), enables a public–private partnership to assess risks to the North American energy system through contingency analyses of interdependent infrastructures. In FY 2022, NAERM begins operations and transitions to a transmission planning tool, and the new Energy Delivery Grid Operations Technology (EDGOT) program takes responsibility for NAERM operations and maintenance.

TRR directly engages energy stakeholders and decision makers to disseminate research results and promote innovation, and risk-informed energy system decisions. TRR activities also focus on advancing university-based power systems research, helping ensure an enduring strategic national capability for innovation in this essential area.

Highlights of the FY 2022 Budget Request
The TRR program continuously looks into ways to make the present and future grid resilient, reliable, efficient, and secure. As part of the FY 2022 Request, TRR's concentration will be on:

- Developing high-fidelity sensing technologies and analytics that manage uncertainty associated with data and decision support capabilities
- Advancing the application of cognitive science and human factors to identify and develop tools needed for decision making and training
- Advancing protective relaying methods to improve the functional integrity and effectiveness at preventing and mitigating power outages
- Researching the impact of changes in the grid with a concentration on transmission planning to accommodate large deployment of renewables
- Increasing the collaboration between OE and other public and private entities

Technology, tools, and applications developed under TRR will be evaluated for security risks including cybersecurity. Testing and evaluations will be conducted to ensure that security is built-in and new security risks are not being introduced into the electric sector.

Support of R&D activities through the Grid Modernization Laboratory Consortium (GMLC) will continue.

Centers[a]
The Request includes planned DOE support for a new university-based Engineering Research Center (ERC), which would be jointly funded by NSF and the Department. Through the new Center, DOE would seek to develop fundamental knowledge in different aspects of the Electric Power System, contributing to a reliable, resilient, and secure electric power grid, while educating a new generation of electric power and energy systems engineering leaders.

[a] Per the guidance on inclusion of centers in budget justifications in H.Rpt. 113–135, the House report for the FY 2014 Energy and Water Development appropriations.

Transmission Reliability and Resilience
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Transmission Reliability and Resilience	57,000	48,220[a]	37,000	-11,220	-23.3%

SBIR/STTR:

- FY 2020 Enacted: SBIR/STTR: $1,731
- FY 2021 Enacted: SBIR/STTR: $1,527
- FY 2022 Request: SBIR/STTR: $1,223

Transmission Reliability and Resilience
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• Phase II research goals were achieved for NAERM in FY 2021; NAERM will transition to a transmission planning tool under EDGOT in FY 2022 • DOE's request in FY 2022 supports a planned new university-based Engineering Research Center • Grid Research Integration & Deployment Center work completed	**-11,220**

[a] The FY 2021 appropriation includes support to complete phase 2 NAERM development. NAERM will transition to a transmission planning tool under the EDGOT program in FY 2022.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Transmission Reliability and Resilience $48,220,000	**$37,000,000**	**-$11,220,000**
• Continue conducting research in protective relaying. These approaches will include efforts to improve system resilience against modern threats while enhancing recovery operations following natural disasters • Continue technical support for the North American SynchroPhaser Initiative (NASPI) to conduct information sharing and joint problem solving among utilities, vendors, universities, and the Federal Government • Initiate assessment of research needs for a new university-based engineering research center related to electric power systems in coordination with NSF • Continue exploring the mathematical and computational research to manage uncertainty, associated with data, modeling, and model validation • Continue development, co-funded with the NSF's AMPS program, of next-generation mathematical and statistical algorithms to improve the security, reliability, and resilience of the electric power system • Continue support for existing sensor activities	• Develop advanced protective relaying methods that will address changing topologies and dynamic generation sources of the future grid • Identify and develop methods that will improve the functional integrity and effectiveness of protective relaying • Continue technical support for NASPI to conduct information sharing and joint problem solving among utilities, vendors, universities, and the Federal Government • Initiate support for a new university-based engineering research center related to electric power systems in coordination with NSF • Develop transmission system data management, modernization of transmission system tools for wide area situational awareness, and analysis of economic dynamics. • Support cognitive science and human factors research to catalyze development and adoption of new tools for workforce training and development, control room application improvements, and robust decision making. • Advance analytics to fully capture and understand system impacts and opportunities from changes in supply due to fossil-fueled generation retirements and the integration of renewable energy.	• Having successfully completed synchrophasor-based research themes, TRRI is refocusing on sensor research, data analytics, and software tool development • DOE's request in FY 2022 supports a planned new university-based Engineering Research Center

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	• Develop tools for planners and operators to benefit from and utilize advances in power electronics, and advanced transmission control schemes (such as dynamic line rating and topology control) to improve system flexibility and reliability. • Continue exploring the mathematical and computational research to manage uncertainty, associated with data, modeling, and model validation • Continue development, co-funded with the NSF AMPS program, of next-generation mathematical and statistical algorithms to improve the security, reliability, and resilience of the electric power system • Support advanced data analytics for transmission system operation and planning • Demonstrate power flow control using impedance technologies	
North American Energy Resiliency Model • Continue supporting the incorporation of real-time data into dynamic models for NAERM to provide situational awareness • Develop use cases for NAERM to study the impact of electricity and other infrastructures on each other and develop plan to minimize the risk • Complete NAERM Phase II development	• With the phase II research goals achieved, NAERM operations and maintenance activities are funded in the EDGOT program starting in FY 2022 as NAERM transitions to a transmission planning tool	• NAERM operations and maintenance transitions to the EDGOT program in FY 2022 as NAERM is refocused on transmission planning

Resilient Distribution Systems

Overview

Resilient, reliable, and affordable electricity is a cornerstone for equitable economic growth and job creation, a critical platform to address climate change, and a foundation for communities to grow and attract new businesses and meet energy demands. For the most part, the existing electrical distribution system—the infrastructure that takes power from the transmission system and delivers it to individual businesses and homes—was designed and built using engineering principles established over 100 years ago. However, that same distribution system is facing dramatic changes—increased electrification, decarbonization of the electricity supply, and continued energy efficiency and conservation. While these changes provide new benefits and new opportunities, they also present significant operational challenges. As the electricity distribution system continues to evolve and its complexity increases, new technologies are needed that enable changes to the way the electric grid is planned and operated. For utilities to maintain reliable and resilient operations, they require tools and capabilities to enhance observability, control, and dynamic protection across all distribution system assets.

The Resilient Distribution Systems (RDS) program focuses on addressing challenges facing the electric power grid by developing transformative technologies, tools, and techniques to enable industry to modernize the distribution portion of the electric delivery system. RDS pursues strategic investments in innovative technologies and practices that improve reliability, increase resilience, support vehicle electrification, integrate clean distributed energy resources (DER), and provide consumers with more choices for managing their energy consumption. The program builds upon previous and ongoing grid modernization efforts including the Grid Modernization Laboratory Consortium (GMLC).

Microgrid research & development (R&D) focuses on developing and validating new technologies and methods to improve grid reliability and resilience under both normal and disruptive conditions, while enabling DER integration, enhancing consumer participation and choice, and driving grid technology innovation. Microgrid investments have successfully enhanced reliability, resilience, and efficiency, particularly at the community level, and continue to be an RDS focus area.

New approaches and technologies will also be investigated, including Dynamic Controls R&D to enhance the Nation's electric distribution grid to harness flexibility across all distribution assets. This includes expanded sensor research to increase situational awareness at the distribution level, which provides the ability to withstand and recover from disruptions caused by extreme weather events and man-made events, as well as supporting normal operations.

Results from the RDS research in Microgrids and Dynamic Controls will enable industry to strengthen the reliability and resilience of electrical infrastructure and support the ongoing evolution of the electric grid in a manner that supports a just transition to a decarbonized economy.

Highlights of the FY 2022 Budget Request

Microgrid activities in FY 2022 support R&D in several areas:

- Developing modeling and simulation capabilities for optimal system design and operations of networked microgrids continues. Networking two or more microgrids that share loads and complementary power resources can increase their combined resilience during power outages, while lowering capital and operational costs for normal operations.
- The Developing Resilient Operations of Networked Microgrids (RONM) software will be completed in FY 2022. RONM will allow utilities to operate networked microgrids to support rapid recovery of the existing distribution infrastructure during extreme weather events, while meeting their defined resilience goals.
- Advanced concepts (self-assembly of microgrids and collaborative autonomy operations of networked microgrids via distributed control architectures), along with standard-based microgrid-to-microgrid communication and control, will progress towards field demonstration in FY 2022. The demonstration will validate the benefits of operating networked microgrids, defined in utility use cases, to support bulk system operations and critical end-use loads.
- Development and application of consequence-based, quantitative models for improving electric power distribution system resilience to support resilience planning continues. The multi-objective optimization model will be used to formulate a more detailed microgrid system design that meets resilience requirements of both the microgrid installation and its surrounding community. Key microgrid building blocks (MBBs), such as switching, power conversion, voltage and power control, dispatch, and interfacing, will be further developed. Readily integrating these MBBs to form microgrids for all purposes addresses a key challenge: the costly and lengthy customization required for microgrid

designs and builds. Modeling and simulation testing on a test feeder circuit will be conducted to evaluate the steady state and dynamic performance of the MBB-based microgrid.

- Development of protection schemes for microgrids with high penetration of inverter-based resources and development of new microgrid fault location algorithms using real-time sensor data and analytics will continue for both singular and networked microgrids. In addition, protection research for secondary networks that involve DERs and microgrids, initiated in FY 2021, will continue to develop adaptive algorithms for the additional functionality needed. The new research is expected to inform a fractal grid framework that is applicable for future meshed distribution systems, networked microgrids, and transmission protection.

Dynamic Controls R&D activities will support priorities on grid resiliency and dynamically sourced grid support services to transform distribution grid infrastructure. Activities will be supported in the following areas:

- Dynamic Controls: These activities will develop the theoretical basis for methods and tools to evolve from centralized command and control to a more decentralized but coordinated system. Economic-control theory hybrid work will see continued simulation, development, and demonstration. A new effort in this area will explore data efficiency, maximizing the utilization of high volumes of data while minimizing computing and communications resources. Blockchain and other digital-ledger technology concepts will be explored through public private partnerships in academia and industry for the purposes of secure peer-to-peer transactions, high integrity distributed data stores, and secure computing platforms in untrusted environments.
- Grid Data Science: R&D activities will develop highly resilient distribution designs capable of accommodating evolving electricity supply and adapting to extreme events and disruptions. Efforts on adaptive spectrum research and co-simulation of power and communications to enhance communications bandwidth for utility applications will be completed. The effort will also extend the linkage between secure distributed compute environments and their associated impacts on data transport architectures within the utility environment.
- Funding Opportunity Announcement (FOA): A new industry FOA will be launched, featuring advanced electrification, which capitalizes on harnessing emerging sources of energy for balance, reliability, and control: EV's and connected homes and buildings, distributed solar, and energy storage. A balance-centric grid would enable increased deployment of innovative new technologies and expanded value to their owners, the grid, and society. Successful proposals will feature innovative resilience, enhanced transmission agility, and market transformation, supportive of FERC Order 2222 and State and local trends.

Distribution Sensors: R&D activities will support the development and integration of high-fidelity, fast-acting sensor technologies and advanced data analytics into the power grid. The program will also revolutionize the use of these technologies in electricity operations and delivery—from transmission to distribution to end-use load (including behind-the-meter DER)—for improved diagnostics and prediction of system variables and assets during normal and extreme-event conditions. These sensors provide the foundation for enhanced observability and flexibility—from advanced distribution management systems to microgrid controllers to distributed controls.

Technology, tools, and applications developed under RDS will be evaluated for security risks including cybersecurity. Testing and evaluations will be conducted to ensure that security is built-in and new security risks are not being introduced into the electric sector.

OE coordinates with the Office of Energy Efficiency and Renewable Energy (EERE) and other relevant DOE programs through the Grid Modernization Initiative and regular programmatic outreach to ensure the programs support complementary R&D and avoid duplication. Work in this area will continue to leverage and integrate energy storage, power electronics, systems controls and first-of-a-kind technologies that could meet the technical needs of microgrids supporting urban, rural, and underserved communities, as well as islanded and remote grids.

In FY 2022, RDS and EERE will also jointly fund competitively selected projects to engage with regional and local partners, especially in underserved communities, to develop and demonstrate innovative technologies (including distributed solar, energy storage, EVs, and other DERs) and planning practices to enhance community resilience to physical hazards and to support decarbonization goals.

RDS is managed to support a just transition to a modern electricity delivery system, including:

- An institutional process roadmap developed in concert with stakeholders that identifies barriers to the implementation of advanced technology by regulators, utilities, and consumer advocates and provides recommended pathways for addressing them.
- A demonstrated multi-objective decision framework incorporating decarbonization, resilience, flexibility, and energy justice with traditional planning objectives that can then guide the formulation of holistic and equitable grid modernization strategies and technology investment plans at the distribution system level.
- The development of architectural views and staged strategies for achieving needed functionality for a distribution system platform that can accommodate all forms of distributed energy resources, ownership models, and market structures.
- A set of guidelines to shape the formulation and implementation of coordination frameworks that enable the effective utilization of distributed energy resources across the transmission, distribution, consumer, and merchant domains.

Resilient Distribution Systems
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Resilient Distribution Systems	**45,000**	**50,000**[a]	**50,000**	**0**	**0.0%**

SBIR/STTR:

- FY 2020 Enacted: SBIR/STTR: $1,359
- FY 2021 Enacted: SBIR/STTR: $1,265
- FY 2022 Request: SBIR/STTR: $1,290

Resilient Distribution Systems
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• Foundational research efforts on advanced resilient grid communications network concepts will be initiated	**0**
• Fund competitively selected projects to engage with regional and local partners, especially underserved communities, to develop and demonstrate innovative technologies to enhance community resilience to physical hazards, and to support decarbonization goals (joint EERE-OE effort)	
• A Balance-Centric Grid FOA, designed to harness the potentially disruptive technologies in DER and storage to enhance grid reliability, resilience, and sustainability, is planned for FY 2022.	
• Coordinated Management of Microgrids and Networked Distributed Energy Resources (COMMANDER) and Sensor Demonstration activities were fully funded in FY 2021.	
• Situational Awareness Network (SAN) activities related to operational support, maintenance, and expansion will move to Energy Delivery Grid Operations Technology (EDGOT) program	

[a] FY 2021 funding includes support for SAN activities. Operational support, maintenance, and expansion activities for SAN transition to the EDGOT program in FY 2022.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Resilient Distribution Systems $50,000,000	**$50,000,000**	**$0**
• Continue software development for resilient operations of networked microgrids (RONM) and Version 1 testing at utility hardware-in-loop (HIL) • Advance standard-based microgrid-to-microgrid communication and control that involves self-assembly of microgrids and collaborative autonomy operations • Continue development and application of consequence-based, quantitative models for system resilience applied to microgrids • Provide technical assistance on resilient microgrid implementation to critical defense facilities in meeting their mission-critical needs utilizing national laboratory expertise • Continue development of a key, standardized building-blocks with combined capabilities for power conversion and microgrid control functions • Develop protection schemes for microgrids with high penetration of inverter-based resources and develop new microgrid fault location algorithms using real-time sensor data and analytic • Conduct funding opportunity on highly resilient adaptive networks leveraging analysis and laboratory activities accomplished in FY 2020 • Initiate the development of a comprehensive communications planning toolkit • Demonstrate the feasibility and benefits of resilience services utilizing Dynamic Control Source • Operation, maintenance, and expansion of the SAN	• Validate the resilient operations of networked microgrids (RONM) software capability; deploy the software on an industry-sponsored platform • Field demonstrate advanced concepts of operating networked microgrids (self-assembly and collaborative autonomy), utilizing standard-based microgrid-to-microgrid communication and control, under conditions defined in utility use cases • Continue development and application of consequence-based quantitative models for a holistic approach to system resilience applied for microgrids and surrounding communities • Provide technical assistance on resilient microgrid implementation to critical defense facilities in meeting their mission-critical needs utilizing national laboratory expertise • Complete MBB design including power conversion and microgrid control • Conduct modeling simulation testing of a key, standardized microgrid building- block with combined capabilities for power conversion and microgrid control functions • Develop protection schemes for microgrids with high penetration of inverter-based resources and secondary networks; develop new microgrid fault location algorithms using real-time sensor data and analytics • Demonstrate and continue simulation development of economic-control theory hybrid work	• Extend linkage between research on secure distributed compute environments and their associated impacts on data transport architecture • SAN activities related to operational support, maintenance, and expansion move to EDGOT • Jointly fund competitively selected projects to engage with regional and local partners with EERE • A FOA, designed to harness the potentially disruptive technologies in DER and storage to enhance grid reliability, resilience, and sustainability is planned for FY 2022. • COMMANDER is fully funded in FY 2021. • Sensor Demonstration activities in partnership with PNNL and the Vermont Electric Power Company (VELCO) are fully funded in FY 2021

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	• Explore blockchain and other digital ledger technologies • Initiate foundational research efforts on advanced resilient grid data transport network concepts • Demonstrate the feasibility and benefits of resilience services utilizing Dynamic Control Sources • Distribution Sensors R&D activities will support priorities on the development and integration of high-fidelity, fast-acting sensor technologies and advanced data analytics into the power grid • Fund competitively selected projects to engage with regional and local partners, especially underserved communities, to develop and demonstrate innovative technologies to enhance community resilience to physical hazards, and to support decarbonization goals (joint EERE-OE effort) • Support a Balance-Centric Grid FOA, designed to harness the potentially disruptive technologies in DER and storage to enhance grid reliability, resilience, and sustainability	

Energy Storage

Overview

The Energy Storage program leads a national effort to ensure a more flexible, resilient, and equitable North American power grid through increased deployment of bi-directional electrical energy storage. The electric power grid is the backbone of our modern economy and success of the grid has rested on two key principles: reasonably predictable load and a measure of control over generation. As the electric grid evolves to accommodate carbon-free renewable generation, new models and tools, such as energy storage, can help effectively manage these changes. Energy storage is an enabling element for this transition as it is a bi-directional flexible resource capable of providing a suite of grid services while improving the inherent resiliency of the grid. Utilizing energy storage to improve grid resiliency in underserved communities can promote greater energy equity and, when paired with renewable generation or augmenting fossil-based resources, can help alleviate environmental issues in these communities.

The U.S. electric grid's installed electricity generation summer capacity of just over 1 terawatt (TW) (1,000 GW) has roughly 23 GW of energy storage, of which 22 GW is provided by large pumped hydro energy storage plants. Historically, less than one percent of installed generation capacity is provided by modular, flexible energy storage assets (such as batteries and flywheels) that offer the greatest potential for large scale deployment and operational flexibility. To make energy storage ubiquitous throughout the grid infrastructure, further research is needed in reducing the cost of energy storage systems, along with significant improvements in the safety and long-term reliability of utility-scale energy storage systems. In addition, further research is needed in developing analytic models that can facilitate not only greater understanding of technical and economic benefits energy storage can provide to utilities and grid operators, but also the societal benefits it can provide to consumers and communities.

The Energy Storage program is designed to develop new and advanced technologies that will ensure the stability, reliability, and resilience of electricity infrastructure. The R&D program focuses on:

- Energy Storage Technology Development
  - Performing advanced research on the development of novel materials and system components to resolve key cost and performance challenges with respect to novel flow, lithium, sodium, zinc manganese dioxide, and lead-based batteries, electrode materials, membranes, electrolytes, interconnects, and supporting power electronics and power conversion systems. These advanced battery and device technologies will lead to significant improvements in the cost and performance of energy storage systems that enable widespread deployment and increased domestic manufacturing.
- Safety and Reliability
  - Developing a scientifically derived knowledge base to improve the understanding and predictability of energy storage systems and components under realistic grid use cases, inspiring greater confidence in the safety and reliability of energy storage systems.
  - Improving the safety and reliability of energy storage technologies and their installation in close collaboration with fire departments, building managers, and other approval authorities.
- Energy Storage Analytics
  - Developing open-source analytic tools for small and large utility customers and regulatory agencies to facilitate planning and implementation of energy storage in transmission and distribution infrastructure.
  - Supporting the development of open-source tools for optimal sizing, placement, and valuation of energy storage and develop performance protocols for rapid adaption of energy storage.
  - Designing and building advanced control systems to optimize fleets of diverse energy storage systems to supply existing and emerging grid services.
  - Developing new analytical tools that help quantify the societal and environmental impacts storage provides to communities with poor electrical reliability.

Highlights of FY 2022 Budget Request

Grid energy storage is one of the key components for the development of a flexible and resilient electric grid infrastructure and the proposed OE research portfolio greatly advances the deployment of grid scale energy storage. The Request continues support for the program's core R&D agenda including materials research on the next generation of battery chemistries, development of new materials and device technologies for efficient power conversion, improved safety and

reliability of storage systems, development of optimal design and control architectures for energy storage integration, and development of open-source models and software tools for system level energy storage planning and evaluation. The request also continues the Program's outreach and support to the energy storage industry through workshops with public utility commissions (PUCs), educational materials for code officials and first responders, and technical conferences for industry.

The research program builds on a long history of successful research, development, and deployment (RD&D) by the OE Energy Storage program.

- Advanced materials R&D is focused primarily on improving the cost and performance of earth abundant, domestically available battery chemistries for the next generation of battery technologies including flow batteries and advanced sodium-, and zinc-, and lead-based systems.
- Materials research is aimed at improving the lifetime and performance of the chemistries and all critical cell components and moving these technologies toward practical prototypes that can achieve cost-competitive long-range cost targets under $150 per kWh.
- Targeted R&D efforts in aqueous soluble organic redox flow batteries as well as sodium, zinc manganese dioxide, and lead-based systems are coordinated in national programs that engage a cross-section of national laboratories, universities, and industry partners to meet ultimate performance objectives.

In FY 2022, R&D efforts will have an expanded focus to include key reliability issues in non-battery technologies, novel storage technologies that can cost-effectively provide longer discharge durations (12+ hours continuously), and storage systems that may enable seasonal shifting of electrical energy usage.

Power electronics and power conversion systems can represent up to 30% of an installed storage system's cost. The program's leadership in advanced power electronics will continue with expected breakthroughs in new wide-bandgap materials for power electronics and advanced dielectric materials for high voltage capacitors. R&D activities investigating new topologies for optimal control and safety of power electronics will continue, as well as the development of advanced power electronic architectures to address stranded energy, improve battery failure diagnostics, and integrate highly accurate state-of-charge and state-of-health monitoring of energy storage systems.

Safety and reliability of energy storage systems are critical for large-scale deployment of storage technologies into grid infrastructure and will continue to be an active R&D area in the program. The OE Energy Storage program continues to be the primary conduit between research and industry for energy storage safety and is enabling the establishment of strong safety standards. The program continues working closely with fire departments, building managers, and other approval authorities to understand the critical R&D needs of the end users, and providing fundamental research information for use by standards development organizations such as the Institute of Electrical and Electronics Engineers (IEEE), National Fire Protection Association (NFPA), and UL. The Program will continue to engage with international safety organizations to understand known failures and facilitate uniformity of safety codes and standards. Establishing a validated and referenceable database of energy storage degradation and expected lifetimes, in collaboration with industry, will continue to be a significant priority for the program as new storage technologies are introduced into the marketplace. Both the Reliability Test Capability (< 10kW) and the Grid Storage Launchpad (< 100kW) will make critical testing and validation capabilities available to industry and academia aimed at long-term and accelerated testing methodologies to determine the expected lifetime of storage technologies when operated under grid duty cycles.

The scarcity of technical information on the economic performance of energy storage technologies continues to be a serious barrier to the wider-scale adoption of grid energy storage. The program's energy storage analytics focus has an established track record for providing analysis on performance of energy storage systems for a full range of grid application. The program will continue to support the development of open-source analytic tools for the North American electric utility industry to ensure availability of tools required for greater adoption of flexible energy storage assets. In addition, these new models must also capture the societal and environmental benefits storage can provide to consumers. The impact of improving electrical reliability in underserved communities and improvements in air-quality through reduction of fossil generation are examples of benefits that are not currently captured in analytical models but are critical to achieve social equity. Additionally, these models should also quantify the contribution of energy storage to the reduction of greenhouse gas emissions. Developmental tools that accurately capture the complete economic and societal value proposition for storage in both well-defined markets and non-market conditions will continue to be a priority. The program will also

continue to support the development of robust user tools for storage planning, operation, and evaluation. This entails open-source software development for optimal sizing and placement, optimal control and coordination, cyber-threat analysis and protection, and techno-economic assessment. It is critical that these tools are validated on real-world storage deployments as increased fidelity of these analytical tools can greatly lower the barrier for acceptance by stakeholders by enabling them to fully understand how integrating storage into the grid can lower energy prices, secure their electrical supply, and solve a variety of reliability and equity challenges faced by specific localities across the United States. Providing technical assistance to states and regional stakeholders in the use of these analytical tools and how to safely install, integrate, and operate deployed energy storage systems will continue to be a vital element of the program. The program's support of energy storage installations to enhance the resilience of defense critical infrastructures will continue through joint projects with local and rural utilities responsible for supplying resilience to critical infrastructures. The data and experience from these projects will be used to develop and validate the North American Energy Resiliency Model (NAERM) by advancing the Nation's understanding of the strategic use and placement of energy storage systems, including batteries, within the energy sector.

The Request supports a competitive funding opportunity announcement (FOA) consistent with the goals of OE's energy storage program. The purpose of this FOA is to target innovative, late-stage long-duration energy storage technologies that have already received early-stage validation. The FOA will support 3-4 projects and provide a pathway for demonstration and deployment of these novel, mature storage technologies that will provide substantial benefits to the electric grid. This opportunity has the potential to equitably serve communities and encourage U.S. manufacturing innovation. This FOA leverages prior work performed within OE and directly supports the Energy Storage Grand Challenge (ESGC).

This request also supports the OE Grid Storage Launchpad (GSL) construction project, which is aimed at accelerating materials development, testing, and independent evaluation of battery materials and battery systems for grid applications. The GSL will focus on materials development and prototype battery systems (less than 100 kW, rather than megawatt-scale systems integration and testing) to identify and solve issues before moving to larger-scale systems and will standardize grid performance testing across the spectrum of battery materials, battery systems, inverters, auxiliary power, and battery management systems under grid use-case conditions. The GSL will provide an objective national resource to report battery testing performance under grid conditions and will integrate and coordinate researchers from universities and national labs together to rapidly solve crosscutting science and technology challenges. The GSL will also develop new capabilities to rapidly scale-up new materials for grid scale storage, deliver dedicated state of the art characterization capabilities that do not exist, and conduct realistic testing of design options in a laboratory environment. The mission directly supports the ESGC crosscut. Project Engineering and Design (PED) funds were used in FY 2020 and FY 2021 to complete the DOE O 413.3B requirements leading up to Critical Decision (CD)–2/3. FY 2021 funding is being used to initiate the design-build acquisition strategy in which design and construction services are secured together, including start of construction. The FY 2022 request will support final construction and commissioning of the GSL facility. CD-4 (to approve start of operations) is planned in the last quarter of FY 2025 (including 18 months of schedule contingency for risk mitigation).

Technology, tools and applications developed under Energy Storage will be evaluated for security risks including cybersecurity. Testing and evaluations will be conducted to ensure that security is built-in and new security risks are not being introduced into the electric sector.

Support of R&D activities through the Grid Modernization Laboratory Consortium (GMLC) will continue.

Energy Storage Grand Challenge: ESGC is a crosscutting effort managed by DOE's Research and Technology Investment Committee (RTIC) and co-chaired by OE and the Office Energy Efficiency and Renewable Energy (EERE). ESGC coordinates R&D across DOE, including complementary R&D investments beyond the applied energy offices, to advance energy storage and technologies that provide similar capabilities. OE's Energy Storage program's request supports grid-related ESGC objectives and other OE R&D efforts are also complementary to ESGC goals. DOE is taking a holistic approach to accelerate the development, commercialization, and utilization of next-generation energy storage technologies. The Department integrated the existing disparate storage efforts from the Grid Modernization Initiative (GMI), Advanced Energy Storage Initiative (AESI), Beyond Batteries (BB), and others into the Energy Storage Grand Challenge, an integrated, comprehensive DOE-wide strategy. The ESGC is deploying the Department's extensive resources and expertise to address technology development, commercialization, manufacturing, valuation, and workforce challenges. The vision for the ESGC is to create and sustain global leadership in energy storage utilization and exports, with a secure domestic manufacturing supply chain that is independent of foreign sources of critical materials, by 2030.

Energy Storage
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Energy Storage					
Research	55,000[a]	57,000	72,000	+15,000	+26.3%
Construction	1,000[a]	23,000	47,000	+24,000	+104.3%
Total, Energy Storage	**56,000**	**80,000**	**119,000**	**+39,000**	**+48.8%**

SBIR/STTR:

- FY 2020 Enacted: SBIR/STTR: $1,618
- FY 2021 Enacted: SBIR/STTR: $1,606
- FY 2022 Request: SBIR/STTR: $2,102

Energy Storage
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Research	**+15,000**
• Supports a FOA targeting innovative, late-stage, long-duration energy storage technologies to provide a pathway for demonstration and deployment of novel, mature storage technologies that provide substantial benefit to the electric grid, equitably serve communities, and encourage U.S. manufacturing innovation.	
• Supports additional deployment and validation of long duration (6+ hour) storage technologies for defense critical infrastructures and integration of new generation sources.	
• Supports deployment, valuation, and performance validation of electrical energy storage systems for rural co-operatives, municipalities, and utilities.	
• Continues R&D efforts focused on next-generation storage technologies (battery and non-battery) including enhanced safety, reliability, and performance testing, and storage valuation tools and methodologies for grid applications.	
Construction	**+24,000**
• The FY 2022 request provides final construction funding for the Grid Storage Launchpad (GSL).	
Total, Energy Storage	**+39,000**

[a] $4,000,000 was reprogrammed into the 20-OE-100 Grid Storage Launchpad in FY 2020, bringing the total funding to $5,000,000. The sources for the reprogramming were $3,592,000 from Energy Storage Research, bringing total research funding to $51,480,000, and $408,000 from prior year balances.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Research $57,000,000	**$72,000,000**	**+$15,000,000**
• Demonstrate a 5 kW prototype of a novel aqueous soluble organic flow battery technology capable of achieving 400 mA/cm² with a projected 1 MW/4 MWh system cost of less than $200 per kWh • Demonstrate large format (300 Ah) zinc-manganese dioxide batteries with an energy density of 150 Wh/L with projected cell level costs below $50 per kWh when produced in volume • Demonstrate performance and long-term stability of sodium batteries technologies (sodium-ion and sodium metal halide) in greater than 5 Ah prototypical formats capable of achieving less than $100 per kWh when produced at scale • Continue research and development of new power electronics and power converter topologies for efficient coupling between batteries and power electronics for improved power conversion optimized for aqueous batteries including flow batteries and zinc-based batteries • Migrate novel control strategies and architectures for distributed control of energy storage from R&D to industry for improved grid stability, economic dispatch, and system reliability and safety • Expand reliability testing of new battery chemistry under defined grid use cases and develop comprehensive reliability metric for grid scale storage systems • Disseminate open-source software tools and validated analytical models for optimal sizing, location, and operation of grid scale energy storage	• Demonstrate enhanced novel aqueous soluble organic flow battery technologies capable of achieving over 500 continuous cycles with greater than 90% capacity retention with a projected system cost of less than $175 per kWh at scale. • Demonstrate prototype pack architectures with capacities greater than 5 kWh based on 300 Ah zinc-manganese dioxide batteries and projected cell level costs below $50 per kWh when produced in volume • Demonstrate performance and long-term stability of sodium ion batteries technologies in conjunction with DOE's Vehicle Technologies Office in prototypical pack formats and validate cost-performance metrics of $100 per kWh when produced at scale • Downselect and migrate new power electronics and power converter topologies from R&D to scalable prototype formats and demonstrate efficient coupling between batteries and power electronics • Validate novel control strategies and architectures with industry for distributed control of energy storage for improved grid stability, economic dispatch, and system reliability and safety • Develop standardized reliability testing of protocols and promulgate within stakeholder community for evaluation of new storage technologies under defined grid use cases	• Novel aqueous soluble organic flow battery R&D shifts from prototype scale-up to long-term cycle-life validation • Supports maturation of storage design and analysis tools and transition to industry • Expanded R&D efforts on non-battery technologies for grid storage applications • Expanded emphasis on exploring the role of storage in providing energy equity and environmental justice. Developing analytical metrics to quantify societal benefit of storage leading to demonstrations validating these models • Issue a competitive FOA for long-duration storage technologies that support grid operations; energy equity within urban, rural, and tribal communities and U.S. manufacturing and innovation

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Support installation, integration, and validation of at least 3 new electrical energy storage projects that highlight longer term (6+ hour) storage applications for defense critical infrastructures • Support installation, integration, and validation of at least 2 new electrical energy storage projects aimed at improving resiliency and operational efficiency of rural co-operatives • Expand R&D efforts on lead-acid batteries as potential grid scale energy storage solutions	• Continued refinement and validation of open-source software tools and analytical models for optimal value, sizing, and location, based on field deployments • Support installation, integration, and validation of 4 additional electrical energy storage projects that highlight longer term (6+ hour) storage applications that support local resiliency and energy equity • Expand R&D efforts on non-battery storage technologies as potential grid scale energy storage solutions • Support a competitive FOA targeting innovative, late-stage long-duration energy storage technologies that have already received early-stage validation, providing a pathway for demonstration and deployment of these novel, mature storage technologies that provide substantial benefit to the electric grid, equitably serve communities, and encourage U.S. manufacturing innovation	
Construction $23,000,000	**$47,000,000**	**+$24,000,000**
• Complete DOE O 413.3B requirements and the design-build acquisition strategy, in which design and construction services are secured together, and begin construction	• Complete funding for construction and commissioning of the Grid Storage Launchpad facility	• The increase completes funding for the project

Construction Projects Summary ($K)

	Total Project Cost (TPC)	Prior Years	FY 2020 Appropriation[a]	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted	Future Years
20-OE-100 Grid Storage Launchpad							
Total Estimated Cost (TEC)	75,000	0	5,000	23,000	47,000	+24,000	0
Other Project Costs (OPC)	2,000[b]	1,000[b]	0	0	0	0	1,000[b]
TPC	77,000	1,000	5,000	23,000	47,000	+24,000	1,000

[a] Includes $1,000,000 of enacted appropriation for GSL plus $4,000,000 from an approved reprogramming into the project.
[b] OPC is funded through laboratory overhead.

20-OE-100, Grid Storage Launchpad
Pacific Northwest National Laboratory, Richland, Washington
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary: The FY 2022 Request for the Grid Storage Launchpad (GSL) will be used to execute the design-build acquisition strategy in which the design and construction services team will provide the design and perform the construction of a new building and associated infrastructure that will consolidate existing grid energy storage research capabilities at PNNL with new characterization, validation and independent testing capabilities for next generation grid scale energy storage materials under grid operating conditions. With a design-build acquisition strategy, design and construction services are integrated to ensure effective constructability is factored into the design. In FY 2022, design will be completed and construction will ramp up. This project has a total project cost (TPC) of $77,000,000 based on a total estimated cost (TEC) of $75,000,000 and $2,000,000 of other project costs (OPC). The most recent DOE Order 413.3B Critical Decision (CD) is CD-2/3, Approve Performance Baseline and Start of Construction, and was approved on March 2, 2021. CD-4, Start of Operations, is planned for FY 2025.

A certified Federal Project Director (level II candidate) is assigned to the project.

The scope of this project is to design and construct a facility and associated infrastructure to consolidate existing materials development research and new characterization and testing capabilities focused on grid scale energy storage research. The facility is needed to house critical research capabilities devoted to accelerated materials development, testing and independent validation of storage materials and systems for grid applications. These early stage validation and testing capabilities are not readily available in the private sector. The GSL will also complement current industry efforts by developing standardized grid testing protocols that the entire stakeholder community can use for performance validation of storage technologies. Finally, the GSL will provide new, dedicated capabilities—such as the in-operando storage characterization capability—that are critical to accelerate materials development and does not exist in industry.

Significant Changes: This construction project data sheet (CPDS) does not include a new start for FY 2022.

- The data sheet fully funds remaining TEC requirements in FY 2022.
- Critical Decisions 2 and 3 were approved on March 2, 2021
- A Design-Build contract was awarded on March 31, 2021.
- Performance Measurement Baseline is in process of being implemented to reflect the performance baseline parameters approved at CD-2/3.

Critical Milestone History

(Fiscal Quarter or Date)

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	D&D Complete	CD-4
FY 2020	11/30/2018	3Q FY 2019	1Q FY 2020	4Q FY 2020	1Q FY 2021	TBD	N/A	TBD
FY 2021	11/30/2018	7/9/2019	8/21/2019	4Q FY 2021	4Q FY 2022	4Q FY 2021	N/A	1Q FY 2026
FY 2022	11/30/2018	7/9/2019	8/21/2019	3/2/2021	3Q FY 2022	3/2/2021	N/A	4Q FY 2025[a]

[a] Includes 18 months of schedule contingency for risk mitigation.

Fiscal Year	Performance Baseline Validation
FY 2020	4Q FY 2020
FY 2021	4Q FY 2021
FY 2022	3/2/2021

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range
Conceptual Design Complete – Estimated/actual date the conceptual design will be/was complete
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
Final Design Complete – Estimated/actual date the project design will be/was complete
CD-3 – Approve Start of Construction
D&D Complete – Completion of decontamination and decommissioning (D&D) work
CD-4 – Approve Start of Operations or Project Closeout

Project Cost History

(Dollars in Thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D[a]	OPC, D&D	OPC, Total[a]	TPC
FY 2020	5,000	TBD	TBD	1,000	N/A	1,000	6,000
FY 2021	5,000	70,000	75,000	2,000	N/A	2,000	77,000
FY 2022	5,000	70,000	75,000	2,000	N/A	2,000	77,000

2. Project Scope and Justification

Scope

The scope is for the design and construction of a new capital asset at PNNL, including utilities and infrastructure capabilities, capable of the development and testing of new materials for grid energy storage. A facility is needed to consolidate, modernize and expand critical research capabilities that will enable accelerated materials development, testing and independent validation of battery materials and systems for grid applications and complementary technologies. The GSL project design will lead to construction and turnover of facilities and infrastructure that will provide nominally 85,000 gross square feet of wet chemistry, instrumentation, and computational space to include 30 laboratory modules along with 6,000 square feet of energy storage system testing and validation space and workstations for approximately 105 research and support staff.

The Pacific Northwest National Laboratory (PNNL) has a shortage of onsite institutional laboratory space. The GSL offers relief from the shortage by providing modern agile research space that not only enables the missions of today but is readily adaptable to the needs of tomorrow. Consolidation of this research community also benefits related and ongoing work for other programs likely resulting in synergic and complementary outcomes.

Justification

America's security, economy, and sustained global leadership depend on a clean, secure, and resilient power grid. Through a mix of technology and policy solutions and in partnership with the private and public sectors, OE harnesses innovation to enable the North American energy system to progress on a path towards clean energy independence.

OE invests in next-generation technologies to support the Administration's power sector and economywide decarbonization goals. A major enabler for the clean energy transition is megawatt-scale energy storage capable of supporting regulation, ramping, and long-duration energy time shifting for bulk and distribution power systems. Storage activities include

[a] Other project costs (OPC) are funded through laboratory overhead.

collaboration with other DOE offices through the Energy Storage Grand Challenge (ESGC) to investigate and integrate new technologies for advancing megawatt-scale storage with added resilience and control capabilities and working with the national laboratories to identify and pursue capabilities in flow batteries for grid scale energy storage.

Development of grid-scale energy storage, at levels facilitate the decarbonization of the future U.S. power grid, will require the development of new technologies that are more cost effective, safer, and durable. To help accomplish this goal, OE proposes the development of a Grid Storage Launchpad to enhance critical research capabilities for the development and testing of new grid energy storage materials. GSL development will help maintain U.S. R&D leadership in energy storage through validation, acceleration, and collaboration. The GSL will enable independent validation of next-generation grid energy storage materials and systems under realistic grid operating conditions. From benchtop to systems, the GSL will de-risk and accelerate new technology maturation by propagating rigorous grid-performance requirements to all stages of storage development. By linking the DOE and storage R&D communities in a new collaboration facility, the GSL will lower barriers to solving key crosscutting challenges.

The GSL will provide a holistic set of storage development capabilities that does not exist in industry and is not currently accessible to the general R&D community. The GSL will promulgate rigorous grid-performance requirements throughout the R&D development cycle—from basic materials synthesis to testing of near-commercial prototypes—in order to accelerate the development lifetime and ensure continuous validation of new technologies. Current commercial capabilities, focused on later stage prototyping of known storage architectures and device testing, lack the GSL's planned ability to validate new grid-storage technologies at smaller scales and earlier technology maturity stages. The GSL will complement current industry efforts by developing standardized grid testing protocols that the entire stakeholder community can use for performance validation of storage technologies. Finally, the GSL will provide for new, dedicated capabilities, such as an in-operando storage characterization capability, that are critical to accelerate materials development and do not exist in industry. The GSL will also enable broader collaboration across DOE, university, and industry R&D communities than potential proprietary commercial efforts. Because the GSL offers a transformational approach for the accelerated validation of grid-storage technologies, DOE stewardship is critical to ensure open access to these capabilities to enable U.S. leadership in gird-storage technologies.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets.

Baseline Scope Quantities

- 30 Lab Modules (~ 22' x 33' each)
- 6,000 Net Square Feet (ESS Test & Validation)
- 100 Workstations
- 85,000 Gross Square Feet

Baseline Scope Quantities form the basis of estimate for the cost and schedule baseline and represent the minimum acceptable performance that the project must achieve. The project will be considered complete once physical construction has delivered the baseline scope quantity in a complete and usable facility. The baseline scope quantities were approved as part of the CD-2/3 approval.

3. Financial Schedule

(Dollars in Thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2020	5,000[a]	5,000	376
FY 2021	…	…	4,124
FY 2022	…	…	500
Total, Design[b]	5,000	5,000	5,000
Construction			
FY 2021	23,000	23,000	5,000
FY 2022	47,000	47,000	30,000
FY 2023	…	…	20,000
FY 2024	…	…	15,000
Total, Construction	70,000	70,000	70,000
Total Estimated Cost (TEC)			
FY 2020	5,000	5,000	376
FY 2021	23,000	23,000	9,124
FY 2022	47,000	47,000	30,500
FY 2023	…	…	20,000
FY 2024	…	…	15,000
Total, TEC	**75,000**	**75,000**	**75,000**
Other Project Costs (OPC)			
FY 2019	1,000	1,000	1,000
FY 2023	1,000	1,000	1,000
Total, OPC[c]	**2,000**	**2,000**	**2,000**
Total Project Costs (TPC)			
FY 2019	1,000	1,000	1,000
FY 2020	5,000	5,000	376
FY 2021	23,000	23,000	9,124
FY 2022	47,000	47,000	30,500
FY 2023	1,000	1,000	21,000
FY 2024	…	…	15,000
Grand Total	**77,000**	**77,000**	**77,000**

[a] The enacted FY 2020 appropriation provided $1,000,000. The amount shown includes an additional $4,000,000 that was reprogramming into the project to fully fund the design phase in FY 2020 at $5,000,000.
[b] PED funding is being used by the Project to perform the DOE O 413.3B requirements for CD-2/3.
[c] Other Project Costs (OPC) are funded through laboratory overhead.

4. Details of Project Cost Estimate

(Dollars in Thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	4,000	4,000	4,000
Contingency	1,000	1,000	1,000
Total, Design	5,000	5,000	5,000
Construction			
Construction	59,500	58,100	59,500
Contingency	10,500	11,900	10,500
Total Construction	70,000	70,000	70,000
Total, TEC	**75,000**	**75,000**	**75,000**
Contingency, TEC	*11,500*	*12,900*	*11,500*
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design	1,000	1,000	1,000
Other OPC Costs	1,000	1,000	1,000
Total, OPC[a]	**2,000**	**2,000**	**2,000**
Total Project Cost	**77,000**	**77,000**	**77,000**
Total Contingency (TEC+OPC)	*11,500*	*12,900*	*11,500*

5. Schedule of Appropriations Requests

(dollars in thousands)

Request Year	Type	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	Total
FY 2020	TEC	…	5,000	…	…	…	…	5,000
	OPC	1,000	…	…	…	…	…	1,000
	TPC	1,000	5,000	…	…	…	…	6,000
FY 2021	TEC	…	1,000	40,000	34,000	…	…	75,000
	OPC	1,000	…	…	…	…	1,000	2,000
	TPC	1,000	1,000	40,000	34,000	…	1,000	77,000
FY 2022	TEC	…	5,000[b]	23,000	47,000	…	…	75,000
	OPC[a]	1,000	…	…	…	1,000	…	2,000
	TPC	1,000	5,000[b]	23,000	47,000	1,000	…	77,000

[a] Other Project Costs (OPC) are funded through laboratory overhead.

[b] The enacted FY 2020 appropriation provided $1,000,000. The amount shown includes an additional $4,000,000 that was reprogramming into the project to fully fund the design phase in FY 2020 at $5,000,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	4Q FY 2025
Expected Useful Life (number of years)	50
Expected Future Start of D&D of this capital asset (fiscal quarter)	4Q FY 2075

Related Funding Requirements
(Budget Authority in Millions of Dollars)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate[a]	Previous Total Estimate	Current Total Estimate
Operations and Maintenance	0.9	0.9	44.8	44.8

7. D&D Information

This project will be providing a new facility and does not include demolition of an existing facility.

	Square Feet
New area being constructed by this project at Pacific Northwest National Laboratory	85,000
Area of D&D in this project at Pacific Northwest National Laboratory	None
Area at PNNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	None

8. Acquisition Approach

The PNNL Management and Operating (M&O) contractor, Battelle Memorial Institute, will perform the acquisition activities for this Project, with oversight provided by the Pacific Northwest Site Office. Various acquisition approaches and project delivery methods were evaluated prior to achieving CD-1. A design/build best value technical qualification approach was selected as the best method to acquire the services to deliver the Grid Storage Launchpad facility. The contract was competitively selected based on demonstrated competence and qualifications to perform the required services at a fair and negotiated maximum price and a firm fixed price award was made on March 31, 2021.

[a] Operations and Maintenance cost is based on the Life Cycle Cost Analysis associated with the Analysis of Alternatives. FIMS data for similar type facilities on the PNNL campus was used to estimate the annual value.

Cybersecurity Research and Development

Overview

The increasingly sophisticated cybersecurity exploit capabilities of our adversaries, coupled with changes to the cyber-physical control of our Nation's energy systems, have made it extremely challenging for the energy sector to stay ahead of this quickly evolving risk landscape. Thus, the Department has prioritized investment in cybersecurity to identify solutions to reduce risk for the energy sector. The Cybersecurity Research and Development (Cyber R&D) program strengthens electricity infrastructure against cyber-related threats and mitigates vulnerabilities through support of game-changing R&D. The program focuses on enhancing the inherent resilience (the ability to withstand and quickly recover from disruptions and maintain critical function) and security (the ability to reduce risks in the protection system assets and critical functions from unauthorized access and actions) of U.S. energy infrastructure.

The Cyber R&D program is designing next-generation systems that are built from inception to automatically detect, reject, and withstand cyber incidents, regardless of the threat. To accomplish this goal, the increasing focus is on data and physics to redesign the current grid architecture that exposes the electricity system to cyber threats. For instance, one strategy is using technology, design modifications, or operational considerations to mitigate physical consequences that might result from a cyber-attack and to protect national critical infrastructure. This directly complements ongoing OE research to understand, characterize, and model the electricity system.

Complementing its strategic R&D approach, Cyber R&D also pursues coordinated engagement with the Department's other cyber-related activities, including that of the Office of Cybersecurity, Energy Security, and Emergency Response (CESER) and the Office of Intelligence and Counterintelligence. Through these partnerships, the Cyber R&D program will develop unmatched scientific and technical expertise in support of the Department's national security mission; strengthens public-private sector outreach, information sharing, training, and technical assistance; and enhances emergency preparedness, response, and recovery of U.S. Infrastructure from all threats and hazards.

Highlights of the FY 2022 Budget Request

The FY 2022 Budget request transfers responsibility for R&D for energy sector cybersecurity associated with electricity delivery systems from the Office of Cybersecurity, Energy Security, and Emergency Response (CESER) to OE, providing an opportunity to strengthen the relationship with other OE research for accelerated results. CESER retains lead responsibility for crosscutting cybersecurity issues that span beyond electricity delivery systems, as well as for coordinating energy sector cybersecurity activities across the Department.

The Cyber R&D program will accelerate and expand efforts to strengthen electricity infrastructure against cyber threats while mitigating vulnerabilities. Working closely with the energy sector and our government partners, the request focuses on accelerating game-changing R&D to mitigate cyber incidents in today's systems and to develop next-generation resilient electricity delivery systems. The resilient electricity delivery systems will be designed, installed, operated, and maintained to survive a cyber incident while sustaining critical functions. For instance, research could accelerate development of artificial intelligence (AI) techniques for critical electricity delivery infrastructure, such as machine learning using data generated by the underlying physical process of electricity delivery as well as data generated by the cyber-systems that control that physical process, to provide for an automatic response to cyber-attack. This effort may leverage advancements in grid modeling and data analytics from other OE programs, such as Transmission Reliability and Resilience, Resilient Distribution Systems, and the North American Energy Resilience Model (NAERM). Such AI techniques could allow for electricity delivery systems or components to automatically adapt operations and survive a cyber-attack that would otherwise disrupt energy delivery.

The request continues to support university collaborations focused on advanced energy sector cybersecurity R&D. Project activities will integrate rigorous academic approaches with real-world expertise. Academic R&D is an important aspect of the Cyber R&D portfolio because it involves technology-focused activities that, when combined with industry guidance, results in real-world, impactful solutions, as well as helping to train and develop the next generation of cybersecurity specialists.

Cyber R&D will support R&D activities through the Grid Modernization Laboratory Consortium (GMLC).

Cyber R&D
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Cyber R&D	**…**	**…**	**25,000**	**+25,000**	**N/A**

SBIR/STTR:

- FY 2020 Enacted: SBIR/STTR: $0
- FY 2021 Enacted: SBIR/STTR: $0
- FY 2022 Request: SBIR/STTR: $748

Cyber R&D
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• Cyber R&D is a new program in OE in FY 2022. Associated R&D activities in FY 2021 and before were funded within the Cybersecurity for Energy Delivery Systems program in CESER.	**+25,000**

Cyber R&D

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Cyber R&D $0	**$25,000,000**	**+$25,000,000**
	• Supports a competitive solicitation to survive a cyber-attack, placing the electricity sector's cyber-defender at an advantage by using operational data and the physics of electricity delivery to research, develop, and demonstrate tools and technologies that prevent, detect, and mitigate cyber incidents in today's and tomorrow's electricity delivery systems. • Expands field-testing of the tools and technologies for prevention, detection, mitigation, or resilience against cyber-incidents in electricity delivery systems. • Supports university collaborations focused on advanced energy sector cybersecurity R&D	• Cyber R&D is a new program in OE in FY 2022. Associated R&D activities in FY 2021 and before were funded within the Cybersecurity for Energy Delivery Systems program in CESER. • Activities will improve domain-related mitigation of cyber threats and vulnerabilities that disrupt, degrade, or threaten electricity infrastructure and operations.

Transformer Resilience and Advanced Components

Overview

The Transformer Resilience and Advanced Components (TRAC) program develops innovations for grid hardware carrying, controlling, and converting electricity. These technologies help the electric grid achieve decarbonization goals, ensure reliability and resilience of electric infrastructure, and adapt the electricity delivery system to the evolution of the electric power grid. TRAC addresses the unique challenges facing transformers, critical components, and other grid hardware technologies responsible for delivering electricity from where it is available to where it is needed. As the electric power system evolves, legacy grid components will need to overcome historic performance limits. Research in advanced power electronics, materials, and sensors will provide the enhancements in next-generation grid hardware required to accommodate the rapidly changing power system. Program activities will ultimately address the need for real and reactive power flow control, facilitate the integration of grid-scale energy storage, develop new system components, and increase system efficiency, stability, and resilience.

Decarbonization of electric grid will require modernization of the transmission and distribution (T&D) systems and application of new components to support changing mix and characteristics and types of electricity generation. In addition, T&D equipment such as transformers, power lines, and substation equipment are often exposed to the elements and are vulnerable to adverse conditions, which are occurring increasingly often. To support the transition to a decarbonized grid and enhance the security, reliability, and resilience of the electric power system, the next generation of these grid hardware technologies will need to support the requirements of an evolving grid and be built to withstand and rapidly recover from the impact of extreme terrestrial or space weather events, electrical disturbances, equipment failures, accidents, deliberate attacks, and other unknowns. Other important characteristics include flexibility and adaptability to address the wide range of designs and specifications across these critical assets, facilitating interchangeability and sharing in emergency situations as highlighted in the July 2017 National Academies Report, *Enhancing the Resilience of the Nation's Electricity System*.[a]

TRAC focuses on innovative designs, materials research, exploratory concepts (such as a high-voltage direct current backbone), and modeling and analysis to address the range of challenges associated with transformers and other grid components. Program activities, developed in close coordination with industry, aim to fill fundamental R&D gaps and encourage the adoption of new technologies and approaches. Next-generation solutions are urgently needed; many existing components cannot support evolving grid demands, while the age of existing grid assets degrades their ability to withstand physical stresses and may result in higher failure rates that could lead to widespread outages and long restoration times. For example, failure of a large power transformer (LPT) could disrupt power to the equivalent of 500,000 homes and take over 12 months to procure, transport, and install a replacement. As a large percentage of these assets reach replacement age, results of the TRAC program will help lay the foundation for the grid of the future by catalyzing advances in the underlying physical infrastructure. TRAC supports projects that spur innovative LPT designs that are more flexible and adaptable, increasing the resilience of the Nation's power grid, and providing the foundation to reinvigorate domestic LPT manufacturing.

Highlights of the FY 2022 Budget Request

Based on the Administration's decarbonization goals, TRAC will accelerate work to address the unique challenges facing LPTs and other critical components, such as advanced conductors and cables, power flow controllers, high voltage direct current (HVDC) equipment, and related grid hardware. The increase in FY 2022 supports a 1–2-year acceleration of the timeline for field validation of innovative, flexible, and adaptable prototypes for LPTs and other critical components. Field validated novel LPTs will promote greater standardization to increase grid resilience. Integrating sensors and data analytics (such as for health monitoring) can further enhance the flexibility and adaptability of LPTs. Additionally, field validated novel LPTs will be encouraged to include embedded intelligence to improve asset operation in a range of environments, both steady-state and under extreme conditions, including the ability to monitor and predict the health of the asset.

TRAC will also continue to address critical research needs for solid-state power substations (SSPS) with an emphasis on advanced materials, embedded intelligence for equipment monitoring, and validation of prototype converter building blocks.[b] The high voltage, high power, and high reliability requirements of grid applications present unique challenges for

[a] https://www.nap.edu/catalog/24836/enhancing-the-resilience-of-the-nations-electricity-system

[b] https://energy.gov/oe/downloads/solid-state-power-substation-roadmapping-workshop-june-2017

these technologies, especially when operating at higher frequencies. Greater utilization of high voltage power electronic converters within substations, including in hybrid and solid-state transformer applications, can provide power flow control capabilities and reactive power support, limit fault currents, and increase system reliability and resilience. Understanding the value and impact of these improved capabilities will benefit from high-fidelity modeling and simulation. Continued efforts in this cutting-edge technology concept can enable more flexible and adaptable designs that are interoperable with legacy systems, help reduce the criticality of substations, and facilitate integration of distributed energy resources (DERs) and energy storage for enhanced resilience. Additionally, efforts will be pursued to expand on the current consortium of academics, vendors, national laboratories, other government agencies, and utilities to guide advancement of the SSPS vision.

Technology, tools, and applications developed under TRAC will be evaluated for security risks including cybersecurity, electromagnetic pulses, and geomagnetic disturbances. Testing and evaluations will be conducted to ensure that security is built-in and new security risks are not being introduced into the electric sector.

TRAC will also expand activities in technology solutions that can provide continued grid reliability under an increased frequency of extreme climate and weather events. Such solutions include fire-resistant distribution infrastructure and improved cost and performance of undergrounded power lines to improve, or harden, the current infrastructure.

Support of R&D activities through the Grid Modernization Laboratory Consortium (GMLC) will continue.

Transformer Resilience and Advanced Components
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Transformer Resilience and Advanced Components	**7,000**	**7,500**	**22,500**	**+15,000**	**+200.0%**

SBIR/STTR:

- FY 2020 Enacted: SBIR/STTR: $223
- FY 2021 Enacted: SBIR/STTR: $247
- FY 2022 Request: SBIR/STTR: $742

Transformer Resilience and Advanced Components
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• The request continues R&D of SSPS converter building blocks and expand efforts in evaluation and use-case demonstration for these novel technologies and concepts	**+15,000**
• The request continues R&D of LPTs, expanding and accelerating efforts in field demonstration and validation of these novel technologies	
• The request supports the evaluation of advanced electricity delivery technologies for increased transmission capacity and flexibility	
• The request expands evaluation of technologies that maintain delivery reliability under extreme weather and climate conditions	

Transformer Resilience and Advanced Components

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Transformer Resilience and Advanced Components **$7,500,000**	**$22,500,000**	**+$15,000,000**
• Establish modeling and testing capabilities to evaluate the performance and interoperability of SSPS building blocks • Continue applied materials research on converter components with an emphasis on packaging and embedded intelligence • Establish a consortium of diverse stakeholders around the SSPS vision to help guide technology development and maturation	• Field validate large power transformers and other critical components showing increased adaptability and resiliency • Evaluate and test the performance and interoperability of SSPS building blocks	• Expand evaluations and use-case demonstration for SSPS building blocks and associated concepts; evaluation of advanced electricity delivery technologies; and field validation of LPTs and other critical components • Evaluate technologies that support increase of delivery capacity, such as HVDC conversion, power flow control • Evaluate technologies that maintain grid reliability and safety under extreme weather and climate conditions

Energy Delivery Grid Operations Technology

Overview

Development of a Nation-wide energy resilience strategy would benefit from a public–private partnership to develop national-scale energy planning and real-time situational awareness capabilities based on rigorous and quantitative assessment, sensing, prediction, and deep learning. The Energy Delivery Grid Operations Technology (EDGOT) program will enhance this national-scale operational capability to ensure reliable and resilient energy delivery across multiple energy sectors and provide the architecture and process for a range of large-scale mitigation solutions to emerging threats. EDGOT will specifically focus on developing large, networked energy transmission, distribution, communication, and data infrastructures across multiple utility boundaries in support of reliable and resilient energy delivery systems. EDGOT efforts will support energy infrastructure investments and critical infrastructure protection responsibilities for the energy sector under Presidential Policy Directive 21—Critical Infrastructure Security and Resilience.[a] The EDGOT technology portfolio will enable assessment of risks and uncertainty, evaluation and identification of effective mitigation strategies, and support of more informed infrastructure planning and investment decisions by both public and private sectors, thereby enhancing energy and economic security, benefiting the United States.

The core of the EDGOT portfolio is the North American Energy Resilience Model (NAERM), which begins operations in FY 2022. NAERM development was funded under the Transmission Reliability and Resilience program in FY 2019–2021. EDGOT also supports networked communications activities previously funded under the Resilient Distribution Systems program. NAERM will improve analysis of the significant interdependencies that have evolved within the energy sector and help us transition from the current reactive state-of-practice to a new energy planning and operations paradigm for transmission and distribution planning for expansion and for ever-changing customer and industrial load profiles, while proactively anticipating damage to energy system equipment, predicting associated outages and lack of service, and recommending optimal mitigation strategies. The Federal Government, as part of a public–private partnership, will have the ability to better evaluate strategic opportunities for improving system performance through the deployment of certain types of infrastructure, such as energy storage for frequency control and renewable penetration in support of the Administration's 2035 objectives for clean energy conversion. NAERM and other EDGOT tools will provide for enhanced planning and analysis capabilities that can be leveraged to facilitate grid investments that address disproportionate health, environmental, economic, and climate impacts on disadvantaged and energy communities and will increase the reliability and resilience of the energy infrastructure, inform national security investments, and enhance decision making under DOE's authorities to respond to grid security emergencies. Under the new directives of the Administration, NAERM will expand the capabilities to transmission and investment planning providing and supporting carbon-free and renewable infrastructure to use taxpayer dollars more efficiently in providing the concept and operations for the resilient, clean grid of the future.

EDGOT's tools will support several private and public efforts:

- Utilizing a systems perspective to compare and collectively plan for impacts across organizational, geographic, sector, and jurisdictional boundaries
- Providing the capability to systematically define critical energy infrastructure criteria through a defensible and repeatable methodology.
- Targeting collaboration on mitigations with the Department's Power Marketing Administrations (PMAs) and other energy infrastructure owners and operators to effectively address national security concerns
- Supporting and advising on better utilizations of optical power ground wire (OPGW) to support grid timing and synchronization, and potentially rural broadband

The EDGOT portfolio leverages previous national laboratory efforts to fully understand the resilience risks associated with the highly diversified, regionally isolated North American electric system and associated fuel delivery systems. National laboratories including the Argonne, Idaho, Los Alamos, National Renewable Energy, Oak Ridge, Pacific Northwest, Lawrence Livermore, and Sandia National Laboratories have a long history of developing system-wide modeling and analysis tools, as well as transformational sensing and communications technology.

[a] https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil

Highlights of the FY 2022 Budget Request

Predicting the impact of a specific event on energy system operations, restoration, and recovery is vexing due to the scale of the North American energy system—crossing organizational, geographic, sector, and jurisdictional boundaries—and the underlying physics of energy transport. Our current ability to analyze extreme events in this context is presently limited due to the lack of the following key information and capabilities:

- Unclassified details regarding potential threats
- Data and predictions on resulting impacts
- Tools required to model multiple infrastructures, such as natural gas or communications, taking into account the different modeling needs of the infrastructures
- Tools and infrastructure to support an electricity delivery system (EDS) infrastructure grid planning tool
- Expertise in characterizing and analyzing the relationships between energy and associated infrastructures
- Details concerning the coordination and interdependencies of numerous utilities and stakeholders involved in regional and national-scale energy system operations

The FY 2022 EDGOT request will focus on developing new, and enhancing the existing portfolio of, tools to help address these limitations and to transition the underlying capabilities to a robust, secure operational state:

- Incorporate the best available information on threat characteristics and their evolution over time
- Expand the Situational Awareness Network (SAN) and the availability of real-time data feeds and integrate SAN and the feeds into the NAERM platform
- Formalize procedures and establish partnerships for sharing data with utilities and independent system operators (ISOs)
- Harden and integrate research innovations in advanced analytics to rapidly identify system vulnerabilities and enhance decision support for system analysis
- Initiate development of complex multi-infrastructure contingency analysis providing day-ahead snapshots of the national resilience posture
- Enhance infrastructure models, and facilitate their integration into the NAERM architectural framework
- Expand NAERM's operational capability in protecting and supporting the increase in data sources and access to the NAERM
- Collaborate with PMAs on implementation and validation of mitigation approaches
- Engage with industry experts to get a better understanding of issues and practices on a regional basis to ensure that threat and consequence models are realistic and representative of actual system responses
- Deploy large scale-communication and data architecture solutions for advanced sensing, risk mitigation, and increased security
- Support information, communication, technology, and data infrastructure requirements for the sector (such as precision timing)
- Work in partnership with the national labs to build a framework and layers for an EDS infrastructure grid planning tool for transmission and distribution level network planning supporting short- and long-term planning of grid activities

Technology, tools, and applications developed under the EDGOT program will be evaluated for security risks including cybersecurity. Testing and evaluations will be conducted to ensure that security is built in.

Grid Operations Technology
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Energy Delivery Grid Operations Technology	**…**	**…**	**43,500**	**+43,500**	**N/A**

Grid Operations Technology
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• Support operation and maintenance for the NAERM platform and PEAC network; prior development costs were funded in Transmission Reliability and Resilience	**+43,500**
• Integrate SAN features into NAERM real-time system	
• Expand the visibility of threat levels within NAERM by expanding coverage, features, and layers	
• Develop a new EDS transmission planning tool framework while researching and acquiring data sources to carry out planning at the transmission and distribution levels	
• Expand the architecture and security posture to support data storage and access capabilities	
• Complete the conversion of PEAC from TRR to EDGOT and operationalizing by providing PMA and laboratory access to the system	
• Combine power sensor projects into a sensor network while integrating into NAERM	

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Grid Operations Technology $0	**$43,500,000**	**+$43,500,000**
	• Expand situational awareness functionality for assessing energy infrastructure interdependencies • Continue to enhance the regulatory compliance and security management of the NAERM platform as it shifts from a research-oriented tool to near-operational capability • Maintain and integrate SAN into the NAERM real-time platform • Continue operational support for the PEAC network	• Activities from OE R&D programs transfer into EDGOT as they transition from R&D into operations: • Operation and maintenance of NAERM platform and PEAC network transition from TRR • Operational support and expansion of SAN transitions from RDS

Defense Critical Electric Infrastructure Energy Mission Assurance

Overview

The Defense Critical Electric Infrastructure (DCEI) Energy Mission Assurance program was established in FY 2021 to identify, evaluate, prioritize, and assist in developing executable strategies to ensure that critical national defense and security missions have reliable access to power as energy supply disruptions threaten the civilian grid due to intensifying cybersecurity threats and other hazards. This effort directly supports Secretary of Energy's authority to designate Critical Defense Facilities (CDFs) and identify their associated DCEI under Sec. 215A of the Federal Power Act (FPA) as amended by the Fixing America's Surface Transportation (FAST) Act in 2015. This effort complements additional DOE authorities including emergency grid orders under Sec. 202(c) of the FPA, the protection of critical infrastructure in the energy sector under Presidential Policy Directive 21, improving critical infrastructure cybersecurity under Executive Order 13636, strengthening the cybersecurity of federal networks and critical infrastructure under Executive Order 13800, and other Departmental authorities and capabilities.

In FY 2022, DOE is proposing a realignment of activities, and as part of that realignment, the functions of the DCEI Energy Mission Assurance program are moved to the Office of Cybersecurity, Energy Security, and Emergency Response (CESER) to be integrated with CESER's suite of activities partnering with, supporting, and sharing information with the electric utility industry to enhance energy resilience through its energy assurance planning efforts.

Highlights of the FY 2022 Budget Request

The Budget Request transfers responsibility for the activities formerly funded in the DCEI Energy Mission Assurance program to CESER.

DCEI Energy Mission Assurance
Funding ($K)

	FY 2020 Enacted	FY 2020 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
DCEI Energy Mission Assurance	**…**	**1,000**	**…**	**-1,000**	**-100.0%**

DCEI Energy Mission Assurance
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• The Budget Request transfers responsibility for the activities formerly funded in the DCEI Energy Mission Assurance program to CESER	-1,000

DCEI Energy Mission Assurance

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
DCEI Energy Mission Assurance $1,000,000	**$0**	**-$1,000,000**
• Develop electric power resiliency requirements and metrics for essential critical infrastructure nodes • Develop electric power resiliency strategies and evaluation methodologies for Critical Defense Facilities • Identify and select at least one site for execution of a suite of site-specific strategies	• The Budget Request transfers responsibility for the activities formerly funded in the DCEI Energy Mission Assurance program to CESER	• The Budget Request transfers responsibility for the activities formerly funded in the DCEI Energy Mission Assurance program to CESER

Final Transmission Permitting and Technical Assistance

Overview

The mission of the Transmission Permitting and Technical Assistance (TPTA) program is to work with electricity system partners and stakeholders to modernize the grid and ensure equitable and adequate transmission capacity across the United States to achieve 100% carbon-free electricity by 2035.

TPTA:

- Works with Federal, State, local, Tribal, and territorial (SLTT) partners, regional planning organizations and grid operators, the electric utility industry and electricity system stakeholders to address emerging electricity system needs through research, analysis, and technical assistance to support a carbon-free, reliable, resilient, safe, secure, and affordable electricity system
- Informs the formulation and implementation of policies, programs and strategies regarding electricity system planning, design, and operation
- Collaborates on, and leads as appropriate, Grid Modernization Laboratory Consortium (GMLC) projects, including institutional projects
- Prepares statutorily required reports, including the National Electric Transmission Congestion Study and Data Review, Economic Dispatch Report, Energy Storage Report, and Energy Storage R&D Report
- Leads and implements authorities related to designation of National Interest Electric Transmission Corridors
- Conducts analysis of electricity system grid modernization trends, related economic impacts, and Federal, State, and regional policies on electric market operation and system reliability, as well as financial impacts to customers and other issues
- Manages and directs the formulation and implementation of DOE policies and programs related to the development of Presidential Permitting and of cross-border electric transmission line permitting
- Evaluates and, as appropriate, approves export authorization applications to export electricity from the United States
- Oversees and supports all aspects of the Electricity Advisory Committee—a group of energy experts appointed by the Secretary of Energy to advise the Department and help spearhead innovative collaborations

Highlights of the FY 2022 Budget Request

TPTA is requesting additional resources to expand its outreach and support activities with Federal, State, and industry partners to address the climate crisis by decarbonizing the electricity sector, transmission planning, and maximizing cost-effective demand-side resources and solutions to achieve 100% carbon-free electricity by 2035. TPTA is working with experts around the country, including the national laboratories and Power Marketing Administrations (PMAs), to provide thought leadership, analysis, and strategic technical assistance to key partners to address critical challenges and opportunities driven by and impacted by modernization of the North American grid. These challenges and opportunities include but are not limited to:

- Integration of grid-scale renewable energy and distributed energy resources
- Increasing electrification of transportation and other sectors
- Encouraging grid services provided by energy efficiency, demand flexibility, and energy storage
- Application of grid-connected devices, automation, and digitalization of distribution systems
- Electricity system planning and operation for resource adequacy, reliability, and resilience
- Climate resilience planning support to mitigate future risks
- Analyzing the implications of energy interdependencies to improve the alignment and integration of generation, distribution, and transmission planning
- Considering the full range of investment options to meet established and emerging grid needs and analysis for grid investment decision making
- Addressing needs to improve aging and poorly maintained infrastructure
- Facilitating electric/gas system coordination; addressing affordability, evolving customer expectations and behaviors, and electricity access and equity issues, all with a focus on energy justice.
- Supporting the application of regulatory, operations and business models toward alignment of incentives for a resilient, clean, affordable, and efficient electricity system

TPTA will provide support in these areas to State and other jurisdictional agencies and partner organizations seeking to advance their capabilities with respect to addressing these key challenges and opportunities.

Work in these issue areas will result in the development of strategic technical assistance engagements, tools, reports, analyses, and stakeholder discussions that can help Federal, SLTT, and regional electricity officials make more-informed decisions about their respective elements of the electricity system.

TPTA will also continue to exercise and carry out its statutory authorities and responsibilities to develop and improve our Nation's electricity infrastructure in several areas:

- Addressing the barriers to increasing transmission infrastructure, long permitting and review times, cost allocation issues, and generation-specific challenges such as with off-shore wind
- Working with stakeholders on collaborative, voluntary National Interest Electric Transmission Corridor designations
- Providing technical assistance and guidance to SLTT, ISO/RTOs, and other stakeholders on specific transmission development projects
- Conducting environmental reviews and technical analyses needed for Federal authorization of transmission projects that cross U.S. international borders
- Coordinating Federal permitting by other agencies of new transmission infrastructure that involves Federal authorizations, as required by Section 216(h) of the Federal Power Act
- Evaluating any new applications under Section 1222 of the Energy Policy Act of 2005, which authorizes DOE to participate in third-party-financed transmission projects within the Western Area Power Administration (WAPA) and the Southwestern Power Administration (SWPA) regions

Transmission Permitting and Technical Assistance
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Transmission Permitting and Technical Assistance	**7,000**	**7,000**	**10,000**	**+3,000**	**+42.9%**

Transmission Permitting and Technical Assistance
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• Expand outreach and support activities with Federal, State, and industry partners to address the climate crisis by decarbonizing the electricity sector and maximizing cost-effective demand-side resources and solutions to achieve a 100% carbon-free electricity by 2035	**+3,000**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Transmission Permitting and Technical Assistance **$7,000,000**	**$10,000,000**	**+$3,000,000**
• Develop grid resilience tools and analyses to help State electricity officials promote prudent, strategic decision-making • Provide technical assistance to Federal, State, Tribal, territorial, and regional entities for current and future electricity-related issues • Continue to implement regulatory responsibilities and evaluate regulatory reform to reduce Federal burden • Support for technical assistance work to provide stakeholders an in-depth understanding of the resilience of the electricity and related infrastructure • Provide institutional support to potential infrastructure investments that addresses the vulnerabilities of the North American energy system	• Pursue transmission permitting and planning initiatives to accelerate the deployment of carbon-free generation and address the climate crisis • Develop grid reliability and resilience tools and analyses to help State electricity officials promote prudent, strategic decision-making • Provide technical assistance and analytical support to Federal, State, local, territorial, Tribal, and regional entities, and other partners, to advance modernization of the U.S. electric grid and address key challenges in the energy system • Continue to implement regulatory responsibilities	• Expand outreach and support activities with Federal, State, industry, and other partners to modernize the grid and ensure adequate transmission capacity to address the climate crisis by decarbonizing the electricity sector and maximizing cost-effective demand-side resources and solutions to achieve a 100% carbon-free electricity by 2035

Program Direction

Overview

Program Direction provides for the costs associated with the Federal workforce, including salaries, benefits, travel, training, building occupancy, IT services, security clearance, and other related expenses. It also provides for the costs associated with contractor services that, under the direction of the Federal workforce, support the Office of Electricity (OE) mission.

Salaries and Benefits support Federal employees who provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program. This includes staff at Headquarters and at the National Energy Technology Laboratory (NETL). While OE funds NETL staff within its budget, the NETL Federal employees are included within the full-time equivalent (FTE) total for the Fossil Energy Research and Development account.

Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively manage research and development programs and projects in the field; to provide the Department's electricity-related outreach to regions, states, and tribes regarding planning needs and issues, policies, siting protocols, and new energy facilities.

Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analyses to management. These efforts include issue-oriented support on science, engineering, environment, and economics that benefit strategic planning; technology and market analysis to improve strategic and annual goals; development of management tools and analyses to improve overall office efficiency; assistance with communications and outreach to enhance OE's external communication and responsiveness to public needs; development of program-specific information tools that consolidate corporate knowledge, performance tracking and inventory data, improve accessibility to this information, and facilitate its use by the entire staff.

Other Related Expenses includes corporate IT support (for DOE's Energy Information Technology Services [EITS] desktop services and IT equipment) and working capital fund (WCF) expenses, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes office safety requirements, equipment upgrades and replacements, commercial credit card purchases using simplified acquisition procedures where possible, security clearance expenses, and other needs.

Highlights of the FY 2022 Budget Request

The FY 2022 Program Direction Request reflects an increase in the Headquarters staffing level to manage OE's proposed growing portfolio of activities in OE's programs. The increases also address critical staffing vacancies in some program areas. With the heightened attention and priority of OE's mission to accelerate the transformation of our Nation's power grid, sufficient staffing is crucial to expeditiously and successfully meet our goals and objectives. This request allows for depth and breadth of staff and allows the programs to address skill gaps and succession planning.

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	9,789	9,873	11,284	+1,411	+14.3%
Travel	350	300	410	+110	+36.7%
Support Services	1,254	1,440	1,540	+100	+6.9%
Other Related Expenses	3,034	2,965	3,206	+241	+8.1%
Total, Washington Headquarters	**14,427**	**14,578**	**16,440**	**+1,862**	**+12.8%**
National Energy Technology Laboratory					
Salaries and Benefits	1,698	1,700	1,749	+49	+2.9%
Travel	180	130	52	-78	-60.0%
Support Services	371	371	375	+4	+1.1%
Other Related Expenses	1,324	1,221	1,384	+163	+13.3%
Total, National Energy Technology Laboratory	**3,573**	**3,422**	**3,560**	**+138**	**+4.0%**
Total Program Direction					
Salaries and Benefits	11,487	11,573	13,033	+1,460	+12.6%
Travel	530	430	462	+32	+7.4%
Support Services	1,625	1,811	1,915	+104	+5.7%
Other Related Expenses	4,358	4,186	4,590	+404	+9.7%
Total, Program Direction	**18,000**	**18,000**	**20,000**	**+2,000**	**+11.1%**
Federal FTEs	**62**	**63**	**68**	**+5**	**+7.9%**
Additional FE FTEs at NETL supporting OE[a]	12	11	11	…	…
Total OE-funded FTEs	74	74	79	+5	+6.8%

[a] OE funds FTEs at FE's National Energy Technology Laboratory who support OE activities. The FTEs are included in FE's FTE totals and not in the OE FTE totals shown on the "Federal FTEs" line.

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Support Services and Other Related Expenses					
Support Services					
Technical Support	780	964	1,073	+109	+11.3%
Management Support	845	847	842	-5	-0.6%
Total, Support Services	1,625	1,811	1,915	+104	+5.7%
Other Related Expenses					
Other Services	1,444	1,250	1,386	+136	+10.9%
EITS Desktop Services	380	392	420	+28	+7.1%
WCF	2,534	2,544	2,784	+240	+9.4%
Total, Other Related Expenses	4,358	4,186	4,590	+404	+9.7%

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $18,000,000	**$20,000,000**	**+$2,000,000**
Salaries and Benefits $11,573,000 • Salaries and Benefits support 70 FTEs at HQ and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program • An additional 4 OE FTEs at HQ are reimbursed by FEMA through an interagency agreement for place-based long-term recovery and power system resilience planning	**$13,033,000** • Salaries and Benefits support 75 FTEs at HQ and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program • An additional 4 OE FTEs at HQ are reimbursed by FEMA through an interagency agreement for place-based long-term recovery and power system resilience planning	**+$1,460,000** • Increase to support 5 new FTEs as well as the 2022 Federal pay increase
Travel $430,000 • Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission	**$462,000** • Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission	**+$32,000** • Increase due to staff hires and per diem for intergovernmental personnel act (IPA) assignments

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Support Services $1,811,000 • Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. Support Services may include support for post-doctoral fellows and IPA assignments	**$1,915,000** • Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. Support Services may include support for post-doctoral fellows and IPA assignments	**+$104,000** • Increase in support services to support NAERM, Cyber R&D, and increasing IT Governance requirements while Federal staff is being trained
Other Related Expenses $4,186,000 • Other Related Expenses includes EITS desktop services and WCF expense, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, security clearance expenses and other needs	**$4,590,000** • Other Related Expenses includes EITS desktop services and WCF expense, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, security clearance expenses and other needs	**+$404,000** • Other Related Expenses increases due to additional training, IT equipment, cellular services and WCF expenses associated with new staff, and to support an enhanced telework-readiness posture for OE staff

Electricity

Research and Development ($K)[a]

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Basic	15,404	14,146	16,723	+2,577	+18.2%
Applied	67,881	56,453	90,804	+34,351	+60.8%
Development	70,584	75,587	78,794	+3,207	+4.2%
Total, R&D	153,869	146,186	186,321	+40,135	+27.5%
R&D-related construction	1,105	25,137	50,062	+24,925	+99.2%
Total, R&D and related facilities	154,974	171,323	236,383	+65,060	+38.0%

Electricity

Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2020 Enacted Transfer	FY 2021 Enacted Projected Transfer	FY 2022 Request Projected Transfer	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Transmission Reliability and Resilience	1,731	1,527	1,223	-304	-19.9%
Resilient Distribution Systems	1,359	1,265	1,290	+25	+2.0%
Energy Storage	1,618	1,607	2,102	+495	+30.8%
Cyber R&D	…	…	776	+776	N/A
Transformer Resilience and Advanced Components	223	247	742	+495	+200.4%
Total, SBIR/STTR	4,931	4,646	6,133	+1,487	+32.0%

[a] R&D reporting includes a proportional share of program direction funding in addition to direct R&D funding. FY 2020 and FY 2021 amounts may not reconcile to MAX A-11.

DEPARTMENT OF ENERGY

Funding by Site

TAS_0318 - Electricity BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Ames Laboratory			
Transformer Resilience and Advanced Components	50	0	0
Total Ames Laboratory	**50**	**0**	**0**
Argonne National Laboratory			
Transmission Reliability and Resilience	5,961	3,972	2,600
Resilient Distribution Systems	1,277	1,400	1,600
Transformer Resilience and Advanced Components	60	0	0
Grid Operations Technology	0	0	2,500
Transmission Permitting and Technical Assistance	125	250	1,000
Total Argonne National Laboratory	**7,422**	**5,622**	**7,700**
Brookhaven National Laboratory			
Transmission Reliability and Resilience	370	900	900
Total Brookhaven National Laboratory	**370**	**900**	**900**
Idaho National Laboratory			
Transmission Reliability and Resilience	3,155	2,908	4,700
Resilient Distribution Systems	1,618	600	800
Cyber R&D	0	0	1,000
Transformer Resilience and Advanced Components	390	170	280
Grid Operations Technology	0	0	2,000
Total Idaho National Laboratory	**5,163**	**3,678**	**8,780**
Lawrence Berkeley National Laboratory			
Transmission Reliability and Resilience	520	1,288	1,300
Resilient Distribution Systems	1,228	1,250	1,500
Energy Storage Research	122	0	0
Energy Storage	122	0	0
Transmission Permitting and Technical Assistance	325	0	1,000
Total Lawrence Berkeley National Laboratory	**2,195**	**2,538**	**3,800**
Lawrence Livermore National Laboratory			
Transmission Reliability and Resilience	5,028	6,339	2,400
Resilient Distribution Systems	839	1,275	1,300
Grid Operations Technology	0	0	5,000
Total Lawrence Livermore National Laboratory	**5,867**	**7,614**	**8,700**
Los Alamos National Laboratory			
Transmission Reliability and Resilience	4,294	3,082	2,000
Resilient Distribution Systems	544	900	980
Grid Operations Technology	0	0	2,500
Total Los Alamos National Laboratory	**4,838**	**3,982**	**5,480**
National Energy Technology Lab			
Transformer Resilience and Advanced Components	106	0	0
Program Direction - Electricity	3,249	3,422	3,560
Total National Energy Technology Lab	**3,355**	**3,422**	**3,560**
National Renewable Energy Laboratory			
Transmission Reliability and Resilience	4,069	5,319	2,500

DEPARTMENT OF ENERGY

Funding by Site

TAS_0318 - Electricity BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Resilient Distribution Systems	4,625	3,500	4,300
Energy Storage Research	250	0	0
Energy Storage	250	0	0
Cyber R&D	0	0	500
Transformer Resilience and Advanced Components	300	400	1,000
Grid Operations Technology	0	0	7,000
Transmission Permitting and Technical Assistance	655	225	1,000
Total National Renewable Energy Laboratory	**9,899**	**9,444**	**16,300**
Oak Ridge National Laboratory			
Transmission Reliability and Resilience	16,393	8,894	3,000
Resilient Distribution Systems	13,051	14,000	4,600
Energy Storage Research	2,399	3,200	3,000
Energy Storage	2,399	3,200	3,000
Transformer Resilience and Advanced Components	4,965	6,000	7,000
Grid Operations Technology	0	0	9,000
Total Oak Ridge National Laboratory	**36,808**	**32,094**	**26,600**
Pacific Northwest National Laboratory			
Transmission Reliability and Resilience	10,873	9,520	4,000
Resilient Distribution Systems	10,530	15,838	12,200
Energy Storage Research	23,462	17,700	16,870
20-OE-100 Grid Storage Launchpad	1,000	23,000	47,000
Construction - Energy Storage	1,000	23,000	47,000
Energy Storage	24,462	40,700	63,870
Cyber R&D	0	0	2,500
Transformer Resilience and Advanced Components	62	0	0
Grid Operations Technology	0	0	8,000
Transmission Permitting and Technical Assistance	507	140	1,000
Total Pacific Northwest National Laboratory	**46,433**	**66,198**	**91,570**
Sandia National Laboratories			
Transmission Reliability and Resilience	2,679	2,111	1,500
Resilient Distribution Systems	5,610	1,507	1,800
Energy Storage Research	26,165	29,610	27,600
Energy Storage	26,165	29,610	27,600
Transformer Resilience and Advanced Components	200	300	1,000
Grid Operations Technology	0	0	3,000
Transmission Permitting and Technical Assistance	529	0	1,000
Total Sandia National Laboratories	**35,184**	**33,528**	**35,900**
Savannah River National Laboratory			
Resilient Distribution Systems	142	0	0
Total Savannah River National Laboratory	**142**	**0**	**0**
SLAC National Accelerator Laboratory			
Transmission Reliability and Resilience	0	200	200
Resilient Distribution Systems	250	25	0
Energy Storage Research	928	0	0
Energy Storage	928	0	0
Total SLAC National Accelerator Laboratory	**1,178**	**225**	**200**

DEPARTMENT OF ENERGY

Funding by Site

TAS_0318 - Electricity BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Southwestern Power Administration Office			
Resilient Distribution Systems	3,000	0	0
Total Southwestern Power Administration Office	**3,000**	**0**	**0**
Washington Headquarters			
Transmission Reliability and Resilience	1,700	1,750	3,000
Resilient Distribution Systems	481	1,700	700
Energy Storage Research	2	500	500
Energy Storage	2	500	500
Transformer Resilience and Advanced Components	644	318	400
Grid Operations Technology	0	0	750
DCEI Energy Mission Assurance	0	500	0
Transmission Permitting and Technical Assistance	2,422	2,085	1,750
Program Direction - Electricity	14,751	14,578	16,440
Total Washington Headquarters	**19,999**	**21,431**	**23,540**
Western Area Power Administration Office			
Transmission Reliability and Resilience	30	0	0
Total Western Area Power Administration Office	**30**	**0**	**0**
Grants			
Transmission Reliability and Resilience	1,918	1,937	8,900
Resilient Distribution Systems	1,806	8,005	20,220
Energy Storage Research	1,618	5,990	24,030
Energy Storage	1,618	5,990	24,030
Cyber R&D	0	0	21,000
Transformer Resilience and Advanced Components	223	312	12,820
Grid Operations Technology	0	0	750
Transmission Permitting and Technical Assistance	2,437	4,300	3,050
Total Grants	**8,002**	**20,544**	**90,770**
Undesignated LPI			
Transmission Reliability and Resilience	9	0	0
Resilient Distribution Systems	0	0	0
Energy Storage Research	55	0	0
Energy Storage	55	0	0
Grid Operations Technology	0	0	3,000
DCEI Energy Mission Assurance	0	500	0
Total Undesignated LPI	**64**	**500**	**3,000**
Total Funding by Site for TAS_0318 - Electricity	**190,000**	**211,720**	**326,800**

Cybersecurity, Energy Security, and Emergency Response

Cybersecurity, Energy Security, and Emergency Response

Cybersecurity, Energy Security, and Emergency Response
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for energy sector cybersecurity, energy security, and emergency response activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, **[**$198,000,000**]** *$201,000,000*, to remain available until expended: Provided, That of such amount, [$12,900,000] *$16,000,000* shall be available until September 30, **[**2022**]** *2023*, for program direction. *(Energy and Water Development and Related Agencies Appropriations Act, 2021.)*

Public Law Authorizations

Public Law 95–91, "Department of Energy Organization Act", 1977

Public Law 109-58, "Energy Policy Act of 2005"

Public Law 110-140, "Energy Independence and Security Act, 2007"

Public Law 114-94, "Fixing America's Surface Transportation Act", 2015

Public Law 110-246, "Division Z Energy Act", 2020

Cybersecurity, Energy Security, and Emergency Response
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY2021 Enacted
156,000	156,000	201,000	+45,000

Overview

The Department of Energy's (DOE's) Office of Cybersecurity, Energy Security, and Emergency Response (CESER) leads the Department's efforts to secure U.S. energy infrastructure against all hazards, reduce the risks of and impacts from cyber events and other disruptive events, and assist with restoration activities. CESER is the Office responsible for DOE's responsibilities as lead agency for Emergency Support Function #12 (Energy), or ESF #12, under the National Response Framework, and is the Energy Sector Risk Management Agency (SRMA) for national efforts to enhance the preparedness, resiliency, and recovery of the U.S. energy infrastructure from all threats and hazards.

The energy sector plays a critical role across Federal, State, and local jurisdictions and with nearly all other critical infrastructures relying on the power and fuel to operate. CESER programs work in an integrated manner with industry, state, and federal partnerships to enhance the resilience--the ability to withstand, maintain critical function and quickly recover from disruptions---and security --the ability to reduce risks in the protection system assets and critical functions from unauthorized access and actions --of the U.S. energy infrastructure for all consumers, in line with clean energy and energy justice principles. Secure and resilient energy infrastructure is critical to U.S. economic competitiveness, innovation, and leadership and must be considered with equity and energy justice as priorities.

In 2021, CESER launched a coordinated effort with the electricity industry and Cybersecurity and Infrastructure Security Agency (CISA) to enhance the cybersecurity of electric utilities' industrial control systems (ICS) and operational technology networks. The 100- day plan, initiated on April 16, includes swift, aggressive actions and resources for utilities to confront cyber threats from adversaries who seek to compromise critical systems that are essential to U.S. national and economic security. This plan builds on utility investment in this area and advance technologies and systems that will provide cyber visibility, detection, and response capabilities across investor owned, municipal, and cooperative utilities. CESER will also work with the natural gas pipeline sector on a similar effort, in coordination with interagency partners.

The FY 2022 Budget Request also proposes that the Office of Petroleum Reserves report to the Assistant Secretary for CESER in order to align the Department's non-nuclear emergency management and national security functions.

Within the appropriation, CESER funds:

- Develop and deliver game-changing tools and technologies to help utilities secure and reduce risks to todays' energy infrastructure from advanced cyber threats and design next-generation systems that are built from inception to automatically detect, reject, and withstand cyber incidents, regardless of the threat. As the U.S. moves to a carbon-pollution free energy sector by 2035, CESER will stand ready to develop, deploy, and operationalize tools and technologies to better secure the grid against threats to the evolving grid, from distributed generation to electric vehicles.
- Public and private-sector partnerships which strengthen the energy sector's cybersecurity posture, leveraging DOE-supported tools, guidelines, outreach, training, and technical assistance. CESER will ensure that all communities have equitable access to this support.
- Emergency preparedness and response, supporting the energy sector, to pursue enhancements to national efforts, in cooperation with public and private-sector stakeholders, for preparedness, resilience, and recovery of U.S. energy infrastructure from all threats and hazards.
- CESER will transition the bulk of its cyber research and development portfolio to the Office of Electricity. This shift will allow CESER to expand its risk management tools and technologies focus across all risks and hazards, as well as on cyber risks. Also, the work will tackle significant issues in the sector related to supply chain threats, the rapid modernization of the grid, and additional connectivity due to broader distributed energy resources and electric vehicles. Finally, there is a strong focus on developing cyber visibility in the ICS environment due to significantly increased cyber threat in that space.

Highlights and Major Changes in the FY 2022 Budget Request

- **Risk Management Tools (RMT) formerly Cybersecurity for Energy Delivery Systems (CEDS)** ($103,100,000; +$31,900) The new control line now also accounts for development of cyber and non-cyber tools activities formerly under the Infrastructure Security and Energy Restoration (ISER) control point. RMT seeks to accelerate and expand efforts to strengthen the energy infrastructure against cyber threats and mitigate vulnerabilities. As the Sector Risk Management Agency (SRMA) for Energy, DOE will invest in threat and vulnerability situational awareness tools and capabilities to develop and maintain sector-wide situational awareness of cyber and physical/natural hazards and emerging trends focused on energy sector disruption and leverage DOE partnerships with energy sector industry, other federal agencies such as DHS, and state, local, and tribal governments. RMT will enable maintenance of real-time sector-wide situational awareness combined with time-sensitive analysis, visualization, and dissemination of actionable threat and vulnerability information in support of key DOE, federal government, and energy sector stakeholders. These tools will incorporate rapid dissemination and processing of energy sector data for identification and characterization of threats for intelligence analysis, assessments, products, and services in unclassified and classified environments required to support CESER's operational cyber and energy security responsibilities. These specialized tools will use analytics to understand, enrich, and fuse data and enable intelligence-driven action to improve resilience for the energy sector. Working closely with the energy sector and our government partners, the request focuses on enhancing the speed and effectiveness of threat and vulnerability information sharing. including bi-directional machine-to-machine information sharing, and accelerating game-changing tools to mitigate cyber incidents in today's systems and to develop next-generation resilient energy delivery systems while developing analyses to quantify the resulting relative risk reduction. The request also supports continuing our efforts in support of addressing vulnerabilities of the energy sector from threats such as electromagnetic pulse (EMP) and geomagnetic disturbance (GMD) and on addressing supply chain threats to industrial controls systems and energy systems broadly.

- **Infrastructure Security and Energy Restoration (ISER)** will be split into two lines **Response and Restoration (R and R) (25,000,000)** and **Information Sharing, Partnerships and Exercises (ISPE) (25,000,000).** Accounting for development of cyber and non-cyber tools will be consolidated under the RMT (formerly CEDS) control point.

    - **Response and Restoration (R and R) ($25,000,000)** coordinates a national effort to secure U.S. energy infrastructure against all hazards, reduce impacts from disruptive events, and assist industry with restoration activities. During incidents requiring a coordinated federal response the Response and Recovery program activates the Energy Response Organization (ERO) to manage Emergency Support Function (ESF) #12 and Sector Risk Management Agency (SRMA) activities to include deployment of responders and sector engagement. As the lead for ESF #12 CESER works with partners to assess the impacts of disasters on local and regional energy infrastructure; to provide situational awareness updates to Federal, state, and private sector partners; to facilitate legal and regulatory waivers to accelerate restoration of damaged energy systems; and to provide technical expertise on energy damage assessment, restoration and logistical assistance. To fulfill the Department's ESF #12 responsibilities, CESER trains and coordinates a cadre of volunteer ESF #12 responders across DOE. When activated ESF #12 DOE deploys responders to FEMA National and Regional Response Coordination Centers, FEMA Joint Field Offices and/or State Emergency Operations Centers. Each FEMA Region is represented by an ESF #12 Regional Coordinator who maintains regular contact to support planning efforts with regional and state counterparts. Catastrophic and incidents in remote locations are managed by the ESF #12 Catastrophic Incident Response Team (CIRT), a subset of ESF #12 responders. CIRT delivers critical capabilities including energy sector emergency response and recovery; near-real-time situational awareness and information sharing about the status of the energy systems; analysis of evolving threats and hazards to energy infrastructure; and technical assistance that incorporates exercises in order to strengthen Federal, Regional, State, Local, Tribal, and Territorial (SLTT) abilities to work together to prepare for and mitigate the effects of an energy sector emergency. By working with the SLTT energy community to plan and develop mitigations the Nation's energy systems will become more secure and resilient. Further, CESER will continue to support interagency partners such as DHS/CISA, FBI, and the Office of Director National Intelligence, as outlined in Presidential Policy Directive (PPD)-41, on cyber incident response coordination to ensure that CESER and Department are prepared to provide subject matter expertise on energy systems during significant cyber incidents impact that could lead to a distribution of the energy supply in the U.S.

- **Information Sharing, Partnerships and Exercises (ISPE) ($25,000,000)** supports energy sector security and resilience through coordination with government and industry partners. The ISPE program advances the Department's efforts to support SLTT and industry in preparing for, mitigating, and recovering from all threats and hazards facing the U.S. energy sector. ISPE achieves this through information sharing, risk assessments, capacity building in planning and resilience, and targeted training and exercises. This budget request is focused on the Secretary's priorities for combating climate change, creating clean energy jobs, and promoting energy justice. Activities include studies of economically disadvantaged communities for response and recovery, the vulnerability of energy assets, and workforce development. Additionally, ISPE will focus on training the next generation workforce on energy sector risks and developing a cyber educated workforce will be an overall emphasis in both Planning, Preparedness and Resilience and Exercises and Training activities.

FY 2020 Key Accomplishments

CESER made notable progress this fiscal year that is rooted in the strategic partnerships it has fostered across the energy sector in executing its mission. In 2020, CESER:

- Ensured the reliability of critical energy infrastructure during the COVID-19 pandemic, in close coordination with the States and energy system owners and operators.
- Supported the energy sector's emergency response to a record number of hurricanes. Initiated a Department-wide cyber vulnerability testing program, leveraging unparalleled technical expertise from the National Labs, to assess digital components in energy systems. The program has participation agreements with five manufacturers and asset owners and is testing components of priority policy and security importance.
- Initiated the Energy Sector Pathfinder, in partnership with industry and the Department of Defense (DOD), Department of Homeland Security (DHS), and Federal Bureau of Investigation (FBI), to pilot and exercise increased operational coordination in cybersecurity between government and industry.
- Updated the energy sector's list of entities at greatest risk of attacks that could reasonably result in catastrophic regional or national effects on public health or safety, economic security, or national security (Section 9 entities) for the first time in seven years to include a representative segment of all energy subsectors and align to DOD defense-critical facilities.
- Completed 20 research and development (R&D) projects and launched seven new projects along with transitioning seven technologies into practice at energy companies.
- Launched the Operational Technology (OT) Defender Fellowship. This program offers middle- and senior-level OT security managers in the U.S. energy sector an opportunity to more fully understand the cyber strategies and tactics that adversarial state and non-state actors use in targeting U.S. energy infrastructure, in concert with our partners at Idaho National Laboratory and the Foundation for Defense of Democracies.
- Launched the Securing Energy Infrastructure Executive Task Force to convene key stakeholders from all levels of government, industry, academia, and the National Labs to jointly address priority technical vulnerabilities in energy systems.
- Identified use cases and developed tools to enhance detection of malicious cyber activity in OT networks and expanded tools to include application in the wind industry.

CESER also built capacity across the energy sector to mature preparedness and response efforts and develop the energy and cyber workforce:

- 450 energy sector officials engaged in CESER natural disaster and cyber exercises.
- 1,500 State energy officials, governors, energy advisors, public utility commissioners, State legislators, and emergency managers participated in CESER-supported events and training for energy and cyber-security planning.
- 145 cybersecurity experts from 75 electricity, oil, and gas sector companies participated in updating and validating the Cybersecurity Capability Maturity Model (C2M2).
- More than 200 university students from 36 States participated in the CyberForce Competition™.

Cybersecurity, Energy Security, and Emergency Response
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Risk Management Technology and Tools[a]	95,000	96,000	135,000	+39,000	+40.6%
Response and Restoration[b]	48,000	48,000	25,000	-23,000	-47.9%
Information Sharing, Partnerships, and Exercises[b]	0	0	25,000	+25,000	N/A
Program Direction	13,000	12,000	16,000	+4,000	+33.3%
Total, Cybersecurity, Energy Security, and Emergency Response	**156,000**	**156,000**	**201,000**	**+45,000**	**+28.8%**
Federal Full Time Equivalent Employees (FTEs)	27	43	50	+7	+16.3%
Additional FE FTEs at NETL supporting CESER[c]	9	9	10	+1	+11.1%
Total CESER-funded FTEs	**36**	**52**	**60**	**+8**	**+15.4%**

SBIR/STTR:

- FY 2020 Enacted: SBIR/STTR: $1,305
- FY 2021 Enacted: SBIR/STTR: $1,077
- FY 2022 Request: SBIR/STTR: $1,276

[a] The previous Cybersecurity for Energy Delivery Systems corelate to Management Technology and Tools.
[b] The previous Infrastructure Security and Emergency Response corelate to the Response and Restoration; and Information Sharing, Partnerships and Exercises points.
[c] CESER funds FTEs at FE's National Energy Technology Laboratory who are FE employees, but support CESER activities. The FTEs are in FE's FTE totals and are not included in the CESER's FTE totals shown on the "Federal Full Time Equivalent Employees (FTEs)" line.

Final Risk Management Tools (RMT)

Overview

The U.S. Department of Energy (DOE) is the Sector Risk Management Agency (SRMA) for the energy sector and CESER is responsible for carrying out the duties and responsibilities of that role, which include identifying, analyzing, and addressing risks to the energy system. CESER works closely with the energy sector to collect requirements and develop tools to mitigate the most significant risks to energy infrastructure and systems. Securing and managing risk and ensuring reliable energy delivery is a major challenge:

- The Nation's energy infrastructure and digital supply chain present a key target for cyber compromise, and the frequency and sophistication of cyber threats is increasing, including from nation-state actors. The SolarWinds cyber-attack demonstrated the ever-present supply chain threats, which could be devasting if a similar attack vector were used in the operational technology (OT) / industrial control systems environment.
- Energy systems are geographically dispersed, increasingly interconnected, and interdependent across multiple States, companies, and sectors, creating a multi-threat environment with the potential for cascading impacts during a disruption.
- Technological innovation and increasing connectivity are rapidly changing the risk posture for the energy sector. These trends have been accelerated by the global pandemic and resulting push for remote operation of geographically dispersed infrastructure. Energy sector companies are highly heterogenous; entities vary greatly in size, resourcing, and maturity level in capability to detect, deter, and mitigate cyber threats.
- All segments of the energy sector face evolving physical threats that if combined with a cyber-attack could further degrade system reliability.
- The energy sector faces ongoing and evolving risks from natural hazards, which have the potential to be localized or very widespread in terms of impact area or scale, especially with the impacts of climate change accelerating the frequency and impact of significant events. State policymakers are actively exploring and adopting energy policies to encourage innovation, fairness and equity, energy economic development, and energy efficiency, all of which have energy security and cybersecurity implications.

DOE has collaborated with the energy sector for nearly two decades in a voluntary public-private partnership to identify and mitigate physical and cyber risks to energy systems. Through this partnership, DOE has earned the trust of energy companies and helped accelerate the mutual exchange of information and deployment of new technology, tools, and best practices to improve security and resilience. As DOE and industry learn more about the potential influence of evolving threats such as cyber-attacks and climate change, enhanced analysis and risk tools enable better decision-making and investment in the interest of national security and reliability.

Partnerships with the national laboratories, private sector, and academia have helped CESER advance tool development, demonstration, and deployment projects in the hands of the private sector for a number of years. CESER's Risk Management Tools (RMT) efforts will build upon those effort to take a risk-based approach in tackling the risks of today and tomorrow.

These initiatives will leverage emerging technologies and techniques for critical energy infrastructure security to identify, detect, and protect critical energy infrastructure and networks from these threats, such as machine learning using data generated by the underlying physical process of energy delivery as well as data generated by the cyber-systems that control that physical process, to provide for automatic response to cyber-attacks. Such initiatives can also help identify new technologies for protecting equipment and systems subject to higher risks from changing natural hazards or identify improvements to consider in new builds of critical infrastructure.

As the SRMA for energy, DOE will invest in threat and vulnerability situational awareness tools and capabilities to develop and maintain sector-wide situational awareness of cyber and physical/natural hazards and emerging trends focused on energy sector disruption and leverage DOE partnerships with energy sector industry, other federal agencies such as DHS, and state, local, and tribal governments. RMT will also enable maintenance of real-time sector-wide situational awareness

combined with time-sensitive analysis, visualization, and dissemination of actionable threat and vulnerability information in support of key DOE, federal government, and energy sector stakeholders. The tools will incorporate rapid dissemination and processing of energy sector data for identification and characterization of threats for intelligence analysis, assessments, products, and services in unclassified and classified environments required to support CESER's operational cyber and energy security responsibilities. These specialized tools will use analytics to understand, enrich, and fuse data and enable intelligence-driven action to improve resilience for the energy sector.

The dynamic threat landscape, climate crisis, advances in energy system technologies, and the use of legacy devices in ways not previously envisioned underscore the importance of this continuous transition. Some examples of these threats include:

- The 2015 and 2016 cyber-attacks on the Ukraine electrical distribution system demonstrated the vulnerability of power grids to cyber events and the advanced capabilities of cyber adversaries. The 2015 attack knocked out power to 225,000 customers for several hours. Attackers used spear phishing emails to gain initial access to utility Information Technology (IT) networks. The hackers went undetected for nine months as they stole credentials using keystroke loggers, identified hosts and devices, and hijacked OT systems to open breakers and cause a power outage. The attackers' ability to perform long-term reconnaissance operations and execute a highly synchronized, multistate, multisite attack represents a major change in sophistication and intent. Subsequent cyberattacks targeting U.S. energy systems have shared some traits with those seen during the Ukraine events.
- In December of 2020, law enforcement and private sector security professionals identified an advanced supply chain compromise affecting the SolarWinds Orion series of products. Orion is a network monitoring and asset management software used by thousands of companies to manage their networks and systems. The nation-state attacker compromised SolarWinds as early as March of 2020, inserting backdoor code into a digitally signed component of the Orion software. This backdoor contacted servers on the Internet controlled by the attacker to retrieve attacker instructions. This sophisticated compromise was against the SolarWinds development system, which was altered to add the backdoor code at a process step which would result in SolarWinds cryptographically verifying the authenticity of the maliciously modified code.

  This sophisticated supply chain attack by an advanced nation state adversary affected 9 federal agencies and at least 375 private energy sector companies. The attackers leveraged this access to burrow into selected victim networks with more advanced tools, gaining additional access to privileged documents and emails, and installing additional remote command capabilities outside the initial Orion vector. The impact of the SolarWinds compromise is still being assessed, but it will be a case study for supply chain attackers for years to come.

  Securing and managing cyber risk within the energy sector and ensuring reliable energy delivery is a major challenge. The dramatic increase across multiple attack vectors such as probes, innovative social engineering, and malware exploits has strained the financial, technical, and human resources of energy companies as they continuously adjust to manage a new risk paradigm.
- The Texas Power Crisis in February 2021 and annual hurricanes, wildfires, and flooding incidents are a reminder about the importance risk assessments in the natural hazard space as well. CESER's RMT program will continue to tackle those non-cyber threats and hazards to energy systems that occur across the country in an effort mitigate and quickly respond during an emergency. Also, the RMT Program will partner with other parts of DOE to build in resilience and security into long-term grid modernization and R&D efforts.

Highlights of the FY 2022 Budget Request

Working closely with energy sector and government partners, the budget request for CESER RMT supports a more economically competitive, environmentally responsible, secure and resilient U.S. energy infrastructure focusing on following activities:

- **ADVANCE TOOLS TO SUPPORT CYBER THREAT SITUATIONAL AWARENESS AND ANALYTICS ($50M)**

    - Develop, demonstrate, deploy, and transition to next generation cyber information sharing tools and technologies for broad adoption in the energy industry for cyber situational awareness. The tools will advance the energy sector's ability to detect and respond to cyber threats on both the information technology (IT) and operational technology (OT) environments of energy sector companies. Specifically, these tools will focus on protection, monitoring, detection, response, containment, forensics, and recovery. Furthermore, these efforts will leverage grid and pipeline operational data and physics of energy delivery to inform owners and operators of anomalous cyber activities on their networks.

    - This effort also supports the newly announced DOE Electricity Industrial Control Systems (ICS) effort, which is being done in partnership with the electric industry, Cybersecurity and Infrastructure Security Agency (CISA), and the National Security Council. The Electricity ICS Initiative combines basic grid and ICS operations with cyber adversary tactics, techniques, and procedures to rapidly identify known threat actors. Further, the effort will provide the USG awareness of cyber threats through correlation with intelligence community information.

    - These efforts also include targeted support to municipal and cooperative electric utilities to help them further mature cybersecurity in their systems.

    - Finally, this effort will also continue to support increased cyber threat information sharing efforts with the most critical companies across the country, including cyber dependent critical infrastructure identified under EO13636 and Defense Critical Electric Infrastructure (DCEI), companies which are vital to U.S. national security and economic security.

- **RISK MITIGATION TOOLS AND SITUATIONAL AWARENESS FOR NON-CYBER THREATS AND HAZARDS ($27M)**

    - **<u>EAGLE-I and Situational Awareness Tools</u>**
      To ensure that CESER can fulfill DOE's responsibilities as the SRMA for the energy sector and as the coordinating agency for ESF #12, CESER needs to maintain continuous situational awareness of threats and incidents affecting, or with the potential to affect, U.S. energy systems, as well as capabilities to support timely preparedness, response, and recovery efforts, including models of potential power outages from hurricanes and remote sensing to quickly identify damaged components. To fulfill these requirements, the Response and Recovery program maintains and updates the EAGLE-I™ Platform to provide situational awareness across the energy sector and collaboration during a response, for DOE, interagency partners, and state energy assurance coordinators.

      The FY 2022 budget request will enable CESER to continue to maintain and update the EAGLE-I platform, including efforts to expand near real-time situational awareness of both electricity and oil and natural gas systems, as well the development and integration of new and/or update capabilities, such as predictive power outage estimates for other severe weather, restoration models, FEMA Lifeline interdependency modeling and analysis, imagery, post-incident damage detection, and remote sensing to further support emergency preparedness, response, and recovery efforts. Additionally, the EAGLE-I Platform is being developed to enable enhanced collaboration between deployed responders, personnel at DOE Headquarters, as well as industry, state, and interagency partners.

- **Other Risk Mitigation Efforts**
  DOE would continue to engage in efforts to address the risks associated with electromagnetic pulse (EMP) and geomagnetic disturbances (GMD). These would include activities such as performing EMP vulnerability assessments of critical assets and identifying and estimating the cost of several mitigation options for each asset; performing EMP and GMD system assessments; testing critical generation components (setting up future testing on the most expensive critical components) to determine withstands to EMP and GMD; and partnering with industry (through cost shares) to field deploy an increased number of innovative cost-effective mitigation options for EMP and GMD based on results of vulnerability assessments.

  Additionally, RMT would tackle other risks and hazards to the energy sector due to the impacts of climate change such as wildfires and severe hurricanes. The RMT will focus on the development of tools and risk characterization effort for early detection and mitigation from these types of risks to energy infrastructure. Finally, the RMT work will also address physical threats to infrastructure such as the Metcalf Substation physical attack.

- **SUPPLY CHAIN RISK MANAGEMENT ($32M)**

  - **Cybersecurity Testing for Industrial Control Systems (CyTRICS)**
    CyTRICS is the Department of Energy's program for cybersecurity supply chain vulnerability testing, digital subcomponent enumeration, and mitigation. CyTRICS partners across energy sector stakeholders to identify threat-informed, high priority operational technology (OT) components, perform expert testing, share information about vulnerabilities in the digital supply chain, and inform improvements in component design and manufacturing. CyTRICS leverages best-in-class test facilities and analytic capabilities at four DOE National Laboratories (INL, PNNL, SNL, and LLNL) and strategic partnerships with key stakeholders including technology developers, manufacturers, asset owners and operators, and interagency partners. CyTRICS completed full pilot testing in 2020 and scaled up testing operations in FY2021, delivering its first publicly announced results - discovery of significant cyber vulnerabilities – in early 2021. FY2022 funding will enable inclusion of two additional testing Labs (NREL and ORNL) and scaling up cyber supply chain testing of digital components in renewables and distributed energy systems. CyTRICS includes integrated cyber supply chain programs for the energy sector that leverage outputs of cyber vulnerability testing. These include integration with intelligence community programs, DOE CIO cyber supply chain programs, energy sector demonstration projects for automated generation and exchange of hardware and software bills of materials, and digital subcomponent supply chain illumination tools. The Securing Energy Infrastructure Executive Task Force, mandated in the FY2020 National Defense Authorization Action, Section 5726, provides energy sector engagement and feedback on CyTRICS and cyber supply chain programs.

  - **Cybersecurity of Distributed Energy Resources and Electric Vehicles**
    In 2022, CESER's RMT program will be focusing on improving the cybersecurity tools and technologies geared toward the grid of the future , such as distributed energy resources (DERs) and electric vehicles (EVs). As DERs and EVs become more and more prevalent on the grid, there should be an increased focus on the cybersecurity tools and technologies for these new technology environments. In some communities across the U.S., DERs will begin to supply 100% of generation by 2030 and therefore it is critical for CESER's RMT program to not only address the crosscutting cybersecurity research and development that can be applied to broader resilience of the grid, but also the need for innovative cyber risk management tools, methodologies, and guidance for this new technology landscape.

  - **Other Activities to Address Supply Chain Threats**
    CESER RMT will work to develop a long-term supply chain threat management strategy that looks at supply chain concerns from cradle to grave (e.g., manufacturer product development to deployment in the sector) to identify engagement points for CESER and other parts of the DOE. The goal will be to build in security by design. In addition,

CESER's RMT will launch a pilot project to specifically tackle supply chain attack vectors similar to those seen in the SolarWinds attack by performing hash/signature check prior to the installing new software and systems within operational technology (OT) environments. CESER will coordinate with interagency partners to facilitate information sharing and lessons learned, as part of a whole-of-government approach to supply chain threat management.

- **Cyber Risk Assessments, Frameworks, and University Collaborations ($26M)**

  - **Cybersecurity for the Operational Technology Environment (CyOTE)**
    The Cybersecurity for the Operational Technology Environment (CyOTE) program continues to investigate asset owner data in the complex OT environment to correlate operational anomalies with malicious actions using an efficient approach that manages data by exception. The request will continue to mature CESER's understanding of OT cyber threats and their correlation to the IT networks and intelligence. The work will also expand into developing case studies of historical attacks to create a library of artifacts that asset owners can identify in their environments. CyOTE aims to design an industry-led approach for investigating operational anomalies with OT data, and corelating these anomalies to adversary techniques with a goal to identify the existence of attack campaigns earlier in the attack cycle to realize ever decreasing impacts to the operations.

  - **Cybersecurity Capability Maturity Model (C2M2), NIST Cybersecurity Framework Integration, CCE, and University Collaborations**
    Develop and transition to practice tools, guidance, and practices that help energy organizations' understanding and management of cybersecurity risk to systems, people, assets, data, and capabilities. The CESER Cybersecurity Capability Maturity Model (C2M2) and energy sector Cybersecurity Framework profiles initiatives improve understanding of cybersecurity capabilities, gaps and challenges facing electricity, oil, and natural gas sectors. These tools connect business context, critical resources and functions, and the related cybersecurity risks to enable an organization to focus and prioritize its cybersecurity efforts, consistent with its risk management strategy and business needs.

    Additionally, RMT will continue maturing efforts on cyber resilience through cyber engineering by way of program such as the Consequence-driven Cyber-informed Engineering (CCE) that has proven immensely successful in helping energy company secure critical systems and networks. This effort includes a crown jewel analysis and links it with known threat actor behavior to help energy companies better protect and prioritize those systems.

    Finally, CESER RMT also plans to continue collaborations with universities to both support workforce development initiatives, but also stimulating innovation by students to address cyber risks to energy infrastructure. The continued collaboration with universities, colleges, and technical schools will be important initiatives for CESER RMT in 2022 across the various CESER divisions.

  - **Grid Modernization Laboratory Consortium and Department-Wide Coordination on Cyber R&D**
    Support Grid Modernization Laboratory Consortium (GMLC) initiatives. GMLC employs an integrated approach to ensure DOE funded study efforts are efficiently coordinated for the greatest return on taxpayer dollars. CESER has a central role in the Department's plan for integration of cybersecurity activities across CESER will coordinate with DOE offices through the GMLC to engage experts and resources at DOE National Laboratories. This collaboration ensures the goal of modernizing the Nation's electric grid. CESER has a central role in the Department's plan for integration of cybersecurity activities across Further, CESER will coordinate with DOE offices to engage experts and resources at DOE National Laboratories. This collaboration ensures the goal of modernizing the Nation's electric grid.

Risk Management Technology and Tools
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Risk Management Technology and Tools	**103,100**	**96,000**	**135,000**	**+39,000**	**+40.6%**

SBIR/STTR:

- FY 2020 Enacted: SBIR/STTR: $1,305
- FY 2021 Enacted: SBIR/STTR: $1,077
- FY 2022 Request: SBIR/STTR: $1,276

Risk Management Technology and Tools
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Risk assessment tools (C2M2, CCE), Information Sharing tools, Other tool development and deployment (cyber and non-cyber) (monitoring, forensic etc.)	**+5,000**
• CyTRICS	**+27,000**
• Other Risk Mitigation, Testing and deployment strategies (EMP, composite poles)	**+7,000**
Total, Risk Management Technology and Tools	**+39,000**

Risk Management Technology and Tools

Funding ($K)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Risk Management Technology and Tools $96,000,000	**$135,000,000**	**+$39,000,000**
• Continue the Advanced Threat Mitigation initiatives supporting cybersecurity projects that use advanced and emerging technologies to protect and secure the energy delivery systems. The program is creating advanced capabilities that align with the Agency Priority Goal, "Identify, contain, and defeat cyber threats to our Nation's energy delivery systems through a shared understanding between industry and government of adversarial techniques to mitigate energy sector cyber-attacks." • Advance threat information sharing initiatives to additional utilities to broaden the base to operationalize lessons learned • Continue to develop and deploy analytics for emerging adversary tools, techniques and procedures under OT-focused initiatives. • Continue the Cybersecurity Capability Maturity Model (C2M2) to improve transparency, cybersecurity preparedness and provide a better understanding of the cybersecurity capabilities, gaps and challenges facing utilities.	• Develop, demonstrate, and transition to practice next generation cyber risk management technology and tools for broad adoption in energy industry. These tools will focus on protection, monitoring, detection, response, containment, forensics, and recovery. • Advance Supply Chain Risk Management initiatives supporting the energy security identify and detect threats and vulnerabilities in critical systems. This work is being done in close partnership with utilities and grid industrial control system (ICS) manufacturers and suppliers. These efforts support the Agency Priority Goal, "Identify, contain, and defeat cyber threats to our Nation's energy delivery systems through a shared understanding between industry and government of adversarial techniques to mitigate energy sector cyber-attacks." • Address risks (e.g., earthquake, wildfire, hurricanes, climate) to the energy sector more broadly to include increased natural hazard risks due to climate change and the modernization of the grid more broadly. Continue to mature cybersecurity frameworks and guidelines for the sector to use in the OT cybersecurity environment and also implement	• Expand focus to include all risks and hazards as well as on cyber risks. Also, the work is tackling significant issues in the sector related to supply chain threats, the rapid modernization of the grid, and additional connectivity due to broader distributed energy resources and electric vehicles. Finally, there is a strong focus on developing cyber visibility in the industrial control system (ICS) environment due to significantly increased cyber threat in that space.

"security by design" philosophies through efforts such as CCE, CyOTE, and C2M2.

Response and Restoration

Overview

The U.S. Department of Energy (DOE) is the coordinating agency for Emergency Support Function (ESF) #12, under the National Response Framework, and the Sector Risk Management Agency (SRMA) for the energy sector, pursuant to Presidential Policy Directive (PPD) 21, PPD 41, Executive Order 13636, and the FAST Act. As the lead for ESF #12, CESER works with partners to: assess the impacts of a disaster on local and regional energy infrastructure; provide situational awareness updates to Federal, state, and private sector partners; facilitate legal and regulatory waivers to accelerate restoration of damaged energy systems; provide technical expertise on energy damage assessment, restoration and logistical assistance. During an incident requiring a coordinated federal response, the Response and Recovery program activates the Energy Response Organization (ERO) to manage ESF #12 and SRMA activities, including deployment of responders and sector engagement. DOE also serves as a primary agency for the Infrastructure Systems Recovery Support Function (RSF), under the National Disaster Recovery Framework. Within DOE, these responsibilities are managed by the Response and Recovery program in the Office of Cybersecurity, Energy Security, and Emergency Response (CESER),, which supports preparedness, response, restoration, and recovery efforts in the energy sector, across federal, state, local, territorial, and tribal governments, private industry, trade associations, and non-governmental organizations.

To fulfill the Department's ESF #12 responsibilities, CESER trains and coordinates a cadre of volunteer ESF #12 responders, from across DOE. Upon activation of ESF #12, DOE deploys responders to the FEMA National Response Coordination Center, FEMA Regional Response Coordination Centers, and/or FEMA Joint Field Offices and State Emergency Operations Centers. Each FEMA Region is represented by an ESF #12 Regional Coordinator, who maintain regular contact and supports planning efforts with regional and state counterparts. Additionally, a subset of ESF #12 responders are part of the ESF #12 Catastrophic Incident Response Team (CIRT) to respond to catastrophic incidents and remote locations.

The Response and Recovery program also coordinates DOE's response to cyber incidents impacting or potentially impacting the energy sector that requires a coordinated response with industry and interagency partners. The Department will be supporting the Department of Homeland Security –whole of government, cyber assessment teams when needed during cyber incidents. The Department will follow the National Cyber Incident Response Plan.

To ensure that CESER can fulfill DOE's responsibilities, the Response and Recovery Program maintains and develops capabilities to coordinate response operations, enhance situational awareness, and provide analysis of threats and incidents affecting the energy sector, including cyber. Overall, the Response and Recovery program works closely with the electricity and oil and natural gas industries; other Federal agencies; State, Local, Tribal, and Territorial (SLTT) communities; and DOE's national laboratories to advance national energy security and prepare for, respond to, and recover from evolving threats and events.

Highlights of the FY 2022 Budget Request

The FY 2022 Response and Recovery program budget request will enable CESER to maintain existing capabilities, while improving operational response coordination and collaboration; situational awareness across the energy sector; and analysis of threats and incidents affecting the sector. Additionally, the FY 2022 Response and Recovery program budget supports further development of CESER's cyber incident analysis and response capabilities as the Nation's energy infrastructure continues to face evolving and increasing threats.

All-Hazards Incident Response, Regional Support, and Situational Awareness

As the SRMA for the energy sector and the coordinating agency for ESF #12, CESER must maintain a baseline emergency all-hazards response capability that ensures adequate resources and training are available to facilitate the reestablishment of damaged energy systems and components with potential impact to national and economic security. To fulfill this mission, CESER trains and coordinates a cadre of approximately 120 volunteer ESF #12 responders, from across DOE. The cadre is organized into Regional Response Teams, aligned to the 10 FEMA regions, each led by an experienced Regional Coordinator. The regionalization concept has enabled CESER's ability to respond to multiple, simultaneous, and back-to-back events. Long term commitment to the regionalization concept as an organizing structure for deployment coordination and annual refresher training will solidify current response capabilities, and provide a foundation for the expansion of skills, tools and products that improve responder effectiveness and t add value and energy expertise at the regional, state, and local levels. Initial training for new members of the cadre and refresher training for existing volunteers also now includes a model providing an overview of cyber incident response and how ESF #12 responders may be utilized to support consequence management during a cyber incident with physical impacts.

The FY 2022 Budget Request will enable the Response and Recovery program to maintain baseline activities while continuing to develop long term relationships at the regional level, as well as a day-to-day regional presence to work side-by-side with regional FEMA, interagency, and states partners during steady state operations; enabling more efficient response capabilities. The Response and Recovery program will also continue to recruit, train, and expand the Catastrophic Incident Response Team cadre to better support FEMA's Incident Management and Assessment Teams (IMAT), and provide technical expertise in damage assessment and energy system restoration; specifically to support island, earthquake, and other catastrophic response and restoration requiring federal assistance. The program will also build a reserve cadre available to support long term, remote, and/or catastrophic incidents that require additional subject matter expertise and support for extended periods. The Response and Recovery program is also working to upgrade and expand resilient communication capabilities for remote or isolated responders to ensure responder safety and connectivity in austere environments, as well as the ability to maintain communications with key industry partners during contingency scenarios.

The FY 2022 Budget Request will also help ensure that CESER can fulfill DOE's responsibilities by expanding the Office's situational awareness team into a CESER Watch Office at Headquarters, which will provide continuous monitoring, initial incident reporting, and communication coordination with field elements, deployed personnel, and interagency partners. The CESER Watch will also serve as the primary point of contact to manage information, requests, and assist with response activations.

Cyber Incident Response and Cyber Situational Awareness

CESER is the lead for cybersecurity for the energy sector as the SRMA, pursuant to the FAST Act, Executive Order 13636, and Presidential Policy Directive-41 (PPD-41). PPD-41 and interagency cyber response documents that were developed in partnership with Department of Homeland Security (DHS)/Cybersecurity and Infrastructure Security Agency (CISA), the Federal Bureau of Investigation (FBI), and other agencies that outline the roles of sector specific agencies and the importance of them being able to provide subject matter expertise during cyber response efforts. To fulfill DOE's responsibilities, CESER will develop and expand capabilities, to support the energy sector, in coordination DHS, FBI, and other interagency partners.

Cyber actors are becoming increasingly sophisticated and CESER must developing the response capabilities commensurate with the threat landscape. CESER will develop and expand our capacity and capability to provide cyber incident response technical assistance to complement response efforts from interagency partners with analysis and expertise unique to the energy sector or when other resources are not available. This will include a training program for cyber responders, equipment, and forensic capabilities as required, and deep knowledge of energy management systems (e.g., distributed energy resources, grid SCADA controls, etc.). Additionally, CESER will establish a mechanism to quickly leverage technical resources and capability of DOE's National Laboratories, Power Marketing Administrations (PMAs), and other resources to be utilized during a cyber incident response that requires federal support.

Further, the FY 2022 Budget Request will support enhanced situational awareness of cyber threats to the energy sector, including information about ongoing incidents and rapid assessment of potential impacts to the energy sector from emerging threats, vulnerabilities, and adversary capabilities. Leveraging the expanded cyber situational awareness, CESER will continue to support Analysis of Risks in the Energy Sector (ARES) Reports for provide timely and actionable cybersecurity information to trusted industry partners. Additionally, CESER will strengthen its cyber situational awareness capabilities and processes so that it can pull in and share data streams from and to energy sector owners and operators, other departments and agencies (e.g., DHS/CISA, FBI), the intelligence community, along with data from CESER's other tools such as CyTRICS, NAERM, CRISP, etc.

Finally, CESER will expand its analytical capabilities to investigate incidents and analyze potential national-level risks or identify cyber campaigns in the energy infrastructure. This will include rapid analysis around supply chain incidents, international and domestic events, indicators of compromise, and other signatures related to the energy sector. These analytical capabilities will pull in data from tools developed by other parts of CESER, OE, and other offices to quickly identify risks or threats to critical equipment and act swiftly.

Response and Restoration
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Response and Restoration	**11,990**	**9,635**	**25,000**	**+15,365**	**+159.5%**

Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• Cyber Incident Response & Cyber Situational Awareness.	**+10,000**
• All-Hazards Incident Response, Recovery, Regional Support, and Situational Awareness.	**+12,000**
• EAGLE-I Situational Awareness & Response Collaboration Platform- moved to Risk Management technology and Tools	**-6,635**
Total, Response and Restoration	**+15,365**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Response and Restoration $ 9,635,000	**$25,000,000**	**+$15,365,000**

• *ESF 12 Responsibilities*: Maintain and expand cadre of trained volunteer emergency responders, focusing efforts on:
  • Expanding regionalization of emergency response cadre to ensure established regional relationships and understanding.
  • Develop critical incident response responder team to provide initial support challenging incidents and incidents in remote locations.
  • Educating responders to evolving adversarial threats and energy sector interdependencies.
  • Maintain availability of DOE to provide subject matter expertise, from DOE's Power Marketing Administrations.
	• *ESF 12 Responsibilities*: Maintain and expand cadre of trained volunteer emergency responders, focusing efforts on hurricanes, wildfires, and cyber-attacks.
	• Focus on expanding training and capability to support remote location responses, educating responders to changing energy sector interdependencies, and expanding access to available subject matter expertise across DOE.
	• CESER Regional Coordinators focused on western FEMA Region, as well as the ESF #12 Catastrophic Incident Response Team (CIRT). During steady-state operations these personnel will serve as regional energy advisors to support steady-state operations and preparedness efforts within their regions, provide all-hazards analysis, as well as project management support for CESER.
		• Increasing capabilities to effectively respond to disasters through training, analysis, and to support operations and continuity.
		• Recruit and train cyber subject matter experts focused on cyber incident response and energy system restoration.
		• Increasing capabilities to analyze trends and cyber events in the energy sector.

• *Situational Awareness and Emergency Response Tools*: Enhance EAGLE-I™ to expand near real-time situational awareness capabilities and make it platform for integration energy infrastructure situational awareness tools. • Support development, operationalization, and integration of modeling and tools, such as predicted power outage restoration timelines and remote sensing to provide damage assessments to further improve response efforts.	• Develop Energy Sector Cybersecurity Response capabilities that can support CISA and FBI cyber incident response teams to provide energy sector subject matter expertise about energy systems.	• This enhancement will build on DOE's ESF#12 catastrophic response capabilities to add cybersecurity and cyber incident response capacity that better supports energy sector entities impacted by a cyber event. The enhanced capability will also improve and expand DOE's support to the Federal Government's coordinated cyber incident response as mandated by PPD-41 and the National Cyber Incident Response Plan.

Information Sharing, Partnerships, and Exercises

Overview

The U.S. energy sector is characterized by widely diverse infrastructure components, a multifaceted operational environment, and complex ownership and regulatory structures. As one of the priority enabling functions upon which all other critical infrastructure sectors rely, the Nation's security, public health and safety, and economy depend on energy. With the sector facing evolving threats and risks, such as natural disaster events, cyber and physical security threats, aging/failing infrastructure, and the potential shortage of a skilled workforce, this budget is aimed at assessing security risk, securing critical infrastructure, enhancing infrastructure resilience, sharing information, and promoting learning and adaptation through strategic partnerships with the energy sector. The hazards to the energy system, including cyber, can only be effectively addressed through partnerships across all levels of government, private industry, and academia. CESER is focused on cultivating these trusted partnerships to share information, manage risk, and increase the security and resilience of critical infrastructure in the energy sector.

CESER's partnerships—with energy owners and operators, manufacturers, and trade associations; with other Federal agencies; across States, local governments, tribes, territories (SLTT); with academia and the National Labs; and with the energy information sharing and analysis centers (ISACs)—help to advance collective preparedness and resilience to the growing landscape of threats, technology developments, and energy system trends. This budget is directed at: 1) building capacity and support for energy sector and SLTT partners to advance critical energy infrastructure security and resilience from all-hazards; and 2) managing key DOE authorities and responsibilities, including serving as the Sector Risk Management Agency (SRMA) for the energy sector and fulfilling DOE responsibilities under the Fixing America's Surface Transportation (FAST) Act and the National Defense Authorization Act (NDAA). True public-private partnership is integral to meeting CESER's cybersecurity, energy security, and emergency response objectives. As the SRMA for energy, the Department is currently assessing the following risks that are a priority for the energy sector, including, but not limited to, hurricanes/severe weather, wildfires, earthquakes, cyber-attacks and electromagnetic interference.

- This program is the point of entry for SLTT and energy private sector partners when collaborating with DOE and the Federal Government on critical infrastructure protection and resilience, energy security, and emergency response and recovery. The Department is placing emphasis on supporting Section 9 companies[a], Defense Critical Electric Infrastructure companies, municipal utilities, and cooperative utilities in addition to SLTT entities.

Highlights of the FY 2022 Budget Request

The budget request supports energy sector security and resilience in coordination with government and industry partners. By seeding public-private partnerships this program will advance the Department's efforts to support SLTT and industry in preparing for, mitigating, and recovering from all threats and hazards facing the U.S. energy sector through information sharing, risk assessments, capacity building in planning and resilience, and targeted training and exercises. The budget request is focused on the President's priorities for combating climate change, creating clean energy jobs, and promoting energy justice. Activities will include studies of economically disadvantaged communities for response and recovery, the vulnerability of energy assets, and workforce development.

Training the next generation workforce on energy sector risks and developing a cyber educated workforce will be an overall emphasis in both Planning, Preparedness and Resilience and Exercises and Training activities.

Planning, preparedness, and resilience

- **Share threat information and manage energy sector risk:** Provide threat information sharing for SLTT and industry partners regarding physical and cyber threats to the energy sector. Establish new and build on existing mechanisms to work with energy companies to identify systemically important critical infrastructure and perform intelligence-informed

[a] The Department of Homeland Security (DHS), in coordination with relevant SRMAs, annually identifies and maintains a list of critical infrastructure entities that meet the criteria specified in Executive Order (EO) 13636, *Improving Critical Infrastructure Cybersecurity*, Section 9(a) ("Section 9 entities") utilizing a risk-based approach. Section 9 entities are defined as "critical infrastructure where a cybersecurity incident could reasonably result in catastrophic regional or national effects on public health or safety, economic security, or national security."

risk analysis through the National Labs and in coordination with other Federal agencies and critical infrastructure sectors. As the SRMA energy sector lead, CESER proposes to develop a robust capacity to better support energy sector (e.g., owners and operators, trade organizations, subsector coordinating councils, SLTT, Defense Critical Electric Infrastructure DCEI, Section 9) demand signals for a cohesive and coordinated set of resources and provide for a more collaborative engagement opportunity to inform risk analysis. Prepare and provide action-oriented, intelligence-informed threat briefings to support energy system investment and decision-making.

Develop recommendations for prioritization of energy infrastructure supply chain equipment testing, supply chain risk management practices, the sharing of risk information, and increasing the manufacture of essential electric equipment by companies subject to U.S. jurisdiction leveraging existing working group structures to solicit stakeholder feedback in the development of these recommendations. The existing working group has membership from the energy industry, including electric utilities and manufacturers recommended by the energy sector coordinating councils; several Federal agencies; State or regional energy agencies; the North American Electric Reliability Corporation; and research institutions. The recommendations would inform the technical assistance to the electricity subsector as well as regulators at all levels.

- **Implement emergency management authorities**: Lead implementation of Section 215A of the Federal Power Act, which authorizes DOE to protect critical electric infrastructure information from inappropriate release under the Freedom of information Act and other "sunshine" laws. Support the Secretary of Energy during electricity emergencies when implementing Section 202(c) of the Federal Power Act. Fulfill the duties and requirements for serving as the Sector Risk Management Agency (SRMA) in coordination with other Federal agencies and critical infrastructure sectors, including maintaining the Energy Government Coordinating Council and policy and preparedness collaboration with the energy subsector coordinating councils, as well as performing risk analysis and assessment specific to the energy sector and related systemic risk. Establish new council relationships to effectively understand and facilitate and eliminate barriers to energy security information sharing across governments and industry.

- **Post Disaster Recovery and Resilience:** When a major disaster strikes, the restoration of energy systems depends on the planning and coordinated response effectiveness of local, State, multi-State, tribal, territorial, and national responses. In FY 2022, the SLTT Energy Assurance and Resilience program will continue to support technical assistance engagement for coordinated risk analysis and energy security and assurance planning with States and territories that improves preparedness to all hazards, including hurricanes, wildfires, fuel emergencies, and cyber events, and impacts from the growing threat of climate change. CESER will expand the dynamic data hub for SLTT energy risk profiles and resilience and build on lessons learned from exercises and real-world energy disruptions.

  CESER will advance methods and approaches to allow SLTT governments to address emerging challenges, including incorporating hardening into energy security and assurance planning processes, and applying regulatory and business models that provide the appropriate incentives to build back better at a community level. CESER will provide competitive funding in these areas to state and local agencies seeking to advance their capabilities with respect to addressing these key challenges. Work in these issue areas will result in the development of resources including reports, workshops, analyses, and interstate discussions that can help Federal, State, Tribal, and territory officials make better risk- informed decisions about their respective elements of the energy system. CESER will also build relationships with other agencies to utilize and leverage resilience and recovery funding for energy infrastructure projects. This requires support to state and local governments applying for these funds, technical assistance in identifying the greatest sources of risk, the plans that will help to identify and utilize the most appropriate, cost-effective, and equitable solutions for their communities. The funds will be directed to disadvantaged communities, especially where the impacts of climate change or from natural disaster events are most prevalent.

- **Establish State Energy Security Grants**: Mitigating the impacts of climate change and cyber-attack on critical energy infrastructure is a priority for state governments. Enabling states to analyze and manage risk, coordinate across agencies and with industry, and providing guidance and training to support these activities will bolster the states' energy security capabilities and national security overall. CESER will support state energy security and assurance planning through funding as well as technical assistance, including a framework that outlines the contents of a plan; designing and implementing a more robust energy security SLTT program; and by continuously updating the framework

and energy assurance and security planning tools. States as well as local, tribal, and territorial government authorities are a critical component of the Nation's energy security as they are on-the-ground resources and are often the first to respond to energy emergencies. However, SLTT communities have struggled in the past to maintain and continuously update their energy security and assurance plans to respond to a new and changing threat landscape. Strengthening SLTT capabilities through tools and resources can enable enhanced mitigation and response capabilities to energy disruptions and emergencies. Strengthening the effective coordination between SLTT communities and the Federal and private sector entities during a federally coordinated response or national emergency could reduce the need for federal intervention and funding of the recovery from energy emergencies.

- **Defense Critical Electric Infrastructure (DCEI)**: The DCEI program will identify, evaluate, prioritize, and assist in developing executable strategies to strengthen the energy infrastructure systems that supply critical infrastructure needed to ensure continuity of defense activities following severe natural and manmade disasters. Specifically, these investments will enable an increased confidence that necessary energy resources will be available to those locations designated by the Secretary of Energy as Defense Critical Infrastructure as codified by the 2015 Fixing America's Surface Transportation Act. The DCEI program's objective is to strengthen energy infrastructure systems for national security purposes. Activities will be undertaken in FY 2022 to begin to implement DOE's DCEI strategic plan by applying successful methods incubated and validated in FY 2021 to a larger group of critical defense facilities from DOE's designated list, increasing national defense and security readiness against power supply interruptions.

Training and Exercises

Exercises are critical to planning a coordinated response to emergencies. CESER prepares for all hazards that could affect energy delivery alongside federal, state, and local government entities, partners from the oil and natural gas and the electricity subsectors, and representatives from other critical infrastructure sectors. By conducting senior-level policy discussions and operationally focused tactical preparedness exercises, CESER is preparing the nation to effectively mitigate any threat to reliable energy. After each exercise, CESER undergoes improvement planning based on exercises feedback and results. Once validated, the improved actions are integrated into CESER's emergency response plans and procedures as well as into future exercises. Exercise results are shared with participants through After-Action Reports, providing participants in CESER-sponsored exercises agreed-upon ways in which they can augment their own preparedness plans.
These recommendations often include ways in which participants can better utilize mutual assistance networks and government resources should an incident affect their energy infrastructure.

Cyber Exercises and Cyber Workforce Development: In support of CESER's energy disruption and emergency response efforts from a cyber incident, this program will conduct cyber exercises with interagency stakeholders, SLTT partners, and industry through leading events such as Liberty Eclipse, as well as by providing technical training such as Cyber Strike. Expand the Operational Technology (OT) Defender Fellowship, which offers middle and senior-level OT security managers in the U.S. energy sector an opportunity to more fully understand the cyber strategies and tactics that adversarial state and non-state actors use in targeting U.S. energy infrastructure, in concert with our partners at Idaho National Laboratory and the Foundation for Defense of Democracies. Design training, exercises and experimentation focused on cyber grid event recognition, cyber mitigation and electric restoration, and resilience, leveraging a testbed of power and industrial control system assets in conjunction with the energy sector asset owners and the national labs. Expand the CyberForce Competition to include a series of continuous events throughout the year and explore the potential for internship and job opportunities for participants in the Federal and industry workforce. The CyberForce competition works universities, colleges, and technical schools across the country to advance cybersecurity in the OT/industrial controls systems environment to train the next generation of energy security cybersecurity experts in the U.S and help create good paying jobs with a free and fair choice to join a union.

Non-cyber Exercises and Training: In support of the response to natural disasters and other non-cyber physical events, CESER will host exercises with interagency stakeholders, SLTT partners and industry that focus on the impacts to energy infrastructure from hurricanes, wildfires, earthquakes, etc. Clear Path is CESER's annual cornerstone all-hazards energy security and resilience exercise series. The Clear Path series is the principal forum for enhancing the energy sector's ability to work together in response to catastrophic incidents. The series examines the energy sector's response and restoration roles, responsibilities, and plans and procedures following a major incident, stressing interdependencies between multiple critical infrastructure sectors. Each year, Clear Path presents response officials from a diverse array of challenging exercise

scenarios, allowing them to build upon and validate improvements made in response to lessons learned from previous exercises and real-world incidents. CESER strives to ensure that each new edition of Clear Path presents an increasingly realistic and challenging experience for all participants. The continued success of Clear Path is predicated on the resolute support and involvement from federal, state, and local municipality government partners, cross-sector entities, and private sector organizations. To date, CESER has engaged over 800 energy sector and cross-infrastructure sector partners.

Information Sharing, Partnerships and Exercises
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Information Sharing, Partnerships, and Exercises	**20,561** (*Portions of CESER ISER and OE TPTA Budgets*)	**19,780** (*Portions of CESER ISER and OE TPTA Budgets*)	**25,000**	**+5,220**	**+26.4%**

Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
• Expand activities specifically on risk management for the energy sector, workforce development and supporting, disadvantaged communities and critical functions.	**+5,220**
Total, Information Sharing, Partnerships and Exercises	**+5,220**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Information Sharing, Partnerships and Exercises **$ 19,780,000**	**$25,000,000**	**$ +5,220,000**

• Exercises, Competitions and Workshops: Conduct Clear Path IX and Liberty Eclipse III with a focus on the connection between emergency response of a cyber nature and consequence management
  • Continue to host CyberForce energy sector cyber defense competition and CyberStrike workshops
  • Support the Presidential Operations Technology Cyber Competition
• Develop grid resilience tools and analyses to help State electricity officials promote prudent, strategic decision-making
• Provide technical assistance to Federal, State, local, territorial, Tribal, and regional entities to address key challenges in the energy system
• Continue to implement regulatory responsibilities and evaluate regulatory reform to reduce federal burden
• Support for technical assistance work to provide stakeholders an in-depth understanding of the resilience of the electric grid and related infrastructure
• Provide institutional support to potential critical electric infrastructure investments that address the vulnerabilities of the North American energy system
	• DCEI: Activities will be undertaken in FY 2022 to begin to implement DOE's DCEI strategic plan by applying successful methods incubated and validated in FY 2021 to a larger group of critical defense facilities from DOE's designated list, increasing national defense and security readiness against power supply interruptions.
	• Exercises, Competitions and Workshops: Conduct Clear Path IX and Liberty Eclipse III with a focus on the connection between emergency response of a cyber nature and consequence management
	  • Expand CyberForce energy sector cyber defense competition and CyberStrike workshops in the interest of supporting energy justice and energy jobs
	  • Support the Presidential Operations Technology Cyber Competition
	• *Establish State Energy Security Grants:* Strengthening SLTT capabilities through tools and resources to enhance mitigation and response capabilities to energy disruptions and emergencies.
	• Expand cyber and non-cyber exercises and training.
		• Establish security and resilience grants and enhance technical assistance that is provided to state and community awardees.
		• Provide additional risk management and assessment opportunities for utilities and energy companies, especially those supporting critical defense facilities
		• Expand training and exercise offerings and provide additional resources, including through additional training opportunities and ongoing engagements throughout the year for the CyberForce Competition and by growing the OT Defenders program to further develop the energy sector workforce
		• Establish new mechanisms to work with energy companies to identify systemically important critical infrastructure (SICI) in the energy sector and perform intelligence-informed risk analysis for critical energy infrastructure, including DCEI, through the National Labs
		• Develop recommendations for prioritization of energy infrastructure supply chain equipment testing, supply chain risk management practices, the sharing of risk information, and increasing the manufacture of essential electric equipment by companies subject to U.S. jurisdiction leveraging existing working group structures to solicit stakeholder feedback in the development of these recommendations.

Program Direction

Overview

Program Direction provides for costs associated with federal workforce staffing to include salaries, benefits, travel, training, and other related expenses. Program Direction funds also provide for costs associated with contractor services managed under the direction of the federal workforce. Contractors support the Office of Cybersecurity, Energy Security, and Emergency Response (CESER) mission.

Salaries and Benefits support federal employees who provide executive management, programmatic oversight, and analysis for the effective implementation of the CESER program. This includes staff at Headquarters and the National Energy Technology Laboratory (NETL) to support the overall mission of CESER. While CESER funds NETL staff within its budget, the NETL Federal employees are included within the full-time equivalent (FTE) total within the Fossil Energy Research and Development account.

CESER federal staff provide oversight for a wide range of cyber and emergency response functions and programs. These programs and functions include: guiding a multi-million dollar Risk Management Tools (RMT) program; staffing and managing the Department's all hazard energy sector emergency response function (ESF #12); training and coordinating a cadre of more than 100 volunteer energy sector emergency responders; overseeing annual programs of energy sector exercises, workshops, interagency and industry engagement, and coordination with states and localities before and during emergencies; and the development of reports and analyses on threats and hazards to the energy sector. Increased need is seen in the area of cyber preparedness and incident response. Federal staff also support crosscutting functions which include budget, procurement, contracts, and human resources.

When Presidential Disaster Declarations are issued CESER staff are called upon under the National Response Framework. Trained staff provide support for Federal Emergency Management Agency (FEMA) Emergency Support Function 12 (ESF #12) missions. Some of these trained responders may be ordinarily employed in other parts of DOE, such as the Office of Energy Efficiency and Renewable Energy or the Power Marketing Administrations. During ESF #12 activations CESER is reimbursed by FEMA for overtime expenses while CESER responder base pay is funded from the CESER Program Direction budget. In FY 2020, trained responders were activated for 214 days. Frequent activations are projected to continue into FY 2021 and FY 2022.

CESER's staffing efforts will continue to focus on building core capabilities of cyber incident response and analytics, infrastructure security tool development and emergency response and recovery programs addressing both natural and man-made disasters in order to meet the Department of Energy's (DOE's) statutory responsibilities included in Fixing America's Surface Transportation Act of 2015, as well as priorities including developing a cyber workforce for operational technology and industrial control systems; Electromagnetic Pulse and Geomagnetic Disturbance ; and DOE's Sector Risk Management Agency responsibilities included in the NESF #12.

Travel includes transportation, per diem, and incidental expenses allowing CESER to effectively deliver on its' mission. Major drivers of travel include the need to oversee development and deployment of risk management tools, programs, and projects in the field; attendance at industry, interagency and regional state government energy sector emergency response coordination meetings; and conducting emergency response training for responders in conjunction with Department of Homeland Security regional response centers. FEMA reimburses DOE for all travel associated with Presidential Disaster Declarations.

Support Services include contractor support directed by Federal staff to perform administrative tasks and provide analysis to management. Additional support services may include support from Internship programs utilized through Oak Ridge Institute for Science and Education and DOE's Minority Educational Institution Student Partnership Program assignments.

Other Related Expenses include equipment purchases, upgrades, and replacements, office furniture, commercial credit card purchases using simplified acquisition procedures when possible, and miscellaneous expenditures.

Highlights of the FY 2022 Budget Request

This budget request supports 7 additional FTEs to support mission critical work.

	Program Direction Funding ($K)				
	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	4,951	6,459	8,751	+2,292	+35.5%
Travel	250	347	254	-93	-26.8%
Support Services	1,378	1,430	2,143	+713	+49.9%
Other Related Expenses	3,521	876	1,392	+516	+58.9%
Total, Washington Headquarters	**10,100**	**9,112**	**12,540**	**+3,428**	**+37.6%**
National Energy Technology Laboratory					
Salaries and Benefits	1,258	1,282	1,658	+376	+29.3%
Travel	120	120	110	-10	-8.3%
Support Services	438	438	315	-123	-28.1%
Other Related Expenses	1,084	1,048	1,377	+329	+31.4%
Total, National Energy Technology Laboratory	**2,900**	**2,888**	**3,460**	**+572**	**+19.8%**
Total Program Direction					
Salaries and Benefits	6,209	7,741	10,409	+2,668	+34.5%
Travel	370	467	364	-103	-22.1%
Support Services	1,816	1,864	2,458	590	+33%
Other Related Expenses	4,605	1,944	2,769	845	+42.4%
Total, Program Direction	**13,000**	**12,000**	**16,000**	**+4,000**	**+33.3%**
Federal FTEs	**27**	**43**	**50**	**+7**	+16.3%
Additional FE FTEs at NETL supporting CESER[a]	9	9	10	+1	+11.1%
Total CESER-funded FTEs	**36**	**52**	**60**	**+8**	**+15.4%**

[a] CESER funds FTEs at FE's National Energy Technology Laboratory who support CESER activities. This number will increase to 10.4 FTEs in FY22. The 10.4 FTEs are in FE's FTE totals and are not included in the CESER FTE totals shown on the "Federal FTEs" line.

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Support Services and Other Related Expenses					
Support Services					
Technical Support	872	1,160	1,549	+389	+33.5%
Management Support	944	688	909	+221	+32.1%
Total, Support Services	**1,816**	**1,848**	**2,458**	**+610**	**+33%**
Other Related Expenses					
Other Services	2,682	721	832	+111	+15.4%
EITS Desktop Services	223	223	564	+341	+152.9%
WCF	1,700	1,000	1,373	+373	+37.3%
Total, Other Related Expenses	**4,605**	**1,944**	**2,769**	**+825**	**+42.4%**

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
$12,000,000	**$16,000,000**	**+$3,000,000**
$7,741,000 • Salaries and benefits support 43 FTEs at HQ and 9 FTEs at NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the CESER program	**$10,409,000** • Salaries and benefits support 50 FTEs at HQ and 10 FTEs at NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the CESER program	**+$2,668,000** • Salaries and Benefits increase is due to 7 additional FTEs in 2022.
$467,000 • Travel includes transportation, subsistence, and incidental expenses that allow CESER to effectively facilitate its mission	**$364,000** • Travel is expected to remain limited due to the COVID-19 pandemic	**-$103,000** • Decrease due to the utilization of virtual meeting options and virtual training.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
$1,848,000 • Support Services includes contractor support directed by the federal staff to provide analysis to management • Support Services may include support for post-doctoral fellows and IPA assignments	**$2,458,000** • As CESER begins to increase Federal Staff the use of support services is expected to decrease/remain at current levels	**+$610,000** • Support Service increases due to contractual increases outlined in Contracts
$1,944,000 • Other Related Expenses includes equipment upgrades and replacements, office furniture, minor construction, commercial credit card purchases using simplified acquisition procedures when possible, and miscellaneous expenditures.	**$2,769,000** • Increase staff will incur additional Other related expenses.	**+$825,000** • Increase for additional FTE and equipment related to increased telework. Transition from desktop computers to laptops and mobile devices.

Cybersecurity, Energy Security, and Emergency Response

Research and Development ($K)[ab]

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Basic	1,308	2,304	0	-2,304	-100%
Applied	18,742	33,010	0	-33,010	-100%
Development	15,691	27,637	70,208	42,571	154%
Total, R&D	35,741	29,941	70,208	40,267	134%

Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2020 Enacted Transfer	FY 2021 Enacted Projected Transfer	FY 2022 Request Projected Transfer	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Risk Management Tools	1,305	2,298	1,276	-1,022	-44%

[a] Development reporting includes a proportional share of program direction funding in addition to direct Development funding.

[b] The Basic and Applied R&D conducted by CESER in FYs 2020 and 2021 will be performed by the Office of Electricity in FY 2022.

DEPARTMENT OF ENERGY

Funding by Site

TAS_2250 - Cybersecurity, Energy Security and Emergency Response (CESER) BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Argonne National Laboratory			
Cybersecurity for Energy Delivery Systems	900	0	0
Infrastructure Security and Energy Restoration	5,000	2,500	0
Risk Management Technology and Tools	0	0	2,500
Response and Restoration	0	0	1,500
Information Sharing, Partnerships and Exercises	0	0	3,000
Total Argonne National Laboratory	**5,900**	**2,500**	**7,000**
Idaho National Laboratory			
Cybersecurity for Energy Delivery Systems	3,000	22,000	0
Infrastructure Security and Energy Restoration	7,000	6,000	0
Risk Management Technology and Tools	0	0	30,000
Information Sharing, Partnerships and Exercises	0	0	3,000
Total Idaho National Laboratory	**10,000**	**28,000**	**33,000**
Lawrence Livermore National Laboratory			
Cybersecurity for Energy Delivery Systems	2,600	0	0
Infrastructure Security and Energy Restoration	4,000	3,300	0
Risk Management Technology and Tools	0	0	2,000
Information Sharing, Partnerships and Exercises	0	0	3,000
Total Lawrence Livermore National Laboratory	**6,600**	**3,300**	**5,000**
Los Alamos National Laboratory			
Infrastructure Security and Energy Restoration	2,500	0	0
Information Sharing, Partnerships and Exercises	0	0	1,000
Total Los Alamos National Laboratory	**2,500**	**0**	**1,000**
National Energy Technology Lab			
Cybersecurity for Energy Delivery Systems	50,900	60,000	0
Infrastructure Security and Energy Restoration	5,250	5,500	0
Risk Management Technology and Tools	0	0	60,000
Response and Restoration	0	0	2,500
Information Sharing, Partnerships and Exercises	0	0	4,000
Program Direction - CESER	2,802	2,000	2,000
Total National Energy Technology Lab	**58,952**	**67,500**	**68,500**
National Renewable Energy Laboratory			
Infrastructure Security and Energy Restoration	4,000	0	0
Total National Renewable Energy Laboratory	**4,000**	**0**	**0**
Oak Ridge Institute for Science & Education			
Infrastructure Security and Energy Restoration	1,600	0	0
Total Oak Ridge Institute for Science & Education	**1,600**	**0**	**0**
Oak Ridge National Laboratory			
Cybersecurity for Energy Delivery Systems	1,300	10,000	0
Infrastructure Security and Energy Restoration	5,500	6,000	0
Risk Management Technology and Tools	0	0	17,000
Total Oak Ridge National Laboratory	**6,800**	**16,000**	**17,000**
Pacific Northwest National Laboratory			
Cybersecurity for Energy Delivery Systems	3,300	1,000	0
Infrastructure Security and Energy Restoration	3,500	10,000	0
Risk Management Technology and Tools	0	0	11,000
Information Sharing, Partnerships and Exercises	0	0	3,000
Total Pacific Northwest National Laboratory	**6,800**	**11,000**	**14,000**
Richland Operations Office			
Infrastructure Security and Energy Restoration	3,000	6,525	0
Response and Restoration	0	0	16,000
Total Richland Operations Office	**3,000**	**6,525**	**16,000**

DEPARTMENT OF ENERGY

Funding by Site

TAS_2250 - Cybersecurity, Energy Security and Emergency Response (CESER) BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Sandia National Laboratories			
Cybersecurity for Energy Delivery Systems	1,800	1,000	0
Infrastructure Security and Energy Restoration	11,150	0	0
Risk Management Technology and Tools	0	0	2,500
Information Sharing, Partnerships and Exercises	0	0	4,000
Total Sandia National Laboratories	**12,950**	**1,000**	**6,500**
Savannah River Operations Office			
Infrastructure Security and Energy Restoration	5,000	0	0
Total Savannah River Operations Office	**5,000**	**0**	**0**
Washington Headquarters			
Cybersecurity for Energy Delivery Systems	10,700	2,000	0
Infrastructure Security and Energy Restoration	11,500	8,175	0
Risk Management Technology and Tools	0	0	10,000
Response and Restoration	0	0	5,000
Information Sharing, Partnerships and Exercises	0	0	4,000
Program Direction - CESER	8,698	10,000	14,000
Total Washington Headquarters	**30,898**	**20,175**	**33,000**
Western Area Power Administration Office			
Infrastructure Security and Energy Restoration	1,000	0	0
Total Western Area Power Administration Office	**1,000**	**0**	**0**
Total Funding by Site for TAS_2250 - Cybersecurity, Energy Security and Emergency Response (CESER)	**156,000**	**156,000**	**201,000**

Naval Petroleum and Oil Shale Reserves

Naval Petroleum and Oil Shale Reserves

Naval Petroleum and Oil Shale Reserves
Proposed Appropriation Language

For Department of Energy expenses necessary to carry out naval petroleum and oil shale reserve activities, [$13,006,000] *$13,650,000* to remain available until expended: *Provided*, That notwithstanding any other provision of law, unobligated funds remaining from prior years shall be available for all naval petroleum and oil shale reserve activities.

Explanation of Changes

New FY 2022 budget authority of $13.65 million will fund continued NPR-1 environmental assessment and remediation activities.

Public Law Authorizations

- P.L. 94-258, U.S. Naval Petroleum Reserves Production Act of 1977
- P.L. 95-91, U.S. Department of Energy Organization Act of 1977
- P.L. 104-106, The National Defense Authorization Act For Fiscal Year 1996
- P.L. 105-261, The Strom Thurmond National Defense Act for Fiscal Year 1999
- P.L. 109-58, Energy Policy Act of 2005

Naval Petroleum and Oil Shale Reserves
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
14,000	13,006	13,650

Overview

The Naval Petroleum and Oil Shale Reserves (NPOSR) program manages five legal agreements that were executed as part of the 1998 sale of Naval Petroleum Reserve 1 (NPR-1) in Elk Hills, California. The legal agreements direct post-sale work, including environmental restoration and remediation, contract closeout, and records disposition. Legal agreements also include payment for post-employment medical and dental benefits to former NPR-1 Management & Operating (M&O) contractor employees. The NPR-1 program continues to work towards closing out the remaining environmental findings at the site, as required by the 2008 agreement between the Department of Energy (DOE) and the California Department of Toxic Substances Control (DTSC).

DOE also operated Naval Petroleum Reserve 3 (NPR-3) and the Rocky Mountain Oilfield Testing Center (RMOTC), co-located near Casper, Wyoming, until its sale in January 2015. DOE retains responsibility for Industrial Landfill number 2 (IND-2) located at NPR-3 until a closure permit is issued by the Wyoming Department of Environmental Quality (WDEQ). Landfill remediation activities were completed in FY 2017 and ground water sampling began in compliance with WDEQ requirements. The period of sampling will be specified by WDEQ but is expected to continue for one to four years. No new FY 2022 budget authority is requested for NPR-3.

The program will continue the ongoing activities to attain release from the remaining environmental findings related to the sale of NPR-1. All 131 areas of concern (AOC) have undergone an initial investigation and the program has made recommendations to California's DTSC for either no further action (NFA) required status, additional field work investigation, or remedial action.

Highlights and Major Changes in the FY 2022 Budget Request

New FY 2022 budget authority of $13.65 million will support continued work with the California DTSC and other stakeholders on the environmental remediation and cultural resource activities in accordance with the 2008 DTSC Corrective Action Consent Agreement to obtain NFA status for all 131 AOCs.

Also included is the payment to former NPR-1 M&O contractor employees for post-employment medical and dental benefits**.** NPR-3 will continue groundwater sampling activities for the landfill closure with oversight by the Washington, D.C., Headquarters office.

Naval Petroleum and Oil Shale Reserves
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Naval Petroleum and Oil Shale Reserves					
Production Operations	12,000	11,000	11,650	+650	+6%
Management	2,000	2,006	2,000	-6	0%
Total, Naval Petroleum and Oil Shale Reserves	**14,000**	**13,006**	**13,650**	**+644**	**+5%**
Federal FTEs	**4**	**4**	**4**		

Naval Petroleum and Oil Shale Reserves
Production Operations

Overview

The NPR-1 program continues to work towards closing out the remaining environmental restoration and remediation activities for 131 AOCs, as required by the 2008 agreement between DOE and California's DTSC. DOE will continue the monitoring and oversight of environmental remediation of the Elk Hills site and the work on records disposition.

The NPR-3 program will continue post-sale activities for the closure of the landfill using prior-year balances. No new FY 2022 budget authority is requested for NPR-3.

Highlights of the FY 2022 Budget Request

The Department is requesting new FY 2022 budget authority of $13.65 million to fund the remediation work at the NPR-1 site.

Of the 131 AOCs for which DOE is responsible for environmental cleanup, as of March 2021, 111 AOCs have received NFA certification from California's DTSC. The remaining 20 AOCs that require remediation are larger-scale projects with substantial funding requirements. New FY 2022 budget authority of $13.65 million supports remediation of 5 AOCs.

Production Operations
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
NPR-1 Closeout	12,000	11,000	11,650	+650	+6%
NPR-3 Disposition	0	0	0	0	0%
Total, Production Operations	**12,000**	**11,000**	**11,650**	**+650**	**+6%**

Production Operations
Explanation of Major Changes
($K)

	FY 2022 Request vs FY 2021 Enacted
NPR-1 Closeout: FY 2022 budget authority will finance continued environmental assessment and remediation activity, in accordance with NPR-1 post-sale legal agreements.	**+$650**
NPR-3 Disposition: No FY 2022 budget authority is requested. NPR-3 ongoing post-sale remediation monitoring activities will continue through NPR-3 closeout in one to four years.	**$0**
Total, Production Operations	**+$650**

Production Operations
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Production and Operations $11,000,000	**$11,650,000**	**+$650,000**
NPR-1 Closeout $11,000,000	**$11,650,000**	**+$650,000**
• Program will continue the ongoing activities to attain release from the remaining environmental findings related to the sale of NPR-1. The FY 2021 Request amount includes funding that supports remediation of 3 sub-areas of concern (AOCs).	• Program will continue the ongoing activities to attain release from the remaining environmental findings related to the sale of NPR-1. The FY 2022 Request includes funding that supports remediation of 5 AOCs.	• Funding supports the ongoing remediation work at the NPR-1 site.
NPR-3 Disposition $0	**$0**	**$0**
• Disposition completed; post-sale remediation monitoring activities for the landfill are ongoing.	• Disposition completed; post-sale remediation monitoring activities for the landfill are ongoing.	• No change.

Naval Petroleum and Oil Shale Reserves
Management

Overview

Management provides funding for payments to former NPR-1 M&O contractor employees for post-medical and dental benefits, a legal requirement of the 1998 NPR-1 sales agreement. Management also provides the Federal staffing resources and associated costs required to provide overall direction and execution of the NPOSR. There are a variety of inherently governmental functions, such as program management, contract administration, and budget formulation and execution that require a dedicated Federal workforce. NPOSR uses contractor support services and other related expenses to support the field environmental assessment, remediation, and management of the program.

Highlights of the FY 2022 Budget Request

The NPR-1 funding supports Federal staff that provide oversight, monitor environmental clean-up, and manage disposition activities. The sales agreement also includes payments to former NPR-1 M&O contractor employees for post-employment medical and dental benefits.

NPR-3/RMOTC final office closeout was completed December 30, 2015; however, administrative oversight of the landfill closure will continue to be conducted by the Department of Energy Headquarters office. No new FY 2022 budget authority is requested for NPR-3.

Management
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Washington Headquarters					
Salaries and Benefits	525	531	525	-6	-1%
Travel	50	50	50	0	0%
Support Services	425	425	425	0	0%
Other Related Expenses	1,000	1,000	1,000	0	0%
Total, Washington Headquarters	**2,000**	**2,006**	**2,000**	**-6**	**0%**
NPR – Wyoming					
Salaries and Benefits	0	0	0	0	0%
Travel	0	0	0	0	0%
Support Services	0	0	0	0	0%
Other Related Expenses	0	0	0	0	0%
Total, NPR – Wyoming	**0**	**0**	**0**	**0**	**0%**
Total Management					
Salaries and Benefits	525	531	525	-6	-1%
Travel	50	50	50	0	0%
Support Services	425	425	425	0	0%
Other Related Expenses	1,000	1,000	1,000	0	0%
Total, Management	**2,000**	**2,006**	**2,000**	**-6**	**0%**
Federal FTEs	**4**	**4**	**4**	**0**	**0%**
Support Services					
Technical Support					
Environmental, Safety, Security & Health	0	0	0	0	0%
Technical Services	400	400	400	0	0%
Total, Technical Support	**400**	**400**	**400**	**0**	**0%**
Management Support					
Business Administration	0	0	0	0	0%
IT Support	25	25	25	0	0%
Total Management Support	25	25	25	0	0%
Total, Support Services	**425**	**425**	**425**	**0**	**0%**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Other Related Expenses					
Rent to Others	0	0	0	0	0%
Communications, Utilities & Misc.	0	0	0	0	0%
Other Services	1,000	1,000	1,000	0	0%
Operation and Maintenance of Equipment	0	0	0	0	0%
Supplies and Materials	0	0	0	0	0%
Total, Other Related Expenses	**1,000**	**1,000**	**1,000**	**0**	**0%**

Management
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Management $2,006,000	**$2,000,000**	**-$6,000**
Salaries and Benefits $531,000	**$525,000**	**-$6,000**
• Continue monitoring activities at NPR-1 (cultural resources mitigation, environmental clean-up, oversight, and audit).	• Continue monitoring activities at NPR-1 (cultural resources mitigation, environmental clean-up, oversight, and audit). No new FY 2022 budget authority is requested for NPR-3.	• New budget authority of $525 thousand will be sufficient for covering expected salaries and benefits requirements in FY 2022 for NPR-1.
Travel $50,000	**$50,000**	**$0**
• Federal travel will be required for environmental cleanup at NPR-1.	• Federal travel will be required for environmental cleanup at NPR-1. No new FY 2022 budget authority is requested for NPR-3.	• No change.
Support Services $425,000	**$425,000**	**$0**
• Support Services for environmental clean-up of NPR-1.	• Support Services for environmental clean-up of NPR-1. No new FY 2022 budget authority is requested for NPR-3.	• No change.
Other Related Expenses $1,000,000	**$1,000,000**	**$0**
• As in prior years, funding provides for post-employment medical and dental benefits for former M&O contractor employees at NPR 1.	• As in prior years, funding provides for post-employment medical and dental benefits for former M&O contractor employees at NPR 1.	• No change.

DEPARTMENT OF ENERGY

Funding by Site

TAS_0219 - Naval Petroleum and Oil Shale Reserve BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Undesignated LPI			
Production Operations - Naval Petroleum & Oil Shale Reserve	12,000	11,000	11,650
Program Direction - Naval Petroleum & Oil Shale Reserve	2,000	2,006	2,000
Naval Petroleum & Oil Shale Reserves	14,000	13,006	13,650
Total Undesignated LPI	**14,000**	**13,006**	**13,650**
Total Funding by Site for TAS_0219 - Naval Petroleum and Oil Shale Reserve	**14,000**	**13,006**	**13,650**

Strategic Petroleum Reserve

Strategic Petroleum Reserve

Strategic Petroleum Reserve
Proposed Appropriation Language

For Department of Energy expenses necessary for Strategic Petroleum Reserve facility development and operations and program management activities pursuant to the Energy Policy and Conservation Act (42 U.S.C. 6201 et seq.), [$188,000,000] *$197,000,000*, to remain available until expended.

Explanation of Changes

This budget FY 2022 request reflects modest increases for Strategic Petroleum Reserve Cavern Integrity program, Maintenance program, Piping Integrity, Data Systems, and Cybersecurity, with modest decreases to Major Maintenance Program and Physical Security Program activities.

Public Law Authorizations
Public Law 109-58, "Energy Policy Act of 2005"
Bipartisan Budget Act of 2015 (P.L. 114-74, Section 403)
Bipartisan Budget Act of 2018 (P.L. 115-123)
Energy Policy and Conservation Act, P.L. 94-163, as amended, Section 151

Strategic Petroleum Reserve
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
195,000	188,000	197,000	+9,000

Overview

The Strategic Petroleum Reserve (SPR) protects the U.S. economy from disruptions in critical petroleum supplies and meets United States (U.S.) obligations under the International Energy Program (Energy Policy and Conservation Act, P.L. 94-163, as amended, Section 151). The SPR benefits the U.S. by providing an insurance policy against potential interruptions in U.S. petroleum supplies, whether originating from domestic or international supply disruptions, natural disasters, sabotage, or acts of terrorism. The SPR also provides limited capability to remove surplus oil from the market in emergencies, such as the significant demand decline caused by the COVID-19 pandemic, and also leases excess storage space to outside entities.

The FY 2022 Budget supports the program's operational readiness and drawdown capabilities. The SPR will continue conducting multiple, non-emergency crude oil sales in FY 2022 as directed by (1) the Bipartisan Budget Act of 2015 (P.L. 114-74, Section 403), which directs the sale of 8 million barrels in FY 2022, and (2) the Bipartisan Budget Act of 2018 (P.L. 115-123), which directs the sale of 30 million barrels from FY 2022 through FY 2025. Of the 30 million barrels SPR is directed to sell by the Bipartisan Budget Act of 2018, the SPR will sell approximately 7.5 million barrels in FY 2022. Combined, the SPR anticipates total FY 2022 sales of about 15.5 million barrels.

The Northeast Gasoline Supply Reserve (NGSR) was administratively established in 2014 as part of the SPR to ease regional shortages resulting from sudden/unexpected supply interruptions (e.g., Superstorm Sandy). The NGSR consists of 1 million barrels of gasoline blendstock stored in leased commercial storage terminals located Maine, Massachusetts, and New Jersey.

Highlights and Major Changes in the FY 2022 Budget Request

The SPR Program will pursue the following major activities in FY 2022:

- Equipment and facility maintenance to sustain drawdown capability.
- Legislatively directed non-emergency multi-year crude oil sales.
- Security Program and maintenance of security related infrastructure items.
- Storage cavern wellbore diagnostic and remediation activities using 1 workover rig and crew that includes 8 cavern wellbore workovers and 1 cavern wellbore remediation. This includes Mechanical Integrity Testing required for cavern wells, and repair actions when wells fail to meet standards during the 5-year state-required testing cycle.

FY 2022 funding includes the utilization of one rig and workover rig crew to perform 1 cavern wellbore remediation and 8 cavern wellbore workovers within the Cavern Integrity Program, compared to 2 cavern wellbore remediations and 4 cavern well workovers to be performed in FY 2021. Unanticipated cavern issues may require reprioritization of projects to fund emergency repairs with consideration to activities associated with normal operations, multi-year crude oil sales and the Life Extension II (LE2) Project. Planned Major Maintenance construction projects will decrease to 3 compared to 9 in FY 2021, in part because of the start of major construction for the LE2 project. An increase to maintenance activities that includes preventive and corrective maintenance for pumps, valves, actuators, and motors. A decrease to the Security Program in Physical Security Personnel training, assessments, and equipment replacements is expected. However, the Security Program retains capable and adequate effectiveness in providing a deterrence and response posture to adversarial threats.

Cybersecurity: DOE is engaged in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center for incident response and the implementation of Department-wide Identity Credential and Access Management.

	Cyber-security	Total
Facilities Development and Operations	3,761	3,761

Strategic Petroleum Reserve
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Strategic Petroleum Reserve					
Facilities Development and Operations	168,235	160,949	168,525	+7,576	+4.7%
Management	26,765	27,051	28,475	+1,424	+5.3%
Northeast Gasoline Supply Reserve	0	0	0	0	0%
Total, Strategic Petroleum Reserve	**195,000**	**188,000**	**197,000**	**+9,000**	**+4.8%**
Federal FTEs	**126**	**126**	**126**	**0**	

Strategic Petroleum Reserve

Overview

The Strategic Petroleum Reserve (SPR) protects the U.S. economy from disruptions in critical petroleum supplies or demand and meets U.S. obligations under the International Energy Program (Energy Policy and Conservation Act, P.L. 94-163, as amended, Section 151). The SPR benefits the U.S. by providing an insurance policy against potential interruptions in U.S. petroleum supplies or demand whether originating from domestic and international supply disruptions, natural disasters, sabotage, and acts of terrorism.

The SPR has 638 million barrels of crude oil inventory (as of December 31, 2020) stored in underground cavern storage, providing the U.S. with multiple geostrategic benefits, and bolstering the world's collective energy security system. A release of petroleum from the SPR can mitigate the potential economic damage of an actual disruption in international or domestic petroleum supplies and the accompanying price increases. The SPR avails the U.S. with international emergency assistance through its participation in the International Energy Agency (IEA) energy supply security initiatives. IEA members are required to maintain 90 days' worth of net petroleum import protection in government-owned and/or commercial stocks and have a commitment to participate with other stockholding nations in a coordinated release of stocks in the event of a major supply disruption. While the U.S. is a net exporter of crude oil and all petroleum products as defined by the IEA, the inventory of 638 million barrels of crude oil as of December 31, 2020 would provide about 236 days of 2020 net crude oil import protection (based on net crude oil imports of 2.7 million barrels per day as reported in the U.S. Energy Information Administration's *Petroleum Supply Monthly with Data Through January 2021*). The SPR has a maximum drawdown capability of over 4 million barrels per day, which could be made available in the event of an IEA collective action. The United States percentage share of an IEA collective action release is 41.5%, as of October 2020.

To accomplish its mission and address the challenges outlined above, the SPR program is organized into two subprograms: Facilities Development and Operations and Management. The Facilities Development and Operations subprogram funds all requirements associated with developing and maintaining facilities for the storage of petroleum, operations activities associated with placing petroleum into storage and operational readiness initiatives associated with drawing down and distributing the inventory within 13 days' notice in the event of an emergency. The Management subprogram funds personnel and administrative expenses related to maintaining the Project Management Office (New Orleans, LA) and the Program Office (Washington, DC), as well as contract services required to support management and technical analysis of program initiatives and issues.

Highlights of the FY 2022 Budget Request

SPR's underground storage caverns require maintenance to assure their storage capability and integrity. Ongoing oil sale activities increase equipment usage and run times and require consistent preventive, predictive and corrective maintenance to prevent or address equipment failures.

Cavern Integrity

The Casing Inspection and Cavern Remediation Program was developed in 2010 to remediate the anomalies in cavern wellbore casings. This is necessary to maintain the required level of operational and drawdown/fill capability. Cavern remediation and diagnostic workovers anticipate and remediate cavern wellbore failures that cause caverns to be removed from service, and in preventing potential environmental releases.

Maintenance and Major Maintenance

Maintenance of SPR equipment and facilities supports drawdown/fill readiness in a safe and environmentally compliant manner. Increased infrastructure use due to legislatively directed, multi-year crude oil sales requires additional Maintenance and Major Maintenance activities to sustain operational readiness. It includes the maintenance of infrastructure items that support Physical Security.

Major changes in FY 2022 include a decrease from 9 to 3 Major Maintenance planned construction projects, in part because of the start of construction for the Life Extension II (LE2) project. Increased maintenance activities to include preventive and corrective maintenance, and equipment and facility maintenance are needed and supported by the FY 2022 request. The Cavern Integrity Program will perform 1 cavern wellbore remediation and 8 cavern wellbore workovers. A decrease to the

Security Program in Physical Security Personnel training, assessments, and equipment replacements will occur. However, the Security Program retains a capable and effective deterrent response posture to adversarial threats.

Strategic Petroleum Reserve
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Strategic Petroleum Reserve					
Facilities Development and Operations	168,235	160,949	168,525	+7,576	+4.7%
Management	26,765	27,051	28,475	+1,424	+5.3%
Northeast Gasoline Supply Reserve	0	0	0	0	0%
Total, Strategic Petroleum Reserve	**195,000**	**188,000**	**197,000**	**+9,000**	**+4.8%**
Federal FTEs	**126**	**126**	**126**	**0**	

Strategic Petroleum Reserve
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Facilities Development and Operations: The Request reflects increases to the Cavern Integrity Program (+$2,106); the Maintenance Program (+$2,438); IT life-cycle upgrades and replacements for support systems projects and contractor service support (+$6,479); it reflects decreases to the Major Maintenance Program (-$3,065); and the Physical Security Program for SPR sites (-$382).	**+7,576**
Management: The Request reflects an increase for salaries and benefits escalation, rent to others, and technical support services.	**+1,424**
Northeast Gasoline Supply Reserve: The FY 2022 Budget Request reflects $0.	**0**
Total, Strategic Petroleum Reserve	**+$9,000**

Strategic Petroleum Reserve
Facilities Development and Operations

Description

The Facilities Development and Operations subprogram funds activities to maintain the SPR's operational readiness capability for successful drawdowns/fills and operate the sites in a safe, secure, and environmentally acceptable manner. Despite a significant reduction in U.S. reliance on imported petroleum, with significant global reserves in regions of the world subject to political unrest, the U.S. economy remains vulnerable to price increases/decreases related to petroleum supply/demand disruptions. The SPR's stockpile of petroleum products and spare capacity diminishes these vulnerabilities to the effects of supply/demand disruptions.

The SPR's underground storage caverns require maintenance to assure their storage capability and integrity. Surface and sub-surface infrastructure and systems that must be maintained to meet operational readiness requirements have been identified and are funded in this subprogram.

Facilities Development and Operations
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Facilities Development and Operations		
$160,949,000	**$168,525,000**	**+$7,576,000**
Casing Inspections and Remediations $31,456,000	**Casing Inspections and Remediations $33,562,000**	**Casing Inspections and Remediations +$2,106,000**
• Funding level supports 1 cavern workover rig and leased crew to execute 2 remediation and 4 cavern wellbore diagnostic workovers.	• Funding level supports 1 cavern workover rig and leased crew to execute 1 remediation and 8 cavern wellbore diagnostic workovers.	• An increase for the Cavern Integrity Program that allows for 1 cavern well remediation and 8 cavern wellbore diagnostic workovers utilizing one leased rig and crew for cavern integrity operations to insure drawdown capability.
Major Maintenance $9,814,000	**Major Maintenance $6,749,000**	**Major Maintenance -3,065,000**
• Continue approach to repair, replace, or upgrade equipment including Security, Environmental, Safety & Health (ESH), Drawdown and Non-Drawdown critical systems.	• Continue approach to repair, replace, or upgrade equipment including Security, ESH, Drawdown and Non-Drawdown critical systems.	• Decreased funding level allows for 3 of 12 scheduled construction projects that supports operational readiness, given multi-year crude oil sales. The decreased level of construction projects is due in part because of the start of construction for the Life Extension II project.
Maintenance $23,937,000	**Maintenance $26,375,000**	**Maintenance +$2,438,000**
• Provides reduced level of preventive/corrective/predictive maintenance of the SPR equipment and facilities to support drawdown readiness in a safe and environmentally compliant manner.	• Provides an increased level of support but a reduced level of support when compared to a full operational level of preventive/corrective/predictive maintenance of the SPR equipment and facilities to support drawdown/fill readiness in a safe and environmentally compliant manner.	• The increase supports additional materials and services for maintenance of pumps, motors, valves, and actuators of drawdown/fill critical equipment while maintaining an acceptable level of risk of equipment failures which could affect drawdown/fill operations.
Security $21,169,000	**Security $20,787,000**	**Security -$382,000**
• Protect and defend personnel, property and resources against assault, sabotage, vandalism, theft, trespass, and compromise of sensitive as well as classified information.	• Protect and defend personnel, property and resources against assault, sabotage, vandalism, theft, trespass, and compromise of sensitive as well as classified information.	• A minor decrease for replacement of security equipment will not hamper the Security Program to provide for a safe and secure workplace to meet DOE and Federal requirements for the protection of resources and information and ensuring drawdown readiness.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Data Systems & Support $74,573,000	**Data Systems & Support $81,052,000**	**Data Systems & Support +$6,479,000**
• Data Systems to support the mission of drawdown readiness, processing, sale and receipt of goods (oil), communications, reporting, providing protection from malware and computer viruses, and all other activity associated with the use of data and information systems. Compliance requirements for Fire Protection, Department of Transportation (DOT) 5-year Navigable Waterway Inspection, Risk Management Approach Implementation Plan (RMAIP), Multi-Factor Authentication and Piping Assurance Program.	• Data Systems to support the mission of drawdown readiness, processing, sale and receipt of goods (oil), communications, reporting, providing protection from malware and computer viruses, and all other activity associated with the use of data and information systems. Compliance requirements for Fire Protection, DOT 5-year Navigable Waterway Inspection, RMIAP (Cyber Security), Multi-Factor Authentication and Piping Assurance Program.	• Funding level reflects an increase for replacement of life-cycle site operations equipment, data system server hardware and software upgrades, RMAIP, Piping Integrity Program, technical services support activities to include Engineering, Quality Assurance, Property Management, Procurement, Safety & Health and Financial Management.

Strategic Petroleum Reserve
Capital Summary[1] ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Capital Operating Expenses Summary (including MIE)					
Capital Equipment > $500K (including MIE)	3,152	6,795	4,209	-2,586	-38%
Plant Projects (GPP >$10M)	0	0	0	0	0%
Total, Capital Operating Expenses	**3,152**	**6,795**	**4,209**	**-2,586**	**-38%**
Capital Equipment > $500K (including MIE)					
Total Non-MIE Capital Equipment (>$500K)	3,152	6,795	4,209	-2,586	-38%
Total, Capital Equipment (including MIE)	**3,152**	**6,795**	**4,209**	**-2,586**	**-38%**
Plant Projects (GPP - Total Estimated Cost >$10M)					
Total, Plant Projects (GPP – Total Estimated Cost)	**0**	**0**	**0**	**0**	**0%**
Total, Capital Summary	**3,152**	**6,795**	**4,209**	**-2,586**	**-38%**

[1] This list of projects is illustrative and can be adjusted based on operational requirements, priorities, and/or funding.

Strategic Petroleum Reserve
Management

Overview

Management provides funding for the salaries and related requirements of the Headquarters federal workforce responsible for providing programmatic policy, planning and oversight, to include strategic project planning, budget formulation and financial management, operations, engineering, safety, security, and technical analysis of programmatic activity of the SPR. The additional Federal workforce of the SPR Project Management Office directs program execution and establishes technical performance standards as well as scope, cost, and schedule milestones for the Management and Operations contractor.

Highlights of the FY 2022 Budget Request

The Federal staff remains at 126 FTEs with additional technical support contractors. Travel is for operational field support and oversight, including site and vendor visits. Other related expenses include field building leases and telecommunications activities**.**

Management
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	5,646	5,674	5,729	+55	+1%
Travel	130	130	130	0	0%
Support Services	2,137	2,109	2,109	0	0%
Other Related Expenses	1,087	1,087	1,032	-55	-5%
Total, Washington Headquarters	**9,000**	**9,000**	**9,000**	**0**	**0%**
Strategic Petroleum Reserve Project Management Office					
Salaries and Benefits	15,119	15,172	15,552	+380	+3%
Travel	587	604	565	-39	-6%
Support Services	461	450	665	+215	+48%
Other Related Expenses	1,598	1,825	2,693	+838	+48%
Total, SPR Project Management Office	**17,765**	**18,051**	**19,475**	**+1,424**	**+8%**
Total Management					
Salaries and Benefits	20,765	20,846	21,281	+435	+2%
Travel	717	734	695	-39	-5%
Support Services	2,598	2,559	2,774	+215	+8%
Other Related Expenses	2,685	2,912	3,725	+813	+28%
Total, Management	**26,765**	**27,051**	**28,475**	**+1,424**	**+5%**
Federal FTEs	**126**	**126**	**126**	**0**	
Support Services					
Technical Support					
Economic & Environmental Analysis	570	570	570	0	0%
Total, Technical Support	**570**	**570**	**570**	**0**	**0%**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Management Support					
Training and OPM Recruitment	150	150	150	0	0%
Technical Support	1,878	1,839	2,054	+215	+12%
Total Management Support	**2,028**	**1,989**	**2,204**	**+215**	**+11%**
Total, Support Services	**2,598**	**2,559**	**2,774**	**+215**	**+8%**
Other Related Expenses					
Rent to Others	609	636	661	+25	+4%
Communications, Utilities, Misc.	75	77	73	-4	-5%
Other Services	1,576	1,699	2,491	+792	+46%
Supplies and Materials	50	50	50	0	0%
Equipment	375	450	450	0	0%
Total, Other Related Expenses	**2,685**	**2,912**	**3,725**	**+813**	**+28%**

Management
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Management $27,051,000	**$28,475,000**	**+$1,424,000**
Salaries and Benefits $20,846,000	**$21,281,000**	**+$435,000**
• The funding supports salaries and benefits for 126 FTEs and associated costs required to provide overall direction and execution of the SPR. The SPR mission is carried out by a workforce composed largely of M&O contractors, although there are a variety of functions that are inherently governmental (i.e., program management, contract administration, budget formulation, and interagency/international coordination) that require a dedicated Federal workforce.	• The funding supports salaries and benefits for 126 FTEs and associated costs required to provide overall direction and execution of the SPR. The SPR mission is carried out by a workforce composed largely of M&O contractors, although there are a variety of functions that are inherently governmental (i.e., program management, contract administration, budget formulation, and interagency/international coordination) that require a dedicated Federal workforce.	• Increase reflects normal escalation in costs.
Travel $734,000	**$695,000**	**-$39,000**
• Provides travel to assure capability to achieve Level 1 Performance criteria for drawdown and distribution of the Reserve.	• Provides travel to assure capability to achieve Level 1 Performance criteria for drawdown and distribution of the Reserve.	• Minor reduction in travel will support travel required to ensure the reserve is drawdown ready.
Support Services $2,559,000	**$2,774,000**	**+$215,000**
• Activities support project-planning efforts to maintain technical, mission essential support capabilities.	• Activities support project-planning efforts to maintain technical, mission essential support capabilities.	• Increase reflects technical support services for EmTRAX (environmental data management system), General Services Administration Federal Telecommunications Service (GSA FTS), and Lexis Nexis services.
Other Related Expenses $2,912,000	**$3,725,000**	**+$813,000**
• Provides teleconferencing capabilities between sites; field site building leases; analytical support services and materials; Information Technology (IT) hardware and software materials and services support; and contingency for DOE field employee evacuation expenses in the event of a hurricane.	• Provides teleconferencing capabilities between sites; field site building leases; analytical support services and materials; Information Technology (IT) hardware and software materials and services support; and contingency for DOE field employee evacuation expenses in the event of a hurricane.	• Increase for field site building leases, IT hardware and software materials and services. Also supports the requirement for DOE field employee evacuation expenses in the event of a hurricane.

Strategic Petroleum Reserve
Facilities Maintenance and Repair

The SPR Program's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget and displayed below are intended to halt asset condition degradation.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
Strategic Petroleum Reserve	50,448	31,240	32,785	31,463
Total, Direct-Funded Maintenance and Repair	**50,448**	**31,240**	**32,785**	**31,463**

Report on FY 2020 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2020 to the amount planned for FY 2020, including congressionally directed changes.

Total Costs for Maintenance and Repair ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost
Strategic Petroleum Reserve	50,448	31,240
Total, Direct-Funded Maintenance and Repair	**50,448**	**31,240**

Strategic Petroleum Reserve
Safeguards and Security ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Protective Forces	21,355	19,113	18,691	-422	-2%
Physical Security Systems	1,193	1,051	1,075	+24	+2%
Information Security	251	231	238	+7	+3%
Cyber Security	3,475	2,664	3,761	+1,097	+41%
Personnel Security	580	661	580	-81	-12%
Material Control and Accountability	0	0	0	0	0
Research and Development	0	0	0	0	0
Program Management	1,713	1,542	1,603	+61	+4%
Security Investigations	0	0	0	0	0
Transportation Security	0	0	0	0	0
Construction	1,764	0	0	0	0
Total, SPR Safeguards and Security	**30,331**	**25,262**	**25,948**	**+686**	**+3%**

Strategic Petroleum Reserve (SPR) Modernization
Various locations

Project Data Sheet is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The Life Extension Phase 2 (LE2) Project is the Strategic Petroleum Reserve (SPR) Modernization Program mechanism whereby the SPR will modernize aging infrastructure through systems upgrades and associated equipment replacement to ensure continued ability to meet mission requirements for the next 15-25 years. LE2 activities will occur at all four SPR storage sites: Bryan Mound, Big Hill, West Hackberry, and Bayou Choctaw. Initially, the SPR Modernization Program was comprised of two subprograms: the LE2 project, and the Marine Terminal Distribution Capability Enhancements (MTE) project; however, the MTE project has since been cancelled due to lack of current mission need.

The Energy Security and Infrastructure Modernization (ESIM) Fund was established as the funding source for the SPR Modernization Program. The ESIM fund contains offsetting collections from the sale of SPR crude up to the authorized annual revenue ceiling. These sales are limited to the period of fiscal years 2017 through 2020. However, the final sale in FY 2020 did not occur because of market dynamics (a lack of demand) related to the COVID-19 pandemic. Section 14002 of the CARES Act (P.L. 116-136) provided the Department of Energy (DOE) with flexibility to conduct the final sale in FY 2020, FY 2021, or FY 2022.

Significant Changes

LE2 Project:

This Construction Project Data Sheet (CPDS) is an update from Fiscal Year 2021 and does not include a new start for the budget year. Design has been significantly completed and the program is on schedule to receive CD-2, Approve Project Baseline, and CD-3, Approve Start of Construction, in FY 2021. The project is on track to complete within the $1.42 billion funding level.

The most recent DOE O 413.3B approved Critical Decision (CD) for LE2 is CD-1 that was approved on December 22, 2016 with a total project cost range of $750 million to $1.4 billion and a CD-4 completion date range of September 2022 to September 2025. Multiple CD-3X's, acquisition of long lead equipment and site preparatory work, have been approved between FY17 and FY 2021. A Federal Project Director (FPD) has been assigned to this project and has approved this Construction Project Data Sheet (CPDS).

MTE Project:

The Marine Terminal Distribution Capability Enhancements (MTE) project scope received no appropriation in fiscal year 2018. On May 21, 2018, the Under Secretary of Energy signed a memorandum approving the cancelation of the MTE project. The most recent DOE O 413.3B CD for MTE was CD-0, approved by the Deputy Secretary of Energy on August 12, 2016, with a preliminary cost range of $0.5 billion to $1.5 billion and a CD-4 range from FY 2024 to 2025.

Life Extension Phase II:

Critical Milestone History

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2018*	10/30/15	09/01/16	12/22/16	3rd Qtr 2019	3rd Qtr 2019	3rd Qtr 2019	4th Qtr 2024
FY 2019*	10/30/15	09/01/16	12/22/16	3rd Qtr 2019	3rd Qtr 2019	3rd Qtr 2019	4th Qtr 2024
FY 2020*	10/30/15	09/01/16	12/22/16	4th Qtr 2020	4th Qtr 2020	4th Qtr 2020	4th Qtr 2024
FY 2021*	10/30/15	09/01/16	12/22/16	2nd Qtr 2021	2nd Qtr 2021	2nd Qtr 2021	4th Qtr 2024**
FY 2022*	10/30/15	09/01/16	12/22/16	3rd Qtr 2021	3rd Qtr 2021	3rd Qtr 2021	2nd Qtr 2025**

***Project does not have CD-2 approval and has not been baselined. The costs are estimates and are consistent with the high end of the cost ranges.**
****CD-4 for three sites is currently estimated FY 2025; West Hackberry estimated CD-4 is 2nd Quarter FY 2026.**

CD-0 – Approved Mission Need for a construction project with a conceptual scope and cost range
Conceptual Design Complete – Actual date the conceptual design was completed (if applicable)
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
Final Design Complete – Estimated/Actual date the project design will be/was complete(d)
CD-3 – Approve Start of Construction
Deactivation & Decommissioning Complete –Completion of D&D work
CD-4 – Approve Start of Operations or Project Completion
PB – Indicates the Performance Baseline

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B	CD-3C	CD-3D
FY 2017		07/14/17			
FY 2018					
FY 2019			11/20/18	10/25/2019	
FY 2020					. 01/2021
FY 2021	TBD				

CD-3A – Approve Long-Lead Procurements, Original Scope
CD-3B – Approve Long-Lead Procurements, Revised Scope
CD-3C – Approve Long-Lead Procurements, Revised Scope
CD-3D – Approve Long-Lead Procurements, Revised Scope

Project Cost History

Fiscal Years	TEC, Design ($000)	TEC, Construction ($000)	TEC, Total ($000)	OPC Except D&D ($000)	OPC, D&D ($000)	OPC, Total ($000)	TPC ($000)
FY 2018	$100,628	$1,299,372	$1,400,000	$6,711	$0	$6,711	$1,406,711
FY 2019	$199,749*	$800,251	$1,000,000**	$5,250	$0	$5,250	$1,005,250
FY 2020	$276,383	$1,163,617***	$1,440,000***	$5,250	$0	$5,250	$1,445,250***
FY 2021	$392,886	$1,047,114	$1,440,000	$5,250	$0	$5,250	$1,445,250
FY 2022	$392,886	$1,022,888	$1,415,774	$5,250	$0	$5,250	$1,421,024

*The increase in design cost is due to: 1) competing the design contract instead of using a reach-back contract to the M&O contractor partner; 2) adding fee to competed contract; 3) adding escalation to schedule delay caused by competing design contract; and 4) adding engineering cost associated with additional scope (deleted scope was represented completely in construction cost).
** The maximum range project cost of $1.4B was approved at CD-1.

***The Project Scope was expanded to include drilling 17 new wells at two sites. The costs for FY 2020 entry have been revised to reflect the increase in scope. This scope has been removed to stay within the $1.42 B funding limit.

The costs are estimates as of July 2020 and consistent with the high end of the cost ranges. No construction funds, except for approved long lead procurement, will be used until the project performance baseline for each sub-project has been validated and CD-3 has been approved.

2. Project Scope and Justification

Scope

The SPR LE2 project involves work at all four SPR storage sites: Bryan Mound, Big Hill, West Hackberry, and Bayou Choctaw. The SPR-LE2 project will be managed as four sub-projects based on site location for baseline development, field execution, and project completion. Completion of the SPR-LE2 project will extend SPR key equipment and infrastructure capabilities for an additional 15-25 years and assure the required drawdown of 4.4 million barrels per day of hydraulic capability is maintained. Actual drawdown rate is highly dependent on cavern/site fill level. The scope at each of the four SPR storage facilities includes modernization of aging SPR infrastructure through systems upgrades and associated equipment replacement including repair or replace crude oil transfer systems, raw water systems, brine disposal systems, power distribution and lighting systems, and physical security systems. It also includes building and initially installing a new portable degasification plant at the Bayou Choctaw site.

Justification

In August 2016, DOE published a Long-Term Strategic Review (LTSR) of SPR capabilities and infrastructure. The LTSR compared current operational capability to Level 1 Technical and Performance Criteria and identified gaps within the storage site infrastructure and distribution system necessary to provide the design delivery rate of 4.4 million barrels per day if capacity is filled, now and for the next 25 years. The results indicated that a significant investment in infrastructure and process equipment is critical to ensure the SPR can maintain readiness, meet mission requirements, and operate in an environmentally responsible manner. The SPR-LE2 Project addresses these requirements. Current surface assets and systems are at or near their original design life of 25 years and early analysis suggests the required Life Extension Program (LEP) could take up to six years to complete. Revitalization of many, but not all, of those assets and systems last occurred from 1995 to 2000 under the first LEP. As these assets continue to age, modernization will be required – either through additional maintenance and/or repair, or outright replacement.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets.

Preliminary Key Performance Parameters (KPPs)

The Threshold KPPs represent the minimum acceptable performance that the project must achieve. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. The Objective KPPs represent the desired project performance. The preliminary KPPs will be finalized when the project is baselined at CD-2.

Preliminary Performance Measure	Threshold	Objective
Raw Water Withdrawal Rate	TBD	4.5 MMBD*
Peak Sustained Drawdown Rate	TBD	4.4 MMBD*
Site Fill Rate	TBD	~~605~~ 785 MBD**

*At full capacity. MMBD is Million Barrels per day.

**At full capacity. MBD is Thousand Barrels per day.

3. Project Cost and Schedule

Financial Schedule

($K)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2015	N/A	$0	$0
FY 2016	N/A	$0	$0
FY 2017	N/A	$137,215	$4,159
FY 2018	N/A	$130,732	$58,950
FY 2019	N/A	$124,939	$61,540
FY 2020	N/A	$0	$96,115
FY 2021	N/A	$0	$45,664
FY 2022	N/A	$0	$40,222
FY 2023	N/A	$0	$39,015
FY 2024	N/A	$0	$29,448
FY 2025	N/A	$0	$17,773
Total, Design **a**	N/A	$392,886	$392,886
Construction			
FY 2015	N/A	$0	$0
FY 2016	N/A	$0	$0
FY 2017	N/A	$27,400	$0
FY 2018 **b**	N/A	$323,929	$569
FY 2019	N/A	$206,000	$14,082
FY 2020	N/A	$465,559	$39,400
FY 2021	N/A	$0	$243,284
FY 2022	N/A	$0	$302,832
FY 2023	N/A	$0	$235,039
FY 2024	N/A	$0	$113,516
FY 2025	N/A	$0	$74,166
Total, Construction	N/A	$1,022,888	$1,022,888

($K)

	Appropriations	Obligations	Costs
TEC			
FY 2015	N/A	$0	$0
FY 2016	N/A	$0	$0
FY 2017	N/A	$164,615	$4,159
FY 2018	N/A	$454,661	$59,519
FY 2019	N/A	$330,939	$75,622
FY 2020	N/A	$465,559	$135,515
FY 2021	N/A	$0	$288,948
FY 2022	N/A	$0	$343,054
FY 2023	N/A	$0	$274,054
FY 2024	N/A	$0	$142,964
FY 2025	N/A	$0	$91,939
Total, TEC	N/A	$1,415,774	$1,415,774
Other Project Cost (OPC)			
FY 2015 **c,d**	$88	$88	$88
FY 2016 **c,d**	$4,190	$4,190	$4,190
FY 2017 **d**	$972	$972	$699
FY 2018 **d**	$0	$0	$273
FY 2019	$0	$0	$0
FY 2020	$0	$0	$0
FY 2021	$0	$0	$0
FY 2022	$0	$0	$0
FY 2023	$0	$0	$0
FY 2024	$0	$0	$0
FY 2025	$0	$0	$0
Total, OPC	$5,250	$5,250	$5,250

	($K)		
	Appropriations	Obligations	Costs
Total Project Cost (TPC)			
FY 2015	$88	$88	$88
FY 2016	$4,190	$4,190	$4,190
FY 2017 **e**	$340,972	$165,587	$4,858
FY 2018 **f**	$350,000	$454,661	$59,792
FY 2019 **g, i**	$300,000	$330,939	$75,622
FY 2020 **h**	$0	$465,559	$135,515
FY 2021	$425,774	$0	$288,948
FY 2022	$0	$0	$343,054
FY 2023	$0	$0	$274,054
FY 2024	$0	$0	$142,964
FY 2025	$0	$0	$91,939
Total, TPC **d,j**	$1,421,024	$1,421,024	$1,421,024

a: DOE and DOE support labor; M&O project support
b: Bayou Choctaw CD-3A Degas Plant
c: Includes costs for Office of Project Management
d: Funding requirements are included in the Facilities Appropriation 089X0218.
e: FY 2017 Omnibus authorized oil sales target of $340,000,000 (Appropriation). Actual proceeds were $323,195,827.
f: FY 2018 Omnibus authorized oil sales target of $350,000,000 (Appropriation). Actual proceeds were $347,828,624
g: FY 2019 Omnibus authorized oil sales target of $300,000,000 (Appropriation). Actual proceeds were $299,999,961
h: FY 2020 Omnibus authorized oil sales target of $450,000,000 (Appropriation). Sales postponed and authorized completion no later than FY 2022 as part of the CARES Act (P.L. 116-136).
i: Includes costs for Office of Project Management EIR which will be funded from the DOE Contingency within LE 2 funds
j: The Total Project Cost (TPC) of $1.4B was approved at CD-1, and final scope will be established at CD-2. The TPC for obligations and costs is the total of funds from Facilities Appropriation and funding received through the sale of SPR crude oil.

Note: Project is being funded through the sale of SPR crude oil and not through the normal congressional appropriations process.

Details of Project Cost Estimate at High Range at CD-1

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design (PED)			
Design	$392,886	$287,681	N/A
Contingency	$6,906	$25,016	N/A
Total,PED	$399,792	$312,697	N/A
Land Acquisition			
Construction			
Site Facilities Construction	$557,594	$293,276	N/A
Off-Site Facilities	$42,217	$26,661	N/A
Drilling/Wellhead/Casings	$31,915	$333,268	N/A
Pipeline Construction	$100,487	$199,961	N/A
Construction Management	$39,354	$133,307	N/A
Project Support	$199,678	$159,970	N/A
Contingency	$44,737	$186,630	N/A
Total, Construction	$1,015,982	$1,333,073	N/A
Total, TEC	$1,415,774	$1,645,770	N/A
Contingency, TEC	$51,643	$211,646	N/A
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design	$1,366	$1,366	N/A
Other OPC Costs	$3,884	$3,884	N/A
Start-up	$0	$0	N/A
Contingency	$0	$0	N/A
Total, OPC except D&D	$5,250	$5,250	N/A
D&D			
D&D			N/A
Contingency			N/A
Total, D&D	$0	$0	N/A
Total, OPC	$5,250	$5,250	N/A
Contingency, OPC	$0	$0	N/A
Total, TPC	$1,421,024	$1,651,020	N/A
Total, Contingency	$51,643	$211,646	N/A

Note: Project is being funded through the sale of SPR crude oil and not through the normal congressional appropriations process.

Schedule of Appropriations Requests

Section 404 of the Bipartisan Budget Act of 2021 authorizes drawdown and sale of SPR crude oil over four fiscal years (FY 2017 – FY 2020) to finance SPR modernization. This CPDS reflects the high end of the cost ranges. The Total Project Cost (TPC) of $1.4B was approved at CD-1, and final scope will be established at CD-2, expected to occur in FY 2021 or early FY 2022. The intent is to execute SPR modernization within the authorized revenue ceiling proposed in the FY 2020 budget request shown below.

($000)

Request		FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	Total
FY 2018	TEC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	OPC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	TPC	$ -	$ -	$375,400	$350,000	$174,600	$100,000	$ -	$ -	$ -	$ -	$ -	$1,000,000
FY 2019	TEC	$ -	$ -	$ 340,000 *	$ 350,000	$ 300,000	$ 10,000	$ -	$ -	$ -	$ -	$ -	$1,000,000
	OPC	$ 88	$ 4,190	$ 972	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$5,250
	TPC	$ 88	$ 4,190	$ 340,972	$ 350,000	$ 300,000	$ 10,000	$ -	$ -	$ -	$ -	$ -	$1,005,250
FY 2020	TEC	$ -	$ -	$ 340,000 *	350,000 **	$ 300,000	$ 450,000	$ -	$ -	$ -	$ -	$ -	$1,440,000
	OPC	$ 88	$ 4,190	$ 972	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$5,250
	TPC	$ 88	$ 4,190	$ 340,972	$ 350,000	$ 300,000	$ 450,000	$ -	$ -	$ -	$ -	$ -	$1,445,250
FY 2021	TEC	$ -	$ -	$ 340,000 *	$ 350,000 **	$300,000 ***	$450,000 ***	$ -	$ -	$ -	$ -	$ -	$1,440,000
	OPC	$ 88	$ 4,190	$ 972	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$5,250
	TPC	$ 88	$ 4,190	$ 340,972	$ 350,000	$ 300,000	$ 450,000	$ -	$ -	$ -	$ -	$ -	$1,445,250
FY 2022	TEC	$ -	$ -	$ 340,000 *	$ 350,000 **	$300,000 ***	$ -	$425,774***	$ -	$ -	$ -	$ -	$1,415,774
	OPC	$ 88	$ 4,190	$ 972	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$5,250
	TPC	$ 88	$ 4,190	$ 340,972	$ 350,000	$ 300,000	$ -	$ 425,774	$ -	$ -	$ -	$ -	$1,421,024

***** FY 2017 Omnibus authorized oil sales target of $340,000,000 (Appropriation). Actual proceeds were $323,195,827.
****** FY 2018 Omnibus authorized oil sales target of $350,000,000 (Appropriation). Actual proceeds were $347,828,624.
*** FY 2019 Omnibus authorized oil sales target of $300,000,000 (Appropriation). Actual proceeds were $299,999,961.
**** FY 2020 Omnibus authorized oil sales target of $450,000,000 (Appropriation). Sale postponed, and authorized completion changed to no later than FY 2022 as part of the CARES Act (P.L. 116-136).

4. Related Operations and Maintenance Funding Requirements

Not applicable for PED.

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	Establish at CD-2
Expected Useful Life (number of years)	25
Expected Future Start of D&D of this capital asset (fiscal quarter)	N/A

(Related Funding requirements)

(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations		N/A		N/A
Maintenance & Repair		N/A		N/A
Total *		N/A		N/A

* Funding requirements are included in the Facilities Appropriation 089X0218.

5. D&D Information

This project does not require D&D funding.

6. Acquisition Approach

The existing SPR Management and Operating (M&O) Contractor did originally procure the Architect-Engineer contractor. With S-3 concurrence in FY 2019, the M&O Contractor is self-performing the remaining A-E scope and will procure all Government Furnished Property and firm fixed priced construction contracts.

SPR Petroleum Account
Proposed Appropriation Language

For Department of Energy expenses necessary for the acquisition, transportation, and injection of petroleum products, and for other necessary expenses pursuant to the Energy Policy and Conservation Act of 1975, as amended (42 U.S.C. 6241, 6239 note); [$0] $7,350,000 to remain available until expended.

Explanation of Changes

Public Law Authorizations
Energy Policy and Conservation Act, Public Law 94-163, as amended.
Section 403 of the Bipartisan Budget Act of 2015 (P.L. 114-74)
Fixing America's Surface Transportation (FAST) Act (Public Law 114-94)
Section 30204 of the Bipartisan Budget Act of 2018, (P.L. 115-141)
21st Century Cures Act (Public Law 114-255)
Tax Cuts and Jobs Act of 2017, (Public Law 115-97)
Bipartisan Budget Act of 2018 (P.L. 115-123)
Consolidated Appropriations Act, 2018 (P.L. 115-141)
America's Water Infrastructure Act of 2018, Section 3009

SPR Petroleum Account
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
10,000	1,000	7,350	+6,350

Overview

The SPR Petroleum Account funds activities related to the acquisition, transportation, and injection of petroleum products into the Strategic Petroleum Reserve; test sales of petroleum products from the Reserve; and the drawdown, sale, and delivery of petroleum products from the Reserve.

Highlights and Major Changes in the FY 2022 Budget Request

Section 403 of the Bipartisan Budget Act of 2015 (P.L. 114-74) and Section 30204 of the Bipartisan Budget Act of 2018, (P.L. 115-141) direct non-emergency, multi-year oil sales that incur logistical and operational costs to the SPR.

SPR Petroleum Account
Funding by Congressional Control
($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
SPR Petroleum Account					
Petroleum Acquisition, Transportation and Drawdown	10,000	1,000	7,350	+6,350	+635%
Total, SPR Petroleum Account	**10,000**	**1,000**	**7,350**	**+6,350**	**+635%**
Federal FTEs	**0**	**0**	**0**	**0**	**0**

SPR Petroleum Account

Overview

The SPR Petroleum Account funds activities related to the acquisition, transportation, and injection of petroleum products into the Strategic Petroleum Reserve (SPR); test sales of petroleum products from the Reserve; and the drawdown, sale, and delivery of petroleum products from the Reserve. SPR Petroleum Account activities can include: 1) the incremental costs of withdrawing oil from the storage caverns and transporting it to the sales point where purchasers take title; 2) petroleum inventory acquisitions and associated transportation costs; 3) U.S. Customs duties; and 4) terminal throughput charges and other related miscellaneous costs.

SPR Oil Acquisition/Transportation/Drawdown

As of December 31, 2020, the SPR crude oil inventory is 638 million barrels. Currently, the Department of Energy is undergoing a series of non-emergency, multi-year oil sales pursuant to the Bipartisan Budget Act (BBA) of 2015 (Public Law 114–74), the 21st Century Cures Act (Public Law 114-255), the Fixing America's Surface Transportation (FAST) Act (Public Law 114-94), the Act to provide for reconciliation pursuant to titles II and V of the concurrent resolution on the budget for FY 2018, also known as the Tax Cuts and Jobs Act of 2017, (Public Law 115-97), the Bipartisan Budget Act of 2018 (P.L. 115-123), and the Consolidated Appropriations Act of 2018 (P.L. 115-141). Drawdown and sales are scheduled as follows:

- From FY 2018 through FY 2025 (eight consecutive years) – sell 58 million barrels of crude oil, with 8 million barrels to be sold in FY 2022. Proceeds will be deposited into the General Fund of the Treasury (BBA 2015, Section 403).
- From FY 2017 through FY 2020 (four consecutive years)[1] – sell the required volumes of SPR inventory to raise up to the authorized revenue ceiling to be deposited into the Energy Security and Infrastructure Modernization (ESIM) Fund (BBA 2015, Section 404). In FY 2017, 6.3 million barrels were sold; in FY 2018, 4.7 million barrels were sold; and, in FY 2019, 4.2 million barrels were sold, with revenues for the three years of sales totaling approximately $971 million. The final sale for ESIM is planned for FY 2021, raising $450 million.
- From FY 2017 through FY 2019 (three consecutive years) – sell 10 million barrels of crude oil in FY 2017, 9 million barrels in FY 2018, and 6 million barrels in FY 2019, for a total of 25 million barrels. Proceeds will be deposited in the General Fund of the Treasury (21st Century Cures Act, Section 5010). All sales authorized from this legislation have been completed.
- From FY 2023 through FY 2025 (three consecutive years) – sell 16 million barrels of crude oil in FY 2023, 25 million barrels in FY 2024, and 25 million barrels in FY 2025, for a total of 66 million barrels. Proceeds will be deposited in the General Fund of the Treasury (Fixing America's Surface Transportation (FAST) Act, Section 32204).
- From FY 2026 through FY 2027, sell 7 million barrels of crude oil. Proceeds shall be deposited in the General Fund of the Treasury during the fiscal year in which the sale occurs (An Act to provide for reconciliation pursuant to titles II and V of the concurrent resolution on the budget for FY 2018, also known as the Tax Cuts and Jobs Act of 2017, Section 20003).
- From FY 2020 through FY 2021, sell 10 million barrels of crude oil. Proceeds will be deposited in the General Fund of the Treasury (Consolidated Appropriations Act, 2018, Section 501). All sales authorized from this legislation have been completed.
- From FY 2022 through FY 2027, sell 100 million barrels of crude oil. Proceeds will be deposited in the General Fund of the Treasury (BBA 2018, Section 30204). Of this amount, the SPR anticipates selling 7.5 million barrels in FY 2022.
- In FY 2028, sell 5 million barrels of crude oil. Proceeds will be deposited in the General Fund of the Treasury (America's Water Infrastructure Act of 2018, Section 3009).

This FY 2022 Budget Request includes a request for direct appropriation for continuing scheduled sales of SPR oil and to maintain readiness for potential emergency drawdown/fill operations.

[1] Section 14002 of the CARES Act (P.L. 116-136) provides the Department flexibility to postpone through Fiscal Year 2022 a sale of crude oil from the Strategic Petroleum Reserve that was originally authorized for FY 2020 in accordance with section 404 of the Bipartisan Budget Act of 2015.

SPR Petroleum Account
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
SPR Petroleum Account					
Petroleum Acquisition, Transportation and Drawdown	10,000	1,000	7,350	+6,350	+635%
Total, SPR Petroleum Account	**10,000**	**1,000**	**7,350**	**+6,350**	**+635%**

SPR Petroleum Account
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
SPR Petroleum Account		
Petroleum Acquisition, Transportation and Drawdown $1,000,000	**$7,350,000**	**+$6,350,000**
Non-Emergency Drawdown • FY 2021 provides for the SPR Petroleum Account to pay for the costs of certain statutorily-mandated crude oil sales.	• The FY 2022 request, along with prior year balances, will be able to support the 15.5 million barrels that the SPR is authorized to sell through legislation described above.	• The increase in funding supports legislative-directed sales in FY 2022.

DEPARTMENT OF ENERGY

Funding by Site

TAS_0233 - Strategic Petroleum Reserve Petroleum Account BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Undesignated LPI			
SPR - Petroleum Account	10,000	1,000	7,350
Subtotal, Strategic Petroleum Reserve	10,000	1,000	7,350
Total Undesignated LPI	**10,000**	**1,000**	**7,350**
Total Funding by Site for TAS_0233 - Strategic Petroleum Reserve Petroleum Account	**10,000**	**1,000**	**7,350**

DEPARTMENT OF ENERGY

Funding by Site

TAS_0218 - Strategic Petroleum Reserve BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Undesignated LPI			
Strategic Petroleum Reserve Management	26,765	0	28,475
Storage Facilities Development	168,235	188,000	168,525
Subtotal, Strategic Petroleum Reserve	195,000	188,000	197,000
Total Undesignated LPI	**195,000**	**188,000**	**197,000**
Total Funding by Site for TAS_0218 - Strategic Petroleum Reserve	**195,000**	**188,000**	**197,000**

Northeast Home Heating Oil Reserve

Northeast Home Heating Oil Reserve

Northeast Home Heating Oil Reserve
Proposed Appropriation Language

Explanation of Changes

No new budget authority is requested in FY 2022 to maintain the Northeast Home Heating Oil Reserve (NEHHOR).

Public Law Authorizations

- P.L. 109-58, Energy Policy Act of 2005

Northeast Home Heating Oil Reserve

($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
10,000	6,500	0

Overview

The Northeast Home Heating Oil Reserve (NEHHOR) was established in 2000 as a short-term supplement to the Northeast commercial system's supply of heating oil. It is to be used in the event of a supply interruption during severe winter weather. The current contract year for the NEHHOR expires on March 31, 2022.

Highlights and Major Changes in the FY 2022 Budget Request

Northeast Home Heating Oil Reserve
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Northeast Home Heating Oil Reserve					
Northeast Home Heating Oil Reserve	10,000	6,500	0	-6,500	-100%
Total, Northeast Home Heating Oil Reserve	**10,000**	**6,500**	**0**	**-6,500**	**-100%**
Federal FTEs	**0**	**0**	**0**	**0**	**0**

Northeast Home Heating Oil Reserve
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Northeast Home Heating Oil Reserve					
Commercial Leases	9,200	5,700	0	-5,700	-100%
Information Technology Support	700	700	0	-700	-100%
Quality Control and Analysis	100	100	0	-100	-100%
Total, Northeast Home Heating Oil Reserve	**10,000**	**6,500**	**0**	**-6,500**	**-100%**

Northeast Home Heating Oil Reserve
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Northeast Home Heating Oil Reserve: No new budget authority is requested in FY 2022 to maintain the NEHHOR.	**-$6,500**
Total, Northeast Home Heating Oil Reserve	**-$6,500**

Energy Security and Infrastructure Modernization Fund

Proposed Appropriation Language

N/A.

Explanation of Changes

The FY 2022 President's Budget requests no appropriation for the Energy Security and Infrastructure Modernization Fund (ESIM or the Fund)**.** The Bipartisan Budget Act of 2015 (Public Law 114-74) authorized a final sale of Strategic Petroleum Reserve crude oil in FY 2020 to raise revenue for the Fund. Section 14002 of the CARES Act (P.L. 116-136) provided the Department flexibility to conduct the final sale in FY 2020, FY 2021, or FY 2022. As market conditions were unfavorable in FY 2020, DOE anticipates conducting the final sale in FY 2021 or FY 2022. Funds derived from such sales are deposited in the ESIM account and will be used for the completion of the Life Extension Phase II (LE2) Strategic Petroleum Reserve Modernization project.

Public Law Authorizations

Public Law 114-74, "Bipartisan Budget Act of 2015."
Public Law 116-136, "CARES Act."

Energy Security and Infrastructure Modernization Fund
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
450,000	0	0

Overview
Section 404 of the Bipartisan Budget Act of 2015 directed the Secretary to establish a Strategic Petroleum Reserve (SPR) Modernization Program to protect the United States economy from the impacts of emergency supply disruptions. The Energy Security and Infrastructure Modernization (ESIM) Fund was established in 2016 for the purpose of providing for the construction, maintenance, repair, and replacement of SPR facilities and associated capital equipment. In establishing the ESIM Fund, Congress made the following findings: 1) The SPR is one of the nation's most valuable energy security assets; 2) The age and condition of the SPR has diminished its value as a federal energy security asset; 3) Global oil markets and the location and amount of U.S. oil production and refining capacity have dramatically changed in the 40 years since the establishment of the SPR; and, 4) Maximizing the energy security value of the SPR requires a modernized infrastructure that meets the drawdown and distribution needs of changed domestic and international oil and refining market conditions.

Section 404 also authorizes the drawdown and sale of crude oil from SPR worth up to $2 billion over four fiscal years (2017 through 2020) to supply revenue to the ESIM fund and thus finance the Life Extension Phase II (LE2) project. Section 14002 of the CARES Act (P.L. 116-136) provided the Department flexibility to conduct the final sale in FY 2020, FY 2021, or FY 2022. The Department intends to raise a total of $1.4 billion through authorized sales of SPR crude oil for this purpose. To date, approximately $950,000,000 has already been raised. A final sale of $450,000,000 is tentatively planned for the third quarter of FY 2021 to avoid delays in the LE2 construction schedule.

The LE2 project will modernize aging SPR infrastructure through systems upgrades and equipment replacement to ensure the SPR is able to meet mission drawdown and distribution requirements and maintain operational readiness for the future.

Highlights and Major Changes in the FY 2022 Budget Request
No budget request is made for FY 2022.

Energy Security and Infrastructure Modernization Fund
Funding by Congressional Control
($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Energy Security and Infrastructure Modernization Fund					
Oil Sale Revenue Targets	450,000	0	0	0	0%
Crude Oil Sales Revenue Offsetting Collections	-450,000	0	0	0	0%
Total, Energy Security and Infrastructure Modernization Fund	**0**	**0**	**0**	**0**	**0%**
Federal FTEs	**23**	**23**	**23**	**0**	**0%**

Overview

The Major Milestones (approved and estimated) for the LE2 SPR Modernization project are as follows:

Life Extension Phase II Critical Decisions (CD):

- CD-0 Approve Mission Need – FY 2016 (Approved October 2015)
- CD-1 Approve Alternative Selection and Cost Range – FY 2016 (Approved December 2016)
- CD-3A Approve Long Lead Time Equipment Procurement Items (Bryan Mound, Big Hill, West Hackberry) (Approved July 2017)
- CD-3A Approve Long Lead Time Equipment Procurement Items (Bayou Choctaw) (Approved November 2018)
- CD-3B Approve Long Lead Time Equipment Procurement Items (Bryan Mound, Big Hill, West Hackberry) (Approved November 2018)
- CD-3B/C Approve Long Lead Time Equipment Procurement Items/ Site Prep (Bayou Choctaw – CD-3B) (Other Sites CD-3C) (Approved October 2019)
- CD-3C/D Approve Long Lead Time Equipment Procurement Items / Site Prep (Bayou Choctaw – CD-3C, Other sites – CD-3D) (Approved January 2021)
- CD-2 Approve Performance Baseline BM, BH, BC – (Estimated April 2021)
- CD-3 Approve Start of Construction/Project Execution BM, BH, BC – (Estimated April 2021)
- Award Construction Contracts BM, BH, BC – May 2021
- CD-2 Approve Performance Baseline WH – September 2021
- CD-3 Approve Start of Construction/Project Execution WH – September 2021
- Award Construction Contracts WH – October 2021
- CD-4 Approve Project Completion (Big Hill, Bayou Choctaw, Bryan Mound) (Estimated April 2025)
- CD-4 Approve Project Completion (West Hackberry) (Estimated October 2025)

LE2 involves work at the Bryan Mound, Big Hill, West Hackberry, and Bayou Choctaw storage sites. The major components of work activities at each site are:

- Bryan Mound and Big Hill: Process Piping, Pipelines, Process & Rotating Equipment
- West Hackberry: Brine System, Civil and Security Systems, Process Piping, and Process Equipment
- Bayou Choctaw: Brine Disposal System, Degas Plant, Roadways and Lighting, Security and Electrical Systems
- Cavern Secondary Well Drilling Program at Bryan Mound, Bayou Choctaw, and West Hackberry sites

Energy Security and Infrastructure Modernization Fund
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Energy Security and Infrastructure Modernization Fund					
Oil Sale Revenue Targets	450,000	0	0	0	0%
Crude Oil Sales Revenue Offsetting Revenue Collections	450,000	0	0	0	0%
Total, Energy Security and Infrastructure Modernization Fund	**0**	**0**	**0**	**0**	**0%**

Energy Security and Infrastruture Modernization Fund
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Oil Sale Revenue Targets: No budget request is made for FY 2022.	**$0**
Total, Energy Security and Infrastructure Modernization Fund	**$0**

Energy Security and Infrastructure Modernization Fund
Life Extension Phase II

Description
The Life Extension Phase II (LE2) SPR Modernization project funds activities to modernize aging SPR infrastructure through systems upgrades and associated equipment replacement to ensure the ability to maintain operational and drawdown readiness capability. The scope of work includes system upgrades and associated equipment replacement for the following systems:

- Crude oil transfer systems
- Raw water systems
- Power distribution and electrical systems
- Physical security systems
- Firefighting systems
- Crude oil processing (degasification) plant
- Auxiliary systems and facilities

By FY 2022, all procurement of government furnished equipment with long lead times, as well as project design, geotechnical and geo-mechanical analyses, surveys, permitting, Title II and III engineering services, real estate and right-of-way issues, wetland mitigation, and permitting will be completed. The project technical baseline will be established. During FY 2022, LE2 will begin the construction phase of the program.

FY 2022 Anticipated Major Milestones:

- LE2 will be in the construction phase.
- All CD-2/3 approvals will be granted.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
SPR Modernization $0	**$0**	**$0**
• No Enacted Budget for FY 2021.	• No Budget Request is made for FY 2022.	• None.

Management Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
ESIM Program Direction					
Salaries and Benefits	2,079	0	0	0	0%
Travel	50	0	0	0	0%
Other Related Expenses	350	0	0	0	0%
Total, Management	**2,479**	**0**	**0**	**0**	**0%**
Federal FTEs	**23**	**23**	**23**	**0**	**0%**

Energy Efficiency and Renewable Energy

Energy Efficiency and Renewable Energy

Energy Efficiency and Renewable Energy

Table of Contents

Energy Efficiency and Renewable Energy
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for energy efficiency and renewable energy activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, [$2,864,000,293] $4,732,000,000, to remain available until expended: Provided, That of such amount, [$165,000,000] $250,000,000 shall be available until September 30, [2022] 2023, for program direction [: Provided further, That of the unobligated balances available from amounts appropriated in Public Law 111–8 under this heading, $806,831 is hereby rescinded: Provided further, That of the unobligated balances available from amounts appropriated in Public Law 111–85 under this heading, $1,433,462 is hereby rescinded: Provided further, That no amounts may be rescinded under the previous two provisos from amounts that were designated by the Congress as an emergency requirement pursuant to the Concurrent Resolution on the Budget or the Balanced Budget and Emergency Deficit Control Act of 1985]. (Energy and Water
Development and Related Agencies Appropriations Act, 2021.)

Public Law Authorizations
P.L. 93-275, "Federal Energy Administration Act" (1974)
P.L. 93-410, "Geothermal Energy Research, Development, and Demonstration Act" (1974)
P.L. 93-577, "Federal Non-Nuclear Energy Research and Development Act" (1974)
P.L. 94-163, "Energy Policy and Conservation Act" (EPCA) (1975)
P.L. 94-385, "Energy Conservation and Production Act" (ECPA) (1976)
P.L. 94-413, "Electric and Hybrid Vehicle Research, Development and Demonstration Act" (1976)
P.L. 95-91, "Department of Energy Organization Act" (1977)
PL 95-617, "Public Utility Regulatory Policies Act Of 1978" (1978)
P.L. 95-618, "Energy Tax Act" (1978)
P.L. 95-619, "National Energy Conservation Policy Act" (NECPA) (1978)
P.L. 95-620, "Power Plant and Industrial Fuel Use Act" (1978)
P.L. 95-238, Title III –"Automotive Propulsion Research and Development Act" (1978)
P.L. 96-512, "Methane Transportation Research, Development and Demonstration Act" (1980)
P.L. 96-294, "Energy Security Act" (1980)
P.L. 100-12, "National Appliance Energy Conservation Act" (1987)
P.L. 100-357, "National Appliance Energy Conservation Amendments" (1988)
P.L. 100-494, "Alternative Motor Fuels Act" (1988)
P.L. 100-615, "Federal Energy Management Improvement Act" (1988)
P.L. 101-218, "Renewable Energy and Energy Efficiency Technology Competitiveness Act" (1989)
P.L. 101-566, "Spark M. Matsunaga Hydrogen Research, Development, and Demonstration Act of 1990"
P.L. 101-575, "Solar, Wind, Waste, and Geothermal Power Production Incentives Act" (1990)
P.L. 102-486, "Energy Policy Act of 1992" (WIND)
P.L. 104-271, "Hydrogen Future Act of 1996"
P.L. 106-224, "Biomass Research and Development Act" (2000)
P.L. 109-58, "Energy Policy Act of 2005"
P.L. 110-69, "America Competes Act of 2005"
P.L. 110-140, "Energy Independence and Security Act of 2007"
P.L. 110-140, title VI, Sec. 641, "US Energy Storage and Competitiveness Act of 2007"
P.L. 110-234, "The Food, Conservation, and Energy Act of 2008"
P.L. 111-5, "American Recovery and Reinvestment Act of 2009"
P.L. 112-210, "American Energy Manufacturing Technical Corrections Act (2012)
P.L. 115-244, "Energy and Water, Legislative Branch, and Military Construction and Veterans Affairs Appropriations Act, 2019"
P.L. 115-246, "Department of Energy Research and Innovation Act" (2018)
P.L. 116-92, "National Defense Authorization Act for Fiscal Year 2020"
P.L. 116-260, "Consolidated Appropriations Act of 2020" (Section Z: Energy Act of 2020)

Energy Efficiency and Renewable Energy
($K)

FY 2020 Enacted[1]	FY 2021 Enacted[2]	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
2,777,277	2,861,760	4,732,000	+1,870,240

Overview

The Office of Energy Efficiency and Renewable Energy (EERE) is the largest funder of clean energy technologies in the Federal government. EERE's mission is to accelerate the research, development, demonstration, and deployment of technologies and solutions to equitably transition America to a carbon pollution-free electricity sector by 2035 and a net-zero emission economy by no later than 2050, creating good-paying jobs with the free and fair chance to join a union and bargain collectively, and ensuring the clean energy economy benefits all Americans, especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution.

To achieve this mission, EERE invests in the integration of clean energy technologies that are ready to be demonstrated and deployed, as well as research and development (R&D) activities that advance early-stage technologies with a clear path to deployment.

EERE's FY 2022 investment strategy focuses on making investments in five programmatic priority areas[3] that are central pillars to the U.S. greenhouse gas (GHG) profile:

- Decarbonizing the electricity sector: To transition to a carbon pollution-free electricity sector by 2035, EERE invests in activities critical to reduce the cost of renewables, as well as to make major strides in renewables integration to ensure reliability, security, and resiliency as the grid evolves.
- Decarbonizing transportation across all modes: air, sea, rail, and road: The transportation sector has historically relied heavily on petroleum, which supports over 90 percent of the sector's energy needs today[4], and, as a result, surpassed electricity generation in 2017 to become the largest source of CO_2 emissions in the country[5]. The goal of this investment is to develop and enable the commercial deployment of net-zero GHG technologies for all modes of transportation (road, rail, sea, and air) while ensuring affordable mobility solutions for people and goods across all economic and social groups, reducing the impact on local air quality and using sustainable water and land practices. In turn, these investments will help the U.S. better compete on the world stage in terms of technological and manufacturing capabilities and enable the U.S. transportation sector to be a worldwide environmental leader, particularly in the international context of other ascendant competitor nations.
- Decarbonizing energy-intensive industries: Industrial processes currently contribute as much as 20 percent of the Nation's carbon emissions. To phase out emissions, EERE supports approaches that rely on renewable energy and fuels such as hydrogen to power industrial processes, capture and use carbon emissions, and vastly improve efficiency.
- Reducing the carbon footprint of buildings: Residential and commercial buildings are the single largest energy-consuming sector in the U.S. economy, representing approximately 39 percent of its total energy consumption, 75 percent of the Nation's electricity use, an even greater share of peak power demand, and are responsible for 36 percent of energy-related carbon dioxide emissions.[6,7] As a result, Americans spend over $400 billion annually to power and otherwise energize the Nation's 129 million homes, offices, schools, hospitals, and other commercial and

[1] Reflects rescission of prior year balances of $70.723 million.
[2] Reflects rescission of prior year balances of $2.24 million.
[3] Please note because investments can support multiple priority areas, there is overlap among the totals.
[4] Transportation Energy Data Book 39th Edition, ORNL, 2021. Table 2.3 Distribution of Energy Consumption by Source and Sector, 1973 and 2019.
[5] Environmental Protection Agency, Draft U.S. Inventory of Greenhouse Gas Emissions and Sinks, 1990-2019, Table 2-11. Electric Power-Related Greenhouse Gas Emissions and Table 2-13. Transportation-Related Greenhouse Gas Emissions.
[6] https://www.eia.gov/environment/emissions/carbon/.
[7] U.S. Energy Information Administration. *Annual Energy Outlook 2019 with projections to 2050*. Washington, DC: U.S. Department of Energy, January 2019. https://www.eia.gov/outlooks/archive/aeo19/pdf/aeo2019.pdf.

residential buildings.[1] However, these energy bills are not equally felt by all. The energy burden for low-income households is on average three times that of non-low-income households and low-income households typically receive a lower quality of energy services.[2] EERE supports critical deployment activities needed to transform the energy economy at the state and local levels as well as investments in high priority research, development, and demonstration (RD&D) needed for new affordable housing and advanced energy efficient retrofits for buildings.

- Decarbonizing the agriculture sector, specifically focused on the nexus between energy and water: Agriculture represents nearly 10 percent of the Nation's carbon emissions, and EERE has significant RD&D investments that can help drive a cleaner agriculture sector while achieving EERE's decarbonization goals. This includes expanding EERE's work related to reducing GHG emissions in the agricultural sector through the development of biofuels, the greater efficiency of off-road agricultural vehicles, on-site production of animal waste to clean energy, and better understanding and predicting water flow to design more water and energy efficient irrigation systems. The work will be additive and complementary to the Department of Agriculture's work.

To accomplish these five programmatic priorities, EERE has identified four key emphasis areas that are inherent to all its work:

- Energy Justice: It is essential that EERE's work ensures clean energy economy benefits for all Americans. EERE recognizes that marginalized and low-income communities have long borne the brunt of pollution to the air, water, and soil within these communities, and is committed to the Administration's Justice40 Initiative. EERE aims to provide equitable RDD&D opportunities throughout its FY 2022 Request. The Request includes increased support for program elements with proven success working in collaboration with disadvantaged and energy transition communities and plans to target equitable distribution of benefits in the near and longer term. EERE's FY 2022 investments take a strategic approach to partnering with a broader array of stakeholders across the RDD&D portfolio while expanding American clean energy innovation leadership. This includes emphasizing and expanding measurably effective programs for serving underserved populations, such as the Weatherization Assistance Program, and establishing new programs specifically identifying and addressing economic, racial, and environmental inequalities. The Request also emphasizes innovative applied research initiatives for which the research implementation itself benefits underserved communities. The end goals will be to advance energy democracy, reduce energy burden, and to alleviate energy insecurity and poverty for all Americans in a fair and equitable manner.
- Workforce: EERE is committed to an office-wide approach to workforce development, which includes, for example, funding research to understand the career opportunities created by the Administration's American Made Challenge program, decarbonization, jobs and infrastructure initiatives, identifying opportunities across technologies and industry sectors, and working with labor unions, trade associations, and educational institutions to enable the training programs and career pathways needed to prepare the American workforce for these good-paying jobs that provide a fair and free choice to join a union.
- Diversity in STEM**:** The Request increases outreach and raises awareness of clean energy research and career opportunities at minority-serving institutions and minority professional organizations and ensures that organizations receiving EERE funding are thinking through diversity and equity in their own work. EERE recognizes that one of the main ways to achieve its goals is to be highly inclusive in development of new technical talent, as well as in the research that is supported by EERE's offices and the National Laboratories. This includes efforts to expand STEM pipeline development programs and new research partnerships among underutilized Minority Serving Institutions across the country, including Historically Black Colleges and Universities (HBCU), Hispanic Serving Institutions, Tribal Colleges and Universities, and many others.
- State and Local: EERE recognizes the essential role that state and local governments play in the transition to a carbon-free economy and works in a unified and coordinated way with its state and local partners to accelerate a just, equitable transition ensuring EERE's investments benefit everyone. In FY 2022, EERE will fund initiatives that empower state and local leaders to develop locally driven, practical, and evidenced-based solutions to create clean energy jobs and the local ecosystem that sustains them. EERE also will collaborate with state and local policymakers, business leaders, community advocates, academics, utilities, transit agencies, and other partners to leverage their regions' unique strengths to tackle the climate crisis and to create healthy, safe, and thriving communities with clean energy

[1] Spending derived from the U.S. Energy Information Administration Monthly Energy Review. https://www.eia.gov/totalenergy/data/monthly/.

[2] https://www.energy.gov/eere/slsc/low-income-community-energy-solutions#:~:text=According%20to%20the%20U.S.%20Department,which%20is%20estimated%20at%203%25.

jobs that cater to different education and experience levels. EERE's place-based initiatives are designed to accelerate deployment of clean energy in every pocket of the country, with an emphasis on communities that have been hardest hit by economic, racial, and environmental injustices.

In FY 2022, EERE plans to add an international coordinator within the office of the Assistance Secretary to act as a central point of contact for coordination between EERE's programmatic offices and DOE's Office of International Affairs. The U.S. accounts for only 15 percent of GHG emissions, and therefore cannot solve the climate crisis alone. Strategic engagement with select countries and through multilateral collaborations can accelerate technological development for climate mitigation, as well as prime major global markets for American technologies and services. EERE will make targeted investments in international collaboration efforts that have the greatest value for potential emissions reductions and creating American jobs.

Additionally, EERE will extend the impact of its RDD&D funding by leveraging creative funding mechanisms such as prizes, competitions, technical assistance, and programs targeted to small businesses. EERE will also help enable climate innovation at the Federal procurement level by working across the government to drive purchasing decisions that take into account the impact on climate and other considerations. The goal is to enable the commercialization of climate change and clean energy innovations that will activate job creation, expand other public impact outcomes, and yield a more geographically diverse and impactful research portfolio.

Highlights and Major Changes in the FY 2022 Budget Request

In FY 2022, EERE will invest $4,732,000,000 to help achieve a carbon pollution-free electricity sector by 2035 and net-zero emissions, economy-wide, by no later than 2050 through investments in the five programmatic priority areas, through the lens of its four key emphasis areas. The Request prioritizes increased investments to reduce emissions in the near term drastically, while investing in research to ensure American leadership and competitiveness in advanced clean energy technology. In FY 2022, EERE will also continue to streamline and enhance its operations, conduct rigorous analysis and evaluations of its portfolio, and achieve the greatest possible impact in each of its technical pillars designed to advance cross-technology solutions, and a Corporate Program pillar that serves as the central organization for all EERE products, services, processes, and systems.

Sustainable Transportation ($1,132,500,000) supports RDD&D efforts to decarbonize transportation across all modes, working to enable vehicle electrification, commercially viable hydrogen fuel cell trucks, sustainable aviation fuel from biomass and waste carbon resources and low-GHG options for off-road vehicles, rail, and maritime. Many new investments in the Request in this pillar are directly focused on deployment or demonstration of technology to show viable commercial paths in time to allow for major 2030 commercialization activities and 2035 large scale transition. These interim demonstration and deployment goals support an overall path to decarbonization by 2050, including appropriate fleet turnover. The Request in this pillar also supports hydrogen use for industrial decarbonization and energy storage as well as sustainable biomass to support reduced GHG from the agricultural sector.

- Vehicle Technologies ($595,000,000) supports RDD&D of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the National Laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well as innovations in connected infrastructure for significant systems-level energy efficiency improvement); combustion engines to reduce GHG emissions; and technology deployment and integration at the local and state level. In coordination with the other offices across EERE and DOE, the Vehicle Technologies Office advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources. In accordance with Executive Order 14008: Tackling the Climate Crisis at Home and Abroad,[1] the Request deemphasizes support for RDD&D designed to expand the use of fossil-fueled internal combustion engines.

[1] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

Batteries are a key technology supporting many significant objectives associated with decarbonization, both in transportation directly, and also in energy storage more broadly to support decarbonization of the electricity sector. The Request initiates laboratory and cooperative agreements for projects aimed at achieving the following new objectives: reducing electric vehicle (EV) battery cell cost by 50 percent to $60/kWh by 2030 to achieve EV cost parity with internal combustion engine vehicles; eliminating dependence on critical materials such as cobalt, nickel, and graphite, reducing battery supply chain vulnerabilities by 2030; and establishing a lithium battery recycling ecosystem to recover 90 percent of spent lithium batteries and re-introducing 90 percent of key materials into the battery supply chain by 2030. The Request also includes expanded efforts for the SuperTruck 3 activity with a focus on pivoting medium and heavy-duty trucks to electrified solutions (plug-in hybrid EV, battery EV, and fuel cell EV) and improving the energy efficiency of the entire freight system.[1]

The Request also increases support for robust local and regional partnerships including the Clean Cities activity to ease barriers and promote the use of new transportation technologies with a focus on opportunities for light-, medium-, and heavy-duty plug-in electric vehicle (PEV) deployment, especially in underserved communities (e.g., low-income, rural, and other demographics that currently have minimal access to PEVs). Lack of charging infrastructure, PEV cost parity with conventional vehicles, education, and workforce training impede widespread PEV adoption. Improving equitable access to the benefits of electrified transportation must take into consideration PEVs and charging infrastructure availability for mobility choices such as personal vehicle ownership, car sharing, ride sharing, school transport, and public transit. Such activities also support the Administration's goal to deploy 500,000 PEV charging stations throughout the Nation.

- Bioenergy Technologies ($340,000,000) supports research, development, and demonstration to advance technologies that convert domestic biomass and other waste resources into cost effective, low-carbon biofuels and bioproducts. These technologies can enable a transition to a net-zero emission economy, create high-quality jobs, support rural economies, and spur innovation in renewable energy and chemicals production. As part of a comprehensive strategy to decarbonize all modes of transportation, the Request supports RD&D to produce "drop-in" biofuels that are compatible with existing fueling infrastructure and vehicles across a range of transportation modes, including diesel, jet, and marine fuels. This includes initial support for a Sustainable Aviation Fuel (SAF) Initiative that will fund RDD&D to enable the technologies required for domestic producers and refiners to eventually supply 100 percent of the airline industry's need demand for SAF FY 2022 funds will support engineering, construction, and operation of up to two pilot-scale projects that employ advanced technologies suitable for various community circumstances to demonstrate overall potential of SAF. Funds will also support analyses on SAF markets, both domestic and international, and increase efforts across Agencies to support the growing SAF industry.

  The Request also supports a new initiative using "traditional" biofuels facilities (e.g., current ethanol plant) to demonstrate advanced technologies. Technologies and practices include low-carbon agricultural practices, fuel switching to renewable process heat and power (i.e., renewable natural gas, or biomass), and new productivity or conversion efficiency measures to assess the costs and verify the lifecycle GHG benefits. If these technologies and practices were deployed across U.S. industry, it would preserve current biofuels jobs and could reduce GHG emissions by over 42.7 MMT (CO_2-eq) per year – or approximately 2 percent of total U.S. transportation emissions.

  In support of EERE's priority to deploy technologies to help decarbonize the agricultural sector while achieving the above goals, the Request includes support to initiate a R&D program to study sustainable agriculture practices and help farmers maximize profits on marginal lands while providing valuable feedstocks for bioenergy production. This also includes funding to develop sensors and tools for soil carbon monitoring and soil carbon enhancement via biochar while enabling carbon credit banking markets and other activities requiring verifiable carbon emission data, and new community-scale, public-private partnerships to reduce harmful emissions and other environmental issues from operations that produce manure and other wet wastes along with RD&D on wastewater treatment with biosolids in support of EERE's investment in the nexus between Energy and Water.

- Hydrogen and Fuel Cell Technologies ($197,500,000) supports RDD&D of innovative technologies to facilitate widespread adoption of hydrogen and fuel cell technologies across sectors. This can be achieved by reducing cost,

[1] Fuel cell electric vehicle work is in coordination with and funded by HFTO.

improving performance and durability, demonstrating and deploying technologies, and addressing safety, codes, standards, and workforce development. Producing affordable clean hydrogen is a key priority in conjunction with enabling diverse end uses including grid integration and stationary energy storage; transportation (e.g., trucks, marine, rail, aviation); chemicals (e.g., ammonia, synthetic fuels); industry (e.g., iron and steel making); backup power (e.g., emergency power, data centers); and others. The portfolio comprises core materials-, component-, and systems-level RD&D in fuel cells and hydrogen production, storage, and distribution technologies; as well as deployment projects targeting scale-up and affordability of integrated energy systems essential to H2@Scale.

The Request represents a shift from early-stage research in fuel cells to accelerating RD&D to enable more affordable fuel cell system costs (nearly $200/kW today). The cost and durability R&D are also applicable to fuel cells for stationary markets enabling resilience and potential future deployment in disadvantaged communities and in poor air quality regions to address environmental justice priorities. In addition to materials and components R&D, there will be increased focus on systems design and integration to accelerate progress towards deployable systems. This includes increased support for the Million Mile Fuel Cell Truck consortium (M2FCT), which includes National Laboratories in partnership with universities and industry to accelerate RD&D that will enable a fuel cell durability of a million miles—a market requirement for long haul trucks. Likewise, the Request also represents a shift from early-stage materials research to accelerated target-driven RD&D in Hydrogen Technologies with an emphasis on significantly reducing the cost of hydrogen generated by electrolysis over a greatly accelerated timeline compared to prior years. To support the H2@Scale initiative, activities include RD&D on clean hydrogen production, delivery, and storage, including materials development, and integration with diverse net-zero emissions generation sources. This includes increased funding to demonstrate the use of green hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production, in support of H2@Scale.

Renewable Power ($951,765,000) supports RDD&D efforts in solar, wind, water, and geothermal power to help reduce the costs and accelerate the use of renewable energy technologies and ensure that the integration of renewables contributes to a reliable, secure, and resilient grid. Efforts include an increased focus on work essential to address barriers to deployment of existing technologies, from support for siting and permitting to improving access to distributed resources among low- and middle-income households and communities. It also includes increased support for demonstration, integration, and validation of technologies such as stationary energy storage, as well as high impact R&D that will lay the foundation for renewable power to expand nationally and reach carbon pollution-free electricity by 2035. Further, in alignment with the Administration's goal to create a net-zero economy by 2050, EERE's Renewables program will support increased intra- and inter-agency collaboration efforts to support the widespread integration of renewables in a resilient, reliable power system. This includes partnering with the EERE Strategic Analysis team and the DOE Office of Electricity to significantly expand data, tools, analysis, and technical assistance for stakeholders faced with making data-driven decisions and investments, including state and local governments, regulators, system operators, utilities, and local communities. In many cases, this work will build on existing cross-office mechanisms like the Grid Modernization Initiative, and the request includes additional new funding for the Energy Storage Grand Challenge to evaluate, validate, and demonstrate a wide range of new long-duration storage technologies, and for the Energy Transition Initiative Partnership Project (ETIPP) to provide on-the-ground assistance to underserved and remote communities to address immediate energy vulnerabilities, develop sector plans, and assess technology fit to help ensure long-term energy affordability, sustainability, and resilience.

- Solar Energy Technologies (SETO) ($386,575,000) works to accelerate the development and deployment of solar technologies while supporting the reliability, resilience, and security of the U.S. electric grid. While solar only provides 3 percent of U.S. electricity today, the solar resource is vast, and solar energy has the potential to be a substantial source of carbon-free, affordable, and reliable electricity across the country. Meeting the goal to decarbonize electricity by 2035 may require solar to supply 30-50 percent of U.S. electricity, and the Budget reflects an increased focus on the complete roadmap of solar energy implementation: advanced R&D; validation of solar technologies to invigorate American technological leadership; supporting industry's development of a robust American solar manufacturing and supply chain including demonstration and deployment of photovoltaics; ensuring there is a trained American workforce employed in the industry, creating and sustaining good-paying jobs; contributing to the decarbonization of the energy and industrial sectors; supporting community resilience; and working to ensure the benefits of the transition to clean energy are shared with those most affected by environmental justice inequities.

Developing the domestic solar manufacturing value chain is a priority for SETO. To that end, the Request includes a new effort targeting innovative approaches to building-integrated photovoltaics, in coordination with the Building Technologies Office. The Request also supports new rounds of the American-Made Solar Prize to incentivize and transition new solar technologies into prototypes ready for real world validation, and other prize competitions to spur U.S. business innovation in solar and create good paying jobs with the free and fair chance to join a union and bargain collectively. Other efforts supported in the Request to enhance U.S. solar manufacturing include continued support for the American-Made Network to provide prize winners commercialization resources, a new, cross-cutting initiative designed to support a qualified clean energy manufacturing workforce and connect trainees with the industry, and continued support for the Incubator Program to accelerate the prototyping and development of new solar energy technologies for commercialization and domestic manufacturing.

The Request also increases support to address critical soft cost barriers, representing scaled-up efforts to catalyze near-term solar deployment and ensure the benefits of solar energy are available to all Americans. This includes support to establish an assistance program to address barriers to interconnecting variable renewable energy to the electric grid, in collaboration with the Wind Energy Technologies Office. In addition, the Request supports a new, cross-cutting initiative to grow a skilled and diverse solar and clean energy workforce and connect trainees with the industry. Funding will also support a new national platform available to states, industry, and other stakeholders to manage the enrollment of community solar subscriptions for low-income customers. This National Platform for Low-income Solar Access will spur direct adoption of rooftop solar, particularly in low-income communities. While the cost of solar PV has decreased dramatically in recent years, further cost reductions are critical to drive large-scale, nationwide solar deployment; therefore, the Request includes increased funding for RD&D activities needed to accelerate cost reductions in photovoltaic energy toward the 2030 goal of $0.02/kWh electricity without subsidies with systems lasting 50 years or more. This includes funding for work needed to ensure photovoltaics can operate over a long lifetime in the face of extreme weather conditions including heat, cold, hail, and wind.

The Request also includes increased funding for first-of-a-kind demonstrations of the provision of grid services from solar and wind technologies for an extended period of time (greater than 6 months) to inform the planning and operation of the electric grid with increasing contributions from wind and solar. As part of EERE's emphasis on engaging state and local partners, the Request also includes support to develop, demonstrate, and deploy innovative technologies and conduct community planning to enhance resilience against physical hazards using distributed solar, energy storage, EVs, and other distributed energy resources in partnership with the DOE Office of Electricity.

SETO also supports EERE's priority to decarbonize industry through increased funding for RD&D to use concentrated solar thermal energy to replace fossil fuels in industrial processes, with a particular focus on high-temperature processes like steel manufacturing, cement production, and chemical/fuels production.

- Wind Energy Technologies ($204,870,000) supports an updated and expanded portfolio of research and innovation designed to accelerate the advancement and deployment of offshore, land-based, and distributed wind energy technologies and their integration with the electric grid. American wind energy resources are vast and mostly untapped, and wind has the potential to contribute up to 35 to 45 percent of U.S. electricity in less than two decades with continued innovation. The Request focuses on key opportunities to address near-term barriers to deployment, drive the continued performance improvements and cost reductions necessary to decarbonize the power sector, and ensure U.S. manufacturing can expand to meet domestic demand, including the creation of good-paying jobs with the free and fair chance to join a union and bargain collectively. Beyond electricity, wind energy can also contribute to the generation of clean fuels to help transition the U.S. economy to net-zero emissions in industry, manufacturing, and agriculture, with associated growth in good-paying jobs across all regions of the country.

  Critical near-term efforts to accelerate deployment include significantly increased support for research and development of technologies to reduce environmental and siting barriers to land-based and offshore wind, as well as efforts to partner with industry, communities, utilities, and other stakeholders to remove barriers to distributed wind deployment. To realize wind energy's full potential to the U.S. power system, Wind Energy Technologies will expand efforts to develop larger, light-weight turbines that allow operation at greater heights, platforms, and turbine designs to enable ultra-large floating wind turbines to access the 58 percent of U.S. offshore wind resources that are in deep water. The Request will also support research to maximize production and efficiency from individual turbine siting and

operation within a facility. The Request also includes critical research and development to support the expansion of U.S. manufacturing capacity and domestic job creation, including manufacturing innovations to enable highly flexible, rail-transportable blades, and support to domestic offshore wind advanced manufacturing, supply chain development, and recycling.

The Request includes substantially increased funding to support the integration of wind into a cost-effective, reliable, secure, and resilient power grid. As wind power is the largest source of variable renewable electricity in the U.S. and primed to expand dramatically, it is critical to develop technologies and operating practices to increase wind energy's contribution to grid reliability and resiliency. The Request will strengthen the wind grid integration program to demonstrate the capability of wind plants to provide grid services; improve grid infrastructure investment to ensure access and use for wind deployment; improve electrical hardware performance and reduce wind energy system costs; address wind-specific cybersecurity needs; integrate wind power with storage and other technologies; and improve the understanding of electricity market operation with high penetrations of wind energy.

The Request also includes increased support for cross-technology investments that leverage wind energy technologies including a joint effort with the Hydrogen and Fuel Cell Technologies Office to integrate and demonstrate a multi-megawatt water electrolyzer coupled with wind power generation to produce low-cost, emissions-free hydrogen, and a joint effort with the Solar Energy Technologies Office to demonstrate the robustness of grid services, such as frequency regulation, load following, and contingency reserves, provided by utility-scale wind and solar plants on the bulk power system under various operating conditions throughout numerous regions of the U.S. The Request also includes support for cross-office collaboration to demonstrate and validate energy storage technologies under varying system conditions to improve electricity service and community resilience.

- Water Power Technologies ($196,560,000) supports a broad portfolio of research activities to strengthen the body of scientific and engineering knowledge and support industry efforts to develop and deploy new hydropower and marine energy technologies at all scales. Hydropower is the primary source of electricity that is simultaneously renewable and fully dispatchable, potentially serving as a linchpin for the integration of substantial amounts of wind and solar. The U.S. has vast marine energy and hydropower resources, and there remains potential to both expand into new markets and applications and to increase generation and flexibility across the Nation's sizable hydropower and pumped storage fleet. Areas of opportunity include existing hydropower facilities and non-powered dams that can use innovative technologies to cost-effectively increase generation and flexibility; innovating on flexible and more rapidly deployable pumped energy storage systems; and advancing marine energy technology to support new and growing industries using waves, currents, tides, and ocean thermal gradients. The integration and improved performance of dispatchable firm renewable power (such as existing hydropower) and predictable power, or power unique in its geographical location (such as marine energy) offer the potential for reliability, flexibility, and other benefits for a decarbonized grid and economy to supplement variable renewable energy (VRE) resources (i.e., sources that can only produce electricity when weather conditions are right) like solar and wind, by ensuring deployment in diverse locations at low cost.

  The Request includes additional funding for the HydroWIRES (Water Innovation for a Resilient Energy System) initiative that enhances the ability of hydropower and pumped-storage hydropower (PSH) to provide increased flexibility and grid-reliability services, and investigates new PSH technologies that can dramatically reduce the capital costs and barriers to new, large-scale, long-duration storage facilities critical to integrating additional VRE while maintaining a reliable and resilient grid. The Request increases support to develop technologies designed to lower costs while increasing efficiency of low head hydropower, engaging both the National Laboratories and the private sector in developing technologies designed to power non-powered dams, particularly marginal dams where developmental costs currently outweigh the power benefits. The Request also continues efforts to develop technologies to ensure safe and effective fish passage for migratory species by partnering with the National Laboratories and the private sector to develop higher Technology Readiness Level systems with an eye toward field demonstration and deployment.

  With respect to climate change effects on watersheds and hydropower, the Request will support development of a suite of climate and hydrologic models, advanced hydrologic sensors, and decision-making tools to provide accurate state-of-the-art climate information and diagnostic capabilities for predicting and managing water and power systems. This will also include support for collaborative efforts with the Advanced Manufacturing Office to initiate development of advanced sensors and data analytics to ensure the continued operability of human-made water systems.

The Request also sustains support for marine energy, providing funding to support the design, fabrication, and testing of marine energy conversion devices at a range of sizes (including grid-scale and Powering the Blue Economy™ technologies), for longer term demonstrations of wave-powered desalination systems for remote communities and disaster relief and recovery, and demonstrations of marine energy powered ocean observing systems. The Request continues support of the Testing Expertise and Access for Marine Energy Research (TEAMER) initiative, a rolling test campaign developed in collaboration with U.S. universities and National Laboratories to provide technology developers with quick and economical access to marine energy testing facilities and capabilities across the U.S. Along with other Renewable Power programs, the Request increases support for the Energy Transition Initiative Partnership Project (ETIPP) with a focus on renewable energy deployment for isolated communities and support for water resiliency through small-scale desalination for remote and coastal communities as part of EERE's emphasis on decarbonizing agriculture and the EERE's Energy-Water Nexus investment (formerly the Water Security Grand Challenge).

- Geothermal Technologies ($163,760,000) supports the deployment of geothermal energy in both the electric and non-electric sectors to help reach a carbon pollution-free electric grid by 2035 and net-zero economy by 2050. Geothermal is a dispatchable, firm renewable resource, with remarkably high potential value for the full decarbonization of the power system. In addition, geothermal can help address environmental justice issues because its high-capacity factor, small physical footprint, and wide-ranging application in the built environment ensure that geothermal energy can be utilized in urban centers, rural areas, and remote communities where geothermal has high technical and economic potential and can reduce dependence on fossil fuels (natural gas, heating oil).

  The Request initiates support for the Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE) consortium designed to leverage oil and gas subsurface assets, technologies, and expertise to help solve geothermal energy's toughest challenges while providing clean energy employment opportunities for energy communities. The Request also initiates support for Geothermal Drilling Technology Demonstrations to support efforts to prove the viability of drilling technologies and methods with promise to reduce the cost of developing geothermal wells and attract private investment. Both these new investments will accelerate decarbonization of the electric sector via technology development, demonstration, and workforce transition, especially in energy communities.

  The Request prioritizes support for the Frontier Observatory in Research in Geothermal Energy (FORGE) research and development. This flagship initiative, started in FY 2014, has drilled several major wells on the Utah site, including the first-ever highly deviated geothermal well, drilled at 8000+ foot depth at a rate twice the industry standard. Utah FORGE made 17 awards for $46 million in five topic areas with its first R&D solicitation in FY 2021. The Request increases support for the next FORGE R&D solicitation to take advantage of the momentum at the FORGE site and provide additional technological progress toward ensuring enhanced geothermal systems viability in the commercial space, contributing to meeting Administration goals for a carbon-free electric grid.

  As part of EERE's programmatic priority to decarbonize buildings and to ensure that the Federal Government leads by example to deploy clean energy technologies, the Request initiates an activity to provide technical assistance to Federal agencies to deploy geothermal energy to heat and cool (and in some limited cases, potentially power) their installations in partnership with EERE's Federal Energy Management Program (FEMP). GTO support will fund advanced feasibility studies on shovel-ready sites and then develop on-site geothermal projects on Federal sites via FEMP performance contracting mechanisms.

Energy Efficiency ($2,179,150,000) supports RDD&D focused on the resilience of homes and buildings and strengthening U.S. manufacturing competitiveness. Most investments proposed in the Request for this pillar are for either deployment of commercially ready technology or demonstrations to show viable paths to deployment. Other investment priorities for FY 2022 include critical R&D needed to accelerate innovation in hard-to-decarbonize heavy industries and strengthening the supply chain for clean energy technologies. Efforts include strengthening the domestic supply chain for critical minerals sustainably and increasing energy efficiency and demand flexibility for the 125 million U.S. homes and commercial buildings. The Request invests in its contribution to achieving net-zero emissions, economy-wide, by no later than 2050 through its statutory responsibilities associated with appliance standards and assessment of energy savings from model building codes through the work of the Building Technologies Office. The Request also supports crosscutting programs that include renewable energy deployment through activities such as the State Energy Program (SEP) and the Federal Energy

Management Program (FEMP). The Request includes substantial increases for these two efforts (SEP, FEMP) as well as near term deployment through the Weatherization Assistance Program.

- Advanced Manufacturing ($550,500,000) supports the decarbonization of the industrial sector and is addressing the climate crisis by driving the innovation that can lead to a more resilient and competitive domestic manufacturing sector that also provides economic opportunities across diverse communities. Manufacturing innovations are required to deliver the clean energy technologies needed to decarbonize other sectors as well, including transportation, buildings, and the electric grid. AMO actively partners with industry to ensure that new energy technologies invented in the U.S. ultimately result in the manufacture of products in the U.S. in support of the Administration priority to deliver an equitable, clean energy future for all Americans. With this approach, AMO will drive the manufacturing innovations needed to support the Biden Administration goal of net-zero greenhouse gas emissions, economy-wide, by 2050 while also investing in the economic engine of American-made energy technology that brings economic prosperity and jobs at a local community level.

  The Request supports materials innovation, including advances that improve domestic availability of materials and resources through resilient and secure supply chains. Specific focus areas include sustainable manufacturing, materials that enable decarbonization, and critical materials supply, substitution, and reuse. In addition, the Request supports advances in materials broadly applicable to energy technologies including energy conversion materials, materials for extreme or harsh conditions, and nanomaterials. In FY 2022, AMO efforts will focus on establishing a new lab-industry consortium to validate technology innovations relating to critical materials and soliciting new projects to address emerging critical materials needs.

  The Request significantly increases the support for industrial decarbonization activities, including research and demonstrations, to address large opportunities and enable an accelerated timeline for achieving carbon emission reductions. Opportunities also exist to advance new manufacturing technologies and improve energy efficiency and reduce carbon emissions in existing manufacturing processes and operations. There is also a need to enable value chains to be nimble, responsive, and adaptive to disruption, change, and opportunity. In FY 2022, AMO will focus efforts on industrial decarbonization activities, including research and demonstrations, to address large opportunities and enable an accelerated timeline for achieving carbon emission reductions especially in hard to decarbonize industries such as steel, cement, and ammonia manufacturing, including a partnership with Hydrogen Technologies on the use of R&D for steel and ammonia manufacturing using hydrogen.

  The Request increases support in energy systems advancing both: 1) systems related to energy conversion, utilization, storage, and management within industrial facilities, and 2) production processes of these energy systems to be used in manufacturing and other sectors. In FY 2022, AMO will eliminate funding for district energy systems that are fossil-fueled and increase funding for research efforts to address manufacturing barriers for innovative energy storage and conversion technology solutions, and advance integrated high temperature electrolyzer manufacturing capabilities.

  As part of EERE's investment in the nexus between Energy and Water, the Request also supports R&D for the energy efficient and resource efficient treatment of nontraditional water sources for beneficial end use applications including energy-efficient and low-cost desalination technologies and technical assistance for waste-water treatment facilities. Efforts include development of technologies that treat seawater, brackish water, and produced waters, for use in municipal, industrial, agricultural, utility, and other water supply needs.

  The Request increases the support for multi-level workforce development activities and focused assistance to energy-intensive manufacturing sectors. Activities will include making knowledge and transformational tools accessible to diverse manufacturing organizations and developing the future manufacturing workforce.

- Federal Energy Management Program (FEMP) ($438,150,000) helps agencies leverage Federal investment in support of mission assurance goals for resilient, efficient, and secure facilities and operations. The Federal Government is the single largest U.S. energy consumer with more than 360,000 buildings and 600,000 vehicles.[1] In FY 2019, the Federal

[1] https://www.energy.gov/sites/prod/files/2020/07/f76/FY2019-performance-findings.pdf

Government used 1.3 quads of primary energy at a cost of $18.4 billion.[1] Energy used in buildings and facilities represents about 58 percent of the total energy use of the Federal Government, while vehicle and equipment energy use accounts for 42 percent.[2] Considering these statistics and an opportunity to lead by example, FEMP will use its resources in FY 2022 to turn the threat of climate change into an opportunity by catalyzing its partners across the Federal Government to lead through the power of collaboration and implementation of innovation to make progress toward the goal of net-zero emissions, economy-wide, no later than 2050.

To meet this goal, the Request includes a significant increase to the Federal Energy Efficiency Fund (FEEF) Program, (+$387 million to a total of $400 million) providing direct funding to Federal agencies for the development of energy and water efficiency projects that mitigate carbon emissions and improve the climate resilience of Federal buildings, facilities, and installations. By leveraging the use of privately financed performance contracts, FEMP will accelerate the adoption of energy and water conservation measures as well as deep retrofits across the Federal Government. The Request also increases FEMP technical assistance, guidance, and on-site training across all focus areas to facilitate implementation of energy and water electrification and decarbonization strategies across the Federal government in support of statutory energy and water management related goals and objectives and Administration priorities. This includes $5 million for technical assistance to transition Federal agencies to carbon-free electricity and zero-emissions fleets, including procurement and installation of charging infrastructure, and funding to enable deployment of geothermal energy in Federal facilities in partnership with Geothermal Technologies.

- Building Technologies (BTO) ($382,000,000) supports investments to reduce the energy intensity of homes and commercial buildings – and thus significantly decarbonize them. Beyond reducing energy waste for consumers and supporting an affordable and reliable grid by reducing overall demand, BTO is committed to seeing buildings play a critical role in decarbonizing the economy by helping to integrate higher levels of renewable resources through demand flexibility, supporting affordable alternatives to pollution-emitting energy equipment, addressing embodied carbon, and to create good-paying jobs with the free and fair chance to join a union and bargain collectively. Reducing building energy use intensity helps conserve valuable natural resources and greatly strengthens the U.S. economy and labor force by improving the productivity of businesses and helping save money by making energy services (e.g., lighting, heating, and cooling) more affordable for all consumers. Increasing the demand flexibility of buildings helps reduce consumers' costs, improves reliability, and helps make better use of variable renewable resources such as solar and wind. In FY 2022, BTO will place a new emphasis on developing market transformation initiatives focused on the highest impact areas to accelerate the transition to a low-to-no-net carbon energy economy.

  Specifically, the Request includes increased support for the Advanced Building Construction (ABC) Initiative to enable the U.S. to become a leader in modernized, low-carbon building construction and renovation through support for scaling of efficient modular new construction and developing easy to install low-cost advanced retrofit solutions. The Request also supports the initiation of the E3 Heat Pump Initiative for Better Energy, Emissions, and Equity. This is a new RD&D effort for new and existing affordable GHG-free heating and cooling solutions. BTO will support market transformation activities to accelerate the adoption of grid-interactive heat pump (HP) technologies and deploy strategies and resources to reduce emissions attributed to building equipment including fossil-fueled equipment and refrigerants.

  Additionally, in support of efforts to prepare the next generation of professionals, tradespersons and other workers needed to create a low-carbon, modernized U.S. building stock, the Request continues efforts to expand interest in these careers among underrepresented groups, augment training programs to improve the skills of existing tradespersons and professionals and streamline pathways from education and training to viable careers with a free and fair choice to join a union as part of EERE's workforce development emphasis.

  As part of EERE's recognition of the essential role that state and local governments play in the transition to a carbon-free economy, the Budget initiates the Climate and Clean Energy Workforce Partnerships for Local Governments competition. This tiered competition will accelerate high-impact solutions tailored to the distinct clean energy goals of cities and counties via their localized workforce. Working with the Weatherization and Intergovernmental Programs

[1] Table A-4 and Table A-2 http://ctsedwweb.ee.doe.gov/Annual/Report/Report.aspx.
[2] In terms of primary (source) energy use.

Office (WIP), BTO will provide competitive awards and technical assistance (e.g., onsite capacity, peer exchanges) to local governments to support the development and deployment of transformative clean energy programs, with an emphasis on small to medium jurisdictions and disadvantaged communities. Topics will be coordinated across EERE, DOE program offices, National Laboratories, and other Federal agencies as appropriate. BTO's efforts will focus on support for local governments' analysis and adoption of building energy codes.

The Request also supports statutory requirements to advance energy and water conservation standards and test procedures for appliances and equipment. DOE is committed to meeting its legislatively mandated deadlines for covered appliances and equipment. Similarly, the Request supports the advancement of building energy codes, including participation in processes to update model energy codes, making a formal determination as to whether new editions increase energy efficiency in residential and commercial buildings, and providing technical assistance to states and local governments to support energy code implementation.

- Weatherization and Intergovernmental Program (WIP) ($808,500,000) partners with state and local organizations to significantly accelerate the deployment of clean energy (e.g., energy efficiency, renewable energy, and energy storage) technologies and practices through place-based strategies involving a wide range of government, community, and business stakeholders. In FY 2022 WIP's mission supports EERE's strategic priority to reduce the carbon footprint of the U.S. building stock and is delivered through three subprograms: the Weatherization Assistance Program (WAP), the State Energy Program (SEP), and a newly proposed Local Government Energy Program (LGEP).

  Weatherization Assistance: The Request provides $400 million in the Weatherization Assistance Program to weatherize at least 50,000 homes per year. This funding is a down payment on the Administration's commitment to retrofit two million homes. The WAP formula grants support the largest and one of the most technically advanced networks of residential energy retrofit providers in the country, providing a foundation for related services funded by other Federal and Non-Federal sources. Funds are allocated on a statutory formula basis and awarded to a single agency within each recipient's jurisdiction that manages the deployment of services to increase the energy efficiency of homes occupied by families with household incomes of 200 percent or less of the Office of Management and Budget's Annual Poverty Guidelines. These agencies, in turn, contract with approximately 700 local service provider organizations, including Community Action Agencies and local governmental and nonprofit agencies, providing approximately 8,500 jobs, and delivering weatherization services to low-income families in every geographic area of the country. Since 1976, WAP has performed 7 million upgrades to low-income households, including 1 million retrofits supported through American Recovery and Reinvestment Act of 2009. From the 38,045 supported home retrofits in FY 2019, estimated savings of $272 million will accrue to these low-income households over the 20-year life of the measures installed.

  The Request also provides $21 million for the creation of a new Weatherization Readiness Fund to enable more low-income Americans to receive Weatherization Assistance by providing funds to address structural and health and safety issues to reduce the frequency of deferred homes that are not weatherization ready when WAP work crews enter the home to perform retrofit services. Deferral of service occurs when the condition of the home renders delivery of weatherization services unsafe or ineffective. WAP crews are often the first or only home services professionals to enter these homes and observe these issues. Deferral means work must be postponed indefinitely until the structural deficiency or health and safety hazard can be resolved, and many low-income households are unable to afford the necessary repairs, particularly in homes of underserved and disadvantaged communities.

  State Energy Program: The State Energy Program (SEP) strategically engages the leadership of states in deploying clean energy technologies across the Nation. SEP funding transforms the energy economy state by state, establishing and implementing clean energy (e.g., energy efficiency, renewable energy, and energy storage) policies, plans, and programs to reduce energy costs, enhance economic competitiveness, improve emergency planning, and improve the environment. States have purview over many of the policy and program levers that can catalyze greater investment in clean energy and help the country realize the suite of economic and environmental benefits (including reduced greenhouse gas emissions) associated with clean energy. The Request sustains support ($62.5 million) for the traditional formula-based SEP grants program to the 50 U.S. states, Washington, D.C., and 5 U.S. territories to advance their energy priorities through the design and implementation of energy efficiency and renewable energy programs.

These grants support state energy offices in their development and implementation of energy programs that deploy portfolios of clean energy technologies addressing their specific goals and needs.

Within SEP, the FY 2022 Request provides $300 million to launch the Build Back Better Challenge grants to incubate novel approaches to clean energy technology deployment, prioritizing investments that meet energy needs at the local level, and are inclusive in elevating impoverished and disenfranchised communities, and/or communities that have been marginalized or overburdened.

Local Government Clean Energy Workforce Program: EERE strives to amplify the transformational impacts of its state-led deployment work in WAP and SEP by expanding the scope of these programs with competitive funding, increased technical assistance to the state and local networks putting advanced technologies to work in communities, and conducting impact analyses to ensure benefits are achieved broadly across the U.S. The Requests provides $25 million to establish the Local Government Clean Energy Workforce Program (LGCEWP) — a new pathway for providing competitive awards, on-site capacity, peer exchanges, and technical assistance to support the development and deployment of transformative clean energy programs that create good paying jobs working with qualifying local governments and Tribal nations, with a focus on disadvantaged or small-to-medium jurisdictions. Within the LGCEWP, WIP proposes to create the Justice for Energy, Workforce, and the Economy across Localities (JEWEL) awards program. This program will operate in coordination BTO and across DOE and other Federal agencies as appropriate.

Corporate Support Programs ($468,585,000) supports activities to make EERE more efficient and effective. This pillar identifies ways to strengthen EERE's overall performance, organization, budget, laboratory management, operations, human capital, and project management while achieving significant cost savings. This includes support for program direction and facilities and infrastructure as part of EERE's stewardship of the National Renewable Energy Laboratory (NREL) in Golden, Colorado.

- Facilities and Infrastructure ($175,000,000) ensures EERE fulfills its role as the steward of NREL and sustains existing research and support infrastructure, maintaining and upgrading in key areas to attract world-class research scientists and to develop innovative solutions to the most challenging technology issues**.** NREL serves as the Nation's preeminent institution for delivering impactful scientific knowledge and technology innovations that transform renewable energy technologies, systems, and markets. NREL's research advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies, and provides the scientific knowledge to integrate and optimize energy systems.

  EERE is committed to put in place at NREL the capabilities to advance the Administration priorities of transitioning the United States to a decarbonized electric grid by 2035 and achieve net-zero emissions, economy-wide, not later than 2050. To that end, the Request prioritizes investment in the Advanced Research in Integrated Energy Systems (ARIES) initiative to address the challenges of designing and constructing future energy systems using the basic principles of operating large-scale hybrid energy systems that interconnect multiple generation and storage technologies and solving the complex problem of controlling the interactions between millions of distributed assets. ARIES research focus areas include Energy Storage, Power Electronics, Hybrid Systems, Future Energy Infrastructure, and Cybersecurity.

  The Request supports the first year of a four-year refresh/upgrade of NREL's High-Performance Computer (HPC). High-performance computing enables unprecedented large-scale numerical models for studying and simulating material properties, processes, and fully integrated energy systems that would otherwise be too expensive, too dangerous, or even impossible to study by direct experimentation. With state-of-the-art computational modeling and predictive simulation capabilities, high-performance computing reduces the risks and uncertainty that are often barriers to industry adopting new and innovative technologies, thereby accelerating the transformation or the Nation's energy system.

  The Request also continues funding for the Energy Materials and Processing at Scale (EMAPS) line-item construction project, a planned design and construction of a multi-disciplinary research capability in process integration that draws on bench scale innovations from multiple institutions and transforms them into integrated and scalable hybrid technology processes needed to ready DOE innovations for commercial development. Such a capability will enable

research activities critical for a more rapid transition to a circular economy for energy-relevant and energy-intensive materials and processes.

- Program Direction ($250,000,000) enables EERE to maintain and support a world-class Federal workforce. The Request provides additional resources for program and project management, oversight activities, contract administration, workforce management, IT support, and Headquarters (HQ) and field site non-laboratory facilities and infrastructure. This includes increased staffing and contract support for areas such as appliance standards development and building codes development, FEMP technical assistance to assist agencies in transitioning to carbon-free electricity and zero-emission fleet, and to support EERE's programmatic priorities. Hiring and retaining staff needed to achieve EERE's priorities continues to be a priority, and the Request also provides increased funding for activities associated with attracting a diverse workforce as well as to onboard staff in an efficient manner. Improving the tracking and evaluation of EERE's investments to make sure every dollar is contributing to mission, with helpful but not onerous metrics and performance processes is a FY 2022 priority as well. The Request therefore includes increased funding for information technology systems development to ensure EERE can collect and analyze data on its investments.

- Office of Strategic Programs ($43,585,000) supports high-impact, crosscutting, integrative activities most efficiently executed by a single crosscutting organization in coordination with EERE technology programs and other DOE offices. This includes support for activities to inform key EERE audiences and stakeholders about the work that EERE is doing to transition America to a clean energy economy and fight the global climate crisis and funding to address high energy costs, reliability, and inadequate infrastructure challenges faced by remote communities as part of the Energy Transitions Initiative in partnership with other EERE Technology Offices and other DOE offices.

  The Request includes increased support for Strategic Analysis, which provides evidence-based, portfolio-wide analysis for energy decision-makers in EERE and beyond. In close coordination with the Renewable Power offices and the Office of Electricity, Strategic Analysis will lead activities to provide extensive data, tools, and technical assistance to relevant stakeholders as the Nation embarks on an unprecedented build-out of clean energy generation and a significant expansion of inter- and intra-regional transmission in support of the Administration's goals. The Request supports efforts to ensure that EERE is maximizing the impact of its research dollars, tracking the impacts of EERE investments, and striving to ensure that the clean energy economy benefits all Americans. Efforts will be coordinated with DOE's larger efforts to meet the goals of the Justice40 Initiative.

  The Request also includes increased funds for capacity building to support Administration priorities including development, implementation, and execution of several activities proposed in the American Jobs Plan – including implementing an Energy Efficiency and Clean Energy Standard. Based on experience implementing significant surges of funding appropriated under the American Recovery and Reinvestment Act of 2009, EERE recognizes the importance of building capacity to ensure effective and efficient implementation. SPO work with stakeholders to build a foundation for expeditiously administering several new investments such as increases for Weatherization, block grants, and other deployment focused programs that will rely on new and existing relationships with stakeholder networks and communities.

Energy Efficiency and Renewable Energy
($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted	
				$	%
Discretionary Summary by Appropriation					
Energy Efficiency and Renewable Energy					
Sustainable Transportation					
Vehicle Technologies	396,000	400,000	595,000	+195,000	+48.8%
Bioenergy Technologies	259,500	255,000	340,000	+85,000	+33.3%
Hydrogen and Fuel Cell Technologies	150,000	150,000	197,500	+47,500	+31.7%
Renewable Power					
Solar Energy Technologies	280,000	280,000	386,575	+106,575	+38.1%
Wind Energy Technologies	104,000	110,000	204,870	+94,870	+86.2%
Water Power Technologies	148,000	150,000	196,560	+46,560	+31.0%
Geothermal Technologies	110,000	106,000	163,760	+57,760	+54.5%
Energy Efficiency					
Advanced Manufacturing	395,000	396,000	550,500	+154,500	+39.0%
Federal Energy Management Program	40,000	40,000	438,150	+398,150	+995.4%
Building Technologies	285,000	290,000	382,000	+92,000	+31.7%
Weatherization and Intergovernmental Programs					
Weatherization Assistance	305,000	310,000	390,000	+80,000	+25.8%
Training and Technical Assistance	3,500	5,000	10,000	+5,000	+100.0%
Weatherization Readiness Fund	0	0	21,000	+21,000	N/A
State Energy Program	62,500	62,500	362,500	+300,000	+480.0%
Local Government Energy Program	0	0	25,000	+25,000	N/A
Total, Weatherization and Intergovernmental Programs	371,000	377,500	808,500	+431,000	+114.2%
Corporate Support Programs					
Facilities and Infrastructure	130,000	130,000	167,000	+37,000	+28.5%
21-EE-001-Energy Materials and Processing at Scale (EMAPS)	0	0	8,000	+8,000	N/A
Total, Facilities and Infrastructure		130,000	175,000	+45,000	+34.6%
Program Direction	165,000	165,000	250,000	+85,000	+51.5%
Strategic Programs	14,500	14,500	43,585	+29,085	+200.6%
Subtotal, EERE	**2,848,000**	**2,864,000**	**4,732,000**	**+1,868,000**	**+65.2%**
Rescission of Prior Year Funds	-70,723	-2,240	0	0	0%
Total, EERE	**2,777,277**	**2,861,760**	**4,732,000**	**+1,870,240**	**+65.4%**

SBIR/STTR:

- FY 2020 Transferred: SBIR $66,758,000; STTR: $11,568,000
- FY 2021 Projected: SBIR $57,673,000; STTR: $8,110,000
- FY 2022 Request: SBIR $84,290,000; STTR: $11,853,000

Vehicle Technologies

Overview

Vehicles move our national economy. Each year in the U.S., vehicles transport 18 billion tons of freight—about $55 billion worth of goods each day[1]—and move people more than 3 trillion vehicle-miles.[2] The transportation sector accounts for approximately 30 percent of total U.S. energy needs[3] and over 15 percent of average U.S. household expenditures[4]— up to 30 percent for lower income households[5]—making it, as a percentage of spending, the most costly personal expenditure after housing. Transportation is critical to the overall economy, from the movement of goods to providing access to jobs, education, and healthcare.

The transportation sector has historically relied heavily on petroleum, which supports over 90 percent of the sector's energy needs today[6], and, as a result, surpassed electricity generation to become the largest source of CO_2 emissions in the country[7]. Transportation sector decarbonization is therefore critical to achieving the overall goal of economy-wide decarbonization by 2050. The Vehicle Technologies Office (VTO) will play a leading role to decarbonize the transportation sector and address the climate crisis by driving innovation within and deployment of clean transportation technologies. VTO will advance the Biden Administration's goals to achieve carbon pollution-free electricity by 2035 (e.g. through electric vehicles (EVs) and managed charging) and deliver an equitable, clean energy future, and put the U.S. on a path to achieve net-zero emissions, economy-wide, by no later than 2050 to the benefit of all Americans.

Achieving deep decarbonization in transportation will require vehicle efficiency improvements, low lifecycle carbon-intensity fuels, and overall system-wide improvements in the transportation system. VTO funds research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. VTO leverages the unique capabilities and world-class expertise of the National Laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well as innovations in connected infrastructure for significant systems-level energy efficiency improvement); combustion engines to reduce GHG and criteria emissions; and technology integration that helps demonstrate and deploy new technology at the community level. Across these technology areas and in partnership with industry, VTO has established aggressive technology targets to focus RDD&D efforts and ensure there are pathways for technology transfer of Federally supported innovations into commercial application. Vehicle technologies research will generate knowledge that industry can advance to deploy innovative energy technologies to support affordable, secure, reliable, and efficient transportation systems across America.

Decarbonization is part of a comprehensive approach to advancing sustainability across the transportation sector. By working closely and in collaboration with the Department's Bioenergy Technologies and Hydrogen and Fuel Cell Technologies Offices, VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Department of Energy is committed to pushing the frontiers of science and engineering, creating good-paying clean energy jobs through RDD&D, and ensuring environmental justice and inclusion of disadvantaged communities. VTO supports the Federal Government in pursuing a comprehensive approach to advancing equity for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality, including those in energy communities. Affirmatively advancing equity, civil rights, racial justice, and equal opportunity is the responsibility of the whole of our Government. By advancing equity across the Federal Government, we can create opportunities for the improvement of communities that have been historically underserved, which benefits everyone.

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[1] Bureau of Transportation Statistics, DOT, Transportation Statistics Annual Report 2020, Table 4-1. https://www.bts.gov/tsar.
[2] Transportation Energy Data Book 39th Edition, ORNL, 2021. Table 3.8 Shares of Highway Vehicle-Miles Traveled by Vehicle Type, 1970-2018.
[3] Ibid. Table 2.2. U.S. Consumption of Total Energy by End-use Sector, 1950-2018.
[4] Ibid. Table 11.1 Average Annual Expenditures of Households by Income, 2019.
[5] Center of Neighborhood Technology (CNT). https://www.aceee.org/blog/2016/07/america-s-transportation-energy.
[6] Transportation Energy Data Book 39th Edition, ORNL, 2021. Table 2.3 Distribution of Energy Consumption by Source and Sector, 1973 and 2019.
[7] Environmental Protection Agency, Draft U.S. Inventory of Greenhouse Gas Emissions and Sinks, 1990-2019, Table 2-11. Electric Power-Related Greenhouse Gas Emissions and Table 2-13. Transportation-Related Greenhouse Gas Emissions.

Highlights of the FY 2022 Budget Request

The Vehicle Technologies Budget Request supports key efforts that contribute to achieving its high-level goals:

- Advanced Battery R&D: In support of EVs and batteries across clean energy applications including the Energy Storage Grand Challenge, identify new battery chemistry and cell technologies with the potential to reduce the cost of electric vehicle battery cells. Initiate new recycling processing technologies and scale-up of lithium battery technologies such as no-cobalt/no-nickel cathodes and solid state systems to reduce constraints from scarce materials, enhance environmental sustainability, and support a U.S.-based circular lithium battery supply chain.
- Electric Drive Systems and Electrification: Increase support for the RD&D of Medium-Duty (MD)/Heavy Duty (HD) technologies for energy efficient powertrain technologies that will improve commercial vehicles through the SuperTruck 3 initiative.
- Advanced Engines and Fuels: Develop energy-efficient engines for all applications that can utilize renewable fuels, such as advanced biofuels, renewable natural gas and hydrogen, and e-fuels, to significantly reduce greenhouse gas (GHG) emissions while achieving near-zero criteria emissions. Activities will prioritize engine efficiency and emission control research for off-road, rail, and marine applications as well as MD and HD truck engines with the integration of hybrids and plug-in hybrid powertrains. MD and HD engine research will focus on increasing efficiencies by 28 percent in 2030 (compared to a 2020 baseline) while cost effectively meeting emission standards and durability requirements.
- Materials Technology: Identify novel approaches to build lightweight, multi-material structures with the potential to reduce light-duty vehicle glider (i.e., chassis, body structure, and interior) weight and develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing methods weight reduction in powertrain and suspension components.
- Energy Efficient Mobility Systems: Create breakthrough modeling, simulations, and high-performance computing-enabled data analytics to support the development of new transportation-system technologies, which have the potential to improve energy productivity through new mobility solutions including connected, shared, and automated vehicles. Identify feasible system-level pathways to improve mobility energy productivity and support the transition to a net-zero economy by 2050.
- Technology Integration: Fulfill statutory requirements for providing alternative fuel information, publishing the Fuel Economy Guide, and implementing the state and alternative fuel provider fleet program. Support demonstration and deployment projects to accelerate implementation of advanced transportation technologies and charging infrastructure development, especially to benefit energy communities. Other projects seek to validate data, technologies, and systems in the field, serving as an important feedback loop to inform future Vehicle Technologies research planning. Support national science, technology, engineering, and mathematics education objectives through an advanced vehicle technology competition to provide hands-on training to university students and prepare them for the future workforce.
- Data, Modeling, and Analysis: Using advanced vehicle and transportation data, conduct technical-, economic-, and interdisciplinary analyses that result in insights critical to informing Vehicle Technologies' targets and program planning.
- Departmental Crosscuts:
  - Advanced Transportation ($595,000,000) – Focus on rapid, widespread deployment of electric vehicle charging stations nationwide, RDD&D in electric vehicle drive systems and batteries, supporting the growth of a domestic battery supply chain, and the development and deployment of the technologies and infrastructure necessary to decarbonize light-, medium-, and heavy-duty transportation, shipping, rail and aviation. These and other investments are crucial towards putting the U.S. on a path to a net-zero carbon economy by 2050.
  - Energy Storage Grand Challenge ($183,000,000) – R&D focused on high-energy and high-power battery materials, cells, and systems;
  - Critical Minerals Initiative ($57,000,000) – Addresses cobalt use and recycling for batteries; reducing heavy rare-earth materials (RE) in EV drive systems; reduce/replace platinum group metals in engine emissions control systems;
  - Grid Modernization Initiative ($18,000,000) – Projects for managing grid charging of EVs, charging infrastructure cybersecurity, and MD/HD high power EV charging;
  - Energy Sector Cybersecurity Crosscut ($2,000,000) – Grid-connected vehicle charging, charging infrastructure resilience, and risk mitigation;
  - Artificial Intelligence and Machine Learning ($10,500,000) — Develop artificial intelligence approaches to sensing, perception, and control of automated vehicle systems and enable virtual calibration of engines to meet emissions and efficiency targets;
  - Advanced Manufacturing ($50,000,000) – Focus on new joining technologies for multi-material structures in vehicles including composites and other new lightweight materials and develop high temperature metal alloys and alloys for additive manufacturing. Address innovations in advanced battery material and anode processing technologies, such as lithium metal; and

- STEM ($2,500,000) – Provide technical support for year 4 of the EcoCAR Mobility Challenge, during which student teams will continue to refine designs developed in FY 2021 and validate hardware implementation.

The 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. The Department of Energy will ensure that, to the extent consistent with applicable law, the Vehicles Technology Office is not directly subsidizing fossil fuels and instead will focus on developing efficient engines for medium- and heavy-duty on-road trucks and off-road vehicles, including construction, agriculture and forestry, and rail and marine, that can utilize renewable fuels, such as advanced biofuels, hydrogen, and e-fuels, or hybrid electric powertrains where full electrification is not yet feasible, so as to reduce GHG and criteria emissions to near-zero levels.

Vehicle Technologies
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Vehicle Technologies				
Battery and Electrification Technologies	174,700	178,700	248,700	+70,000
Advanced Engine and Fuel Technologies	70,000	70,000	30,000	-40,000
Materials Technology	40,000	40,000	60,000	+20,000
Energy Efficient Mobility Systems	45,000	45,000	70,000	+25,000
Technology Integration	60,300	60,300	180,300	+120,000
Data, Modeling, and Analysis	6,000	6,000	6,000	0
Total, Vehicle Technologies	**396,000**	**400,000**	**595,000**	**+195,000**

SBIR/STTR:

- FY 2020 Transferred: SBIR: $10,380,000; STTR: $1,756,000
- FY 2021 Enacted: SBIR: $10,768,000; STTR: $1,514,000
- FY 2022 Request: SBIR: $17,454,000; STTR $2,454,000

Vehicle Technologies
Explanation of Major Changes
($K)

	FY 2022 Request vs FY 2021 Enacted
Vehicle Technologies	
Battery and Electrification Technologies: The increase in funding for this subprogram will support R&D to reduce EV battery cell to achieve EV cost parity with internal combustion engine (ICE) vehicles through enhanced R&D focused on lithium metal, solid state, and next generation battery technologies; eliminate dependence on critical materials such as cobalt, nickel, and graphite, thereby mitigating battery supply chain risks. Research next generation lithium ion batteries such as no-cobalt/no-nickel cathodes, and silicon-based anodes; and establish a lithium battery recycling ecosystem to recover 90 percent of spent lithium batteries and re-introduce 90 percent of key materials into the battery supply chain by 2030. Battery recycling R&D includes the development of new recycling processing technologies and scale-up of lithium battery recycling in addition to expanded joint work between industry and researchers through the existing Recycling Center. Increase also supports expanded efforts for the SuperTruck 3 activity. The increase in funding level for this subprogram reflects the emphasis on prioritization of key crosscutting R&D areas across EERE and the Department, including the Energy Storage Grand Challenge, Critical Materials, Advanced Manufacturing, and the Grid Modernization initiative.	**+70,000**
Advanced Engine and Fuel Technologies: Focus research on engines that can utilize renewable fuels, such as advanced biofuels, renewable natural gas and hydrogen, and e-fuels, to reduce GHG emissions and achieve near-zero criteria emissions. No funding requested for the Co-Optimization of Engines and Fuels activity; R&D will be completed with FY 2021 funds as planned. Research on medium- and heavy-duty engines will be shifted to focus more on off-road, rail, and marine engines and associated catalyst and emission control/after-treatment technologies to meet future emission standards and durability requirements. A multi-lab initiative for medium- and heavy-duty commercial on-road vehicles will focus on research to improve engine efficiency, utilizing renewable fuels and hybrid powertrains. Reduce funding and complete final year of light-duty engine fundamental combustion experimental and modeling research for exascale computing. Shift focus of catalysis research to cost-effectively reduce emissions from medium- and heavy-duty engines, while reducing/replacing critical minerals, i.e., platinum group metals.	**-40,000**
Materials Technology: The increase in funding for this subprogram will support key advances in materials development and manufacturing to decrease lifecycle greenhouse gas emissions and manufacturing cost of electrified vehicles supporting the transition to electric light duty vehicles. New activities will include research on multi-functional materials to enable wiring, sensors, sound, and thermal insulation to be integrated into structural components decreasing weight and manufacturing cost. The Materials Technology subprogram will also coordinate closely with the Battery and Electrification Technologies subprogram to support materials research and development to address key challenges in electrical conductivity, thermal conductivity, magnetic materials, and high temperature operation currently limiting advances in electric powertrain and wireless charging. In addition, new funding will also support research to reduce non-exhaust vehicle emissions including tire and brake wear through materials innovations. Adverse health effects have been correlated to increased exposure to particulate matter that is present near roadways and in urban environments with stop and go traffic, representing an environmental injustice to the communities located in these areas.	**+20,000**

	FY 2022 Request vs FY 2021 Enacted
Energy Efficient Mobility Systems (EEMS): The subprogram will initiate a major new effort to research, develop, and demonstrate clean energy mobility solutions for underserved and energy communities, leveraging results of prior year activities in Computational Modeling and Simulation and Connectivity and Automation Technology. EEMS will continue to support key activities in Computational Modeling and Simulation, including the Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility National Laboratory Consortium – a multi-disciplinary approach to assess the system-level energy productivity impacts from future mobility technologies and transportation systems. SMART Mobility will emphasize the rapid development and application of transportation system-level models to identify pathways to improve mobility energy productivity, transition to a net-zero carbon emission transportation system and ensure clean and affordable transportation solutions are available to all Americans. Transportation system optimization projects selected under the previous "AI for Mobility" lab call, which support the Artificial Intelligence and Machine Learning crosscut, will demonstrate the application of data science and strategic computing capabilities to large-scale mobility challenges. EEMS will also conduct critical research, development, and demonstration in the Connectivity and Automation Technology activity, supporting cross-cutting research in 5G/Advanced Wireless Technologies through a new advanced transportation R&D project to remove technical barriers and accelerate the efficiency and mobility benefits of connected and automated vehicles.	**+25,000**
Technology Integration: The increase in funding will address the barriers to light-, medium-, and heavy-duty plug-in electric vehicle (PEV) deployment, especially in energy communities and other underserved communities (e.g., low-income, rural, and demographics that currently have minimal access to PEVs). Lack of charging infrastructure, PEV cost parity with conventional vehicles, education, and workforce training impede widespread PEV adoption. Improving equitable access to the benefits of electrified transportation must take into consideration PEVs and charging infrastructure availability for mobility choices such as personal vehicle ownership, car sharing, ride sharing, school transport, and transit. This also includes projects demonstrating Smart Charging technologies, and other business models, that improve cost and efficiency for the acquisition and operation of new EV models for local governments, utilities, transit, schools, ports, and goods movement. These projects will demonstrate that new electric transportation solutions, combined with wide-spread technical assistance, can support efforts at the State level to advance the Administration's goal of deploying 500K EV chargers. The increase in funding will also support demonstration activities to validate technologies developed in Super Truck 3.	**+120,000**
Data, Modeling, and Analysis (formerly Analysis): No significant funding change. Work will continue to provide critical information and analyses to prioritize and inform Vehicle Technologies research portfolio planning through technology-, economic-, and interdisciplinary-based analysis, including target-setting and program benefits estimation. In FY 2022, projects will continue to support analytical capabilities and tools unique to DOE's National Laboratories.	**0**
Total, Vehicle Technologies	**+195,000**

Description

The Battery and Electrification Technologies subprogram supports the decarbonization of transportation across all modes, serves to increase American advancement/manufacturing of battery technology, and creates good paying jobs with the free and fair chance to join a union and bargain collectively. The subprogram supports research with partners in academia, National Laboratories, and industry covered under the Energy Storage Grand Challenge key priority and four distinct crosscuts including: Critical Materials; Grid Modernization; Advanced Manufacturing and Energy Sector Cybersecurity. The Energy Storage Grand Challenge encompasses R&D across energy storage and electrification including the discovery of alternative lithium battery materials, processing for raw materials, development of advanced battery cells, discovery of innovative cell manufacturing techniques, battery recycling, and electric vehicle charging infrastructure. The Critical Minerals crosscut aims to reduce or eliminate cobalt and nickel in lithium battery cathode materials, develop substitutes for graphite such as silicon composite anodes and lithium metal anodes, develop advanced recycling and processing through scale up of bench-scale recycling processes and innovative separation processes seedlings, and realize electric drive motor innovations through high energy product magnet R&D to reduce or eliminate heavy rare earth magnet materials. Grid Modernization will continue developing Smart Charge Management technologies for fleets, including medium and heavy duty vehicles, enabling DC-as-a-service based EV charging facilities, integrating the control and management of EV fleet vehicles to provide more advanced grid services such as resiliency of the charging network and continuity of grid and emergency services operations during disruptive events. The Advanced Manufacturing crosscut is focused on coordination with the Advanced Manufacturing Office for joint projects scaling up solid state battery materials and lithium metal electrode processing technologies addressing critical materials for batteries. Energy Sector Cybersecurity research is conducted at National Laboratories for electric vehicle grid connection critical technologies, methodologies, and tools to address the highest priority cyber security risks.

Battery R&D: The Battery R&D activity supports early-stage R&D of high-energy and high-power battery materials, cells, and battery development that can enable industry to significantly reduce the cost, weight, volume, and charge time of PEV batteries. This activity is organized into sub-activities: advanced battery materials research, advanced battery cell R&D, and battery recycling R&D. Advanced battery materials research is coordinated with the Critical Minerals Initiative and includes: early-stage research of new lithium-ion cathode, anode, and electrolyte materials (currently accounting for 50-70 percent of PEV battery cost) and the development of “beyond lithium-ion” technologies, such as lithium metal anodes, solid-state electrolytes, and sulfur-based cathodes, that have the potential to significantly reduce weight, volume, and cost by three times, with a target of $60/kWh. Advanced battery cell R&D includes: early-stage R&D of new battery cell technology that contains new materials and electrodes that can reduce the overall battery cost, weight, and volume while improving energy, life, safety, and fast charging; and high-fidelity battery performance, life, fast charging, and safety testing of innovative battery technologies including recycled material and cells. Battery recycling R&D includes the development of innovative battery materials recycling and reuse technologies, and the Lithium-Ion Battery Recycling Prize, both to assure sustainability and domestic supplies of key battery materials and minerals.

Electric Drive R&D: The Electric Drive R&D activity supports early-stage R&D for extreme high-power density motors that have the potential to enable radical new vehicle architectures by dramatic volume/space reductions and increased durability and reliability. Reduce the cost of electric traction drive through core research of motors, high-density integration technologies, leveraging high performance computing for modeling and optimization, and utilizing new materials for high-density electric motors. Approaches will include novel circuit topologies and new materials for high-density electric motors. Electric traction drive system integration based on electric motor innovations will also be a priority.

Electrification R&D: The Electrification R&D activity supports early-stage R&D to understand the potential impacts on, and benefits of, PEV charging to the Nation’s electric grid. This research will inform the development of communication and cybersecurity protocols; enable industry to enhance the interoperability between charging equipment, the on-board vehicle charger, and charging networks; and foster technology innovations to improve PEV refueling through extreme fast charging. Core research focuses on developing smart charging, extreme fast charging, and wireless charging technologies for reliable

and cost-effective charging of light-, medium-, and heavy-duty electric vehicles. This includes the research of technologies related to cybersecurity of electric vehicle charging/supply equipment, and integration with the electric grid.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Battery and Electrification Technologies $178,700,000	**$248,700,000**	**+$70,000,000**
Battery R&D $115,000,000	$180,500,000	+$65,500,000
• Fund National Laboratory advanced battery materials research projects focused on next-generation Lithium Ion and Beyond Lithium Ion chemistries. Research areas include silicon-based anodes, novel liquid electrolyte formulations, low and/or no cobalt cathode materials, lithium metal anodes, sulfur-based cathodes, solid-state electrolyte materials, and other promising battery technologies. Research into these different material systems are based on their potential to significantly reduce battery weight, volume, and cost.	• Continue to fund high potential National Laboratory research projects for next generation battery materials such as Lithium metal and Lithium Sulfur based chemistries. Research will expand to explore further into solid-state material systems that can meet key performance metrics for weight, volume, and cost, while achieving further improvements in cycle life. • Initiate new cooperative research agreements for lithium metal and solid-state battery materials scale up including processing and cell development and expand participation in the Battery500 R&D Consortium.	• Battery materials research will expand to overcoming the fundamental scientific barriers in extracting the maximum capacity from electrode materials for next generation lithium batteries using higher capacity, more abundant, cathode materials. This expansion will accelerate battery development activities of the most promising lithium metal technologies through materials scale up and accelerating electrode processing and cell development and increase support for the Battery500 R&D Consortium. This further supports objectives for both battery cell cost reduction and eliminating dependence on critical materials.
• Fund National Laboratory advanced battery cell projects focused on novel anode and cathode pairing, new electrode structures, fast charging capabilities, and cell manufacturing improvements.	• Continue to fund National Laboratory battery cell research projects that focus on improving key performance metrics while reducing critical materials use and improving recyclability. Establish early stage research projects for a new class of cell materials that contain no cobalt and no nickel. Begin complementary work through cooperative agreements with industry for the scale-up of these new materials and cells.	• Current R&D is focused on low cobalt cathode development and fundamental studies on a new class of cathode materials that contain no cobalt, and no nickel has shown promise. Fundamental research at National Laboratories has demonstrated that these materials may be a viable alternative to current lithium battery cathode materials, significantly reducing critical material needs.
• Support R&D to enable affordable lithium ion battery recycling technologies and the Lithium Ion Battery Recycling Prize Fund battery development work addressing barriers such as pack and module fast charging, thermal management, and design for recycling or second	• Maintain support for priority battery development including behind the meter storage. Continue to emphasize reuse and recycling business model innovations through the Lithium Ion Battery Recycling Prize.	• This new work will support the establishment of a secure and domestic lithium battery recycling ecosystem to reduce constraints from scarce materials, enhance environmental sustainability, and support a U.S.-based circular materials supply chain. Supports lithium battery recycling

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
use. Continue support for the Behind the Meter Storage (BTMS) in collaboration with the Solar Energy and Buildings Technologies Offices.	• Initiate cooperative agreements for new recycling processing technologies and scale-up of lithium battery recycling. Expand joint work between industry and researchers through the existing Recycling Center	goals and can reduce dependence on critical materials through reuse.
• SuperTruck III: Through five competitively awarded projects, develop energy efficient powertrain technologies that will improve commercial vehicles	• SuperTruck III: Provide the second year of planned funding for projects selected in FY 2021 and support additional awards.	• Fund additional awards for the RD&D of MD/HD technologies for energy efficient powertrain technologies that will improve commercial vehicles.
Electric Drive R&D $44,000,000	$46,000,000	+$2,000,000
• Support National Laboratory-led projects with university participation for early stage research targeting the development of technologies that will enable low cost, high power density electric drive systems, including wide bandgap devices, semiconductor packaging, passive devices, motor materials, and electromagnetic and thermal analysis.	• Maintain support for National Laboratory-led projects with university participation for early stage research targeting the development of technologies that will enable low cost, high power density electric drive systems.	• Projects will work across the research consortium to refine their focus on advanced motor designs for reaching aggressive motor targets. Advanced, high power density power electronics research, including projects on wide bandgap devices, semiconductor packaging, and passive devices will continue.
• Continue competitively awarded research and development projects, working with industry and university partners to address technology gaps in electric drive system performance.	• Issue new cooperative agreements focused on research goals for electric drive systems including cost reduction and increased power density.	• Cooperative agreements serve to bring in new concepts, ideas, and technologies while working on development challenges that need to be addressed to move research further towards realization.
• SuperTruck III: Through five competitively awarded projects, develop energy efficient powertrain technologies that will improve commercial vehicles.	• SuperTruck III: Provide the second year of planned funding for projects selected in FY 2021 and support additional awards.	• Fund additional awards for the RD&D of MD/HD technologies for energy efficient powertrain technologies that will improve commercial vehicles
Electrification R&D $19,700,000	$22,200,000	+$2,500,000
• Support competitively awarded industry led R&D projects to research, develop, and demonstrate affordable and secure plug-in electric vehicle smart charging systems.	• In support of the Grid Modernization Initiative crosscut, continue National Laboratory research projects focused on enabling extreme fast charging of electric vehicles, limiting grid impacts, and controlling smart charging.	• Support projects that emphasize increased electric vehicle adoption across light, medium, and heavy-duty vehicle applications. Technical focus areas include resilient charging infrastructure and charge management incorporating local distributed energy resources (DERs).

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Support National Laboratory research projects focused on enabling extreme fast charging of electric vehicles, advancing wireless charging technology, promoting vehicle-grid integration, controlling smart charging, and designing for cyber-physical security.	• In support of the Cybersecurity crosscut, continue competitively selected, industry-led projects to develop secure vehicle-grid connection and communication technologies. Additional laboratory projects will also address cybersecurity needs for vehicle charging and charging infrastructure resilience.	• Build upon completed risk assessments by competitively selecting industry-led projects that address the most critical needs and highest vulnerabilities.
• SuperTruck III: Through five competitively awarded projects, develop energy efficient powertrain technologies that will improve commercial vehicles.	• SuperTruck III: Provide the second year of planned funding for projects selected in FY 2021 and support additional awards.	• Fund additional awards for the RD&D of MD/HD technologies for energy efficient powertrain technologies that will improve commercial vehicles.

Description

The Advanced Engine and Fuel Technologies subprogram supports R&D necessary for industry to develop efficient engines that can utilize renewable fuels, such as advanced biofuels, hydrogen, and e-fuels, to reduce GHG emissions and achieve a net-zero economy by 2050, all while creating good paying jobs with the free and fair chance to join a union and bargain collectively. Internal combustion engines will continue to be an important power source for medium- and heavy-duty on-road trucks and off-road vehicles including construction, agriculture and forestry, and rail and marine, during the next several decades. Increasing their efficiency and reducing GHG and criteria emissions will ensure that the clean energy economy benefits all Americans. Optimization of high efficiency engines and emission control systems, integration of hybrid powertrains, and utilization of renewable fuels has the potential to improve heavy-duty engine efficiency.

The subprogram supports cutting-edge research at the National Laboratories, in close collaboration with academia and industry, to strengthen the knowledge base of high-efficiency, advanced combustion engines, fuels, and emission control catalysts. The Advanced Engine and Fuel Technologies subprogram will apply the unique facilities and capabilities at the National Laboratories to create knowledge, new concepts, and research tools that industry can use to improve combustion engines using renewable fuels that will provide efficiency improvements and GHG and criteria emission reductions.

The subprogram will work closely with the DOE Office of Science to build on basic research results at the National Laboratories. It will use a multi-laboratory initiative, including high performance computing (HPC) and hardware in-the-loop resources, for early-stage research to optimize the efficiency of on- and off-road medium- and heavy-duty vehicles.

Advanced Combustion, Fuels and Emissions Research: Activity will support National Laboratory development of predictive, high-fidelity sub-models and simulation tools that are scalable and can leverage future exascale computing capabilities. These tools will use HPC to simulate and accurately predict the fundamental processes, utilizing artificial intelligence and machine learning, that occur in engines, including fuel injection sprays, heat transfer, turbulence, flame propagation, and emissions formation, to achieve results that are comparable to detailed experiments. The activity will fund research of renewable fuel properties utilizing chemical kinetics modeling of different molecules to determine their impact on combustion efficiency and emissions. It will also develop numerical routines and sub-models of complex chemical reactions that can reduce the computational time and increase the accuracy required for high-fidelity engine models, making them viable for use by industry.

The activity will also support experimental combustion projects conducted by the National Laboratories and will provide data for the new exascale modeling initiative to establish quantitative relationships between fuel properties and efficiency improvement potential for engines operating in advanced compression ignition combustion and multi-mode spark ignition/compression ignition regimes for on- and off-road vehicles. Advanced laser, high-intensity X-Ray, and neutron-based optical diagnostics will be conducted to determine how fuel injection, air mixing, and combustion take place in the engine and how emissions are formed. In combination with HPC, the knowledge from this research will help industry develop combustion engines with higher efficiency and lower emissions.

The activity will conduct experiments at the National Laboratories using high-resolution microscopy for understanding chemical reactions at the atomistic level on catalyst surfaces and within the catalysts that have the potential to reduce emissions at the low exhaust temperatures from high-efficiency engines while reducing/replacing critical minerals, i.e., platinum group metals. New catalyst compounds with higher activity and durability, and lower costs will be synthesized, and models that simulate the chemical reaction rates using HPC will be developed.

The knowledge and high-fidelity models developed for combustion, fuels, and emission control will be available for use by industry (through open-source code, licensing, or development by industry suppliers of commercial tools based on the fundamental models) to design, develop, and deploy more efficient and clean engines. Industry does not have the unique facilities and scientific capabilities that are available at the National Laboratories to conduct this early-stage R&D. The

subprogram will utilize cost shared CRADAs and pre-competitive research to address critical industry needs while leveraging unique National Laboratory resources.

Integrated Powertrain Systems Development: This activity will support a R&D portfolio focused on increasing the efficiency of on- and off-road medium- and heavy-duty vehicles, including engines used for marine and rail, while improving their ability to utilize renewable fuels and reduce emissions. The goal of this portfolio is to conduct coordinated research with industry, universities, and the National Laboratories through cooperative agreements and CRADAs. R&D will include technologies to investigate new opportunities for hybridization/electrification of powertrains. The subprogram will coordinate with and utilize expertise from other subprograms as needed.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Advanced Engine and Fuel Technologies $70,000,000	**$30,000,000**	**-$40,000,000**
Fundamental Combustion, Fuels and Emissions Research $35,000,000	$20,000,000	-$15,000,000
• Predictive Modeling of Engine Combustion and Fuels: Develop computer simulations and high-fidelity sub-models of engine combustion and fuels, including adaption for future exascale-based high performance computing using facilities at the National Laboratories. Develop detailed models of: fuel injection sprays, intake and exhaust flows, and heat transfer processes; chemical kinetics mechanisms of combustion and fuels; and air-fuel motion and mixing inside an engine along with movement of internal engine components, and numerical techniques to reduce processing time.	• Predictive Modeling of Engine Combustion and Fuels: Reduce funding and complete development of high-fidelity sub-models to accurately predict abnormal combustion events that limit efficiency, adapt simulation tools to future exascale-based high performance computing at the National Laboratories, and utilize artificial intelligence and machine learning to create data-driven models and tools that can be used by industry.	• Focus on simulation capabilities most needed by industry to maximize efficiency and power density while reducing emissions from downsized, boosted engines.
• Lean/Next Generation Combustion Engines and Fuels R&D and Heavy-Duty Combustion Engines and Fuels R&D: Conduct engine and fuels research at National Laboratories using single- and multi-cylinder engines. This work supports fundamental combustion research in optically accessible engines using laser, high intensity X-Ray, and neutron-based diagnostics for fuel injection spray visualization and advanced ignition systems to provide experimental validation for simulation models. Generate chemical kinetics data using a rapid compression machine.	• Commercial Off-Road Engines, Combustion, Fuels and Emission Control R&D: Use advanced experimental research tools at the National Laboratories (e.g., laser, X-ray light sources), single and multi-cylinder research engines, and modeling and simulation tools to improve the understanding of advanced combustion processes and emissions formation inside engines found in off-road equipment. Integrate hybridized/electrified powertrains and renewable biofuels to further improve efficiency and reduce GHG and criteria emissions. Support cost shared CRADAs with industry to address advanced emission control technologies.	• Shift efforts at the National Laboratories to improving the efficiency of off-road engine/powertrains. Increase efforts using single- and multi-cylinder engines for experimental validation of simulation models. Shift focus to reducing emissions from off-road engines and the impact of renewable fuels on catalyst. Shift focus on catalyst for gasoline engine emission control for MD off-road vehicles.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	Conduct research at the National Laboratories on single-atom catalysis and predictive modeling to improve conversion efficiency and reduce need for critical minerals (i.e. platinum group metals) that will reduce the cost of emission control systems.	
• Co-Optimization of Engines and Fuels (Co-Optima): Support projects at National Laboratories, with industry and universities focused on performance tailored bio-derived, synthetic, and petroleum-based blend stocks to improve combustion efficiency in engines. Focus light-duty engine research on multi-mode (kinetically controlled/spark ignition) engine technologies and on determining fuel properties that maximize engine performance under kinetically controlled operation. Investigate kinetically controlled combustion in heavy-duty engines.	• Medium- Heavy-duty Truck Consortium: Capabilities developed in the Co-Optima lab program will be re-focused to support a multi-lab consortium focusing on improving MD/HD engine efficiency, compatibility with renewable fuels, and fuel effects on emission control systems, using experimental data and high performance computing algorithms. Work collaboratively with BETO and HFTO to efficiently use renewable fuels such as advanced biofuels and renewable hydrogen while reducing their impact on emission control systems. Continue development of computer models to simulate the performance of multi-functional emission control systems optimized for multi-mode combustion systems and hybrid/electric powertrains	• Focus effort on MD/HD engines and renewable fuels with hybrid powertrains and their impact on emission control systems.
• Catalyst R&D for Emission Control/After-Treatment: Support four cost-shared CRADAs with industry to address advanced emission control technologies.	• No funding requested.	• Projects will continue using prior year funds until completed.
• Conduct research at the National Laboratories on single-atom catalysis to improve conversion efficiency and reduce precious metal content.	• No funding requested.	• Projects will continue using prior year funds until completed.
• Continue development of computer models needed to produce the kinetics and mechanistic information for simulating chemical reactions within and on catalyst surfaces to predict the	• No funding requested.	• Projects will continue using prior year funds until completed.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
performance of lean NOx trap (LNT) and selective catalytic reduction (SCR) catalysts, as well as advanced multi-functional emission control systems for multi-mode combustion systems and hybrid powertrains.		
Integrated Powertrain Systems Development $35,000,000	$10,000,000	-$25,000,000
• Continue natural gas and propane engine technology R&D focused on reducing vehicle total cost of ownership, improving engine efficiency and emissions, and expanding natural gas and propane engine and vehicle availability through competitively awarded projects with industry and universities.	• No funding requested.	• Projects will continue using prior year funds until completed.
• Continue two cost-shared research projects, competitively selected in FY 2019, that will design and demonstrate lightweight high-efficiency engines that will enable a 25 percent fuel economy improvement and 15 percent powertrain weight reduction relative to a 2015 baseline.	• No funding requested.	• Projects will continue using prior year funds until completed.
• Continue research, through competitively awarded projects selected in FY 2019, FY 2020 and FY 2021 that support improving the vehicle-level energy efficiency of commercial off-road vehicles using fluid power systems that are directly applicable to the agricultural, construction, mining, and forestry sectors.	• Commercial Off-Road R&D: Through cooperative agreements and CRADAs, develop technologies to increase efficiency and reduce emissions while improving the ability to utilize renewable fuels. Integrate hybridized/electrified powertrains to further improve efficiency of the agricultural, construction, mining, and forestry sectors.	• Current projects will continue using prior year funds until completed. Increase focus on improving powertrain efficiency.
• Continue research on opposed-piston two-stroke engines to increase efficiency and reduce emissions through competitively awarded projects to industry-led teams in FY 2020 and FY 2021.	• No funding requested.	• Projects will continue using prior year funds until completed.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• SuperTruck II: Through five competitively-awarded projects selected in FY 2016, develop energy efficient powertrain technologies that will improve commercial vehicle engine efficiency by 30 percent and freight hauling efficiency of heavy-duty Class 8 long-haul vehicles by greater than 100 percent in 2021, compared to a 2009 baseline vehicle, and demonstrate applicability and cost-effectiveness of these technologies to heavy-duty Class 8 regional-haul vehicles.	• No funding requested for SuperTruck II competitive awards.	• SuperTruck II activities will continue using prior year funds until completed.
• SuperTruck III: Competitively select and award industry-led projects focused on improving the energy and operational efficiency of moving freight with medium and heavy-duty trucks. This effort will focus on improving engine efficiency with co-optimized fuels while reducing emissions. This effort will integrate and coordinate work in the areas of electrified driveline systems, powertrain hybridization, materials, vehicle-level technologies, and mobility systems that can reduce fuel consumption through more efficient operation.	• Continue projects selected in FY 2021 to improve engine efficiency and reduce emissions from MD/HD vehicles and incorporate hybridization and electrification. No funding requested for new SuperTruck III competitive awards.	• SuperTruck III activities will continue using prior year funds until completed.
	• Rail and Maritime Engine R&D: Initiate efforts with industry, through cooperative agreements and CRADAs at the National Laboratories, to improve the efficiency of large engines and their ability to utilize renewable fuels such as advanced biofuels and hydrogen to reduce GHG and criteria emissions.	• Increase focus on these modes since they will continue to use engines for several decades and will produce an increasing portion of GHG and criteria emissions as other sectors become electrified.

Description

The Materials Technology subprogram supports the Vehicle Technologies Office goals of achieving 100 percent decarbonization of the transportation sector by 2050. This ambitious goal will be realized through the increased deployment of electric and hydrogen fuel cell vehicles. Materials play an important role in increasing the efficiency of electric vehicles through weight reduction as well as enabling additional functionality such as faster charging and new sensing technologies. Lighter weight vehicle structures and electric drivetrains will require fewer batteries to achieve the same range, which in turn reduces battery cost, material needs, and reduces the greenhouse gas emissions from battery production. Functional materials with improved properties such as electrical conductivity, thermal conductivity, and unique sensing capabilities will enable innovations in charging and autonomous vehicles. The materials and manufacturing methods used to make vehicles also contribute to greenhouse gases and the Materials Technology subprogram supports research, development, and deployment to increase recyclability and reduce the overall embodied energy of vehicles. The Materials Technology subprogram accomplishes its technical objectives through research programs with academia, National Laboratories, and industry.

Subprogram activities focus on the following cost and performance targets, which contribute to Vehicle Technologies program level goals:

- Enable a 25 percent weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2015 baseline at no more than a $5/lb.-saved increase in cost by 2030; and
- Develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing methods resulting in a 25 percent weight reduction in powertrain and suspension components by 2030.

Lightweight Materials: Lightweight Materials supports National Laboratory, academia, and industry-led research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites, and multi-material systems with potential performance and manufacturability characteristics that greatly exceed today's technologies. This includes projects addressing materials and manufacturing challenges spanning from atomic structure to assembly, with an emphasis on establishing and validating predictive modeling tools for materials applicable to light- and heavy-duty vehicles. In FY 2022, a new priority focus area is the reduction of non-exhaust vehicle emissions including tire and brake wear through innovative materials solutions. Changes in composition to brakes and tires could reduce adverse health effects caused by the prevalence of harmful particles near roadways. Another new priority focus area is the development of multifunctional materials to incorporate smart sensing, thermal management, and wiring into structural components to reduce weight and enable innovative vehicle designs. Current focus areas for the subprogram include reducing the cost of polymer matrix composite components, novel manufacturing processes to improve the properties of light metals and maturing new joining technologies for multi-material structures in vehicles towards industry readiness. Polymer composites have the potential to reduce component weight by up to 70 percent but suffer from high raw material and manufacturing costs. Increased used of composites in vehicles requires the development of affordable fiber, matrix, and filler materials, efficient intermediate processes, and manufacturing methods suitable for high volume production. In order to provide the maximum amount of lightweighting, the automotive industry today takes the approach of implementing the right material in the right place. For lightweight metals, this has resulted in the proliferation of new aluminum and steel alloys with specialized properties. Unfortunately, this creates challenges for automakers by increasing the complexity of supply chains, storage of materials, and recycling of scrap metal. Development of scalable processing methods to locally enhance the properties of aluminum and magnesium will eliminate the conflict between optimal lightweighting solutions and manageable production environments. New joining methods will be required in order to incorporate these lightweight composites and tailored property metals into the vehicle assembly. Vehicle weight reduction and efficiency improvement will be enabled by broadening the applicability of individual joining methods, moving lab-scale joining methods towards industry readiness, addressing challenges with adhesion and corrosion, and providing the automotive industry confidence in the quality of dissimilar material joints. The Vehicle Technologies Office has the unique ability to create partnerships among academia, National Laboratories, and all aspects of the industrial supply chain in order to find solutions to these technical challenges that any one entity could not achieve on their own.

Powertrain Materials: Powertrain Materials supports research at National Laboratories, academia, and industry to develop higher performance materials to address the future properties needs of electric and hydrogen fuel cell vehicles to increase efficiency and decrease manufacturing cost, supporting the transition to all electric light duty vehicles by 2035. Research funded through this activity applies advanced characterization and multi-scale computational materials methods, including HPC, to accelerate discovery and early-stage development of cutting-edge structural and high temperature materials for lighter and more efficient powertrains. In FY 2022, a multi-lab research effort for powertrain materials research will support weight reduction and electric powertrain system efficiency improvements for heavy-, medium-, and light-duty vehicles by expanding to address the materials property requirements of challenging components such as inverters, motors, and gear-train using an integrational materials engineering approach to alloy development and innovative production techniques like additive manufacturing. This early-stage research will support the development of new alloys with improved electrical/mechanical properties and enhanced resistance to corrosion/oxidation of components operating in harsh environments such as electrical bus bars, lightweight gears, underbody suspension, and brakes. Current priority focus areas for the subprogram include: (1) lightweight alloys with high fatigue strength for suspension components, (2) high temperature materials for lighter brakes, (3) predictive models for powertrain materials, and (4) Integrated Computational Materials Engineering (ICME) tools that use HPC capabilities, multi-length scale (atoms to components) material models, and boundary layer resolved thermo-kinetic models. The Powertrain Materials portfolio is closely aligned with other Vehicle Technologies subprograms to identify critical future materials needs of next generation high-efficiency powertrains for both heavy- and light-duty vehicles that are beyond current market drivers.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Materials Technology $40,000,000	**$60,000,000**	**+$20,000,000**
Lightweight Materials $33,500,000	$45,000,000	+$11,500,000
• Initiate Joining Core Program Phase 2 research efforts awarded through FY 2020 lab call to broaden the applicability of individual joining methods, move lab-scale joining methods towards industry readiness, and develop Artificial Intelligence and Machine Learning (AI/ML) techniques to ensure quality of dissimilar material joints.	• Support Joining Core Program Phase 2 research efforts to broaden the applicability of individual joining methods, move lab-scale joining methods towards industry readiness, and develop AI/ML techniques to ensure quality of dissimilar material joints.	• No significant change.
• Support polymer composite materials research at the National Laboratories, including the operation of the Carbon Fiber Technology Facility (CFTF) at Oak Ridge National Laboratory (ORNL) and the Composites Core Program targeting core innovation science R&D, and two cost-shared industry led projects competitively selected in FY 2020.	• Support polymer composite materials research at the National Laboratories, including the operation of the Carbon Fiber Technology Facility (CFTF) at Oak Ridge National Laboratory (ORNL) and the Composites Core Program targeting core innovation science R&D, and two cost-shared industry led projects competitively selected in FY 2020.	• No significant change.
• Establish new Light Metals Core Program at the National Laboratories awarded through FY 2020 lab call to research advanced processing techniques to tailor localized microstructure and properties of metal alloys to increase penetration of lightweight metals and address challenges for recyclability.	• Conduct National Laboratory research on lightweight automotive metal alloys (Al and Mg) with tailorable localized microstructure. Focus on local property optimization through mechanical processing rather than chemical alloying addresses challenges for recyclability and simplifies supply chain.	• No significant change.
• Competitively select and award 1-3 projects to demonstrate multi-material joining at an industrially relevant scale on a prototype sub-assembly that represents a weight savings of 160 lbs.	• No funding requested.	• Projects selected in FY 2021 will continue using prior-year funds until completed.
• No funding requested.	• Competitively select and award projects to increase the efficiency of electric vehicles	• New research effort on multi-functional materials including polymer matrix composites

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	through the development of multi-functional materials to reduce the cost, weight, and volume of EV batteries through associated vehicle structural component weight reductions.	will increase efficiency and decrease manufacturing cost of electric vehicles which will support the transition to electric light duty vehicles.
• No funding requested.	• Competitively select and award projects to reduce non-exhaust vehicle emissions including tire and brake wear through innovative materials solutions. Address knowledge gaps in the specific contributions of vehicle non-exhaust emission sources in the U.S. and their health effects.	• New research effort on non-exhaust emissions (tire wear, brake wear, road wear, and stirred up dust) which contribute more particulate matter ((PM2.5) particles than exhaust emissions. Adverse health effects have been correlated to increased exposure to particulate matter that is present near roadways and in urban environments with stop and go traffic, representing an environmental injustice to the communities located in these areas.
Powertrain Materials $6,500,000	$15,000,000	+$8,500,000
• Continue the Powertrain Core Program, a multi-lab research effort, to support five research areas to enable powertrain weight reductions and efficiency improvements over a wide range of vehicle classes, and utilize ICME approach to address materials needs for developing a suite of next generation powertrain materials.	• Focus Powertrain Core Program research tasks on materials development relevant to increased efficiency and decreased manufacturing cost of electric powertrain applications. Advanced characterization tools and computational methods through the National Laboratories will be maintained.	• Expand development and characterization of materials supporting electrification such as lightweight conductors, ferrites, and high Si-steels for electrified powertrains. No new funding for research specific to ICE applications.
• No funding requested.	• Support new National Laboratory research on affordable, recyclable, high conductivity materials for lightweight electric powertrain components.	• Build on previous exploratory efforts at the National Laboratories to manufacture high conductivity materials to address electric vehicle challenges.
• No funding requested.	• Competitively select and award projects to address the materials property requirements of challenging electric vehicle powertrain components such as inverters, motors, and gear-train.	• New research effort to address key challenges in electrical conductivity, thermal conductivity, magnetic materials, and high temperature operation currently limiting advances in electric powertrain and wireless charging.
• Continue two cost-shared research projects, competitively selected in FY 2019 that will design and demonstrate lightweight high-	• No funding requested for existing Lightweight High Efficiency Medium Duty Truck Engine competitive awards.	• Lightweight High Efficiency Medium Duty Truck Engine activities will continue using prior year funds until completed.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
efficiency engines that will enable a 25 percent fuel economy improvement and 15 percent powertrain weight reduction relative to a medium duty 2015 baseline truck engine.		
• SuperTruck III: Competitively select and award industry-led projects focused on improving the energy and operational efficiency of moving freight with medium and heavy-duty trucks. This effort will support work in the areas of electrified driveline systems, powertrain hybridization, and lightweight materials to reduce fuel consumption through more efficient operation.	• Provide the second year of planned funding for projects selected in FY 2021 and support additional awards. Focus to improve freight efficiency and reduce emissions from MD/HD vehicles and incorporate advanced materials for lightweighting, hybridization and electrification.	• Increase support for the RD&D of MD/HD technologies for energy efficient powertrain technologies that will improve commercial vehicles.

Description

The Energy Efficient Mobility Systems (EEMS) subprogram supports research, development, and demonstration of innovative mobility solutions that improve the affordability, accessibility, and energy productivity of the overall transportation system. EEMS leverages emerging disruptive technologies such as connected and automated vehicles, information-based mobility-as-a-service platforms, and artificial intelligence-based transportation control systems to accelerate the transition to a zero carbon-emission transportation future. The EEMS subprogram also develops and utilizes large-scale transportation modeling and simulation capabilities to evaluate the impacts of new mobility solutions across multiple geographies and populations, ensuring that all Americans, especially underserved and energy communities, benefit from the development and deployment of clean transportation technologies.

The EEMS subprogram consists of two primary activities: Computational Modeling and Simulation, and Connectivity and Automation Technology. The subprogram's overall goal is to identify feasible system-level pathways and develop innovative technologies and systems that can dramatically improve mobility energy productivity for individuals and businesses when adopted at scale. The EEMS subprogram has developed a quantitative metric for mobility energy productivity, which measures the affordability, energy efficiency, convenience, and economic opportunity derived from the mobility system. The metric, while encompassing multiple vehicle classes and modes for passenger and goods movement, is used by the subprogram to evaluate success and by the transportation community to inform planning decisions. The EEMS subprogram's target is a 20 percent improvement in mobility energy productivity by 2040 relative to a 2020 baseline.

Computational Modeling and Simulation: The Computational Modeling and Simulation activity includes the SMART (Systems and Modeling for Accelerated Research in Transportation) Mobility National Laboratory Consortium, a multi-disciplinary approach to transportation research that is beyond the scope or capability of a single company or organization, which will assess the energy productivity impacts from future mobility technologies and transportation systems. The current priority is the development, refinement, and deployment of city/regional-scale multi-fidelity transportation system-level models to identify feasible pathways to improve mobility energy productivity, determine the most promising approaches to decarbonize the transportation sector, and assist local decision-makers in planning transportation investments that benefit all segments of their communities.

As part of the Computational Modeling and Simulation activity, the high-performance computing-enabled data analytics effort will use unique National Laboratory capabilities to apply artificial intelligence, machine learning, high-performance computing, and data science tools to improve vehicle and transportation efficiency. This effort supports cross-cutting efforts in Artificial Intelligence and Machine Learning. The exponential growth in available transportation-related data presents opportunities to evaluate and improve mobility and energy efficiency at the city and regional transportation network level. However, challenges exist in management, analysis, and visualization of these large and complex data sets. The EEMS subprogram will complete the development of transportation system optimization capabilities, initiated FY 2021, using data science and strategic computing resources, aimed at solving specific transportation energy challenges faced by cities, states, and regions of the U.S.

The Computational Modeling and Simulation activity also includes the development of core evaluation tools and mobility testbed facilities. This effort will develop and maintain a critical set of experimental evaluation capabilities that support EEMS' research, development, modeling, simulation, and demonstration of advanced vehicles and transportation systems. These capabilities include vehicle and component test procedure development, highly instrumented proof-of-concept hardware evaluation, transportation system controls algorithm validation, high-fidelity physical simulation, and transportation data management.

Connectivity and Automation Technology: Significant opportunities exist to improve mobility efficiency, affordability, accessibility, and convenience through connected and automated transportation system-level solutions. The Connectivity and Automation Technology activity will develop technology solutions that improve the mobility energy productivity of both passenger and freight movement through the development of connectivity, communication, automation, and other

technologies that are enabled by advanced wireless communication networks. EEMS will initiate 2-3 new competitively selected advanced transportation R&D projects to remove technical barriers and accelerate the efficiency and mobility benefits of cooperative driving automation.

In FY 2022, the EEMS subprogram will initiate a new large-scale effort to research, develop, and demonstrate Clean Energy Mobility Solutions for Underserved Communities, leveraging results of both the Computational Modeling and Simulation activity and the Connectivity and Automation Technology area. This new activity will include a variety of mobility solutions, such as improving public transportation (access, affordability, efficiency, convenience), implementing new last-mile services and modes (micromobility, automated point-to-point transportation), and other connected and automated transportation technology solutions for both urban and rural communities. Demonstrations will focus on zero carbon emission/electric transportation solutions and include participation from members of the community to address their specific needs. The overall objective will be to design transportation solutions that meet the needs of various underserved populations, including those in energy communities, and to conduct pilot demonstrations to evaluate their effectiveness.

Energy Efficient Mobility Systems

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Energy Efficient Mobility Systems $45,000,000	**$70,000,000**	**+$25,000,000**
Computational Modeling and Simulation $26,000,000	$30,000,000	+$4,000,000
• Support the validation, refinement, application, and deployment of transportation system models to specific cities and regions, to simulate mobility and energy outcomes across various future transportation scenarios, through projects initiated through the FY 2020 lab call for SMART Mobility 2.0.	• SMART Mobility research will continue, and focus on transportation system model refinement and deployment, experimental validation, stakeholder outreach, model application, and connected and automated vehicle controls development.	• New functionality planned for the SMART Mobility integrated modeling platform will continue, and emphasis will increase on engaging with local departments of transportation and transportation planners to deploy software to multiple geographies and populations.
• Building upon transportation data science and strategic computing capabilities validated in the previous year, initiate three new transportation system optimization projects through the "AI for Mobility" (AIM) lab call, using artificial intelligence and deep-learning techniques to accelerate the pace of solution discovery in mobility planning and operations.	• Continue support for projects selected under the AI for Mobility lab call demonstrating the application of high-performance computing-based artificial intelligence techniques to improve the time, cost, and effectiveness of transportation planning and operations management.	• Existing projects will continue in their final year. No new AI for Mobility projects will be initiated.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Develop, maintain, and apply core vehicle energy consumption simulation and data management tools and lab testing and evaluation capabilities critical to support early-stage mobility research.	• Funding will be provided for core tools development and maintenance, and new investments in National Lab capabilities in mobility simulation and testing will be made.	• Support for core laboratory evaluation and data management activities will continue, as these investments enable mobility research across the subprogram portfolio.
Connectivity and Automation Technologies $19,000,000	$20,000,000	+$1,000,000
• Initiate up to three new competitively selected advanced R&D projects to develop low-cost infrastructure-based enablers for cooperative driving automation, and in collaboration with the Technology Integration subprogram, initiate up to 5 new competitively selected awards to implement energy efficient mobility systems technologies in real-world applications.	• Initiate one competitively selected R&D project focused on using advanced wireless technologies to enabled efficient connected and automated vehicle control systems.	• Focus will shift to connectivity-based solutions using new communication network technologies.
• Testing and model validation work will continue using prior year funds, generating experimental test data of connected and automated vehicle technologies operating in a variety of scenarios.	• Continue previously awarded connected and automated vehicle testing and validation project.	• Existing project will continue with no new projects initiated.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Competitively select and award industry-led projects and/or new laboratory research projects focused on improving the energy and operational efficiency of moving freight with medium and heavy-duty trucks. This effort will integrate and coordinate work in the areas of efficient freight mobility systems, engine and fuels, electrified driveline systems (both battery and hydrogen fuel cell), powertrain hybridization, waste energy recovery, advanced materials, and vehicle-level technologies. This effort will be coordinated with the Fuel Cell Technologies Office.	• Competitively select new projects to improve Medium Duty – Heavy Duty (MD/HD) truck energy efficiency and improve the operational efficiency of freight transportation. New effort will capitalize on work completed in Super Truck II.	• Previously selected projects will continue, with a focus on system-level freight efficiency. Additional selections may be made with FY 2022 funds.
Clean Energy Mobility Solutions for Underserved Communities $0	$20,000,000	+$20,000,000
• No activity in FY 2021 (new investment for FY 2022).	• Support place-based research, development, and pilot demonstrations of connected and automated mobility solutions that provide accessible, affordable, and efficient transportation options for underserved and energy community populations.	• DOE will invest in technologies that enable transportation opportunities for all communities, focusing on those who are currently underserved, including those in energy communities, in support of the Administration's priority for Environmental and Energy Justice.

Vehicle Technologies
Technology Integration

Description

The Technology Integration subprogram covers a broad technology portfolio that includes alternative fuels (e.g., advanced biofuels, electricity, hydrogen, renewable natural gas) and energy efficient mobility systems. The successful deployment of these technologies can support the decarbonization of the transportation sector, strengthen national security through fuel diversity and the use of domestic fuel sources, reduce transportation energy costs for businesses and consumers, address the needs of underrepresented communities, and support energy resiliency with affordable alternatives to conventional fuels that may face unusually high demand in emergency situations. At the national level, the Technology Integration Program offers technical assistance, information resources, online training, and an array of data and analysis tools. At the local level, Clean Cites coalitions leverage these resources to create networks of community stakeholders and provide hands-on technical assistance to fleets.

Technical Assistance: The Technical Assistance activities support projects to provide information, insight, online tools, and technology assistance to cities and regions working to implement alternative fuels and energy efficient mobility technologies and systems. Projects will; demonstrate proof-of-concept of alternative fuel/advanced technology vehicles, charging infrastructure, new mobility systems for goods and people movement and modeling and simulation. For FY 2022, the subprogram will provide funding to support technical assistance activities, including the State and Alternative Fuel Provider regulatory program.

Data Collection and Dissemination: The Data Collection and Dissemination activity will collect and provide objective, unbiased data, information, and real-world lessons learned to inform future research needs and provide fleets and local decision makers with a suite of resources to identify and address technology barriers. This includes projects to disseminate data, information, and insights. For FY 2022, the subprogram will provide funding for the statutory requirements related to the Alternative Fuels Data Center and the annual Fuel Economy Guide.

STEM and Workforce Development: The EcoCar Mobility Challenge challenges 12 university teams to apply advanced powertrain systems, as well as connected and automated vehicle technology to improve efficiency, safety, and consumer appeal. In FY 2022, student teams will complete and implement their vehicle design through hardware development and engineering.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Technology Integration $60,300,000	**$180,300,000**	**+$120,000,000**
Technical Assistance $**49,900,000**	$169,900,000	+$120,000,000
• Complete competitively awarded, prior year funded, Living Lab projects to collect data, validate technology, and provide real-world technology usage feedback to inform Vehicle Technologies research planning efforts.	• No funding requested.	• Projects will continue using prior year funds.
• Track covered fleet compliance with annual alternative fuel vehicle acquisition requirements, in accordance with Title V of the Energy Policy Act of 1992.	• Track covered fleet compliance with annual alternative fuel vehicle acquisition requirements, in accordance with Title V of the Energy Policy Act of 1992.	• No significant change.
• Support the Clean Cities Coalition's cooperative agreements to work in communities across the country to help local decision makers and fleets understand and implement advanced technology vehicles and infrastructure, new mobility choices, and emerging transportation technologies.	• Continue support of the network of Clean Cities Coalitions.	• No significant change, continue to collect and share data, best practices, and lessons learned to inform local decisions and build a strong national network.
• Initiate two to five competitively awarded, small-scale alternative fuel vehicle fleet projects in communities, fleets, or geographic areas with little or no experience with these technologies but where the technology shows economic or efficiency opportunities.	• No funding requested.	• Projects will continue using prior year funds.
• Initiate three to five competitively awarded large-scale Electric Vehicle Charging Community Partner projects to encourage strong local and/or regional partnerships to create an enduring local ecosystem to support increased consumer and business PEV use. Projects are encouraged to demonstrate various PEV applications by concentrating multiple sub-projects in a region or geographic area.	• No funding requested.	• Projects will continue using prior year funds.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Projects for consumers in underserved communities are a high priority.		
• In collaboration with the Energy Efficient Mobility Systems subprogram, initiate three to five competitively awarded projects that focus on the implementation of energy efficient mobility systems technologies into real-world system applications.	• No funding requested.	• Projects will continue using prior year funding.
• No funding requested**.**	• New competitively awarded projects will focus on EV Charger Deployment with States to support the Administration's 500K EV Charging initiative.	• Demonstrate use of charging infrastructure such as innovative charging technology for various types of EV owners (e.g., public charging, multi-family housing, car sharing, ride hailing, goods delivery sectors.
• No funding requested**.**	• New competitively awarded EV Community Partner Demonstrations & Workplace Charging Challenge 2.0 projects.	• These projects will encourage strong local/regional/national partnerships to create an enduring ecosystem to accelerate increased consumer and business EV adoption and to deploy the required charging infrastructure.
• No funding requested.	• New competitively awarded Smart Charging Vehicle- Grid Integration Project.	• Projects will demonstrate smart charging and business models that improve costs and efficiency for the acquisition and operation of new EV models for local governments, utilities, transit, schools, ports, and goods movement.
• No funding requested**.**	• Fund competitively selected projects to engage with regional and local partners, especially underserved and energy communities, on planning, and to develop and demonstrate innovative technologies to enhance community resilience to physical	• Projects will address environmental justice and equity for underrepresented communities, including energy communities.
• No funding requested.	hazards using distributed solar, energy storage, EVs, and other DERs (joint EERE-OE effort). • Funding for Super Truck III demonstration projects.	• The projects will provide real-world validation of new technologies being developed by the Super Truck III teams.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Data Collection and Dissemination $7,900,000	$7,900,000	$0
• In accordance with "Public Information Program" requirements in section 405 of the Energy Policy Act of 1992, update alternative fuel, vehicle, and infrastructure information, including station locator, cost calculator tool, incentives database, and fuel savings strategy information in the Alternative Fuels Data Center.	• In accordance with "Public Information Program" requirements in section 405 of the Energy Policy Act of 1992, update alternative fuel, vehicle, and infrastructure information, including station locator, cost calculator tool, incentives database, and fuel savings strategy information in the Alternative Fuels Data Center.	• No change.
• In accordance with requirements in the Energy Policy and Conservation Act of 1975, publish and distribute the new model year Fuel Economy Guide, in partnership with the U.S. Environmental Protection Agency, update data and tools (e.g. Find-a-Car, Fuel Cost & Savings Calculator) and fuel economy information on www.fueleconomy.gov.	• In accordance with requirements in the Energy Policy and Conservation Act of 1975, publish and distribute the new model year Fuel Economy Guide, in partnership with the U.S. Environmental Protection Agency, update data and tools (e.g. Find-a-Car, Fuel Cost & Savings Calculator) and fuel economy information on www.fueleconomy.gov.	• No change.
STEM and Workforce Development 2,500,000	$2,500,000	$0
• Support to university student competition, "The EcoCAR Mobility Challenge," that provides science and technology training for the future advanced automotive workforce. Support student teams' initial design phase, integrating advanced powertrain technologies, electrification, Level 2 automation, and connectivity.	• Complete the final phase of the EcoCAR Mobility Challenge, during which student teams will implement designs developed in FY 2022 into hardware.	• Provide support to enable student teams to complete vehicle design, development, and engineering.

Vehicle Technologies
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis subprogram provides critical information and analyses to prioritize and inform Vehicle Technologies research portfolio planning through technology-, economic-, and interdisciplinary-based analysis, including target-setting and program benefits estimation. In FY 2022, projects will continue to support analytical capabilities and tools unique to DOE's National Laboratories. For data activities, trusted and public data are critical to Vehicle Technologies efforts and are an integral part of transportation and vehicle modeling and simulation. For modeling activities, the subprogram supports the creation, maintenance, and utilization of vehicle and system models to explore energy impacts of new technologies relevant to the Vehicle Technologies Office portfolio. Finally, for analysis activities, integrated and applied analyses will bring together useful findings and analysis of the energy impacts of transportation systems through the integration of multiple models including vehicle simulation and energy accounting of the entire transportation system. The result creates holistic views of the transportation system, including the opportunities and benefits that advanced vehicle technologies create by strengthening national security, increasing reliability, and reducing costs for consumers and businesses. Overall, Data, Modeling, and Analysis activities explore energy-specific advancements in vehicles and transportation systems to inform Vehicle Technologies' early-stage research and offer analytical direction for potential and future research investments.

Data, Modeling, and Analysis (formerly Analysis)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Enacted vs FY 2021 Request
Data, Modeling, and Analysis $6,000,000	**$6,000,000**	**$0**
• Leveraging analytical capabilities and tools unique to National Laboratories, use vehicle and transportation data and models to conduct technology, economic, and interdisciplinary analyses to inform and prioritize technology investments and research portfolio planning. Funds will support 10 to 12 projects.	• Continue support analytical capabilities and tools unique to National Laboratories, including expanding analysis to identify cost-efficient and equitable transportation decarbonization scenarios to inform and prioritize technology investments and research portfolio planning. Funds will support 10 to 12 projects.	• No significant change.

Bioenergy Technologies

Overview

The Bioenergy Technologies Office (BETO) conducts research, development and demonstration to advance technologies that convert domestic biomass and other waste resources into cost effective, low-carbon biofuels and bioproducts. These technologies can enable a transition to a clean energy economy, create high-quality jobs, support rural economies, and spur innovation in renewable energy and chemicals production as part of the bioeconomy. DOE's investments in cutting-edge technologies designed to produce biofuels and bioproducts are expanding the viability of the Nation's abundant biomass and waste resources including, forest and agriculture residues, municipal solid waste (MSW), trees, switchgrass, and algae. As part of a comprehensive strategy to decarbonize all modes of transportation, BETO is primarily focused on research, development, and demonstration (RD&D) to produce "drop-in" biofuels that are compatible with existing fueling infrastructure and vehicles across a range of transportation modes, including diesel, jet, and marine fuels. The program also supports RD&D on converting biomass into high-value chemicals, products, and power where they can enhance the economics of biofuel production, help grow critical infrastructure to support the bioeconomy and further reduce carbon emissions of the U.S. economy.

Today, the U.S. transportation sector relies almost completely on petroleum, supplying over 90 percent of its energy needs. In 2017, the transportation sector surpassed electricity generation to become the largest source of CO_2 emissions in the country[1]. Aviation, marine, and heavy-duty vehicles account for 34 percent of transportation energy use. Aviation, maritime and heavy-duty vehicle use (on and off-road) are projected to grow considerably faster than other modes and are more difficult to electrify, making drop-in biofuels a near-term option to reduce petroleum use and CO_2 emissions. Based on the joint DOE-USDA "Billion Ton Study," BETO estimates that about 1 billion dry tons/year of biomass can be grown sustainably to produce 50-60 billion gallons of advanced biofuels and 40-50 billion pounds of renewable chemicals without impacting agriculture, trade, and current uses of biomass by 2030. If fully utilized, this is sufficient to meet the projected needs of the U.S. aviation industry, supply fuel for some maritime and diesel applications, and support the need for displacement of petroleum-based chemicals with renewable alternatives[2].

DOE investments can help realize this potential by focusing on innovation in areas that industry either does not have the technical capability to undertake or where there is too much technology uncertainty to merit sufficient industry focus. Cost sharing development and demonstration reduce the risks of market entry and encourage investment from across the industry. The Bioenergy Technologies Office is focused on both the R&D to develop new technologies and the later stage demonstration of that technology to help industry de-risk the scale-up of new bio-fuels.

Highlights of the FY 2022 Budget Request

Bioenergy Technologies funding in FY 2022 will support research, development and demonstration across several crosscutting areas, including:

- Substantially increase the scale-up of promising technical pathways that produce cost effective biofuels with a priority on the production of sustainable aviation fuel (SAF). The major focus of the effort is to construct and operate integrated biorefineries at demonstration scale that are capable of producing SAF. These projects would increase the domestic production of SAF and put the transportation sector on the trajectory for net-zero emissions by 2050, as part of a strategy to decarbonize Transportation. BETO will conduct a down-select from cost-shared projects previously funded, advancing the strongest to construction and new projects will be added to the portfolio to support de-risking and demonstration of production processes for fuels from a variety of domestic biomass and waste feedstocks. The successful scale-up and commercial deployment of these integrated biorefineries could decrease CO_2 emissions by 450 million metric tons (MMT) per year by 2050.
- New initiative using "traditional" biofuels facilities to demonstrate advanced technologies that will reduce CO_2 emissions from 40 percent, to over 70 percent, compared with petroleum. Technologies and practices include low-carbon agricultural practices, fuel switching to renewable process heat and power (i.e., renewable natural gas, or biomass), and new productivity or conversion efficiency measures in order to assess the costs and verify the lifecycle greenhouse gas (GHG) benefits. If these technologies and practices were deployed across the existing U.S. industry, it

[1] https://www.eia.gov/energyexplained/use-of-energy/transportation.php.

[2] https://www.energy.gov/sites/default/files/2016/12/f34/2016_billion_ton_report_12.2.16_0.pdf.

would preserve current biofuels jobs and could reduce GHG emissions by over 42.7 MMT (CO_2-eq) per year – or approximately 2 percent of total U.S. transportation emissions.

- New community-scale, public-private partnerships will be formed to reduce harmful emissions and other environmental issues from operations that produce manure and other wet wastes. Engineering, construction, and operation of up to 2 pilot-scale projects that employ advanced technologies suitable for various community circumstances will be pursued to demonstrate overall potential.
- Initiate an R&D program to study sustainable agriculture practices and help farmers maximize profits on marginal lands while providing valuable feedstocks for bioenergy production. RD&D to develop sensors and tools for soil carbon monitoring and soil carbon enhancement via biochar while enabling carbon credit banking markets and other activities requiring verifiable carbon emission data.

The Bioenergy Technologies Program coordinates its outcome-driven applied R&D activities with the U.S. Department of Agriculture and six other agencies through the Biomass Research and Development Board to leverage resources and avoid duplication across the Federal Government. The program's transformational research and development is fostering partnerships that will support American industry and rural economies, including start-up enterprises, to create new jobs in emerging energy and manufacturing fields ultimately benefiting the U.S. economy and all Americans.

Bioenergy Technologies
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Bioenergy Technologies				
Feedstock Technologies	40,000	40,000	50,000	+10,000
Advanced Algal Systems	40,000	40,000	35,000	-5,000
Conversion Technologies	110,000	110,000	110,000	0
System Development and Integration	60,000	55,500	135,500	+80,000
Data, Modeling, and Analysis	9,500	9,500	9,500	0
Total, Bioenergy Technologies	**259,500**	**255,000**	**340,000**	**+85,000**

SBIR/STTR:

- FY 2020 Transferred: SBIR $8,079,000; STTR $1,367,000
- FY 2021 Projected: SBIR $7,128,000; STTR $1,002,000
- FY 2022 Request: SBIR $10,842,000; STTR0 $1,525,000

	FY 2022 Request vs FY 2021 Enacted
Bioenergy Technologies	
Feedstock Technologies: The increase in funding level for this subprogram reflects the prioritization of the linkage between a sustainable bioeconomy and enabling a net-zero emissions agricultural sector that supports the modernization, security, and resilience of our interconnected food, water, and energy systems. U.S. agricultural soils could increase their soil organic carbon (SOC) content by over 60 million tons per year. Proper monitoring and quantification of this potential is essential to ensure farmers are properly compensated for their efforts and that feedstocks for bioenergy are produced with a lower carbon footprint. Activities include developing tools and remote sensors for soil carbon monitoring, researching the long-term carbon-drawdown potential of biochar, pursuing landscape design analysis, and investigating the feasibility and carbon sequestration potential of sustainable bioenergy carbon capture and sequestration (BECCS) practices, including biomass conversion to advanced fuels and chemicals. The subprogram will continue efforts on characterization, sorting, and preprocessing of municipal solid waste to produce a conversion-ready feedstock and continue funding for the Feedstock-Conversion Interface Consortium to improve the operational reliability of integrated biorefineries.	**+10,000**
Advanced Algal Systems: The reduction in funding level for this subprogram reflects the prioritization of the most critical algal system activities within the broader priorities of EERE and the Department. The subprogram will focus on research and demonstration projects that shows the greatest promise for improving algae productivity, including improving CO_2 utilization efficiency in algae, developing crop protection strategies, and continuing work on strain and cultivation improvements with the goal to make biofuels from algal systems cost competitive.	**-$5,000**
Conversion Technologies: The funding in this subprogram will focus on technologies to produce sustainable aviation fuels (SAF) and co-products and other fuels that can improve viability of SAF production. This includes continued support for the deconstruction of biomass into useful intermediates needed for the production of low carbon fuels and chemicals, via biological and chemical or thermal means. Intermediates will then be upgraded to targeted products using biological organisms, chemical catalysis, or a combination of the two. National Laboratory and competitive R&D in support of the Plastics Innovation Challenge will target plastics with low recycling rates and research that can support plastic reduction and substitution strategies with the greatest impact on greenhouse gas emissions. Co-products R&D will focus laboratory work on predictive model development for performance-advantaged bioproducts and partnering with industry to accelerate adoption of biobased chemicals and materials that can reduce greenhouse gas emissions from the industrial sector while growing the supply chain of biomass feedstocks necessary for fuels production. Funding will be increased for CO_2 conversion and utilization research to further draw down carbon from the atmosphere to create useful end products. Deconstruction and Synthesis R&D will continue to address wet waste streams in support of improved economics and reduced environmental impact. No funding is requested for co-	

	FY 2022 Request vs FY 2021 Enacted
optimization of fuels and internal combustion engines (with the Vehicle Technologies Office) as the National Laboratory Consortium completed its work on on-road vehicles in FY 2021. No funds are requested for competitive awards to produce renewable natural gas, in favor of strategies to produce sustainable aviation fuels and higher-value products.	
System Development and Integration: The significant increase in funding for this subprogram reflects the critical need to integrate, and scale-up, advanced bioenergy technologies to decarbonize all modes of transportation, providing necessary operational data at engineering-scale for commercial deployment. Specifically, competitive awards will be focused on supporting scale-up of biofuel production technologies with an emphasis on sustainable aviation fuels to directly support the Biden Administration priorities, including research, development, demonstration and deployment of innovative technologies and systems that will transition to a 100 percent clean energy economy no later than 2050. Funds will support community scale waste to energy pilots that will improve the negative environmental impact of manure and organic waste disposal on rural communities and improve the CO_2 emissions profile in existing biorefineries. The program will verify R&D to produce drop-in biofuels from biomass feedstocks.	**+80,000**
Data, Modeling, and Analysis: Activities will focus on techno-economic and lifecycle analyses and strategies to achieve price reductions for biofuel and bioproduct production, including analyses of additional pathways to produce sustainable aviation fuels. Activities will also include new analysis to determine the best use of biomass resources to achieve GHG reduction goals in the transportation, industry and agricultural sectors as part of a transition to a 100 percent clean energy economy no later than 2050.	**0**
Total, Bioenergy Technologies	**+85,000**

Description

To produce sustainable aviation fuel targets, the U.S. will need access to many tons of sustainable, conversion-ready feedstocks, including waste feedstocks. The primary goal of the Feedstock Technologies subprogram is to conduct research and development focused on supporting industry as they develop and supply high-quality, energy-dense, and sustainable conversion-ready feedstocks for bioenergy applications. The subprogram achieved the FY 2017 target of a total average delivered cost of $84/dry ton [1] (from $137/dry ton in FY 2014 in 2014 dollars) and will deliver conversion-ready feedstocks for the 2022 verification through the fundamental R&D supported in the Feedstock-Conversion Interface Consortium (FCIC). To best meet the needs of a decarbonized fuel and agriculture sector, the Feedstock Technologies subprogram supports R&D in the following two activities:

Feedstock Supply: This activity includes supply chain analysis and the development of methods to identify, quantify, and mitigate supply chain risk. This activity is expected to increase the type and availability of new cost-advantaged feedstocks into the subprogram portfolio and to lower the cost of producing biofuels and bioproducts. This activity includes work on sustainable agriculture practices, including soil organic carbon sequestration, landscape design, and other climate-friendly soil, agriculture, and forest management work.

Pre-processing R&D: Pre-processing R&D seeks to 1) increase understanding of the fundamental physical properties that govern feedstock behavior, energy density, and conversion performance; and 2) develop new technologies to convert biomass into a more reliably convertible resource. This activity addresses the flowability and abrasiveness challenges that have caused problematic feed handling events at integrated biorefineries. Pre-processing R&D supports the Feedstocks Conversion Interface Consortium (FCIC). The FCIC is a consortium involving eight National Laboratories and is directed toward addressing feed handling issues encountered by integrated biorefineries. Funds also support logistics research activities considered upstream of the interface activities, such as harvest logistics and quality assurance, biomass densification, and biomass analytics tools. Collectively, these activities will lower cost and reduce risk by improving the operational reliability of integrated biorefineries both in terms of reliability of equipment and process operation, as well as reliability of the throughput and quality of finished products coming out of the biorefinery. While this work has historically focused on biomass such as agricultural and woody residues, the Feedstock Technologies subprogram is supporting new work in characterization and pre-processing of municipal solid wastes and plastics to support the Program's broader efforts to use economically-advantaged waste streams as feedstocks for production of fuels, chemicals, and co-products.

[1] Verified in FY 2017 for a modeled potential of 285 million dry tons, accessible at up to $84/dry ton in FY 2022 in a national model.

Feedstock Technologies
(Formerly Feedstock Supply and Logistics)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Feedstock Technologies $40,000,000	**$50,000,000**	**+$10,000,000**
Feedstock Supply $2,500,000	$12,500,000	+$10,000,000
• Support ongoing National Laboratory research on supply chain analysis and developing methods to identify, quantify, and mitigate supply chain risk and mobilization of model woody and herbaceous feedstocks.	• Continue ongoing National Laboratory research on supply chain analysis and developing methods to identify, quantify, and mitigate supply chain risk.	• No change.
• No funding.	• Fund resource assessment analyses at the National Laboratories that build upon the Billion Ton Study and addresses carbon sequestration, environmental justice, climate change, and end uses such as sustainable aviation fuels.	• National Laboratory R&D will produce a series of resource assessment analyses that build upon the Billion Ton Study and addresses carbon sequestration, environmental justice, climate change, and end uses such as sustainable aviation fuels.
• No funding.	• Initiate National Laboratory and competitive R&D on biogenic carbon drawdown, soil carbon sequestration, and bioenergy with carbon capture and sequestration (BECCS).	• National Laboratory and competitively awarded research will focus on the interface of carbon management and how sustainable agriculture and forestry can advance climate priorities.
Pre-processing R&D $37,500,000	$37,500,000	+$0
• Support National Laboratory research under the Feedstock-Conversion Interface Consortium (FCIC) to improve operational reliability of biomass feedstock handling, preprocessing and conversion.	• Continue research under the FCIC to improve the operational reliability of integrated biorefineries through increased understanding of biomass materials and the fundamental physical properties that govern feedstock behavior, energy density, and conversion performance.	• No change.
• National Laboratory R&D will focus on harvest logistics and biomass analytics tools.	• Continue ongoing National Laboratory research on harvest logistics and biomass analytics.	• No change.
• Support competitive awards for industry-led R&D on Characterization of Municipal Solid Waste (MSW).	• Competitive awards on preprocessing MSW to make this waste resource suitable for conversion into fuels and products.	• New competitive awards will seek to address additional barriers to the use of MSW as feedstock for bioenergy production.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Infrastructure and equipment upgrades at the Biomass Feedstock National User Facility at the Idaho National Laboratory.	• Continue planning and implementation of infrastructure upgrades at the Biomass Feedstock National User Facility using prior year funds.	• Prior year funds will support the completion of needed upgrades at the Biomass Feedstock National User Facility; no additional funds are requested.

Bioenergy Technologies
Advanced Algal Systems

Description

The Advanced Algal Systems subprogram supports R&D of algal biomass[1] production and logistics systems, as well as R&D on processes to convert algal biomass to biofuels and co-products. Algal biomass has potential as a domestic energy resource due to its ability to grow quickly, use waste resources (including non-potable water and non-arable land), and produce fuel and co-product precursors from CO_2 and sunlight. Algal biofuels could contribute up to 5 billion gallons of advanced biofuels per year by 2030. This will be a necessary component of the overall domestically derived sustainable aviation fuels needed to decarbonize the aviation sector.

In recent years, DOE funded research has improved capabilities to predict, breed, and select the best-performing algal strains; developed better tools to monitor and control system dynamics; improved methods to harvest algae at high-throughputs; and improved processes to extract and convert more algal biomass components into fuels and high-value co-products.[2] Accordingly, the subprogram activities are oriented towards delivering technologies that, if scaled up by industry, could produce climate-friendly algal biofuels such as sustainable aviation fuel.

In FY 2021, the subprogram increased algal biomass productivity to 19 grams of algae per square meter of cultivation per day, on annual average and an ash-free dry weight basis. This is an increase of 67 percent relative to the 2018 baseline. Increasing algal productivity is a key barrier that the subprogram's R&D seeks to overcome and is directly related to lowering the cost and increasing the GHG impact of algal biofuels. The subprogram is organized in two activity areas to deliver progress.

Strain and Process R&D: Activities related to Strain and Process R&D include early technology readiness level (TRL) work to develop stable algal cultivars that produce high yields, resist predators, and are suitable for cultivation in farming operations. Efforts also include the deep characterization of highly productive and resilient microalgae strains with the overall goal of delivering new robust performers for year-round outdoor cultivation via the "Development of Integrated Screening, Cultivar Optimization, and Verification Research" (DISCOVR) multi-national laboratory consortium. In addition, activities include R&D on harvest and processing considerations for algae biomass and the interface between algae biomass production and the conversion of algae feedstocks to fuels and co-products, including convertibility and targeted fuel and co-product development.

Systems Integration R&D: Activities related to Systems Integration R&D include identifying and addressing gaps in bringing multiple areas of algae R&D together in advanced systems of research-scale technologies, as well as producing reliable and repeatable algal system performance data from relevant outdoor algae cultivation systems to increase the yield of conversion processes making algal biofuels and bioproducts. Additionally, activities in this area integrate the latest technological advances into robust state of technology techno-economic, resource, and life-cycle analyses. This work allows the subprogram to effectively evaluate the agronomy of algae cultivation and strategically target pre-competitive R&D strategies that have the greatest potential to support businesses to successfully pursue larger-scale integration and demonstration.

[1] The term algae refers to microalgae, cyanobacteria (often referred to as "blue-green algae"), and macroalgae (or seaweed).

[2] U.S. Department of Energy. 2016. *National Algal Biofuels Technology Review.* Office of Energy Efficiency and Renewable Energy. Bioenergy Technologies Program. Available at: https://www.energy.gov/eere/bioenergy/downloads/2016-national-algal-biofuels-technology-review.

Advanced Algal Systems

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Advanced Algal Systems $40,000,000	**$35,000,000**	-$**5,000,000**
Strain and Process R&D $37,000,000	$32,000,000	-$5,000,000
• Support the National Laboratory DISCOVR Consortium to integrate bench-to-field research and stress-testing of novel algae technologies.	• Continue support of the DISCOVR Consortium to improve areal productivity and reduce biomass production costs that can be validated at long-term outdoor cultivation testbeds.	• No change.
• National Laboratory research on resource use and sustainable designs in algae cultivation (including addressing harmful algal blooms) with bioenergy systems to align these systems with cost and quality goals for algae biomass.	• R&D on technologies and strategies to integrate algae biomass technologies with municipal wastewater treatment to increase the energy efficiency and lower the costs of treatment while also enabling consistent yields of algal biomass.	• No change.
• National Laboratory research on applications of foundational genomics for algae strains to harness algal diversity towards meeting subprogram targets for productivity and quality.	• Continue National Laboratory research on strain and process R&D.	• National Laboratory research will focus on strategies to meet harvest and conversion targets established in previous state of technology assessments.
• Competitive awards on Algae productivity to increase productivity by 20 percent by 2025 while meeting composition requirements.	• Competitive awards on developing new strategies for crop-protection to prevent pond crashes.	• Competitive awards will focus on new strategies for algae crop protection and demonstrating algae cultivation with high CO_2 utilization efficiency.
• Competitive awards on increasing algae productivity by 20% while supporting carbon dioxide capture from the atmosphere into highly alkaline solutions using algae-to-energy technologies.	• No funds are requested for additional competitive awards to increase algae productivity with direct air capture technology.	• Reduced funding for direct air capture technologies in light of previous investments, the low technology readiness and the high cost of these technologies in favor of addressing critical barriers to reduce cost and improve viability of algae to accelerate the production of sustainable aviation fuels and bioproducts.
System Integration R&D $3,000,000	$3,000,000	+$0
• State of technology cultivation trials to verify progress towards productivity improvements using indoor simulations.	• State of technology cultivation trials will continue.	• No change.

Description

The Conversion Technologies subprogram pursues applied R&D to generate knowledge that supports industry efforts to demonstrate and deploy technologies for converting biomass feedstocks into transportation fuels and co-produced bioproducts. Conversion research explores concepts in both biological (using biological organisms) and thermochemical (using heat, pressure, and chemical processes) routes to convert biomass, waste feedstocks, and other complex organic polymers into "drop-in" biofuels (sustainable aviation fuels, marine fuels, and legacy fuels such as diesel), fuel components, and chemical intermediates.

In recent years, there has been a growing urgency to address the carbon emissions from hard to electrify modes of transportation, which include aviation fuels. Given the diversity of biomass resources, there is no single, superior conversion process or pathway to use to convert all the biomass and waste streams across America. Therefore, the program conducts applied research on a portfolio addressing technical challenges that support promising feedstock-flexible conversion technologies that can produce cost effective low-carbon drop in fuels to meet market demand. This research lowers technology uncertainty and establishes a knowledge base that supports industry to demonstrate and deploy novel technology for their unique market opportunities. This applied research supports multiple possible biorefinery configurations that industry may pursue. For example, improved organism development could improve the viability of direct conversion of cellulosic sugars to fuels and co-products and/or add value to a thermal conversion process by converting a current waste stream to a fuel and co-products.

Bio-Processing R&D: The goal of this activity is to reduce the time and cost for developing and implementing biological conversion of biomass and other materials into useful fuels and products. This includes organism development, metabolic pathway engineering and optimization, and novel approaches such as cell-free biocatalysis. One component of this effort, the Agile Biofoundry (ABF) consortium, is seeking to industrialize synthetic biology tools and machine learning to develop a Design-Build-Test-Learn infrastructure, accessible to all, that will reduce the time and cost to develop an industrially-relevant host organism producing a user-defined target molecule. This will substantially reduce the time, and up-front investment required to bring new fuel and product molecules to market with improved conversion efficiencies. The ABF consortium consists of several DOE National Laboratories and industrial partners guided by an Industrial Advisory Board.

Catalysts R&D: The goal of this activity is to significantly reduce the time and cost required to develop new catalysts for converting organic molecules derived from biomass and other relevant feedstocks via inorganic catalysis into fuels, chemical intermediates, and products. This is being accomplished through advanced chemical and surface characterization techniques, novel and advanced catalyst preparation strategies, numerical modeling of surface chemistry and mass and heat transfer, and understanding the performance and cost implications of various catalytic materials, support structures, and preparation methods. A principle implementing entity for the effort is the multi-lab ChemCatBio (CCB) consortium. Additionally, advanced numerical modeling techniques for computational chemistry and fluid dynamics are being developed to address numerous challenges in the bioenergy space related to the design and operation of processes and equipment in an integrated biorefinery. This activity also undertakes research into electrocatalytic conversion of carbon-dioxide (CO_2) to intermediates and use of chemical catalysis to convert those intermediates to fuels, chemicals, and bioproducts.

Co-Products R&D: This activity focuses on employing the rich, functional nature of biomass to produce value-added and performance-advantaged bioproducts to enhance the economic feasibility of biorefineries, supporting lower carbon alternatives for the chemical industry. The lignin valorization activity focuses on novel chemical, enzymatic, and biological techniques to decompose and re-assemble the lignin component of biomass into useful and valuable chemicals and materials. Since lignin comprises approximately one third of biomass by mass, valorizing this material is essential to the economic viability of many biorefineries. The Performance Advantaged Bioproducts activity focuses on developing chemicals and materials from biomass, such as new polymers designed for recyclability, that perform better in their target applications than the current incumbents derived from petroleum. In addition, since biomass is highly originated relative to petroleum feedstocks, performance advantaged bioproducts may not only provide improved function but also require less energy to produce than incumbent petroleum-based polymers. The activity is developing structure-function relationships, models as well as artificial intelligence and machine learning to assist in prospecting for these biobased products as well as

working with ABF and CCB to develop synthesis pathways for creating them. Early successes include plastics with decreased gas permeability and increased Ultra-Violet resistance. These value-added products can contribute significantly to the economic viability of biorefinery and biofuel processes.

Deconstruction and Synthesis R&D: This activity examines and develops more efficient and effective technologies to convert biomass to fuels and products via well-defined conversion technology pathways. The Deconstruction and Synthesis activity investigates more energy efficient and cost-effective techniques for disassembling biomass feedstocks, separating the constituents, and identifying catalytic, biochemical, and hybrid pathways for synthesizing desired end products using the organisms and catalysts developed elsewhere in the Program. Additionally, this activity includes development of novel techniques for process measurement and control to benefit the R&D and industry.

Waste or residue materials represent a widely available and relatively affordable feedstock for the production of fuels and products. As well, many wastes such as animal waste, food waste, municipal solid waste (including plastics), and biosolids represent significant environmental challenges. The Waste-to-Energy component of this activity examines technologies to efficiently and economically convert these wastes and residues into useful and valuable products including biofuels and bioproducts while also improving the quality of discharged water and reducing environmental impacts from these materials, which are often located in disadvantaged urban and rural communities.

Separation processes can represent up to 40 percent of the capital and energy cost for many processes. Many separation techniques currently in use are either unsuitable for application to biobased processes or require one-off and trial and error approaches, which is costly and time consuming. The Bioprocessing Separations consortium under this activity is developing novel separation techniques specific to biorefineries.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Conversion Technologies $110,000,000	**$110,000,000**	**+$0**
Bio-Processing R&D $28,500,000	$31,500,000	+$3,000,000
• Agile BioFoundry consortium to accelerate the R&D of new biologically-derived molecules through the completion of ≥ five cycles of Design-Build-Test-Learn (DBTL) on ≥ three target host pairs with at least 100 percent improvement in baseline titer, rate, and yield, including competitive selections for industry and academic partners.	• Agile BioFoundry consortium will support acceleration of biotechnology R&D by achieving > 5x DBTL cycle efficiency gains. Three hosts will be developed to produce 15 strategic beachhead molecules. Production will be demonstrated at industrially relevant titers, rates, and yields, and support collaboration projects for industry to utilize capabilities of the Agile BioFoundry.	• Funds prioritize industrially-relevant beachhead molecules that provide a flexible platform for industry to produce a wide range of products.
• Continued improvements to processes for producing cellulosic sugars and organisms for the biological upgrading of sugars and other intermediates via acid and diol pathways.	• Biochemical conversion research and development will focus on conversion of lignocellulosic biomass to upgradable intermediates. These intermediates will prioritize molecules that can readily be upgraded to sustainable aviation fuel and co-products that improve the economic and environmental profile of the biorefinery.	• R&D will increase focus on intermediates most suitable for conversion to sustainable aviation fuels. Other process configurations will also be examined to potentially reduce the number and scale of R&D barriers to be overcome.
• No funding for competitive awards.	• Competitively-selected awards to improve the economic viability of fermentation and other biological processes by improving the productivity and robustness of the engineered microorganisms via improving the understanding of microbial performance at a single cell resolution.	• Competitive awards will build upon Lab research to improve understanding why organisms lose viability or productivity during a fermentation.
Catalyst R&D $16,500,000	$31,500,000	+$15,000,000
• ChemCatBio National Laboratory consortium research on catalytic upgrading of intermediates from indirect liquefaction and biochemical processing, CO_2, catalytic fast pyrolysis, catalyst synthesis and characterization, and computational physics and chemistry for faster, less-expensive development of catalytic processes, including partnerships with industry to	• Continue research under the ChemCatBio consortium to develop new catalysts with higher conversion efficiencies, selectivity and longer lifetimes to reduce costs of catalytic upgrading of intermediates from indirect liquefaction and biochemical processing, CO_2, and catalytic fast pyrolysis. Funding will support computational modeling and simulation, as well as publicly-	• ChemCatBio activities will prioritize research for the production of sustainable aviation fuels, including upgrading syngas intermediates, CO_2 utilization strategies, and R&D to identify and mitigate catalyst deactivation mechanisms.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
address challenges in developing new catalyst technologies.	available tools and databases to support catalyst development and commercialization.	
• Funding for partnerships between National Laboratories and industry to evaluate and develop technologies for conversion of CO_2 to useful end-products including fuels and chemicals.	• Expand funding for National Laboratory research to convert CO_2 to fuels and chemicals.	• Research will investigate the important feedstock and system requirements, the carbon intensity and energy efficiency of these CO_2 utilization strategies.
Co-Products R&D $15,500,000	$24,000,000	+$8,500,000
• Initiate the fully-realized National Laboratory consortium and competitive funding for innovative technologies for plastics recycling and up-cycling (Bio-Optimized Technologies to Keep Thermoplastics out of Landfills and the Environment, BOTTLE), and launch partnerships with industry and academia, with a focus on the most abundant synthetic polymers, as well as novel biological plastic degradation technologies. Support competitive awards on plastics recycling and new biobased plastics for multilayer films.	• Continued funding for National Laboratory plastics BOTTLE consortium to include pilot-scale testing for recycled plastic upgrading/upcycling processes and novel mechanisms for biodegradation. Funding would support joint competitive awards with the Advanced Manufacturing Office for industrial partnerships to improve recycling for plastics numbers 3-7.	• No change in funding, however there will be an Increased emphasis on technoeconomic and lifecycle analyses to focus efforts on plastic reduction and substitution strategies with the greatest impact on greenhouse gas emissions and targeting plastics with low recycling rates.
• National Laboratory R&D will synthesize and verify the predicted performance for at least one performance-advanced bioproduct.	• Lab Direct R&D will focus on further developing artificial intelligence and machine learning to identify target bio-based molecules with enhanced properties. Funding will support partnerships with industry to transition higher TRL work on low carbon footprint biopolymers, such as bio-polyethylene (BioPE).	• Increased emphasis on industry partnerships to increase adoption and scale-up of advanced, high-value bioproducts to reduce greenhouse gas emissions from chemicals production and grow the supply chain of biomass feedstocks. BioPE is fully compatible with current industry infrastructure, which could lead to rapid deployment of this carbon negative alternative to certain traditional plastics.
• Lignin valorization research at the National Laboratories that will focus on a single potential pathway to convert at least 50 percent lignin stream to upgradeable intermediates and investigation of novel feedstocks including those derived electrocatalytically.	• Lignin valorization research will continue to pursue production of upgradable monomers and dimers as well as alternate pathways for conversion to fuels.	• Research on converting lignin to co-products will be de-emphasized in favor of lignin conversion to biofuels.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Deconstruction and Synthesis R&D $49,500,000	$23,000,000	-$26,500,000
• National Laboratory-based research on pretreatment, process hydrolysis and integration of these unit operations into functional bench-scale systems.	• Continue National Laboratory biochemical conversion R&D with focus on conversion of lignocellulosic biomass to upgradable intermediates.	• Prioritize molecules that can be upgraded to sustainable aviation fuel and co-products that improve the economic and environmental profile of the biorefinery. De-emphasize pathways for deconstruction of biomass into intermediate sugar and lignin fractions.
• National Laboratory research on conversion of wet wastes to energy and modeling and analysis of these systems.	• Continued National Laboratory research on techniques and methods to derive additional value from and improve the economics of waste-to-energy systems through production of liquid fuels (including for aviation), and co-products.	• National Laboratory efforts will supplement additional funding for pilot-scale demonstration of promising wet waste conversion technologies (under Systems Development and Integration subprogram).
• National Laboratory research under the Bioprocessing Separations Consortium to reduce cost and increase efficiency of separations for thermochemical and biochemical processes through experimentation and modeling.	• Continue National Laboratory research under the Bioprocessing Separations Consortium to enable comprehensive and scalable bioprocess development with a focus on technologies and barriers identified as most central to value-added chemicals and fuels including separation of organic acids for conversion to aviation fuels.	• Separations research will focus on pathways and technologies for the production of sustainable aviation fuels.
• Complete research by the National Laboratories under the Co-Optima initiative on R&D and related analysis on biofuel candidates to support fuel economy and efficiency targets for advanced compression ignition (ACI) engines used in medium- and heavy-duty vehicles.	• No funds are requested for work on the co-optimization of fuels and engines.	• BETO and VTO are completing the last phase of work under Co-Optima in FY 2021. The funds will transition to higher priority activities supporting cost effective sustainable aviation fuels.
• Competitive awards for industrial partnerships to produce and demonstrate suitability of clean cellulosic sugars.	• Additional competitive awards to further the availability of inexpensive cellulosic sugars that also achieve the same conversion performance (by organisms or catalysts) as starch-derived sugars.	• No change.
• Competitive funding for industrial partnership to develop and demonstrate advanced separation technologies for the production of fuels and other useful intermediates including from anaerobic digestion processes.	• BioSep consortium research will continue research on critical separation technologies and strategies to improve the economics of community-scale and other digesters.	• National Laboratory separations research will continue to focus on strategies to reduce cost of sustainable aviation fuels and enabling co-products.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Competitive funding for development and piloting of technologies to produce renewable natural gas as well as community assistance in assessing local waste resources and their potential for energy production.	• Expand National Laboratory technical assistance to communicate, assess and determine best uses for local waste resources. No funds are requested for new competitive awards for renewable natural gas production.	• Competitive awards on renewable natural gas technologies will continue using prior year funds. In FY 2022, efforts will focus on other fuel and product strategies, including sustainable aviation fuels.

Bioenergy Technologies
Systems Development and Integration

Description

The Systems Development and Integration subprogram supports research, development, and demonstration with partners in industry, academia, and the National Laboratories to reduce technology risk and enable industry scale-up of integrated biorefinery systems for the production of biofuels, biopower, and bioproducts, with an emphasis on sustainable aviation fuels. This subprogram focuses on the development, testing, and verification of engineering-scale research and development for integrated biorefinery process performance, development of novel methods to expand end-user acceptance of biofuel and bioproducts, and identification of new, robust market opportunities in the future bioeconomy.

Production Process R&D: The Production Process R&D activity develops, tests, and verifies engineering-scale R&D for integrated biorefinery process performance to reduce technology uncertainty. This work also supports cost-shared pre-pilot, pilot- and demonstration-scale biorefinery projects with industry, as well as investments in the DOE National Laboratories to support these scale-up activities. Through portfolio assessment and project reviews of prior, smaller scale work, this activity area will identify existing capital engineering-scale resources and initiate implementation of necessary improvements.

Fuels and Co-Products R&D: The Fuels and Co-Products R&D activity area will identify fuel properties that can enhance engine efficiency and reduce emissions for multiple end uses, including medium- and heavy-duty vehicles and non-road applications (e.g., aviation, marine), enabling new, robust market opportunities. This activity area will identify high performance, biofuel blendstocks that impart these desired properties and develop novel methods to expand end-user acceptance of biofuels and bioproducts. This activity area includes work in partnership with the Vehicle Technologies Office, other government agencies and external stakeholders to address R&D challenges at the fuel-engine interface and barriers to the deployment of new fuels for use in on-road and non-road applications, such as fuel testing and certification.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Systems Development and Integration $55,500,000	**$135,500,000**	**+$80,000,000**
Production Process R&D $53,000,000	$130,500,000	+$77,500,000
• Competitive awards to support scale-up of biofuel production technologies with a focus on sustainable aviation fuels to directly support the Biden Administration priorities through decarbonization of the transportation sector, supporting a 100 percent clean energy economy no later than 2050.	• In support of DOE strategies to decarbonize all modes of transportation, expand competitive awards to support scale-up of biofuel production technologies with a focus on sustainable aviation.	• Significant budget increase is required to support large pilot- and demonstration-scale projects; these cost-shared projects with industry will be essential to reducing risks and commercializing new sustainable aviation fuels.
• National Lab research and development to lower risk and enable scale-up of integrated systems to produce biofuels, bioproducts, and biopower.	• National Laboratory funding will focus primarily on process development units to verify R&D to produce drop-in biofuels from biomass feedstocks. Additional Laboratory funding will focus on technologies related to improving performance of lab capabilities to support technology scale-up, as well as the development of aviation and marine biofuels.	• Lab Direct R&D will focus on equipment and research.
• No funding.	• Support for new competitive awards with industry to demonstrate technologies and strategies to reduce greenhouse emissions from existing biofuel production, including implementation of sustainable agricultural practices and measures to improve efficiency or reduce emissions from fuel production.	• New competitive awards will increase understanding of the costs and benefits of sustainable bioenergy measures for decisionmakers.
• No funding.	• Support for new competitive awards with industry to demonstrate waste-to-energy technologies, targeting manure and other organic wastes suitable for community circumstances. These technologies will be replicable, reduce waste as well as nitrogen,	• New competitive awards will support communities with waste issues providing solutions that support community development with energy solutions.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	phosphorus and potassium often found in these waste streams.	
• Competitive awards to support the development and testing of low-emission, high efficiency, and cost competitive residential wood heaters.	• Lab Direct support to develop, design and launch a wood heater design challenge in partnership with industry.	• Competitive awards to develop and test wood heaters will continue using prior year funds. In FY 2022, efforts will focus on stakeholder engagement to inform a new wood heater design challenge that would take place in FY 2023.
Fuels and Co-Products R&D $2,500,000	$5,000,000	+2,500,000
• Complete research by the National Laboratories under the Co-Optima initiative on R&D and related analysis on biofuel candidates to support fuel economy and efficiency targets for advanced compression ignition (ACI) engines used in medium- and heavy-duty vehicles, including competitive selections to transition R&D to industry and academia.	• No funds are requested for work on the co-optimization of fuels and engines.	• The National Laboratory Consortium research under Co-Optima is completed; biofuel candidates will be pursued through separate investments in the RD&D portfolio.
• No funding.	• Support R&D and analysis, in coordination with the U.S. Department of Agriculture, Department of Transportation and other Biomass R&D Board agencies to accelerate the commercialization of Sustainable Aviation Fuels.	• New initiative in support of interagency efforts to advance the domestic production and use of Sustainable Aviation Fuels.

Bioenergy Technologies
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis subprogram activities provide quantitative analysis to inform the Bioenergy Technologies Office's decisions regarding the future direction and scope of its research, development and demonstration (RD&D) portfolio. Activities include techno-economic, life-cycle, resource, impact, and risk assessments that provide the analytical basis for planning and assessing progress against program goals and cost targets. System-level analyses identify the key gaps in existing knowledge and where additional research could have the greatest impact. Decision support, data management, and analytical tools allow the program to identify and verify performance goals and measure progress toward these goals. The subprogram plays a key role in determining the most efficient ways to use bioenergy technologies to achieve the largest greenhouse gas (GHG) emissions reductions for the least cost.

The subprogram's sustainability activities are focused on developing science-based strategies to understand and enhance the environmental and socio-economic benefits of advanced bioenergy and bioproducts, while minimizing potential negative impacts. This includes research targeting underproductive aspects of agricultural and forestry systems and leveraging the ability of biomass to improve degraded soil and water resources. Sustainability research also fills critical knowledge gaps about how to increase bioenergy production without detriment to food security, air, land, and water resources.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Data, Modeling, and Analysis $9,500,000	**$9,500,000**	**+$0**
• Begin development of analysis for additional GHG reduction potential in each current BETO State of Technology pathway, as well as widely used industrial pathways, to accelerate progress toward a 100 percent clean energy economy no later than 2050.	• Continue analyses on current State of Technology and industrial pathways to optimize for GHG reduction and other key environmental factors, identifying strategies to accelerate progress toward a 100 percent clean energy economy no later than 2050.	• Analysis on additional pathways and feedstocks will be needed to achieve pathways capable of supplying SAF to meet aviation sector needs, as well as, other decarbonization goals.
• Conducted supporting analysis for the Co-Optima Program on biofuel candidates to support fuel economy and efficiency targets for advanced compression ignition (ACI) engines used in medium- and heavy-duty vehicles.	• No funds are requested for this effort.	• Analysis work to support the Co-Optima program has been completed.
• No funding.	• Issue a National Laboratory call topic to best understand how bioenergy technologies can support administration priorities in equity and environmental justice.	• Analysis work will provide insights to direct R&D portfolio in meeting the objectives of equity and environmental justice.
• No funding.	• Conduct analysis to determine the best use of biomass resources to achieve GHG reduction goals including determining which processes can reduce emissions the most for the lowest cost.	• Biomass can meet needs in reducing GHG emissions from the transportation, industry, and agriculture sectors. This analysis will examine the most impactful use of biomass to meet the administration goal of a 100 percent clean energy economy by 2050.
• Updated models and tools (including Greenhouse gases, Regulated Emissions, and Energy use in Transportation, GREET, Water Analysis Tool for Energy Resources, WATER and Feedstock Production Emissions to Air Model, FPEAM) and apply them to conduct high-priority National Laboratory sustainability	• Update models and tools (including GREET and WATER) to continue high-priority sustainability research and analyses.	• No change.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
research and analyses to identify and fill knowledge gaps related to land and water resources.		
• Bioenergy sustainability research by the National Laboratories to identify and fill knowledge gaps related to land and water resources.	• Bioenergy sustainability research by the National Laboratories to quantify environmental and social sustainability benefits and identify and fill knowledge gaps related to land and water resources.	• Increase emphasis on social sustainability benefits.

Hydrogen and Fuel Cell Technologies

Overview

Hydrogen and fuel cell technologies are part of a comprehensive portfolio of solutions needed to address the climate crisis and position America as a global leader in clean energy technology and clean energy jobs, as well as provide benefits to all Americans. The versatility of hydrogen as a clean-energy carrier across applications offers opportunities to address priorities in the Administration's clean energy plan through affordable carbon-free hydrogen to address hard-to-decarbonize applications across sectors. In transportation, the use of hydrogen-powered fuel cells in heavy-duty fleets offers one of the most promising opportunities to reduce emissions while meeting long driving-range and short refueling-time requirements. Heavy and medium duty vehicles, including trucks and buses, utilizing hydrogen fuel cells offer zero tailpipe emissions and opportunities to reduce local pollution, particularly to address environmental justice and equity in regions that may typically have poor air quality. In the industrial and chemical sectors, steel manufacturers, fertilizer producers, and producers of liquid fuels – such as sustainable aviation fuels – are increasingly turning to clean hydrogen as one of the few means to achieve their decarbonization goals. Emissions-free technologies in such industries can also address environmental justice in certain regions of the country, and hydrogen technology deployments can support good paying jobs in new clean energy industries. In the power sector, integrated hybrid energy systems coupling variable renewable generation sources such as solar and wind with baseloads like nuclear, are looking to hydrogen and fuel cell technologies for energy storage and grid services such as voltage and frequency stabilization. Grid resiliency as well as accelerated decarbonization of the power sector, transportation, and industry, are primary drivers, aligned with the Department's strategic priorities. Finally, hydrogen can offer the potential for long-duration energy storage, a key enabler to renewables and achieving the Administration's goal for a carbon-free grid by 2035.

The role of the Hydrogen and Fuel Cell Technologies Office (HFTO) is to drive the research, development, demonstration, and deployment (RDD&D) of innovative technologies to facilitate widespread adoption of hydrogen and fuel cell technologies across sectors. This can be achieved by reducing the cost, improving performance and durability, demonstrating, and deploying technologies, and addressing safety, codes, standards, and workforce development. Producing affordable clean hydrogen is a key priority in conjunction with enabling diverse end uses including grid integration and energy storage; transportation (e.g., trucks, marine, rail, aviation); chemicals (e.g., ammonia, synthetic fuels); industry (e.g., iron and steel making); backup power (e.g., emergency power, data centers); and others. HFTO has established application-specific targets relevant to the affordability of these options, considering expectations regarding cost and performance for different markets. These efforts will help pave the way for low-greenhouse gas (GHG) emissions and hydrogen-powered fleets that are affordable and attractive to the consumer.

The HFTO portfolio comprises core materials-, components-, and systems-level research, development, and demonstration (RD&D) in fuel cells and hydrogen production, storage, and distribution technologies; as well as deployment projects targeting scale-up and affordability of integrated energy systems essential to H2@Scale[1]. Additional supporting activities include efforts to reduce vulnerabilities and build supply chain resilience (e.g., in rare earth and critical minerals used as catalysts in fuel cells and electrolyzers); accelerate RD&D through machine learning and -high-performance computing; build and strengthen the STEM (Science, Technology, Engineering and Mathematics) workforce in the hydrogen and fuel cell communities; and prioritize investments that facilitate and strengthen multisector partnerships consistent with H2@Scale. In addition to its collaborative partnerships with the National Laboratories, HFTO also drives strategic coordination with other DOE offices (such as Fossil Energy and Nuclear Energy), Federal agencies, state and local governments, industry, and non-governmental partners. A key focus of these partnerships remains on environmental justice to ensure that the economic and environmental benefits of HFTO investments are available to disadvantaged communities (underserved or pollution over-burdened communities). HFTO investments also focus on building a trained workforce, creating energy-focused jobs, and advancing diversity in STEM within hydrogen and fuel cells industries.

[1] H2@Scale is a concept that explores the potential for wide-scale hydrogen production and utilization in the United States to enable resiliency of the power generation and transmission sectors, while also aligning diverse multibillion dollar domestic industries, domestic competitiveness, and job creation.

Highlights of the FY 2022 Budget Request

- Fuel Cell Technologies will focus on applied fuel cell component and systems RD&D with potential for both transportation and crosscutting applications, such as reversible fuel cells, to meet application-specific targets. In FY 2022, a key focus area will be the Million Mile Fuel Cell Truck consortium (M2FCT), which includes National Laboratories in partnership with universities and industry to accelerate RD&D that would enable a fuel cell durability of a million miles –a market requirement for long haul trucks. The main shift in FY 2022 is from early-stage research to accelerating RD&D to enable an affordable fuel cell system cost. The cost and durability R&D are also applicable to fuel cells for stationary markets enabling resiliency and potential future deployment in disadvantaged communities and in poor air quality regions to address environmental justice priorities. In addition to materials and components R&D, there will be increased focus on systems design and integration to accelerate progress towards deployable systems. Such systems and systems integration work includes stacks and innovative balance of plant (BOP) components and systems. Efforts on fuel cell stack components (e.g., membranes, catalysts, membrane electrode assemblies, gas diffusion layers) and component integration will enable meeting targets for fuel cell performance and durability across applications. Activities will include manufacturing and standardization approaches to strengthen the domestic supply chain, enabling economies of scale across applications (e.g., trucks, maritime, rail, mining/construction, datacenters, reversible fuel cells, and energy storage).

- Hydrogen Technologies will emphasize applied RD&D related to materials, components, systems, and process development to enable deployment of commercially viable, low, or zero-carbon hydrogen production, storage, and infrastructure technologies. The main shift in FY 2022 is from early-stage materials research to accelerated target-driven RD&D to enable affordable hydrogen cost of from electrolysis. To support the H2@Scale initiative, activities include RD&D on clean hydrogen production, delivery, and storage, including materials development, and integration with diverse generation sources. Hydrogen production will focus on RD&D to enable high-performing, durable, cost-competitive technologies, including low and high-temperature electrolysis, photo-electrochemical, and solar-thermal hydrogen production. Hydrogen storage efforts will focus on applied RD&D on advanced storage technologies for stationary and mobile applications offering high-energy density at lower pressures and higher round-trip efficiencies compared to today's systems, as well as reducing costs of carbon fiber tanks. In FY 2022, increased emphasis will be on electrolysis through the H2NEW consortium established in 2021, which includes National Labs, industry, and academia in a cohesive, concerted effort to meet electrolyzer cost, efficiency, and durability targets. RD&D will continue chemical carriers, materials-based and advanced innovative hydrogen storage technologies, hydrogen liquefaction, compression, and dispensing, as well as materials compatibility, particularly with hydrogen blends. Activities will be coordinated with other offices within DOE involved in hydrogen.

- Systems Development & Integration RD&D will be focused on hybrid systems, grid integration, heavy-duty trucks, and energy storage of hydrogen to enable grid stability/resiliency, avoid curtailment, and produce low-cost, green hydrogen. This work will involve integration of megawatt-scale electrolyzers coupled with either nuclear baseload power or intermittent renewables (e.g., wind/offshore wind, solar, etc.) to produce green hydrogen. Within chemical and industrial processes, RD&D will be focused on demonstrating use of green hydrogen as a feedstock or direct reducing agents to decarbonize ammonia and steel production. Within transportation, RD&D will accelerate long-haul, medium- and heavy-duty fuel cell electric trucks operating on clean hydrogen to reduce emissions and improve the energy and operational efficiency of moving freight. This will include hybridization strategies such as fuel cell range extenders as well as hydrogen fueling. In addition, new market opportunities for hydrogen and fuel cells across applications such as data centers, marine, rail, and agricultural/mining equipment will continue to be evaluated. This subprogram also includes RD&D to demonstrate novel technologies related to the production, delivery, storage, and end use of hydrogen and provide feedback to the R&D subprograms. Finally, the subprogram will enable the development of codes and standards with an emphasis on large-scale hydrogen applications as well as developing and sharing best practices on hydrogen safety. State and regional engagement to support environmental justice, as well as diversity, equity, and inclusion, particularly related to training and workforce development, will be a priority in these activities.

- Data, Modeling and Analysis is focused on analytical research that provides a technical basis for informed decision making for the program's R&D direction and prioritization. Results from this activity also support annual updates to key planning documents that provide direction and milestones for the program, including peer reviews, and supports a Federal advisory committee. State and regional engagement, particularly on analyses of co-locating high volume production and end use of hydrogen, will be a key priority. Analyses on life cycle emissions reduction will also be coordinated with other relevant DOE offices such as the Office of Fossil Energy.

Through the above activities, the program supports the following strategic priorities: decarbonizing transportation; enabling a carbon pollution-free electricity sector no later than 2035 and a 100 percent clean energy economy with net-zero emissions no later than 2050.

Departmental Crosscuts:
The program is involved in several crosscuts, including the following:

- Hydrogen ($197,500,000): The entire office activities are included in this newly created FY 2022 crosscut and activities will be coordinated with all relevant offices, particularly the Offices of Fossil Energy, Nuclear Energy, Electricity, Science, and ARPA-E. Activities include hydrogen production, delivery/infrastructure, storage, fuel cells, and end uses, including systems development and integration, as well as safety, codes, standards, and workforce development.
- Advanced Transportation ($141,500,000): This newly created crosscut includes hydrogen technologies, fuel cells for transportation, SuperTruck, systems development and integration and all other activities with the exception of steel/ammonia, grid energy storage and blending with natural gas. The focus is on RD&D for cost reduction and performance improvements of fuel cell and hydrogen technologies, including hydrogen production, delivery, and storage for multiple end uses.
- Energy Storage Grand Challenge ($127,000,000): Activities include offshore wind, energy storage, grid integration (ARIES) and reversible fuel cells, and a key priority is systems development and integration.
- Space ($89,500,000): Activities focus on areas of interest in space applications and collaborations with NASA, including reversible fuel cells, electrolyzers, and hydrogen storage.
- Critical Minerals ($31,000,000): Efforts include R&D to reduce Platinum Group Metals (PGM) catalysts for fuel cells and electrolyzer technologies.
- Artificial Intelligence ($6,000,000): Activities include machine learning and high throughput techniques for materials R&D including storage materials, fuel cells and hydrogen production materials.
- Cyber Security ($1,000,000): Efforts include identifying vulnerabilities in grid-connected electrolyzers and infrastructure, and other cyber-security priorities.

Hydrogen and Fuel Cell Technologies
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Hydrogen and Fuel Cell Technologies				
Fuel Cell Technologies	26,000	25,000	35,000	+10,000
Hydrogen Technologies	70,000	71,000	78,500	+7,500
Systems Development & Integration	51,000	51,000	81,000	+30,000
Data, Modeling & Analysis	3,000	3,000	3,000	0
Total, Hydrogen and Fuel Cell Technologies	**150,000**	**150,000**	**197,500**	**+47,500**

SBIR/STTR:

- FY 2020 Transferred: SBIR $3,887,000; STTR $658,000
- FY 2021 Projected: SBIR $3,810,000; STTR $536,000
- FY 2022 Request: SBIR: $6,288,000; STTR $884,000

	FY 2022 Request vs FY 2021 Enacted
Hydrogen and Fuel Cell Technologies	
Fuel Cell Technologies: Increased funding reflects the prioritization of enabling fuel cells for heavy duty applications, particularly long-haul, heavy duty trucks. The primary change in FY 2022 is to shift beyond early-stage R&D and include systems, scale-up and demonstration related efforts, particularly in support of the Super Truck program, in coordination with the Vehicle Technologies Office, and in support of the M2FCT. Based on industry projects competitively selected in FY 2021, this subprogram will focus on not only improving catalyst performance but on integration at the electrode, stack, and system level, and on development of other components (e.g., gas diffusion layers, and balance-of-plant components), to enable meeting cost and performance requirements. In addition, demonstration activities will help determine the durability protocols that must be developed to emulate typical drive cycles. Real world validation of performance will be critical in guiding RD&D to meet the fuel cell system cost targets.	**+10,000**
Hydrogen Technologies: The main shift in FY 2022 will be to increase emphasis on reducing the cost of electrolyzers on a greatly accelerated timeline. This is a key requirement to produce affordable clean hydrogen (modeled cost at high volumes). In FY 2022, the subprogram will focus on applied materials and systems RD&D for hydrogen production, storage, and infrastructure. The subprogram will emphasize electrolyzer RD&D, manufacturing, and scale-up while also continuing support of the H2NEW and HydroGEN consortia, shifting their emphasis beyond early-stage R&D, to materials and component integration and further reducing cost, improving durability and performance of low and high-temperature electrolyzers. Infrastructure RD&D will continue to focus on efficient, safe, and low-cost options, including RD&D on carriers, materials-compatibility, and innovative hydrogen liquefaction technologies. Hydrogen Storage RD&D will focus on development and demonstration of higher density materials compared to gaseous hydrogen and will continue support for carbon fiber tanks. Activities will include materials RD&D related to harsh environments such as cryogenic temperatures and high pressures, as well as blending with natural gas. Materials related research will apply artificial intelligence techniques, machine learning, and other computational tools.	**+7,500**
Systems Development & Integration: In FY 2022, the subprogram will emphasize a major effort to develop and demonstrate electrolyzers for hydrogen production and energy storage with a focus on offshore wind, in collaboration with the Wind Energy Technologies Office. Activities will accelerate RDD&D focused on hybrid systems, grid integration, and energy storage (including aspects of dynamic control and optimization) to enable grid stability/resiliency. This work will involve integration of megawatt-scale water electrolyzers coupled with intermittent renewable power generation to produce low cost, emissions-free, green hydrogen for multiple end uses. For chemical and industrial end uses, RD&D will be focused on demonstrating the use of green hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production, in collaboration with the Advanced Manufacturing Office. Within transportation, RD&D will accelerate medium- and heavy-duty fuel cell electric trucks to reduce emissions and improve the energy and operational efficiency of moving freight. Based on SuperTruck proposals selected in FY 2021, the activities in FY 2022 will accelerate progress on fuel cell trucks or the enabling infrastructure, including through lab projects with industry to enable high throughput fueling. In addition, diversity, equity, and inclusion will be a priority in activities related to safety, codes, standards, and training/workforce development.	**+30,000**

	FY 2022 Request vs FY 2021 Enacted
Data, Modeling & Analysis: In FY 2022, the program will focus on providing analysis to identify key areas in which to strategically prioritize R&D efforts. The primary change will be on including analyses related to decarbonization goals as well as hydrogen and fuel cell related jobs.	**+0**
Total, Hydrogen and Fuel Cell Technologies	**+47,500**

Description

The Fuel Cell Technologies subprogram supports applied RD&D and innovative concepts to simultaneously reduce costs, improve durability and efficiency, and enhance performance of fuel cells (including, power density, start-up time, transient response, robust operation, etc.). Key goals include developing and validating concepts to meet a number of metrics to enable fuel cells to be competitive with incumbent and other advanced technologies. Targets are application specific, such as durability for heavy-duty trucks, or durability for automotive applications. Despite the differences, the fundamental knowledge gained from this subprogram will focus on key materials and components and can thus have impact on a range of applications, including transportation and crosscutting applications such as stationary power (primary and backup), off-road applications, and energy storage. Because today's fuel cells rely on expensive Platinum Group Metals (PGM) as catalysts within the electrodes, a key objective of this subprogram, in support of the DOE's Critical Minerals initiative, is to reduce the amount of PGMs used in fuel cells, while also meeting durability, efficiency and other performance requirements (such as fast start, cold weather operation and rapid transient response). Other components that contribute to cost include membranes, ionomer, bipolar plates, gas diffusion layers, as well as balance-of-plant (BOP) components such as air systems. The applied RD&D done in this subprogram will ultimately foster substantial technology advances by industry in new applications with wide-scale commercialization expected beyond the near-term (~5 year) investment focus of industry. This in turn will create high-quality domestic manufacturing jobs across the U.S. (including areas impacted by deindustrialization) for both the supply chain and system integrators and operators. The subprogram will also encourage diversity, equity and inclusion through fostering STEM outreach and fellowships/internships, including collaboration at National Laboratories. Selected activities will also support international collaborations, particularly to leverage global resources, such as developing uniform protocols for accelerated testing of fuel cells and gathering data from global deployments to guide the sub-program's RD&D.

Materials and Component R&D: The Materials and Component R&D activity area encompasses all R&D that is needed to make a membrane electrode assembly (MEA), as well as other stack components (such as bipolar plates, gas diffusion layers, etc.). Fuel cells must simultaneously react and transport oxygen, hydrogen, protons, and electrons in a robust fashion, which places severe demands on the materials and how the components are integrated. The primary areas of focus include catalysts, electrodes, membranes, ionomer, bipolar plates, and gas diffusion layers, as well as advances in modeling and MEA manufacturing approaches. Advances in low-cost materials and components are critical to reaching the Fuel Cell Technologies subprogram's application-specific targets. Improving fuel cell durability, efficiency and performance will also address priorities beyond transportation including grid resiliency, energy storage and national space mission priorities. Innovative concepts will be explored with increased emphasis on a combination of theory, high throughput synthesis and screening, as well as machine learning to help guide R&D to the most promising approaches. The program's M2FCT and ElectroCat National Laboratory consortia will provide critical contributions by providing unique capabilities in synthesis, characterization, and computation to competitively selected projects at universities, industry, and National Laboratories. More specifically, activity under M2FCT directly relates to heavy-duty applications.

Systems Integration R&D: The Systems Integration R&D activity area focuses on systems and systems integration RD&D, including the integration of MEAs and other stack components (e.g., bipolar plates) developed in the Materials and Component R&D key activity, into systems. Efforts include the development and demonstration of fuel cell stacks and balance of plant components (e.g., innovative low-cost air handling and power electronics for fuel cell systems to reduce cost and improve durability) with manufacturability and sustainability in mind. For example, because recent advances in fuel cell power density have relied on higher pressure operation for the cathode, this has resulted in cost and reliability issues due to the air handling system. Therefore, innovative concepts will be explored to enable such systems to achieve optimal performance and to better understand the integration of components into subsystems and full systems. This activity area targets the development and demonstration of innovative concepts for fuel cell stacks and systems across applications, Efforts will be supported by modeling and will incorporate stack and BOP standardization approaches, explore efficient refurbishment/recycling/upcycling approaches, and manufacturing advances for power generation as well as energy storage

(e.g., unitized reversible fuel cells). Advances in these areas will enable the U.S. to retain and establish global leadership, strengthen the supplier base, and expand domestic manufacturing capability.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Fuel Cell Technologies $25,000,000	**$35,000,000**	**+$10,000,000**
Materials and Component R&D $18,000,000	$18,000,000	+$0
• Focus R&D on low-PGM MEAs with enhanced durability through M2FCT and lab/industry/university projects to enable meeting ultimate fuel cell cost and durability targets with a focus on heavy-duty applications. • Fund R&D on PGM-free catalysts and electrodes through lab consortium (ElectroCat) and funding opportunities to enable meeting ultimate fuel cell cost and durability targets across applications and mitigate U.S. dependence on foreign precious metal imports. • Initiate the development of innovative materials, concepts, and manufacturing processes through industry/university projects in coordination with the M2FCT for bipolar plates suited for heavy-duty applications. • Emphasize R&D on MEA components, including high-temperature membranes, through the M2FCT consortium and industry/university projects to improve the durability and efficiency of MEAs for heavy-duty applications.	• Accelerate R&D on low-PGM MEAs with enhanced durability through M2FCT and lab/industry/university projects to enable meeting ultimate fuel cell cost and durability targets across heavy-duty applications. • Fund R&D on PGM-free catalysts and electrodes through lab consortium (ElectroCat) to enable meeting ultimate fuel cell cost and durability targets across applications and mitigate U.S. dependence on foreign precious metal imports. • Ramp up R&D beyond early-stage concepts, including manufacturing processes through industry/university projects in coordination with M2FCT (e.g., gas diffusion layers) to strengthen the domestic supply base. • Emphasize R&D on MEA components and MEAs through the M2FCT consortium and industry/university projects to improve the durability and efficiency of MEAs for heavy-duty applications meeting ultimate targets.	• Continues M2FCT and industry/university competitively selected R&D on low-PGM MEA technology with increased emphasis on materials integration, to meet 2030 targets for heavy-duty applications. • Maintains critical mass of activities in support of ElectroCat with an increased focus on durability in line with heavy-duty/heavy load application needs. • Shifts focus to components beyond catalysts (including gas diffusion layer RD&D) to alleviate dependence on imports and create high-quality domestic manufacturing jobs. • Maintains M2FCT and industry/university innovative MEA component RD&D to meet efficiency and durability targets for heavy-duty/heavy-load applications, including in support of the Super Truck initiative.
Systems Integration R&D $7,000,000	$17,000,000	+$10,000,000
• R&D on BOP components, including low-cost air handling, that would be relevant to both reversible fuel cells and fuel cells for a range of power generation and energy storage applications.	• Increase RD&D and systems integration, including on BOP components, particularly power electronics, as well as stack and BOP manufacturing and standardization approaches to strengthen the domestic supply chain, that would be relevant to both reversible fuel cells and fuel cells and enable economies of scale across applications.	• Continues efforts on stack and BOP RD&D and advanced manufacturing as well as efforts on stack component and materials refurbishment/recycling/upcycling approaches for sustainability and environmental impact. RD&D efforts also contribute to Super Truck initiative.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Initiate projects for heavy/medium duty trucks as part of the Super Truck funding opportunity in collaboration with the Vehicle Technologies Office.	• Demonstrate hydrogen fuel cells in heavy/medium duty trucks as part of the Super Truck funding opportunity in collaboration with the Vehicle Technologies Office.	• Increases funding for SuperTruck award recipients and/or new competitively selected SuperTruck projects based on industry proposals, including lab engagement to support data collection and demonstrations of fuel cell trucks.
• Analysis efforts will focus on new applications and assessment of hydrogen and fuel cell targets as well as status to guide future R&D	• Analysis efforts will continue to focus on assessment of hydrogen and fuel cell targets for various applications as well as status to guide future RD&D.	• Maintains analysis efforts on fuel cell requirements and status for relevant applications.

Description

The Hydrogen Technologies subprogram supports RD&D to enable clean, low-cost, and environmentally sustainable hydrogen production, storage, and infrastructure technologies. Hydrogen can play a pivotal role as an energy carrier, particularly for long-duration energy storage; a valuable feedstock for chemical processes (e.g., steel manufacturing and ammonia production); and versatile fuel for both transportation and stationary applications. The dispensed cost of hydrogen is a key focus area, and the target cost is application specific. Hydrogen must become more cost competitive for transportation applications in order to be commercially viable. This includes all costs related to hydrogen production, transport, and dispensing to a fuel cell vehicle while meeting all performance and quality requirements. The cost is broken down to hydrogen production and the remainder of the pathway, including delivery and dispensing. In the long term, to offer the highest impact potential and to enable widespread use of hydrogen, the subprogram's will develop a stretch goal for hydrogen production for energy storage and chemical processes, where lower quality and lower pressure hydrogen is utilized, and production can occur onsite. The subprogram focuses on innovative strategies for highly efficient, sustainable, carbon-free hydrogen production from diverse domestic resources; high-density hydrogen storage and transport technologies; and low-cost, durable, and safe infrastructure technologies. The subprogram will also encourage diversity, equity and inclusion through fostering STEM outreach and fellowships/internships, including collaboration at user facilities affiliated with the lab-led consortia. Selected activities will also support international collaborations, particularly to leverage global resources, such as developing uniform protocols for testing electrolyzers and gathering data from global deployments to guide the sub-program's RD&D.

Production R&D: The Production R&D activity area addresses advanced water splitting RD&D, with emphasis on electrolysis. The key focus is a reduction in modeled cost for carbon-free hydrogen production. This effort is aligned with the Administration's focus on meeting aggressive climate goals. This important activity will focus on the following key areas: (1) low- and high-temperature electrolysis, (2) direct photo-electrochemical (PEC) hydrogen production, and (3) high-temperature, thermochemical hydrogen production. In addition to materials RD&D, activities will include manufacturing RD&D of system components (e.g., power electronics, control systems, thermal management) to further reduce capital costs for electrolyzer systems. Additionally, the activity will initiate demonstration activities of novel electrolyzer technologies. Efforts leverage the capabilities within the DOE National Laboratories through two multi-laboratory consortia, which includes initiatives to encourage partnerships with industry and academia. The HydroGEN consortium focuses on innovative materials development to advance performance across all four water splitting technologies, and the H2NEW consortium focuses on materials and component integration for low and high temperature electrolyzer systems to enhance durability and performance while lowering stack costs. Leveraged capabilities include advanced high throughput/combinatorial approaches to enable rapid identification and development of promising materials and world-class characterization capabilities to elucidate degradation mechanisms to enable rapid improvements in electrolyzer durability. Research within H2NEW includes investigating failure modes in electrode assemblies and developing validated accelerated stress test protocols to enhance the durability and lifetime of electrolyzers.

In addition to advanced water splitting, technologies with potential to leapfrog today's commercial technologies are included in the activity area, such as hydrogen production through biological processes and other innovative concepts. Approaches include dark- and photo-fermentation processes; microbial electrolysis; novel catalytic and thermochemical processes; and hybrid systems that leverage nuclear, and renewable resources – including technologies that use biomass or industrial waste streams.

Storage R&D: The Storage R&D activity area supports RD&D on advanced technologies to enable efficient, high-density, safe, and cost-effective hydrogen storage for stationary and mobile applications. Today, most hydrogen storage systems rely on either high-pressure, all-metal or carbon fiber composite tanks or vacuum-insulated cryogenic liquid hydrogen tanks. Costs are too high (e.g., $16/kWh for vehicular applications, even at high manufacturing volumes) for carbon fiber composite tanks and vacuum insulation presents limitations for certain applications. This activity area includes RD&D to reduce the cost of carbon fiber composite tanks, and on advanced, innovative liquid hydrogen storage technologies. In contrast to compressed and liquid hydrogen storage technologies, materials-based storage technologies have potential to

provide high energy density storage at significantly lower pressure and at near ambient temperature. In FY 2022 the activity area will initiate industry-led demonstration activities of innovative bulk hydrogen storage technologies that provide high-density, low-cost, efficient hydrogen storage with superior performance over incumbent technologies. The hydrogen storage activity area will continue support of RD&D on innovative hydrogen storage materials (e.g., sorbents, chemical carriers, metal hydrides) with potential to significantly surpass performance of high pressure and cryogenic liquid tanks. These RD&D efforts will be done through the Hydrogen Materials Advanced Research Consortium (HyMARC), leveraging capabilities of the National Laboratories.

Infrastructure R&D: The hydrogen infrastructure RD&D activity area supports RD&D on materials, materials, components, and processes to enable a low-cost, safe, and efficient hydrogen infrastructure. The overall objective of this activity area is to enable achieving the overall cost target for produced, delivered, and dispensed hydrogen. These targets are application-specific, such as for delivery, bulk storage, and dispensing into vehicles. In FY 2022 emphasis will be on advanced hydrogen liquefaction technologies that are scalable with higher energy efficiency and low-cost. RD&D investigating and developing materials (e.g., metals, polymers) compatible for operation in hydrogen and hydrogen/natural gas blends will continue. Efforts will be carried out in collaboration with the H-Mat consortium, leveraging capabilities of the National Laboratories.

Hydrogen Technologies

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Hydrogen Technologies $71,000,000	**$78,500,000**	**+$7,500,000**
Production R&D $30,000,000	$45,000,000	+$15,000,000
• Fund early-stage advanced water splitting projects through the HydroGEN National Laboratory consortium, high-temperature electrolyzer manufacturing R&D and new biological approaches to hydrogen production through competitively selected projects.	• Fund industry-led advanced manufacturing and demonstration of balance of system components and innovative electrolyzer technologies. Continue water splitting projects through the HydroGEN and H2NEW National Laboratory consortia with an emphasis on low and high-temperature electrode assembly durability and performance for electrolysis.	• Emphasis will be on manufacturing, development, and demonstration of electrolyzer systems and components, including balance of plant components and innovative electrolyzer technologies to reduce cost while meeting efficiency and durability goals. Increased funding allows emphasis on meeting accelerated timeline for achieving lower cost hydrogen (modeled cost).
Storage R&D $16,000,000	$13,500,000	-$2,500,000
• Fund R&D on materials-based hydrogen storage technologies (e.g., sorbents, metal hydrides) storage, doubling hydrogen energy density over state-of-the-art commercial technologies through the HyMARC Consortium and initiate bulk liquid hydrogen storage R&D to enable efficient and cost-effective hydrogen storage.	• Fund RD&D of innovative stationary storage technologies and maintain support of the most promising materials-based hydrogen storage technologies (e.g., sorbents, metal hydrides), with a target of doubling hydrogen energy density over state-of-the-art commercial technologies through the HyMARC Consortium.	• Reduces efforts on early-stage on-board materials research that may not have near term impact. Increases focus on demonstration of innovative bulk storage technologies.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Infrastructure R&D $25,000,000	$20,000,000	-$5,000,000
• Fund R&D on the most promising concepts to reduce cost and improve performance for use of hydrogen in steel production (e.g., plasma-based processes).	• No funding requested.	• Competitively selected projects will continue with prior year funds.
• Continue materials compatibility R&D through the H-Mat National Laboratory-led consortium that focuses on reducing the cost of hydrogen service by at least 10 percent without sacrificing safety and develop a publicly available technical reference for non-metallic material behavior in the presence of hydrogen (and natural gas blends) and testing of high priority materials from the coupon to system level.	• Continue materials compatibility RD&D through the H-Mat National Laboratory-led consortium and testing of high priority materials from the coupon to system level.	• Maintains RD&D priorities on materials compatibility, including metals and polymers, for service in hydrogen and hydrogen/natural gas blends.
• Continue to support National Laboratory R&D within HyMARC on priority hydrogen carriers with potential to reduce the cost of hydrogen infrastructure.	• Focuses on RD&D of innovative hydrogen carriers through HyMARC with potential for nearer term impact in diverse end-uses.	• Competitively selected projects will continue with prior year funds.
• Competitively select new industry led projects on component R&D for high throughput refueling components for heavy-duty applications (e.g., marine, rail, trucks).	• Fund R&D on advanced, scalable hydrogen liquefaction technologies to accelerate progress on meeting needs for industrial and heavy-duty transportation applications.	• Maintains emphasis on reducing the cost of hydrogen.

Hydrogen and Fuel Cell Technologies
Systems Development & Integration

Description

The Systems Development and Integration subprogram is focused on technology acceleration, including integrating, developing, and demonstrating hydrogen end use technologies needed to expedite the commercialization of hydrogen and fuel cell systems, produce low cost, clean hydrogen, and realize the H2@Scale vision from a wide array of domestic resources. This includes focusing on key applications including integrating clean energy systems, decarbonizing chemical and industrial processes, and demonstrating heavy-duty transportation applications. In addition, the subprogram aims to demonstrate novel technologies related to the production, delivery, storage, and end use of hydrogen and provide feedback to the R&D sectors. Finally, the subprogram will enable the development of codes and standards with an emphasis on large-scale hydrogen applications, developing and sharing best practices on hydrogen safety, and supporting workforce development.

The goal of the Systems Development and Integration subprogram is to enable the H2@Scale vision by demonstrating the novel integration of hydrogen with diverse domestic sectors including energy storage, industrial and chemical sectors, and transportation. To achieve this goal, the subprogram aims to demonstrate safe, efficient, and low-cost hydrogen and fuel cell technologies with significant potential for greenhouse gas emission reduction and life-cycle cost parity when compared with incumbent and emerging technologies.

The Program also recognizes the essential role that state and local governments play in the transition to a clean energy economy and will work in a unified and coordinated way with state and local partners on activities such as workforce development and analyses, wherever possible to accelerate a just, equitable transition.

Hybrid Systems and Grid Integration: The Hybrid Systems and Grid Integration activity is focused on innovative concepts and solutions that can accelerate the transition from R&D to commercial viability. This activity will address the challenges of integrating components, sub-systems and systems for optimal performance, affordability, and durability.

Hybridized systems such as coupling thermal sources with electrolyzers or other hydrogen generation methods can help reduce overall electricity requirements and improve efficiencies. The co-location of large-scale hydrogen generation with utilization to minimize the cost of transport and storage will be key to achieving the H2@Scale vision, and the optimization of several application-specific parameters must be considered. Depending on the application (e.g., heavy duty trucks, marine, rail, or industrial/stationary use such as steel manufacturing, ammonia production, power for critical loads, and energy storage), the generation, storage, and dispensing technology for providing hydrogen may vary and needs to be addressed.

RD&D will be focused on hybrid systems, grid integration, and energy storage of hydrogen to enable grid stability/resiliency, avoid curtailment, and produce low-cost, green hydrogen. This work will involve integration of multi-megawatt water electrolyzers coupled with clean sources (e.g., nuclear baseload power and intermittent renewable power generation) to produce green hydrogen. Demonstration of a grid-scale electrolyzer, along with storage technologies, will enhance the economics of baseload nuclear plants and accelerate adoption of renewable energy technologies by providing additional revenue streams for electricity generated during off-peak hours. Within hard to decarbonize chemical and industrial processes, RD&D will be focused on demonstrating the ability of green hydrogen to be used as a feedstock (e.g., ammonia production) or direct reducing agent (i.e., steel production) or to provide heat (i.e., steel and cement production). Within transportation, RD&D will accelerate medium and heavy-duty fuel cell electric trucks operating on green hydrogen to reduce emissions and improve the energy and operational efficiency of moving freight while still providing operating range and fueling times on par with incumbent technologies. This will include hybridization strategies such as fuel cell range extenders as well as the associated high-flow hydrogen fueling and onboard hydrogen storage that will be required. In addition, new market opportunities for hydrogen and fuel cells in heavy-duty transportation sector such as marine, rail, and agricultural/excavating equipment will continue to be evaluated.

Codes and Standards: The Codes and Standards activity conducts R&D to enable the development of codes and standards for adoption of hydrogen and fuel cell technologies (e.g., sensor R&D, quantitative risk assessments, hydrogen release/flame propagation impacts, etc.), in support of H2@Scale. Depending on the application (e.g., heavy duty trucks, marine, rail, industrial use, energy storage, etc.), specific issues such as the amount of hydrogen that may be stored in a given location, required hydrogen metering/flow rates, transport of hydrogen in tunnels, or the footprint restrictions onsite, must be addressed. The behavior of hydrogen upon release at certain conditions (e.g., temperatures/pressures) must be understood to inform the development of appropriate codes and standards. In addition, the global harmonization of codes and standards is critical to ensure the U.S. develops a robust and competitive supply chain to serve both domestic and international markets.

This activity also ensures safety considerations are incorporated into RD&D projects, best practices are developed, and lessons learned are shared. A key feature of these activities is diversity, equity, and inclusion, particularly through fellowships/interns and encouraging engagement at HBCUs and other minority serving institutions.

Systems Development & Integration

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Systems Development & Integration $51,000,000	**$81,000,000**	**+$30,000,000**
Hybrid Systems and Grid Integration $41,000,000	$71,000,000	+$30,000,000
• Fund competitively selected industry-led projects for grid-integration with hydrogen technologies, including hybrid approaches, to enhance the stability of the power grid through responsive load and energy storage, in support of H2@Scale.	• Fund competitively selected industry-led projects for grid-integration with hydrogen technologies, including hybrid approaches, to enhance the stability/resiliency of the power grid and enable production of low cost, green hydrogen, in support of H2@Scale, and Energy Storage Grand Challenge.	• Increases funding to integrate and demonstrate a multi-megawatt water electrolyzer coupled with renewable wind power generation (e.g., focusing on offshore wind) to produce low cost, green hydrogen, in collaboration with the Wind Energy Technologies Office.
• Continue support for National Laboratory and competitively selected industry projects focused on modular/scalable concepts for dispatchable hydrogen production, storage, and delivery, coupled with utilization for multiple applications and across sectors such as ammonia and other applications, in support of H2@Scale.	• Fund competitively selected industry-led projects to demonstrate use of green hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production, in support of H2@Scale.	• Increases focus on use of green hydrogen to decarbonize steel production, in collaboration with the Advanced Manufacturing Office. Includes coordination with Hydrogen subprogram and Advanced Manufacturing Office on demonstration for modular dispatchable green ammonia production.
• Fund National Laboratory first-of-a-kind systems integration and validation projects to guide R&D, in support of H2@Scale.	• Continue funding industry and National Laboratory first-of-a-kind systems integration and validation projects to guide R&D, in support of H2@Scale and DOE's Energy Storage Grand Challenge.	• No change.
• Establish research projects, including industry led teams, focused on improving the energy and operational efficiency of moving freight with medium and heavy-duty fuel cell electric trucks in support of Super Truck as well as pursuing other heavy-duty transportation sectors such as marine, rail, and agriculture equipment.	• Continue to establish industry led teams focused on improving the energy and operational efficiency of moving freight with medium and heavy-duty fuel cell electric trucks in support of Super Truck as well as pursuing other heavy-duty transportation sectors such as marine, rail, and agriculture equipment.	• No change.
• Fund manufacturing related projects to help reduce the cost and improve the durability of fuel cells, electrolyzers, and other hydrogen components.	• Continue funding manufacturing related projects to help reduce the cost and improve the durability of fuel cells, electrolyzers, and other hydrogen components.	• No change.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Codes and Standards $10,000,000	$10,000,000	$0
• Directly fund National Laboratory projects that enable the development of codes and standards, with an emphasis on large-scale applications, and ensure activities include safety considerations.	• Support R&D to enable the development of codes and standards (e.g., sensor R&D, risk assessment) with an emphasis on large-scale novel hydrogen end use applications, and ensure activities include safety considerations.	
• Develop and share best practices and lessons learned by expanding education and training activities.	• Further develop and share best practices and lessons learned by pursuing education and training activities.	• No change.

Hydrogen and Fuel Cell Technologies
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis subprogram performs the analytical research that provides a technical basis for informed decision making for the program's R&D direction and prioritization. Analyses include assessing impacts of hydrogen and fuel cell technologies on sustainability metrics, identifying synergies and interactions with other energy sectors such as natural gas as well as assessing R&D gaps, planning, and budgeting. The subprogram gauges the requirements of potential end-users to determine metrics for processes, components, and subsystems. Results also support annual updates to key planning documents that provide direction and milestones for the program, including peer reviews.

The Data, Modeling, and Analysis subprogram will continue to develop, refine, and use analytical models and tools, as well as develop program milestones and technology readiness goals. Modeling and analysis within this subprogram can elucidate the total cost of ownership of hydrogen and fuel cell technologies in specific sectors, regional impacts of deployment on criteria pollutant emissions and water resources, potential for job creation, and impacts of hydrogen and fuel cells on global sustainability. Specific sectors of interest include medium- and heavy-duty transportation, industrial uses of hydrogen, and integration of hydrogen and fuel cell technologies with regional grids for energy storage, nuclear power plants, and natural gas networks (e.g. blending). In FY 2022, the subprogram will increase emphasis on environmental justice, job creation, and energy storage to inform targeted R&D and deployments. The subprogram will support approximately nine projects for these activities with National Laboratory, industry, and university participation.

Analysis efforts will leverage outside activities, through coordination with other offices and agencies and will support peer reviews and relevant activities under relevant legislation, including analyses supporting the federal advisory committees and the interagency working group on hydrogen and fuel cells which has been coordinated by the Program over a decade.

Data, Modeling and Analysis Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Data, Modeling & Analysis $3,000,000	**$3,000,000**	**$0**
• Conduct National Laboratory project to assess cost and impact of hydrogen and fuel cell technologies beyond light duty vehicles. Analysis will be used to prioritize R&D activities and inform updates to multi-year plans.	• Perform analytical research that assesses regional impacts of hydrogen and fuel cell technologies (e.g. criteria pollutants, water), to support program's R&D direction and prioritization. Results also support annual updates to key planning documents that provide direction and milestones for the program.	• Shifts focus to regional sustainability impacts to inform environmental justice goals, and supplement previously completed work on technology cost.
• Conduct National Laboratory project to identify early-stage R&D that can maximize energy independence and increase fuel diversity, including regional impacts. Complete report assessing diverse regional opportunities for hydrogen production and demand, including biofuels production.	• Fund analysis of hydrogen for industrial applications, long-duration energy storage, synthetic fuels, and export opportunities, and address global sustainability impacts.	• Includes a focus on long duration energy storage to meet Administration priorities for a clean grid by 2035.
• Conduct National Laboratory project to assess program milestones and technology readiness goals.	• Continue National Laboratory project to assess program milestones and technology readiness goals.	• No significant change.
• Conduct National Laboratory project to support analysis with the Office of Nuclear Energy on the potential for hydrogen generation through nuclear baseload sources, including hydrogen hybrid energy systems and novel nuclear power generation technologies.	• Perform analysis to assess cost and benefits of hydrogen and fuel cell technology deployments (e.g., job creation, regional emissions reduction), to inform first-of-a-kind demonstrations.	• Broaden focus from nuclear hybrid energy systems to include industrial and heavy-duty transportation sectors.

Solar Energy

Overview

EERE's Solar Energy Technologies Program (Program) works to accelerate the development and deployment of solar technologies while supporting the reliability, resilience, and security of the U.S. electric grid, as well as the Administration's goal to reach a carbon pollution-free electricity sector by 2035 and creating good-paying jobs with a free and fair chance to join a union and collectively bargain. The FY Budget reflects an increased focus on the complete roadmap of solar energy implementation: advanced R&D; validation of solar technologies to invigorate American technological leadership; supporting industry's development of a robust American supply chain; ensuring that there is a trained American workforce employed in the industry; contributing to the decarbonization of the energy and industrial sectors; supporting community resilience; and working to ensure the benefits of the transition to clean energy are shared with those most affected by environmental justice inequities.

The solar resource is vast, and solar energy has the potential to be a substantial source of clean, affordable, and reliable electricity across the country. Analysis by the National Renewable Energy Laboratory[1] estimates that meeting the 2035 goal for a carbon pollution-free electricity sector will require solar to supply a substantial portion of U.S. electricity. Solar technologies can be deployed cost-effectively at both the large, utility-scale and at a smaller scale on the distribution system where they offer opportunities for consumer choice, energy bill savings, local jobs, community health and quality-of-life improvements, and enhanced community resilience. Photovoltaic (PV) deployment has grown rapidly over the past decade; however, solar energy supplies only 3 percent of U.S. electricity today. Unlocking solar energy's potential as an electricity source requires continued cost reductions, developing technologies to open new markets, removing barriers to deployment, and enabling solar technologies to actively support the reliability, resilience, and security of the grid. Solar technology also has the potential to contribute to the decarbonization of the broader energy system, through: increased electrification, the direct production of industrial process heat, and solar fuels. Harnessing innovation, coupled with appropriate policy incentives, also supports growth of the U.S. solar manufacturing sector. Today, solar hardware installed in the U.S. averages 40 percent domestic content. Growing this share will create good-paying, stable manufacturing jobs with the option to join a union and bargain collectively, while also increasing domestic energy security.

Continued reductions in the cost of solar electricity are essential to enabling growth in solar deployment and greater electricity affordability for consumers in diverse regions and communities. As the supply of solar electricity increases in a given region, pairing solar with energy storage and other technologies becomes increasingly important to address the temporal mismatch between the supply of sunlight and shifting peak electricity loads. Pairing solar with energy storage and other technologies adds the flexibility needed for solar to supply large shares of U.S. electricity, but costs of solar must continue to fall to make this broadly affordable. Accordingly, DOE recently accelerated its cost targets for utility-scale PV and CSP systems without subsidies − targets that could make solar electricity the lowest cost form of electricity in the U.S. given cost reductions of 50-60 percent from 2020 benchmarks for PV and CSP.[2] The Program has a history of success in enabling solar energy cost reduction with its previous top-line goal met years ahead of schedule.

As PV deployment becomes a larger share of electricity generation, it becomes critical that PV systems actively contribute to the reliability, resilience, and security of the electric grid. Already today, there are times in the year when solar and wind supply more than half of the demand for electricity in some regions. PV and wind technologies operate differently than conventional electricity generators due to their resource variability and fast power electronics, and research and demonstration are needed to learn to plan and operate a grid reliably with high penetrations of these resources. Further, PV technologies, and other distributed energy resources (DERs), are fundamentally changing the distribution system. There are nearly 3 million PV systems on the distribution system today, representing 95 percent of distributed generators. These PV systems are creating new challenges related to forecasting, real time situation awareness, control coordination, as well as system protection and cyber-security for both distribution systems and bulk power systems they are connected to. They

[1] Internal analysis, publication forthcoming.

[2] D. Feldman et al., "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2020," NREL Technical Report, January 2021. 2020 benchmarks for utility-scale, commercial and residential PV are 4.6, 9 and 13 cents/kWh, respectively. The 2020 CSP benchmark was 10 cents/kWh.

also present new opportunities when coupled with energy storage and other distributed energy resources, to provide grid services and enhance community resilience.

It is critical that cost reductions and other benefits from solar energy extend to all Americans. Many of the challenges to achieving affordable, equitable deployment of solar across the country are a result of non-hardware costs (known as 'soft costs'). Barriers to solar deployment raise soft costs.[1] These barriers can include such issues as lack of affordable financing, burdensome permitting and complex interconnection processes, lack of trained workers, and competition for land. In addition, nearly 50 percent of the population does not have the option to install their own solar panel because they lack adequate roof space or rent their housing. Addressing these barriers requires engaging with state and local governments, utilities, the solar industry, local communities, and other stakeholders on research, tools, and improved processes, as well as on workforce training programs, tools to streamline permitting, and innovative siting strategies.

Today nearly 100 GW of solar technology have been deployed across the U.S.,[2] a nearly 50-fold increase since 2010. This increase in deployment and been a source of significant job growth, with the industry employing 250,000 workers in 2019.[3] Rapid declines in solar costs have, in large part, made these increases possible. Nevertheless, significant work remains before solar realizes its full potential. With continued innovation to drive down solar electricity costs, to improve solar technology's ability to support the reliability and resilience of the grid, to remove market barriers and to open new markets, solar energy is capable of being a foundational source of the Nation's electricity supply, contributing to greater electricity affordability for all Americans, invigorating and supporting an equitable pathway to economic growth, job creation, and opportunity within the American innovation ecosystem.

Highlights of the FY 2022 Budget Request

The Solar Energy Technologies Program will support a portfolio of research, development, demonstration, and deployment activities in FY 2022, including:

- To grow the domestic solar manufacturing value chain as well as the domestic solar industry, $100,000,000 is requested for the Manufacturing and Competitiveness subprogram. Highlights include:
  - New rounds of the American-Made Challenges solar prize competitions.
  - Development and demonstration of PV technologies across the full supply chain with strong potential to be competitively manufactured in the U.S. as well as opening new market segments through new building-integrated PV products.Support the solar manufacturing industry by providing worker training, mentorship, and benefits ensuring well trained workers are ready to enter the workforce as the opportunities grow and create good-paying jobs with a free and fair chance to join a union and collectively bargain.
- To scale-up efforts to decrease soft costs and ensure the benefits of solar energy are available to all Americans, $75,250,000 is requested for the Balance of System Soft Costs Reduction subprogram. These data, analysis, tool development, technical assistance, and workforce training efforts are critical to enabling increased solar deployment and meeting the President's goal of a carbon-free power sector by 2035. Highlights include:
  - National career accelerator to train and diversify the solar and clean energy workforce and build pathways for career placement and advancement. The program will work with other EERE offices to promote cross sector job opportunities, provide worker training, mentorship and benefits, and support industry's workforce needs. The program will work with labor unions to increase opportunity to create good paying jobs with a free and fair chance to join a union and bargain collectively.
  - Overcoming siting, permitting, and interconnection barriers to solar, including research on alternative siting approaches and wildlife impacts; the development of a voluntary online tool for use by local governments to streamline solar permitting; and technical assistance to address barriers to interconnecting solar and wind energy to the electric grid, in collaboration with the Wind Energy Technologies Office.
  - Development of an online platform available to states, utilities, and other stakeholders to manage the voluntary enrollment of low-income customers in community solar and reduce their household energy burden. The platform will also reduce acquisition and management costs of enrolling these customers in community solar.

[1] D. Feldman et al. "Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation," NREL Technical Report NREL/TP-6A20-63892 (April 2015). https://www.nrel.gov/docs/fy15osti/63892.pdf.

[2] Wood Mackenzie/SEIA U.S. Solar Market Insight® https://www.seia.org/us-solar-market-insight.

[3] "National Solar Jobs Census 2019," The Solar Foundation. https://www.thesolarfoundation.org/national/ .

- Technical assistance for stakeholders faced with making data-driven decisions and investments, including evaluating technologies, designing clean energy deployment programs, developing market solutions, and planning transmission and distribution upgrades to facilitate the transition to a 100 percent clean electricity system, in partnership with DOE's Grid Modernization Initiative.

- To accelerate development and demonstration of solar energy's ability to support the reliability, resilience, and security of a carbon-free electric grid, in partnership with DOE's Grid Modernization Initiative, $71,750,000 is requested for the Systems Integration subprogram. Highlights include:
  - First-of-a-kind demonstrations of the provision of grid services from solar and wind technologies for an extended period time (>6 months) and use of the results to inform the planning and operation of the electric grid with increasing contributions from wind and solar.
  - Engaging with regional and local partners, especially in underserved and frontline communities, to develop, demonstrate, and deploy innovative technologies and conduct community planning to enhance resilience against physical hazards using distributed solar, energy storage, EVs, and other distributed energy resources (joint EERE-OE effort).
- To accelerate cost reductions toward the 2030 goal of $0.02/kWh PV electricity with systems lasting 50 years or more, $79,575,000 is requested for PV system research and development. Highlights include:
  - Leveraging core expertise at the National Laboratories to increase the efficiency and energy yield of a portfolio of PV technologies and advance PV characterization and testing capabilities, while developing the knowledge base to enable 50-year system lifetimes. Includes support for the DuraMat consortium, focused on modeling and measuring durable materials for PV modules including advanced encapsulants and flexible packaging concepts.
  - Hardening PV systems for long lifetime in the face of extreme weather conditions including heat, cold, hail and wind.
- To advance CSP and thermal energy storage technologies to provide solar electricity on demand as well as renewable energy options for the industrial sector, $60,000,000 is requested for the CSP subprogram. Highlights include:
  - New emphasis on leveraging CSP technologies to support decarbonization of the industrial sector through research and development of solar thermochemical processes and components for the production of solar-derived industrial products, chemicals, and fuels.
- In support of the Energy Storage Grand Challenge, the CSP subprogram supports research, development, and demonstration of thermal energy storage concepts, which can be charged either with solar energy or grid electricity. Following the selection, in FY 2021, of solid particles as the prioritized 'Gen3 CSP' pathway, FY 2022 efforts will have a particular focus on continuing to develop solid particles as a heat transfer and thermal storage medium.

The Program closely coordinates activities with other EERE Programs, the Office of Electricity, the Office of Cybersecurity, Energy Security and Emergency Response, the Advanced Research Projects Agency – Energy, the Offices of Fossil and Nuclear Energy, and the Office of Science to ensure the most efficient use of taxpayer dollars, while maximizing the Department-wide impact of solar energy. The Program also supports the Energy Storage Grand Challenge to validate and demonstrate promising approaches to long-duration energy storage that can help provide the necessary flexibility to operate a high-renewables power system. This includes working closely with other EERE and DOE offices to refine storage performance metrics, validate technologies in the field, and develop new storage demonstration and pilot programs.

Solar Energy
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Solar Energy				
Concentrating Solar Power Technologies	60,000	60,000	60,000	0
Photovoltaic Technologies	72,000	72,000	79,575	+7,575
Systems Integration	53,000	53,000	71,750	+18,750
Balance of Systems Soft Cost Reduction	35,000	35,000	75,250	+40,250
Manufacturing and Competitiveness	60,000	60,000	100,000	+40,000
Total, Solar Energy	**280,000**	**280,000**	**386,575**	**+106,575**

FY 2020 Transferred: SBIR $11,285,000; STTR $1,458,000
FY 2021 Projected: SBIR $8,025,000; STTR $1,128,000
FY 2022 Request: SBIR $10,199,000; STTR $1,434,000

Solar Energy
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Concentrating Solar Power Technologies: Funding continues efforts at the National Laboratories on developing high temperature components for next generation CSP systems with thermal energy storage. Funding is also requested for a competitive solicitation to develop technologies for solar-thermal-driven industrial processes to help decarbonize a broader scope of industrial applications. CSP funding will also continue to support the development of high-efficiency, reliable thermal energy storage technologies to support the Energy Storage Grand Challenge, with a particular focus on technologies using solid particles as the heat transfer medium, following the selection, in FY 2021, of the solid-particle pathway for the construction of a megawatt-scale Gen3 CSP test facility.	**0**
Photovoltaic Technologies: Funding continues core efforts at the National Laboratories that advance a portfolio of emerging and commercial PV materials and devices and study PV system degradation to improve lifetimes and inform standards. Funding is also requested to support a competitive solicitation that will develop technologies to harden PV systems for extreme weather as well as support research topics in cell metallization, low-cost and high-efficiency III-V PV, waste management and PV system recycling.	**+7,575**
Systems Integration: Increased funding levels reflect greater emphasis on demonstration activities to provide real-world experience using solar technologies, in partnership with other energy technologies, to support grid services and enhance community resilience. Efforts include a new competitive solicitation focused on innovative and sustainable solutions to enhance community resilience against physical hazards using distributed solar, energy storage, and other DERs. Funding will also support demonstrations of grid services from solar and wind power plants, and energy storage integration to support coordinated efforts on renewable integration and grid modernization. Funding also maintains core efforts at the National Laboratories to advance power system modeling and simulation, interconnection standards, data analytics, and other solar grid integration technologies.	**+18,750**

	FY 2022 Request vs FY 2021 Enacted
Balance of Systems Soft Cost Reduction: An incremental funding increase is requested to scale-up efforts to address critical soft cost barriers to solar deployment and to ensure the benefits of solar energy are available to all Americans. A technical assistance program to address barriers to interconnecting solar and wind energy to the electric grid, in collaboration with the Wind Energy Technologies Program, will be established. A new, cross-cutting initiative will grow a skilled and diverse solar and clean energy workforce and connect trainees with the industry. Funding will also support a new national platform available to states, industry, and other stakeholders to manage the enrollment of community solar subscriptions for low-income customers. Funding continues core research programs at the National Laboratories and STEM programming. Funding will also build on previous efforts by addressing barriers to community solar, continuing to develop tools and processes to streamline solar permitting, and supporting a competitive solicitation focused on improving siting of large-scale solar facilities. Funding will also support research and technical assistance for stakeholders on resilience planning (with Systems Integration), grid modernization, and ensuring equitable access to solar.	**+40,250**
Manufacturing and Competitiveness: An incremental funding increase is requested to run new programming related to the research, development and demonstration of new solar energy technologies and tools with potential to grow U.S. manufacturing across the supply chain and supporting Buy American principles. A new effort will target new approaches to building integrated photovoltaics. The American-Made Solar Prize, begun in FY 2018, will continue to incentivize and transition new solar technologies into prototypes ready for real world validation, and other prize competitions to spur U.S. business innovation in solar. Funding will also support the American-Made Network to support all prize competitors with commercialization resources. A new, cross-cutting initiative will support a qualified clean energy manufacturing workforce and connect trainees with the industry. Funding is also requested to support continuing the Incubator program to accelerate the prototyping and development of new solar energy technologies for commercialization and domestic manufacture.	**+40,000**
Total, Solar Energy	**+106,575**

Solar Energy
Concentrating Solar Power Technologies

Description

The Concentrating Solar Power Technologies (CSP) subprogram works toward decarbonization of the electric power and industrial sectors by supporting research, development and demonstration of technologies that convert sunlight into thermal energy, which can be efficiently stored until it is needed for the production of electricity or for direct use in an industrial process. Because they can efficiently incorporate long durations of thermal energy storage, CSP technologies offer a path to supplying affordable and reliable solar power on demand.

Today there are nearly 2 GW of CSP technology deployed for electricity production in the U.S. To significantly increase deployment requires cutting the costs of CSP electricity through technology improvements in the solar collector, thermal systems, and power cycles, as well as component integration and demonstrations of these advances at scale. The CSP subprogram aims to reduce the cost of CSP electricity at utility scale to help make CSP electricity cost competitive with electricity from other dispatchable sources.

CSP technologies can also provide an alternative to conventional fuels to drive industrial processes. Solar industrial process heat can be used for a range of applications including low temperature processes such as water desalination and food processing, and high temperature processes such as cement production, ammonia synthesis, steel manufacturing, and thermochemical water splitting for fuel production, among others. This work is being coordinated with the Advanced Manufacturing Office to align with their Industrial Decarbonization Roadmap.

Within the activities listed below, the Solar Energy fellowship program funds emerging leaders in the field that will pursue breakthrough solar energy technologies at universities, National Laboratories, and other research facilities as well as at DOE. In addition, funds may be used to support efforts such as merit/peer reviews, data collection and dissemination, technical assistance, and technology to market activities.

Thermal Systems R&D: Research, development, and demonstration to test and integrate the components - including the receiver, heat transport media, and thermal energy storage systems - of a CSP thermal transport system capable of operation at substantially higher temperatures than today's commercial systems (i.e., 700 degrees Celsius or above). This activity includes research into novel materials as well as manufacturing and fabrication methods of materials and components that will allow high temperature systems to be cost effective. Following the FY 2021 down-selection of the solid-particle based pathway for the construction of a megawatt-scale test facility, this activity will primarily, although not exclusively, focus on components and systems that use solid particles as the heat transfer medium. This activity also includes RD&D of thermal energy storage technologies, which supports the Energy Storage Grand Challenge.

Power Cycles R&D: Research, development, and demonstration of power cycles capable of net thermal-to-electric efficiency of 50 percent or greater. This activity is particularly focused on power cycles that use supercritical carbon dioxide as the working fluid and have a capital cost of $900/kW-electric or lower, working in collaboration with the Offices of Fossil Energy and Nuclear Energy. This activity also includes the development of primary heat exchangers that can transfer heat between high temperature thermal energy storage and supercritical carbon dioxide.

Solar Collector R&D: Research, development, and demonstration of solar collectors with installed capital costs less than $50 per square meter and the ability to maintain high accuracy through autonomous operation, without the need for manual calibration. The primary activity in this area is the continuation of a National Laboratory consortium for heliostat research, development, and validation.

Industrial Applications R&D: Research, development, and demonstration of industrial processes driven by solar thermal energy. This activity includes both low-temperature systems focused on low-cost embodiments of existing technologies, and the development components and system designs for high-temperature systems that are difficult to decarbonize through electrification. Low temperature systems, in the range of 100 to 300 °C target a levelized cost of heat (LCOH) of 1 cent per kWh-thermal or lower, which would constitute at least a 50 percent decrease in current LCOH. This includes the development of thermal processes, including thermal desalination, which can efficiently couple with a solar thermal energy input. High temperature systems work includes the development of solar thermal pathways for the carbon-emission-free

production of energy-intensive chemicals, commodities, and fuels, like ammonia, steel, cement, and hydrogen.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Concentrating Solar Power Technologies		
$60,000,000	**$60,000,000**	**$0**
Thermal Systems R&D $29,000,000	$23,050,000	-$5,950,000
• Support existing, merit-reviewed R&D work at the National Laboratories to develop and analyze high-temperature, 'Gen3 CSP,' components and integrated thermal systems for CSP technology with long-duration thermal energy storage.	• Funding to initiate FY 2022-24 projects for National Laboratory research programs that extends FY 2019-2021 work on high-temperature, 'Gen3 CSP,' components and integrated thermal systems for CSP technology with long-duration thermal energy storage and add complementary competitive projects.	• No change in funding but research topics will be revised based on external review of program.
• Fund competitively selected projects on improving the performance and reliability of both current and next-generation CSP systems to enable the deployment of low-cost CSP by 2030.	• No funding requested in FY 2022.	• No additional funding requested while current projects are in progress.
• Fund competitively selected projects to develop high-efficiency, long-duration pumped thermal energy storage (PTES) technologies, that can be charged using electric-driven heat pumps, in either standalone or CSP-hybridized configurations.	• Fund competitively selected projects to develop promising thermal energy storage concepts, relevant to both PTES and CSP, in a tiered structure progressing from initial conceptual investigations, to demonstration-scale systems, as well as continued development of the Gen3 particle-based heat transfer system.	• New funding topic reflects an increased focus on demonstration and validation of promising energy storage concepts aligned with the Energy Storage Grand Challenge.
• Support to the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories (SNL).	• Support to the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories (SNL).	• No significant change.
• Funding for FY 2021 FOA topic on 1-year innovative projects for CSP research.	• Funding for FY 2022 FOA topic on 1-year innovative projects for CSP research.	• No significant change.
Power Cycles R&D $13,000,000	$3,250,000	-$9,750,000
• Support existing, merit-reviewed R&D work at the National Laboratories to develop primary heat exchangers for advanced supercritical CO_2 power cycles.	• Funding to initiate FY 2022-2024 projects for National Laboratory research programs that extend FY 2019-2021 work on primary heat exchangers for advanced supercritical CO_2 power cycles and add complementary competitive projects.	• No change in funding but research topics will be revised based on external review of program.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Fund competitively selected projects to integrate high-efficiency, long-duration pumped thermal energy storage (PTES) technologies with advanced supercritical CO2 power cycles.	• No funding requested in FY 2022.	• No additional funding requested while current projects are in progress.
• Funding for FY 2021 FOA topic on 1-year innovative projects for CSP research.	• Funding for FY 2022 FOA topic on 1-year innovative projects for CSP research.	• No change.
Solar Collector R&D $6,000,000	$6,450,000	+$450,000
• Support existing, merit-reviewed R&D work at the National Laboratories to develop optical components and improved optical characterization methods for CSP collector fields.	• Funding to initiate FY 2022-2024 projects for National Laboratory research programs that extend FY 2019-2021 work on optical components and improved optical characterization methods for CSP collector fields and add complementary competitive projects.	• Funding reduced, pending external review of proposals, to shift focus to the National Laboratory heliostat consortium.
• Funding to initiate a test facility at the National Laboratories that can validate novel heliostat designs, particularly including wireless, reliable control systems, at commercially relevant scales.	• Fully fund the first year of a National Laboratory consortium that provides a test facility to validate novel heliostat designs, particularly including wireless, reliable control systems, at commercially relevant scales.	• Funding is increased to support the first full year of the new heliostat consortium.
• Funding for FY 2021 FOA topic on 1-year innovative projects for CSP research.	• Funding for FY 2022 FOA topic on 1-year innovative projects for CSP research.	• No change.
Industrial Applications R&D $12,000,000	$27,250,000	+$15,250,000
• Support an existing, merit-reviewed R&D project at the National Laboratories to research novel pathways for the solar thermal production of ammonia and hydrogen as a means to progress towards decarbonization of the chemical industry.	• Funding to initiate FY 2022-2024 projects for National Laboratory research programs that extend FY 2019-2021 work on novel pathways for the solar thermal production of ammonia and hydrogen as a means to progress towards decarbonization of the chemical industry and add complementary competitive projects.	• No change in funding but research topics will be revised based on external review of program.
• Fund a prize competition for developing innovative advanced solar thermal desalination technologies.	• No funding requested in FY 2022.	• Shifting funding from desalination to other industrial processes that have not been focused on previously.
• Fund competitively selected project to develop solar thermochemical reactors for the production of solar-derived chemicals and fuels	• Fund competitively selected projects to develop solar thermochemical processes and components for the production of solar-derived	• Funding is increased substantially to reflect a significantly larger scope of industrial applications, in line with the Administration

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
to enable decarbonization of the full energy sector. • Funding for FY 2021 FOA topic on 1-year innovative projects for CSP research.	industrial products, chemicals, and fuels to enable decarbonization of the full energy sector. • Funding for FY 2022 FOA topic on 1-year innovative projects for CSP research.	priority on achieving a decarbonized industrial sector by 2050. • No change.

Solar Energy
Photovoltaic Technologies

Description

To support the President's 2035 goal for a carbon pollution-free power sector, a large growth in total U.S. photovoltaic (PV) capacity and annual deployment rate is likely needed. The Photovoltaic Technologies subprogram works to enable this acceleration by reducing the costs of PV electricity while also ensuring that deployed PV systems perform as expected and last up to 50 years. In support of these goals, the PV subprogram supports research, development, and demonstration that advances foundational knowledge and tackles scale-up and fabrication challenges for technologies that increase efficiency and durability while simultaneously reducing cost. Furthermore, the PV subprogram aggregates and analyzes performance data from PV systems deployed across the Nation to identify trends and best practices. Over the last decade, the cost of PV electricity has declined over 80 percent. Yet, significant opportunity remains to continue to reduce costs to reach SETO's cost target for unsubsidized, utility-scale systems from today's current utility-scale benchmark. Reaching such a cost target would enable greater electricity affordability in addition to increased PV deployment.

The PV R&D subprogram advances state-of-the-art and emerging PV cells, modules, systems, and their components, spanning work from early-stage solar cell research up to commercialization. Specifically, the subprogram seeds research to advance materials processes and device design approaches that enable higher PV performance and reduced cost, as well as better predictability and understanding of long-term reliability. Key thrusts include the development and validation of perovskite technologies, a national research consortium to improve cadmium telluride (CdTe) efficiency, new tools to predict system performance through monitoring and data analysis, and a portfolio of research at the National Laboratories advancing PV cell efficiencies, understanding PV system degradation rates and lifetime performance, and developing new measurement and characterization techniques.

Within the activities listed below, the Solar Energy fellowship program funds emerging leaders in the field that will pursue breakthrough solar energy technologies at universities, National Laboratories, and other research facilities as well as at DOE. In addition, funds may be used to support efforts such as merit/peer reviews, data collection and dissemination, technical assistance, and technology to market activities.

Conversion Efficiency R&D: Research and development to increase the power conversion efficiency and reduce the manufacturing costs of PV cells and modules, spanning established (e.g., silicon and CdTe) and emerging materials (e.g., perovskites and tandem structures). This activity also includes research in improved system design to increase energy production of the full PV system in real world operating conditions. Efforts include development of new characterization tools and techniques to build materials and device knowledge and connect with analysis of fielded systems and key performance metrics.

Durability R&D: Research and development to better understand and mitigate performance degradation of PV systems to enable 50-year lifetimes and resilience to extreme weather conditions. This activity includes development of robust and reproducible accelerated degradation protocols to simulate outdoor degradation mechanisms of PV systems to predict and reduce failure and better estimate lifetime. Research has a strong emphasis on developing test conditions that accurately reproduce degradation observed in fielded modules, and therefore, includes destructive testing of harvested modules and comparison of accelerated test results.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Photovoltaic Technologies $72,000,000	**$79,575,000**	**+$7,575,000**
Conversion Efficiency R&D $30,000,000	$30,500,000	+$500,000
• Support to continue the third year of FY 2019-2021 National Laboratory projects to advance PV cell and module performance.	• Funding to initiate FY 2022-24 projects for National Laboratory research programs that extend FY 2019-2021 work and add complementary competitive projects to advance PV cell, module, and system performance. Topics include establishing a National Laboratory capability in tandem photovoltaics, increasing the efficiency of CdTe modules, and developing new perovskite PV devices.	• No change in funding but research topics will be revised based on external review of program.
• Funding for FY 2021 FOA topic on 1-year innovative projects for PV research.	• Funding for FY 2022 FOA topic on 1-year innovative projects for PV research. Additional funding for FOA topics on cell metallization and low-cost and high-efficiency III-V PV research that exceeds typical commercial PV.	• Increased funding to include 2 new FOA topics.
• Initiate a CdTe research and industrial consortium executed by a National Laboratory that will bring together domestic companies, multiple National Laboratories, and academic researchers to advance the performance of CdTe PV systems.	• Funding for additional projects on CdTe system performance within the CdTe consortium launched in FY 2021	• Reduced funding requested since some FY 2021 funding provided to the CdTe Consortium will cover work through FY 2023. Requested FY 2022 funding is for supplemental projects to further grow the scope of the consortium.
Durability R&D $42,000,000	$49,075,000	+$7,075,000
• Maintain DuraMat consortium led by NREL to perform research dedicated to modeling and measuring durable materials for PV modules including advanced encapsulants and flexible packaging concepts.	• Maintain DuraMat consortium led by NREL to perform research dedicated to modeling and measuring durable materials for PV modules including advanced encapsulants and flexible packaging concepts.	• No change in funding but research topics will be revised based on external review of program.
• Support to continue the last year of National Laboratory FY 2019-2021 research projects to understand PV degradation pathways and develop standard tests.	• Funding to initiate FY 2022-24 projects for National Laboratory research programs that extend FY 2019-2021 work focusing on PV degradation pathways and developing standard	• Increased funding to expand durability R&D beyond PV modules to the full system hardware, given recent data showing system components have significant impact on long term

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	tests. Significantly increased funding for projects to expand focus beyond modules into the reliability of the balance of systems components (e.g., inverters).	
• Funding for FY 2021 FOA PV topic on reducing system degradation pathways resulting from balance of system degradation such as wiring and interconnects as well as efforts to develop more resilient systems.	• FY 2022 FOA topic on hardening PV systems for 50-year lifetime and extreme weather conditions (e.g., extreme heat, cold, wind, hail).	• Increased funding for FY 2022 topic that will build upon related topic in FY 2021 FOA and will have focus on extreme weather and hardening PV systems for resilience.
• Additional support for the new CdTe research and industrial consortium to support tasks on increasing the long-term durability of the CdTe systems to enable greater LCOE reduction.	• Funding to add select external projects to the CdTe consortium launched in FY 2021 that will address long term reliability.	• Reduced funding requested as a portion of FY 2021 funding provided to the CdTe Consortium will cover work through FY 2023. Requested FY 2022 funding is for supplemental projects to further grow the scope of the consortium.

Solar Energy
Systems Integration

Description

The Systems Integration (SI) subprogram, in coordination with the DOE Grid Modernization Initiative (GMI) and Energy Storage Grand Challenge (ESGC), funds research, development, and demonstration of technologies that better enable solar energy to support the reliability, resilience, and security of the electric power system. Solar deployment has been growing rapidly over the past decade, with solar producing three percent of the U.S. electricity supply in 2020. Meeting the President's goal for a carbon-free power sector will likely require solar to provide 30 to 50 percent of U.S. electricity by 2035. PV technologies cause challenges for power system operation due to their variable nature, fast-responding power electronics, and deployment on both the bulk power and distribution systems. There are nearly three million PV systems connected to the distribution system today, and this number is growing steadily. At the same time, the power system itself is also evolving rapidly with the deployment of digital sensors and communication networks and the integration of new technologies such as electric vehicle charging infrastructures, resulting in increased connectivity and complexity. As PV deployment becomes a larger share of electricity generation, it becomes critical that PV systems actively contribute to the reliability, resilience, and security of the electric grid.

Solar, wind, and battery storage technologies operate fundamentally differently than conventional power generators owing to the power electronics that are their interface with the grid. Already today, there are regions of the U.S. that have times where wind and solar can supply over half of the instantaneous power. As these levels increase, it will be critical that these technologies can provide essential grid services such as voltage and frequency regulation. These capabilities have been demonstrated in isolated testing, but much more research and demonstration is needed for grid operators and regulators to have confidence in their ability to rely on these technologies to support all aspects of grid reliability.

The SI subprogram addresses the key technical challenges in solar grid integration focusing on power system planning and operation generation variability and uncertainty, lower system inertia, operational flexibility, voltage and frequency control, real time situational awareness, system protection, cybersecurity, black start capability, and optimal power flow control. In addition, the subprogram advances the opportunities for PV, coupled with energy storage and other distributed energy resources (DERs) to enhance community resilience through reconfiguration to supply critical loads in the event of an outage. Further, the SI subprogram supports the development of industry standards and best practices on interconnection requirements, testing, and validation methods so that utilities, regulatory agencies, and solar developers have the most advanced tools for timely and cost-effective interconnection and integration of utility-scale solar and DERs. The portfolio supports activities under the broad areas of SI subprogram research as listed below.

Within the activities listed below, the Solar Energy fellowship program funds emerging leaders in the field that will pursue breakthrough solar energy technologies or analysis at universities, National Laboratories, and other research facilities as well as at DOE. In addition, funds may be used to support efforts such as merit/peer reviews, data collection and dissemination, technology assistance, and technology to market activities.

Planning and Modeling R&D: As more solar energy is added onto the electric grid every day, it's important for utilities and power system operators to plan for a variety of scenarios in order to balance electricity generation from solar and other sources with customer demand. Research in this topic area will focus on modeling and simulation methodologies and software tools for medium- to long-term planning for solar grid integration under various deployment scenarios, including optimal placement of PV and energy storage, the potential need for transmission and distribution upgrade, and interconnection requirements and reliability standards. Projects will address challenges in solar generation variability and uncertainty, resource forecasting and adequacy, system control stability, system flexibility, and co-optimization.

Operation and Control R&D: With increasing amounts of solar energy connected to the grid, it's important for utilities and power system operators to have real-time information about and control capabilities for the amount of generation that's occurring at any given moment, in order to reliably operate the grid with high solar generation contributions. Research in this topic area will focus on hardware and software technologies to enable real-time situation awareness and coordinated control that ensure system reliability during normal and abnormal operating conditions. Projects will address challenges in power electronic devices, sensing and communication, system protection and fault recovery, dynamic power flow control, and data analytics using artificial intelligence and machine learning.

Resilience and Security R&D: The deployment of distributed solar PV and other DERs can provide greater resilience to energy infrastructures and community services by integrating them into emergency response and recovery procedures. Research in this topic area focuses on technologies and solutions that integrate distributed solar PV, energy storage, and other DERs to provide continuity of electric power service for critical infrastructures and critical loads and reduce the magnitude and/or duration of disruptive events such cyberattacks and physical hazards such as hurricanes, floods, and wildfires. Projects will advance the detection and situation awareness of threats and enhance solar PV and power system's capabilities of anticipating, absorbing, adapting to, and/or rapidly recovering from a potentially disruptive event.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Requests FY 2021 Enacted
Systems Integration $53,000,000	**$71,750,000**	**+18,750,000**
Planning and Modeling R&D $13,000,000	$23,750,000	+$10,750,000
• Fund the third year of FY 2019-2021 SETO lab call projects to completion.	• Funding will support the first year of three-year merit-reviewed R&D projects at the National Laboratories and other new lab projects on dynamic models for PV and power systems, open data, solar resource forecast and integration, and reliability standards.	• Increasing focus on availability of high-resolution measurement data, modeling of power system dynamics, reliability metrics, and solar resource forecast and integration.
• Support the third year of FY 2019-2021 Grid Modernization Laboratory Consortium (GMLC) Lab Call projects to completion.	• Funding will support the first year of new three-year GMLC crosscutting projects.	• No significant change.
Operation and Control R&D $32,500,000	$33,000,000	+$500,000
• Fund the third year of FY 2019-2021 SETO lab call projects to completion.	• Funding will support the first year of three-year merit-reviewed R&D projects at the National Laboratories to support advanced data analytics and control coordination for PV and power systems.	• No significant change.
• Support the third year of FY 2019-2021 GMLC Lab Call projects.	• Funding will support the first year of new three-year GMLC crosscutting projects.	• No significant change.
• Fund competitively selected projects to investigate the dynamic characteristics of power electronic-based solar generation and to develop new inverter and master PV plant control methods. Funding will also support projects to develop low cost, efficient, secure methods for real time data management to enhance visibility and controllability of distributed PV systems.	Fund competitively selected projects to develop innovative technologies for power system control coordination, stability, and protection. This includes competitively selected projects on demonstration of grid services from solar and wind power plants (in collaboration with EERE WETO), and energy storage integration, validation, and demonstration pilots to support coordinated efforts in renewable integration and grid modernization. It also includes competitively selected projects to demonstrate the viability of highly energy-efficient, demand-flexible, low-carbon buildings integrated with distributed	• The new solicitations will build upon insights from previous research and industry feedbacks with more emphasis on demonstration and deployment of technologies to support accelerated renewable integration and grid modernization.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Requests FY 2021 Enacted
	energy resources (DERs) and related infrastructure (e.g. EV charging, thermal energy sources) to reliably and cost-effectively contribute to America's transition to a zero-carbon grid (in collaboration with EERE BTO).	
Resilience and Security R&D $7,500,000	$15,000,000	+$7,500,000
• Fund the third year of FY 2019-2021 SETO lab call projects.	• Funding will support the first year of three-year merit-reviewed R&D projects at the National Laboratories to support DER cyber security standard development.	• Modest decrease to focus on more targeted research.
• Support the third year of FY 2019-2021 GMLC Lab Call projects.	• Funding will support the first year of new three-year GMLC crosscutting projects	• No significant change.
	• Fund competitively selected projects to develop, demonstrate, and deploy innovative technologies to enhance resilience against physical hazards using distributed solar, energy storage, EVs, and other DERs (joint EERE-OE effort).	• The new solicitation will build upon insights from previous research and industry feedback and the recognition of increasing importance of resilience in power systems and communities.

Solar Energy
Balance of Systems Soft Cost Reduction

Description

The Balance of Systems Soft Cost Reduction (BOS) subprogram focuses on reducing the non-hardware costs of solar electricity, enabling the benefits of solar energy to reach all Americans, and developing a skilled and diverse workforce with access to good-paying jobs with the free and fair option to join a union and bargain collectively. The non-hardware, or soft costs, of solar energy include siting, permitting, inspection, interconnection, installation labor, project development, customer acquisition, financing, and other related costs. Taken together, soft costs constitute about 64 percent of total system prices for residential PV systems, 55 percent of commercial PV systems, and 35 percent of utility-scale systems.[1] Reaching the DOE 2030 solar cost targets of $0.05/kWh, $0.04/kWh and $0.02/kWh for the residential, commercial and utility-scale market segments, respectively, will require significant reductions in soft costs.

Reducing soft costs like siting, permitting, inspection, and interconnection requires engaging with community organizations, state and local governments, industry, and other stakeholder groups to understand barriers, develop collaborative research, tools, and processes, and broadly disseminate results and best practices to enable replication. For example, solutions to land use competition, which contribute to siting and permitting costs, may come from collaborative research and engagement on topics such the co-location of PV and agriculture, siting of PV on brownfields, and integration of PV into new home construction.

Rooftop solar offers opportunities across the country for consumers to save money on electricity bills. However, about half of U.S. households cannot access rooftop solar due to roof shading, financing barriers, or lack of home ownership.[2] Community solar has the potential to overcome these barriers. The BOS subprogram aims expand access to affordable community solar to every American household by 2025.

The solar industry has been one of the fastest growing employment sectors over the past decade, providing 250,000 jobs in 2019. To meet the President's 2035 carbon pollution-free electricity goals, however, an expanded and highly trained workforce that represents the diversity of the U.S. is critical. Well-designed workforce training and apprenticeship programs that are industry-driven and employee-centered can create communities that are both economically and environmentally resilient. STEM programs for students are also needed to ensure that the next generation has the necessary skills to enter the clean energy workforce.

The solar industry has been one of the fastest growing employment sectors over the past decade, providing 250,000 jobs in 2019. To meet the President's 2035 de-carbonization goals, however, an expanded and highly trained workforce that represents the diversity of the U.S. is needed. Well-designed workforce training and apprenticeship programs that are industry-driven and employee-centered can create communities that are both economically and environmentally resilient. STEM programs for students are also needed to ensure that the next generation has the necessary skills to enter the clean energy workforce.

Within the activities listed below, the Solar Energy fellowship program funds emerging leaders in the field that will pursue breakthrough solar energy technologies at universities, National Laboratories, and other research facilities as well as at DOE. In addition, funds may be used to support efforts such as merit/peer reviews, dissemination activities, and technology to market activities.

Data, Modeling, and Analysis: Foundational data collection, modeling, and analysis to benchmark soft costs, understand barriers to solar and solar plus storage deployment, and evaluate the effectiveness of proposed solutions. This activity includes data and analysis to increase market transparency, evaluate the value of solar, expand access to solar energy, understand land and wildlife impacts, and open new markets. This activity also includes field research to collect data and conduct analysis on alternative siting approaches for solar.

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[1] D. Feldman et al., "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2020," NREL Technical Report, January 2021.

[2] D. Feldman et al. "Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation," NREL Technical Report NREL/TP-6A20-63892 (April 2015). https://www.nrel.gov/docs/fy15osti/63892.pdf

Technical Assistance and Stakeholder Tools: Technical assistance to help solar stakeholders reduce soft costs and overcome barriers to solar and solar plus storage deployment. This activity includes providing technical assistance to stakeholders on permitting, interconnection, community solar, equitable access to solar, resilience planning, solar integration with the grid, and codes and standards. Stakeholders include state, local and tribal governments, the solar industry, utilities, community-based organizations, and others. This activity also includes the development of voluntary online tools for local governments to streamline solar permitting and for states to manage the enrollment of low-income customers in community solar, reducing enrollment costs and subscribers' energy burden.

STEM and Workforce Development: STEM and workforce programs to enable diverse workers to benefit from the clean energy economy. This activity includes and EERE-wide collaboration to promote cross sector job opportunities, provide training opportunities, mentorship, and benefits to diverse workers, and support industry's workforce needs. This activity also includes a program to support placement of selected participants at public utility commissions or electric utilities to conduct research on the integration of solar energy onto the electric grid and a competition that helps to prepare college students with different academic expertise for careers in clean energy.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Balance of Systems Soft Cost Reduction $35,000,000	**$75,250,000**	**+$40,250,000**
Data, Modeling, and Analysis $14,000,000	$21,150,000	+$7,150,000
• Fund the first year of the National Laboratory FY 2022-24 projects that advance data, modeling, and analysis for the reduction of solar soft costs.	• Support National Laboratory FY 2022-24 projects that advance data collection, modeling, and analysis for the reduction of solar soft costs, including alternative siting approaches for solar.	• No change in funding; research projects will be selected based on external review.
	• Fund competitively selected projects to collect data and conduct modeling and analysis on innovative siting alternatives for ground-mounted solar and wildlife impacts with solar facilities.	• No change in funding; research projects will be selected based on external review.
	• Support increased cross-EERE and cross-DOE efforts to provide data, tools, and analysis to support the widespread integration of renewables in a resilient, reliable power system.	• Increased emphasis on holistic approaches to grid modernization and understanding pathways to decarbonize the power system.
Technical Assistance and Stakeholder Tools $18,000,000	$41,500,000	+23,500,000
• Use a FOA to support the extension of the SolSmart program that assists local governments to improve processes for solar energy development.	• No funding requested in FY 2022.	• The FOA is fully funded in FY 2021 for multiple years of work.
• Fund the National Community Solar Partnership, a congressionally-directed program that provides technical assistance to businesses, non-profit organizations, and state, local and tribal governments to expand access to affordable community solar.	• Fund the National Community Solar Partnership, which provides technical assistance to businesses, non-profit organizations, and state, local and tribal governments to expand access to affordable community solar.	• No change in funding.
	• Fund Solar Energy Innovation Network, led by NREL, a program that assists multi-stakeholder teams in researching solutions to real-world challenges associated with solar energy adoption.	• Funding to support multi-stakeholder team participation in the program. New funding topic reflects the Administration's focus on making the benefits of clean energy available for all Americans.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	• Fund the development of an online platform to manage the voluntary enrollment of low-income households in community solar and reduce household energy burden.	• Funding reflects an increased focus on reducing soft cost barriers to solar deployment.
	• Fund the development of a voluntary online tool to streamline solar permitting and technical assistance to help local governments adopt it.	• New funding topic reflects an increased focus on reducing soft cost barriers to solar deployment.
	• Fund stakeholder engagement and technical assistance to address barriers to siting, permitting, and interconnection of solar and wind energy to the electric grid, in collaboration with the Wind Energy Technologies Program.	• Funding topic recognizes the growing importance of community resilience and will build upon insights from previous research and industry feedback.
	• Fund competitively selected projects to engage stakeholders, especially in underserved communities and in remote, island, and islanded communities, to conduct energy planning to enhance resilience against physical hazards using solar and other DERs (joint EERE-OE effort).	• Funding reflects increased emphasis on collaborative efforts with decision-makers on grid modernization and pathways to decarbonize the power system.
	• Technical assistance for stakeholders faced with making data-driven decisions and investments, including evaluating technologies, designing clean energy deployment programs, developing market solutions, and planning transmission and distribution upgrades to facilitate the transition to a 100 percent clean electricity system (joint EERE-OE effort).	• Funding reflects increased emphasis on collaborative efforts with decision-makers on grid modernization and pathways to decarbonize the power system.
STEM & Workforce Development $3,000,000	$12,600,000	+$9,600,000
• Support solar workforce training programs for veterans and other talent pools.	• Fund a career accelerator that promotes cross sector job opportunities, provides training, mentorship, and benefits to diverse workers, and supports industry's workforce needs.	• Additional funding will enable coordinated workforce training for solar and other clean energy technologies and will expand successful training models nationwide, in line with the Administration's focus on creating training opportunities and well-paying jobs in clean energy.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Fund the Solar District Cup, a competition that helps to prepare college students with different academic expertise for careers in clean energy.	• Fund the Solar District Cup, a competition that helps to prepare college students with different academic expertise for careers in clean energy. • Fund the Solar Energy Innovators Program, which supports the placement of selected participants at public utility commissions or electric utilities to conduct research on the integration of solar energy onto the electric grid.	• No significant change. • Funding will enable the program to support additional participants at public utility commissions and electric utilities, in line with the Administration's focus on creating training opportunities in clean energy.

Solar Energy
Manufacturing and Competitiveness

Description

The Manufacturing and Competitiveness (MC) subprogram supports entrepreneurs and companies in developing and commercializing new solar technologies that can grow and diversify the U.S. solar industry, increase U.S. competitiveness in solar energy manufacturing and advance progress toward the carbon-free power sector by 2035. The MC subprogram helps companies with promising solar technologies survive the funding gaps that often emerge in the development cycle of new technologies.

In 2019, about $9 billion were spent on PV hardware in the U.S. About $4 billion of this was spent on domestic content and the balance on imported content. Increasing domestic content in PV hardware will keep more value in the U.S. economy and create valuable, good-paying manufacturing jobs with the free and fair option to join a union and bargain collectively. Reducing reliance on imported goods also reduces cost uncertainty and sensitivity to international supply chain disruptions or cyber-security concerns while also increasing domestic energy security. The MC subprogram supports proof-of-concept development, technology demonstration and validation, and technology transfer of innovative solar technologies across the value chain that can be produced competitively in the U.S.

The MC subprogram utilizes prize programming and the American Made Network to catalyze new businesses pursuing innovative technologies. Manufacturing and value chain research, development, and demonstration efforts aim to advance and validate technology progress to enable subsequent private sector funding to scale into production. This includes the 17th round of the successful Incubator program, which provides early-stage assistance to small businesses developing and validating technology prototypes.

Within the activities listed below, the Solar Energy fellowship program funds emerging leaders in the field that will pursue breakthrough solar energy technologies or analysis at universities, National Laboratories, and other research facilities as well as at DOE. In addition, funds may be used to support efforts such as merit/peer reviews, data collection and dissemination, technical assistance, and technology to market activities.

American-Made Challenges: Prize programming and associated support structures, like the American Made Network, to seed new solar technologies and increase America's market share for added-value manufacturing. Focus of the work is on incentivizing the development of solutions by a diverse set of individuals and new entrants to the solar technology development space in addition to connecting these people to a network of experienced commercialization partners in order to accelerate the process to develop new, innovative solar products. The goal is to enable products to go from concept to pilot testing within one calendar year.

Manufacturing and Value Chain: Cooperative agreements and grants focused on developing and validating new solar technologies with a focus on those which can be domestically manufactured. Funding targets the full value chain, from innovative approaches to producing solar cells and module materials to new tracking technologies to power electronics to technologies to reduce maintenance costs. Programming also aims to bring more private capital funding into solar energy technology development and ensuring well trained workers are ready to enter the workforce as the opportunities grow. The goal is to help companies de-risk technologies and commercial approaches sufficiently to enable investment and commercialization by private sector entities.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Manufacturing and Competitiveness $60,000,000	**$100,000,000**	**+$40,000,000**
American-Made Challenges $11,200,000	$15,300,000	+$4,100,000
• Run an additional round of the American Made Solar Prize to support innovators in launching new products that advance the solar industry and support U.S. manufacturing.	• Run a new round (6th) of the American-Made Solar Prize.	• No significant change.
• Begin Perovskite Prize to establish innovative perovskite companies.	• No additional funding requested.	• Perovskite Prize was planned as a one-time release. Future prize competitions planned for other topics.
• Begin additional prizes to accelerate solar cost reduction solutions.	• Run additional prizes to accelerate solar cost reduction solutions and spur new small businesses.	• Increased funding to accelerate innovation and new product creation in the U.S. solar industry.
	• Provide funding to the American Made Network, which helps provide support to competitors in all the American-Made Challenges and can provide value to the larger MC portfolio.	• Modest funding will increase effectiveness of all American-Made prize programming.
Manufacturing and Value Chain R&D $48,800,000	$84,700,000	+$35,900,000
• Fund competitively selected projects focused on perovskites research addressing manufacturing, durability, sustainability, and reducing market barriers, development costs, and technology risks.	• Fund competitively selected projects to develop and scale new solar cells and materials, manufacturing processes and products, supply chain integrations, and building-integrated photovoltaics/photovoltaic building materials which can lead to increased domestic manufacturing across the solar value chain.	• Incremental increase in funding will focus on developing and scaling domestic technologies along the entire solar value chain with high potential for sustainable domestic manufacturing.
• Fund competitively selected projects focused on accelerating the commercialization of innovative product ideas that can substantively increase U.S. domestic manufacturing across the solar industry supply chain and expand private investment in America's solar manufacturing sector. These products and solutions will lower the cost of solar technologies and facilitate the	• Fund competitively selected projects focused on accelerating the commercialization of innovative product concepts that can considerably increase U.S. domestic manufacturing across the solar industry supply chain and expand private investment in America's solar manufacturing sector. These products and solutions will lower the cost of solar technologies and facilitate the	

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
secure integration of solar electricity into the Nation's energy grid.	secure integration of solar electricity into the Nation's energy grid.	
	• Fund a career accelerator that promotes cross sector job opportunities, provides training, mentorship, and benefits to diverse workers, and supports industry's workforce needs.	• New funding will enable coordinated workforce training for solar and other clean energy technologies and expand successful training models nationwide, in line with the Administration's focus on creating training opportunities and well-paying jobs in clean energy.

Wind Energy

Overview

The Wind Technologies Office (WETO) supports a portfolio of research and innovation designed to accelerate the advancement and deployment of offshore, land-based, and distributed wind energy technologies and their integration with the electric grid. WETO's priorities focus on key opportunities to improve performance and reliability, reduce costs, discover solutions to environmental and siting challenges, engage with place-based interested parties, and facilitate market adoption. These priorities reflect a broad range of stakeholder inputs and are supportive of the Administration's energy and climate goals, namely, to achieve 100 percent carbon pollution-free electricity by 2035 and put the United States on a path to a net-zero carbon economy by 2050. Additionally, the WETO's Request emphasizes the underpinning principles of equity and environmental justice, the creation of good-paying jobs in a diversified U.S. wind workforce, inclusiveness in STEM skills development, and increased engagement with states, local communities and universities, including HBCUs and minority serving institutions across all of its activities planned for FY 2022.

American wind energy resources are vast and mostly untapped. Wind has the potential to contribute up to 35 to 45 percent of U.S. electricity in less than two decades and, with continued innovation, could do so cost-competitively. Beyond electricity, wind energy can also contribute to the generation of clean fuels to help transition the U.S. economy to net-zero emissions in industry, manufacturing, and agriculture, with associated growth in good-paying jobs across all regions of the country. Progress on these fronts, arising from continued innovation in technology, grid systems integration, and unique solutions to deployment challenges, can position the United States to regain its position as a global leader in wind energy development at home and abroad.

Wind technology today is an important part of a diverse energy mix in the United States, and there are over 122 gigawatts (GW) of land-based, utility-scale wind deployed across 41 states[1], supplying over 9 percent of U.S. electricity[2]. The United States has over 85,000 wind turbines deployed in distributed applications across all 50 states[3]. An offshore wind industry is just beginning to develop in the United States, driven by falling offshore wind turbine prices, technological advances, accelerated Federal offshore wind lease auctions, and complementary state policies and commitments. DOE recently announced a joint-agency goal to deploy 30 GW of offshore wind by 2030, which, if realized, would unlock a pathway to 110 GW or more by 2050. Achieving these goals will take a concerted effort on behalf of the Federal government, including critical R&D efforts by the Wind Program in multiple areas.

WETO emphasizes three overarching objectives:

- Reduce the cost of wind energy for all wind applications (offshore, land-based utility-scale, and distributed);
- Enable the interconnection and integration of substantial amounts of wind energy into the dynamic and rapidly evolving energy system, that is cyber-secure, reliable and resilient, and includes systems integrated with other energy technologies, energy storage, and offshore and inter-regional transmission planning;
- Accelerate the deployment of wind energy through siting and environmental solutions to reduce environmental impacts, minimizing timetables for wind energy project development, and facilitating responsible and equitable development and delivery of wind energy resources.

WETO's programmatic authorizations were expanded with the enactment of the Energy Act of 2020. For one, near-, mid-, and long-term wind energy targets are to be developed in the context of a comprehensive wind energy strategy. The strategy is to include requirements for research, development, demonstrations, and deployment. The Energy Act also included a range of new activities to be completed before the end of calendar year 2022, including: an assessment of airborne wind potential; a report on critical materials and the wind energy supply chain risks from non-domestic suppliers; and identification of pathways for recycling of wind technology components.

[1] https://cleanpower.org/news/wind-industry-closes-record-2020-with-strongest-quarter-ever/
[2] https://www.eia.gov/todayinenergy/detail.php?id=46617
[3] https://www.pnnl.gov/sites/default/files/media/file/2019%20Distributed%20Wind%20Data%20Summary-10Aug20.pdf

Highlights of the FY 2022 Budget Request

- Research and development of solutions to reduce environmental and siting barriers to land-based and offshore wind, coordinated with DOE's Solar and Water Programs on related efforts and issues.
- Technology development to enable ultra-large floating wind turbines to access the 58 percent of U.S. offshore wind resources that are in in deep water, including the entire West Coast.
- Research to assess transmission infrastructure requirements to maintain system reliability and ensure cost-effective transmission access for offshore wind, while identifying innovative solutions to provide advanced grid services and reduce costs.
- Advanced materials and manufacturing R&D to develop innovative solutions to scaling, reliability, transportation constraints, materials, and supply chain challenges to accelerate wind deployment of all types and optimize opportunities for domestic manufacturing.
- Joint effort with the Hydrogen and Fuel Cells Technologies Office to integrate and demonstrate a multi-megawatt water electrolyzer coupled with wind power generation to produce low-cost, emissions-free hydrogen.
- Joint effort with the Solar Energy Technologies Office to demonstrate the robustness of grid services, such as frequency regulation, load following, and contingency reserves, provided by utility-scale wind and solar plants on the bulk power system under various operating conditions throughout numerous regions of the United States.
- Cross-office collaboration to demonstrate and validate energy storage technologies under varying system conditions to improve electricity service and community resilience.
- Cross-office collaboration to provide technical assistance and demonstration for cities and communities to reach their 100 percent renewable goals and consider important power system attributes including reliability, resilience, security, affordability, flexibility, and energy equity.

Wind Energy
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Wind Energy				
Offshore Wind	52,500	63,200	100,260	+37,060
Land-Based Wind	31,800	31,800	40,000	+8,200
Distributed Wind	10,000	10,000	17,750	+7,750
Grid Integration & Analysis	9,700	5,000	46,860	+41,860
Total, Wind Energy	**104,000**	**110,000**	**204,870**	**+94,870**

SBIR/STTR:
FY 2020 Transferred: SBIR $2,484,000; STTR $763,000
FY 2021 Projected: SBIR $2,524,000; STTR $355,000
FY 2022 Request: SBIR $5,283,000; STTR $743,000

Wind Energy
Explanation of Major Changes ($K)

	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Wind Energy	
• **Offshore Wind:** The increase in funding level for this subprogram reflects the prioritization of research, development, demonstration, and deployment (RDD&D) innovations to drive U.S. offshore installations to contribute to the achievement of the Administration's goals of 100 percent clean electricity by 2035 and a net-zero carbon economy by 2050. DOE, along with fellow agencies, have established a goal of 30 GW of offshore wind deployed by 2030. Targeted funding will support a wide range of RDD&D activities, specifically including focus on: a) innovative offshore wind environmental and siting solutions, b) cost effective offshore wind floating platform design development, c) domestic offshore wind advanced manufacturing, supply chain development, and recycling, d) offshore wind storage hybrids and hydrogen production, and e) acceleration of cost reductions to offshore wind system manufacturing, installation, and operations through technology innovations and industrialization.	**+37,060**
Land-Based Wind: The increase in funding level for this subprogram reflects the prioritization of RDD&D innovations to drive cost effective land-based wind deployment to contribute to achieve the Administration's goals of 100 percent carbon pollution-free electricity by 2035 and a net-zero carbon economy by 2050. Targeted funding will support a wide range of RDD&D activities, specifically including focus on: a) solutions for land-based wind environmental and siting challenges, b) wind advanced manufacturing, U.S. supply chain development, and recycling, and c) land-based wind storage hybrids and hydrogen production. Project efforts will additionally include efforts to: a) focus on developing and evaluating manufacturing innovations to enable highly flexible, rail-transportable blades; and b) artificial intelligence (AI) methodologies to generate rapid operational wind and power forecast predictions from new neural-network-based weather forecasting models.	**+8,200**
Distributed Wind: The increase in funding level in this subprogram reflects the prioritization of RDD&D innovations to drive cost effective distributed wind deployment in order to achieve the Administration's goals of 100 percent carbon pollution-free electricity by 2035 and a net-zero carbon economy by 2050. Targeted funding will support a wide range of activities with a focus on balance-of-plant costs, wind plant costs and performance, small wind power production risks, hybrid distributed wind systems, and design standards. The funding increase will directly support Wind Innovations for Rural Economic Development (WIRED) Networks to provide technical assistance, develop decision support tools, and establish national networks of rural community and electric utility stakeholders in places with high quality wind resources, and the Energy Transition Initiative Partnership Program (ETIPP) to support underserved, remote, island and islanded communities to navigate pathways to energy resiliency.	**+7,750**

Wind Energy Explanation of Major Changes ($K)	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Grid Integration & Analysis: Increased funding in this subprogram will prioritize Grid Integration activities to ensure cost-effective, reliable, cyber-secure, and resilient operation of the power grid that is essential for wind deployment of all types, to achieve the Administration's goals of 100 percent clean electricity by 2035 and a net-zero carbon economy by 2050. The subprogram will prioritize and advance efforts to address offshore, land-based and distributed wind grid integration challenges, expanding on existing RDD&D and analysis activities to develop, refine, and demonstrate the capability of wind plants to provide grid services; increase wind energy's contribution to grid reliability and resiliency; improve grid infrastructure investment to ensure access and utilization for wind deployment; improve electrical hardware performance and reduce wind energy system costs; address wind-specific cybersecurity needs; integrate wind power with storage and other technologies; and improve the understanding of electricity market operation with high penetrations of wind energy. This subprogram will also prioritize analysis and modeling activities needed to effectively assess technology development options and policy scenario analysis.	**+41,860**
Total, Wind Energy	**+94,870**

Description

The Offshore Wind subprogram promotes the development of U.S. offshore wind research resources through research, technology development, and enabling activities, such as workforce development, all aimed at reducing costs and other barriers to offshore wind development. To accomplish this, the subprogram invests in understanding the fundamental science at the heart of extracting energy from offshore wind, which, in turn, drives the technology innovation necessary to improve wind plant performance, operation, and maintenance. The subprogram also focuses on the evaluation and development of solutions to environmental and siting challenges associated with offshore wind energy development in U.S. waters.

Through these activities, the Offshore Wind subprogram aims to achieve breakthroughs in reducing the levelized cost of energy (LCOE) from a 2019 benchmark of $.08/kWh to $.05/kWh by 2030 without subsidies. Reaching this 2030 goal will make offshore wind energy a cost-competitive option. The approach for realizing cost reduction goals is to identify the top-most cost-contributing elements and find ways to reduce capital costs, improve energy output and operating efficiency, and reduce operating and maintenance costs over the life of the investment. DOE also aims to support the R&D, analyses, and enabling activities necessary to deploy 30 GW of offshore wind by 2030, the achievement of which will also unlock a pathway to 110 GW, or more, by 2050.

Science and Technology Innovation: This activity seeks to advance offshore wind technology and scientific understanding to reduce cost and risks. This activity has three major areas of focus: resource characterization, offshore wind technology innovation, and research to reduce operations and maintenance (O&M) costs. The first of these activities, resource characterization, is critical to better understanding offshore wind resource dynamics and a power plant's interactions with various atmospheric and oceanographic conditions. Due to differences in sea currents, sea surface temperatures, and nearby land interfaces, the U.S. has a unique offshore environment distinctive from Northern Europe and Asia, where most of the world's offshore wind plants have been built to date. Better understanding this environment is critical to predicting offshore wind resources and potential structural loading impacts that will be experienced by future U.S.-based offshore wind systems. The Offshore Wind Resource Science project will improve predictions of wind/wave resources in offshore wind energy development areas around the U.S. coastline, with particular focus on improving the characterization of the offshore marine boundary layer.

This activity also seeks to develop offshore wind technology innovations to open new markets, such as deep-water markets on the West Coast of the U.S., by developing floating technologies, enabling economies of scale with resultant reductions in cost, developing designs optimized for domestic supply chains, and advancing turbine and farm controls to increase output and improve predictability. For floating offshore wind, the industry has demonstrated technology feasibility but still would benefit from significant cost reductions to achieve full commercial viability. With many competing designs and an undeveloped project pipeline, R&D is focused on the significant technology challenges to enabling commercial-scale projects; foremost among these are investments that reduce the levelized costs of floating platforms, increase the certainty of the predicted performance, and enable manufacturing at domestic facilities.

Efficiency and usability of wind technology depends on the reliability and lifetime of components. Operations can be optimized—and thus O&M costs decreased — with the proper tools and data to decrease unplanned maintenance and extend the lifetime of components. The harsh offshore environment introduces significant challenges to maintenance which increases the importance of investments in this area. Also, as wind turbines get larger and more flexible, O&M costs and reliability issues become more critical to the performance of the entire wind system and its economic competitiveness. The activity uses prognostic health management tools to optimize O&M practices driven by AI, automated fault detection, and remote, autonomous inspection and repair methods that will benefit both offshore and land-based wind plant operations.

Manufacturing and Materials R&D: This activity aims to develop and build national capabilities for cost-effectively manufacturing, installing, and maintaining offshore wind plants in the United States, resulting in domestic manufacturing opportunities in support of Buy American and the creation of well-paying jobs with the free and fair option to join a union

and bargain collectively. The complexity and risks associated with offshore wind installation and maintenance activities require specialized infrastructure not yet developed in the United States. Identifying strategies to leverage the Nation's existing infrastructure to reduce the need for specialized vessels and installation equipment will reduce both capital expenditures and long-term operating costs. Through this activity, the Wind Program will conduct technology R&D to ease the technical challenges of installation by reducing turbine weight, finding turbine installation methods that do not require large European-type installation vessels, and use of advanced materials and manufacturing technologies to reduce the fabrication costs of floating offshore turbine foundations. Activities include investigating and prototyping new manufacturing methodologies using additive manufacturing (3D printing) techniques coupled with automated assembly approaches to reduce fabrication costs and mitigate transportation challenges of large and complex wind turbine components. Automation will significantly reduce the manual labor typically involved in manufacturing wind components, allowing for manufacturing of components at larger scales at lower costs, leading to global economic competitiveness and technology leadership.

Environmental and Siting R&D: Siting of offshore wind projects has been a challenge for the last two decades in the U.S. and has proven a significant barrier to the development and market entry and expansion of this renewable energy technology. This activity will focus on developing solutions to key environmental and siting barriers to offshore wind development through research to understand impacts, development of technical solutions, and engagement with coastal communities to facilitate ocean co-use and aid in energy planning. The Wind Program's approach is to identify and focus on the highest-priority concerns, which are primarily related to the environment, radar interference, and community impacts. Research in each case is to be tailored to specific needs of areas or regions where development is anticipated.

This activity will help resolve environmental impacts of offshore wind development by reducing uncertainty surrounding impacts, through knowledge transfer from Europe and collection of environmental impacts data, and by developing tools to monitor and mitigate impacts This activity will support research on the environmental impacts of first-generation offshore wind projects, with an emphasis on addressing issues causing permitting uncertainty and risks for the first U.S. offshore wind projects, including questions regarding impacts on marine mammals and birds, and habitat changes affecting protected and commercially-important species. These data will be used to inform the design of effective and affordable technical mitigation solutions that reduce costs and barriers to offshore wind development. Research efforts will focus on developing and validating monitoring and mitigation solutions for novel offshore issues that pose unique challenges compared with land-based wind, including the need to develop automated wildlife monitoring systems and continued innovation of tools to minimize impacts of construction noise on protected species.

Through this activity, the Wind Program will collaborate under the interagency Wind Turbine Radar Interference Mitigation Working Group to characterize and address the unique impacts of offshore wind development on critical agency missions and operations, which are less understood than the impacts of land-based wind plants. Efforts will focus on both leveraging work in the land-based wind space for radar systems that will likely be impacted by both land-based and offshore wind development, such as long-range air surveillance radars, and on work focused on systems where offshore wind is likely to have a greater effect, such as coastal high-frequency systems for ocean wave and current measurement, and marine navigation radars. Activities will include modeling and field testing and evaluation to characterize wind turbine interference and develop and deploy mitigation measures to increase the resilience of existing radar systems to offshore wind turbines, with a particular focus on high-Technology Readiness Level (TRL) development and deployment of mitigation technologies; and continuing interagency engagement to encourage development of next-generation radar systems that are resistant to interference from wind turbines.

Finally, this activity will support social science and socioeconomic research to understand impacts of wind energy on communities and ocean co-users and provide technical assistance to communities considering offshore wind development. Research will aid in the understanding of impacts of offshore wind development on communities and ocean co-users and allow for strategies that reduce impacts and increase environmental justice for wind energy development. In coordination with EERE offices supporting energy technologies deployed in the ocean, the Wind Program will design programming to ensure communities have access to objective information regarding the benefits and costs of offshore wind energy development. Activities will aid in proactive, place-based community engagement and planning processes that include consideration of offshore wind energy development, in the context of broader energy options, to both ensure that wind development works for communities and to increase siting certainty for future development.

STEM and Workforce Development: Growth of the American offshore wind industry has the potential to provide tens of thousands of well-paying, union-eligible job opportunities by 2030. In order to ensure there is a trained and ready workforce available to meet those jobs, new training and education programs are needed to prepare workers with applicable skills and knowledge. Workforce education and training needs will be linked to the growth of the industry. As a result, there's a need to understand both the projected temporal and geographic patterns of development and associated workforce development needs. Further, today, individual states are conducting analysis and incentivizing or establishing working training programs, but there's a need for greater coordination. This activity will support offshore wind STEM and workforce development activities, including national scale analyses to systematically identify future workforce needs, programming to catalyze solutions to those needs, and efforts to convene industry and educational institutions to develop workforce development solutions. The work will also place a strong emphasis on ensuring the diversity of the future offshore wind workforce.

Offshore Wind

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Offshore Wind $63,200,000	**$100,260,000**	**+$37,060,000**
Science & Technology Innovation $27,166,000	$45,468,000	+$18,302,000
• Continue DOE National Laboratories' support of offshore wind resource characterization and forecasting. No funding is requested for new competitively selected projects.	• Continue DOE National Laboratories' support of offshore wind resource characterization and forecasting.	• Competitive award will continue using prior-year funds. DOE National Laboratories' support funded separately.
• Deploy lidar buoys off the coast of California in conjunction with the Bureau of Ocean Energy Management to characterize the wind energy resource. Analyze current and previous buoy data to develop improved air-sea interaction physics governing the variation of the winds and improve numerical weather prediction models.	• Planning and Resource Monitoring Campaigns.	• Begin planning for the first major offshore wind measurement and validation campaign (build on current LIDAR prospecting deployment) on the West Coast to develop reliable resource forecasts and design basis data.
• Support National Laboratory led project to develop offshore wind full-farm controller using consensus control methodology.	• Continued funding at current levels with additional scope associated with floating offshore wind farms.	• No significant change.
• Support National Laboratory-led projects to advance fully-coupled turbine/foundation engineering design tools for fixed-bottom and floating foundations.	• Continue support at current funding levels for National Laboratory-led projects to advance fully-coupled turbine/foundation engineering design tools for fixed-bottom and floating foundations.	• No significant change.
• New effort in Offshore Integrated Systems Engineering to develop analysis and research capability to improve system-level performance and achieve system-level cost reductions. The effort incorporates advances in computational algorithms, simulation methods, physics-based improvements, cost and performance modules to assess new technology opportunities and advance the state-of-the-art, and best practices in multidisciplinary design analysis and optimization (MDAO) for wind energy applications.	• Continue Offshore Integrated Systems Engineering to address floating offshore wind plants.	• Focus on improving modeling fidelity and modularity. Emphasis on exploring plant co-design and controllability through plant layout, wake steering and loads mitigation.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• No significant efforts.	• Enable O&M optimization for larger turbines through prognostic health management tools, standardized data, advanced inspection, and repair techniques supported by AI and robotics.	• Shift of reliability research focus from land-based turbines to offshore, with an emphasis on use of AI and robotics.
• Support for offshore wind energy technology demonstration projects to advance offshore wind development by demonstrating innovative technologies not previously commercially used in the United States for offshore wind.	• Continued funding at current levels with increased emphasis on component demonstrations.	• Focus on component demonstration increases ability to leverage ongoing industry investments.
• No significant efforts.	• Floating Platform Innovation & Industrialization and Floating Platform Sensitivity analyses.	• Develop designs suitable for U.S. manufacturing facilities, decrease costs of floating platforms, and provide seed funding for improvements until bulk orders are available.
• No significant efforts.	• West Coast Port Assessments, Quayside Assembly.	• Understand available and required infrastructure to enable design and supply chain development.
• Fixed foundation farm-level control design and physics understanding associated with wake steering and hybrids.	• Floating Platform Controls & Hydro/Aerodynamics.	• Develop floating turbine, platform, and farm controls which account for additional platform degrees of freedom in wind farm control schemes.
• No significant efforts.	• Operations & Maintenance Research.	• Reduce personnel actions at-sea and increase the range of sea states during which maintenance actions may be achieved.
Manufacturing and Materials R&D $23,640,000	$29,476,000	+$5,836,000
• Building on FY 2020 activities, initiate National Laboratory led analytical studies for additive design and feasibility of prospective additive processes.	• No funding requested.	• Analytical study completed in FY 2021
• Support for National Laboratory research to develop improved carbon fiber material mechanical properties using non-circular, hollow fibers with larger surface areas (for bonding) and larger inertia for bending and buckling resistance.	• Continued funding at current levels.	• No significant change.
• Continue the manufacturing and additive design of electric machines enabled by three-dimensional printing (MADE3D) project to additively manufacture every part of the	• Continued funding at current levels.	• No significant change.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
generator including the coils/windings, electrical insulation, stator/rotor, magnetic core packs and permanent magnets, structural/mechanical and thermal management components and enabling new design degrees of freedom in terms of shape complexities and materials not previously available.		
• Continue 3D Printed Blade Core Material project to design and manufacture a 3D printed blade core structure which outperforms current solutions in terms of strength, stiffness, mass, cost, and durability.	• Continued funding at current levels.	• No significant change.
• No significant efforts.	• Wind Re-design for Recycling: Emphasize recycling for existing components and also re-design for future components; novel materials and manufacturing ("design for recycling") to extend life and make it economically more cost effective to recycle in the future. Goals include reducing demand for critical materials in wind turbines.	• New effort to improve recycling and recovery of critical materials at the end of life of wind plants. Additionally, responding to FY 2021 Energy Act direction to develop a recycling program and materials physical properties database.
• FOA award down-select to build and test a prototype of a high-efficiency, ultra-light low temperature superconducting generator (SCG) on a wind turbine.	• No funding requested.	• Fully funded in FY 2021.
• No significant efforts.	• Advanced materials and manufacturing R&D to reduce full lifecycle costs and accelerate blade/tower/nacelle factory throughput. Develop new manufacturing methodologies using additive manufacturing techniques coupled with automated assembly approaches to reduce fabrication costs and mitigate transportation challenges of large and complex wind turbine components.	• Responding to Administration priorities to increase offshore wind deployments and develop a domestic supply chain, initiate anew effort in advanced materials and manufacturing R&D to reduce full lifecycle costs and address existing challenges for wind (enable continued scaling and through light weighting; improve reliability of turbines; advanced manufacturing/design to overcome transportation constraints; address materials & supply chain issues.)
• No significant efforts.	• Transition National Laboratory research to improve wind turbine reliability to offshore wind by focusing on application of big data analysis and	• Transition onshore wind focused R&D to offshore wind application.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	AI techniques to optimize operations and maintenance.	
Environmental and Siting R&D $11,282,000	$20,732,000	+$9,450,000
• Offshore wind environmental research and instrumentation validation FOA to increase understanding of environmental impacts of offshore wind, as well as projects that advance and validate tools to monitor and minimize impacts.	• Support for research on environmental impacts of floating and fixed-bottom offshore wind projects to inform solution development and reduce siting and regulatory risk.	• Continue support for research initiated in FY 2020 and FY 2021, including increasing funding for FY 2021 Offshore Wind Energy Environmental Research and Instrumentation Validation to support funding for additional awards and research collaboration with National Oceanographic and Atmospheric Administration (NOAA) and Fisheries and Wildlife Service on selected projects. Support research efforts to prepare the West Coast for future offshore wind development.
• Development and validation of environmental monitoring and mitigation technologies, with an emphasis on tools that allow for autonomous monitoring and impact mitigation.	• Development and validation of environmental monitoring and mitigation technologies, including support for validation of monitoring tools capable of being deployed on buoys to lower baseline data collection costs and provide more robust baseline and post-construction data.	• Increased focus on validation of autonomous monitoring capabilities for areas where there are current performance gaps.
• Continue international research sharing and dissemination through IEA Wind Energy Task 34 (WREN) and the Tethys database.	• Continue international research sharing and dissemination through IEA Wind Energy Task 34 (WREN) and the Tethys database.	• No significant change.
• Co-fund National Laboratory research and development to address wind/radar challenges unique to offshore wind and facilitate the definition of next-generation radar requirements. Key funded partnerships with Department of Defense (DOD), Department of Homeland Security (DHS), Department of Transportation (DOT), Department of the Interior (DOI) and Department of Commerce (DOC).	• Co-fund National Laboratory and industry efforts to address wind/radar challenges associated with radar systems of mutual interest to land-based and offshore wind, while continuing to build understanding of on impacts unique to offshore wind. Continue to facilitate the definition of next-generation radar requirements. Key partnerships with DOD, DHS, DOT, DOI and DOC.	• Increased emphasis on final development and deployment of mitigations for systems likely to be impacted by both land-based and offshore wind.
• Maintain WINDExchange to ensure use of the best available science to support wind energy policy and deployment decisions.	• Maintain WINDExchange, to ensure use of the best available science to support wind energy policy and deployment decisions.	• Increased focus on research to understand effects on coastal economies, including fisheries and other co-users of ocean space.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• No significant efforts	• Expand technical assistance to coastal communities considering offshore wind development to ensure access to fact-based information during planning processes. Expand collaboration with NOAA Sea Grant to support engagement with ocean users regarding offshore wind development.	• Increased assistance to coastal communities to help plan for energy projects at the local level, including energy choice considerations and evaluation of ocean-use options.
• No significant efforts.	• Initiate science and socioeconomic research to understand impacts of wind energy on communities and ocean co-users and facilitate co-use of ocean space.	• Initiate new research area.
• Continue support for the National Wind Turbine Database and research on community impacts.	• Continue support for the National Wind Turbine Database and research on impacts.	• No significant change.
STEM and Workforce Development $1,112,000	$4,584,000	+$3,472,000
• Support for the Collegiate Wind Competition (CWC), an annual event that challenges teams of undergraduate students to develop solutions to complex wind energy projects.	• Increased support for offshore wind STEM and educational opportunities through expansion of current programming and establishment of new offshore wind programs at universities and colleges.	• Broaden the CWC to include an offshore wind focus. Initiate programming to increase offshore wind curriculum, fellowships, and internships, at universities and colleges, including an emphasis on ensuring diversity of the future offshore wind workforce.
• Support National Offshore Wind Workforce Development Roadmap and Network.	• Support National Offshore Wind Workforce Development Roadmap and Network.	• No significant change.

Wind Energy
Land-Based Wind

Description

The Land-Based Wind subprogram emphasizes efforts to reduce the cost of wind energy and develop solutions to an array of siting and environmental concerns associated with land-based wind energy development confronting the vast majority of the U.S. wind resource. Additional activities focus on addressing "Tall Wind" turbine technology innovations, motivated by economies of scale. The quality of the wind resource (e.g., wind speed, wind shear, and wind profile) varies significantly based on location, but is almost uniformly better at higher heights above the ground. Taller towers with larger generators, longer blades, and larger rotor diameters all lead to greater energy capture and lower cost per unit of energy output. But the path to this end is complex and fraught with risks, technical challenges, and uncertain outcomes. Success will require novel designs, light-weighting of massive components, stronger materials, innovative manufacturing, creative transport logistics and construction techniques, real-time monitoring and modeling of wind flows, and dynamic plant optimization. All represent significant opportunities for cost reduction, as well as opportunities for domestic manufacturing in support of Buy American and well-paying jobs with the option to join a union.

Through these efforts, the subprogram seeks to reduce the levelized cost of energy (LCOE) for land-based wind from a 2015 benchmark of $.06/kWh to $.02/kWh, without subsidies, by 2030. Achieving this 2030 goal would represent a 50 percent reduction from today's LCOE and make wind electricity one of the most affordable forms of electricity in the United States.

Science and Technology Innovation: The approach to achieving the Wind Program's LCOE goal is to address the highest cost-contributing elements of today's land-based wind technology and operations and reduce them significantly through science, research, and innovation.

This activity seeks to advance land-based wind technology innovation and scientific understanding to decrease cost and improve the performance and reliability of next-generation tall wind plants and turbine technology. The activity will shift focus to applying the physics knowledge and design tools developed under the Atmosphere to Electrons (A2e) project to address R&D challenges required to facilitate the next generation of rotors for tall wind applications, including large, flexible blade structural design and load control, wind plant controls to mitigate turbine-turbine wake interaction, and atmospheric research to improve weather forecasting specific to wind plant power generation.

Manufacturing and Materials: This activity aims to develop cost-effective, lightweight turbine components that are more efficient, stronger, and more reliable for the full life-cycle of the wind turbine through advanced manufacturing, materials science, and mechanical systems R&D. Very long, highly flexible blades capture substantially more energy both through a greater swept area and by accessing increased wind speeds higher above the ground than accessed by conventional technology. They also allow wind plants to operate at a higher capacity factor, with less variability in power production.

Efforts will focus on composite material research to develop recyclable blade materials and other advanced materials science to develop lubricants, composite materials, and metallic coatings that are resistant to damage in operating conditions that benefit both land-based and offshore wind applications.

Environmental and Siting
Meeting the President's 2035 and 2050 climate goals will likely require deployment of land-based wind on a scale and at a pace not seen in the U.S. to date. Such development will require focused and concerted investments in addressing the associated siting and environmental challenges that will increase in scale and import as deployment accelerates. This activity focuses on facilitating the development of solutions, minimizing impacts, and enabling the efficient siting and operation of land-based wind facilities. The Wind Program's approach is to identify and focus on the highest-priority concerns, which are primarily related to wildlife, radar interference, and communities.

This activity emphasizes efforts develop solutions to environmental impacts of land-based wind by supporting research to inform sound siting of projects and turbines on the landscape, research to characterize impacts, and the development of mitigation tools and technologies. Research focuses on evaluating and addressing impacts on bats, eagles, and grouse species. In FY 2022, the Program will place an emphasis in research on grouse species, to augment prior year investments in bat and eagle research and solution development. DOE will support research efforts to increase understanding of impacts of wind development on grouse species, as well as validation of siting and compensatory mitigation options. Ultimately these research findings could be used to inform policies and practices regarding wind development on grouse habitat, as well as present developers with tools to minimize and offset impacts to aid future development

Through this activity, the Wind Program will collaborate with other agencies through the interagency Wind Turbine Radar Interference Mitigation Working Group to address the impacts of land-based wind development on air surveillance and weather radar missions. Activities will include modeling and field testing and evaluation to characterize wind turbine interference and develop and deploy mitigation measures to increase the resilience of existing radar systems to wind turbines, with a particular focus on high-TRL development and deployment of mitigation technologies; and continuing interagency engagement to encourage development of next-generation radar systems that are resistant to interference from wind turbines.

Finally, this activity will support social science and socioeconomic research to understand impacts of wind energy on communities and provide technical assistance to communities considering land-based wind development. Research will aid in the understanding of impacts of wind development on neighbors and communities and allow for strategies that reduce impacts and increase environmental justice for wind energy development. In coordination with other land-based renewable energy offices, including DOE's Solar Program, the Wind Program will support proactive, placed-based community engagement and planning processes that include consideration of wind energy development in the context of broader renewable energy options and provide communities with access to neutral information regarding the benefits and costs of land-based wind energy development. Such programming will help to both ensure that wind development works for communities and increase siting certainty for future development.

STEM and Workforce Development

Wind energy provides significant domestic job opportunities and the rapid development of additional, substantial wind energy integral to achieving the President's energy targets will provide substantially more. In order to ensure there is a trained and ready workforce available to meet those jobs, new education programs are needed to prepare workers with applicable skills and knowledge. In order to target workforce development programming, there's a need to understand both the patterns of development driven by the President's energy targets, as well as potential gaps in educational and training programs. This activity will support offshore wind STEM and workforce development activities, including national scale analyses to systematically identify future workforce needs, programming to catalyze solutions to those needs, and efforts to convene industry and educational institutions to develop workforce development solutions. The work will also place a strong emphasis on ensuring the diversity of the future land-based wind workforce.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Land-Based Wind $31,800,000	**$40,000,000**	**+$8,200,000**
Science & Technology Innovation $21,611,000	$16,982,000	-$4,629,000
• Support to maintain mission readiness and operational expertise of DOE's specialized research facilities and capabilities at the NREL Flatirons Campus and Sandia Scaled Wind Farm Technology (SWiFT) facility.	• Continue support to maintain mission readiness and operational expertise of DOE's specialized research facilities and capabilities for the NREL National Wind Technology Center at Flatirons and Sandia Scaled Wind Farm Technology (SWiFT) facility.	• No significant change
• Continue National Laboratory research to improve wind turbine reliability by focusing on application of big data analysis and artificial intelligence techniques to optimize operations and maintenance.	• No funding requested.	• Efforts in this area moved to Offshore Program.
• Develop the American Wake Experiment (AWAKEN). National Laboratories will organize and design a landmark international wake observation and validation campaign for A2e wind farm modeling tools.	• Complete data sharing, land lease and environmental impact agreements. Begin the AWAKEN field campaign, deploying long term observational instruments.	• AWAKEN data validation field campaign begins. The AWAKEN field campaign will collect data for 18 months.
• Continue the A2e atmospheric science research to develop, test, refine, validate, and disseminate specific mesoscale to microscale coupling strategies and technologies as well as provide basic research results and enable low order modeling to support new high-performance-computing-based multiscale wind plant simulation tools that couple a broad range of scales	• Continue the A2e atmospheric science research to develop, test, refine, validate, and disseminate specific mesoscale to microscale coupling strategies.	• Work will focus on improved representation of the surface layer in microscale models using next generation techniques (e.g. machine learning) to improve simulations of wind speed and shear.
• Continue the A2e High-fidelity modeling (HFM) and simulation development, ExaWind, to dramatically improve the understanding of the fundamental physics governing whole wind plant performance, including wake formation, complex-terrain impacts, and turbine-turbine-wake interaction.	• Continue the A2e High-fidelity modeling (HFM) and simulation development, ExaWind, to dramatically improve the understanding of the fundamental physics governing whole wind plant performance, including wake formation, complex-terrain impacts, and turbine-turbine-wake interaction	• Perform high-fidelity, blade-resolved turbine simulations, and quantify the influence of different turbulence length scales on the aerodynamic and structural dynamic response of the rotor. Investigate and document the influence of wake evolution and downstream turbine interaction via two-turbine simulations

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• High Fidelity Modeling Toolkit project augments the ExaWind capabilities developed under the high-fidelity modeling effort to include a multi-fidelity approach for wind characterization and allow it to specifically address problems related to farm blockage and site/pad-level wind variations.	• No funding requested	• Project will be completed using prior-year funds
• Continue A2e Rotor Wake Measurements & Predictions for Validation efforts to enable the validation of cross-application simulation tools in the context of wind turbine and plant modeling, and to further our understanding of wind turbine flow physics and wake management.	• Continue A2e Rotor Wake Measurements & Predictions for Validation efforts to enable the validation of cross-application simulation tools in the context of wind turbine and plant modeling, and to further our understanding of wind turbine flow physics and wake management.	• Initiate the Rotor Aerodynamics Aeroelastics, and Wake (RAAW) experiment. The RAAW experiment is focused on the inflow, turbine response, and the resulting wake and the results will be used to inform the AWAKEN field campaign.
• Continue the A2e Integrated Systems Design and Analysis – Systems Engineering and Optimization (ISDA-SEO) initiative to develop analysis and research capability to improve system-level performance and achieve system-level cost reductions. The effort incorporates advances in computational algorithms, simulation methods, physics-based improvements, cost and performance modules to assess new technology opportunities and advance the state-of-the-art, and best practices in MDAO for wind energy applications.	• No funding requested	• Systems Engineering efforts moved to Offshore subprogram
Manufacturing and Materials R&D $3,112,000	$2,830,000	-$282,000
• Build upon previous National Laboratory activities and advanced materials science research to develop new novel coatings and lubricants for improved reliability of bearings and gears.	• This project will focus on quantifying the effect of numerous contact conditions as well as the effectiveness of potential mitigation methods on white etching cracks failures in bearings and gears.	• The investigation into white etching crack formation is expanded to investigate the effect of stray electrical currents. Specifically, the effect of steel morphology, lubricant composition, and variable electrical currents will be studied.
• Design, implementation, and validation of fusion joining of thermoplastic composites applied to wind turbine blades.	• No funding requested.	• Project will be completed using prior-year funds.
• Support for National Laboratory led Big Adaptive Rotor (BAR) collaboration to mitigate transportation constraints of very large rotors by focusing R&D on methodologies to control the	• Continue BAR Phase II program initiated in FY 2021 to continue the maturation of the advanced rotor concepts through the following objectives: 1) A comprehensive technoeconomic analysis of	• BAR Phase I completed in FY 2021. BAR Phase II will address the technical challenges identified in Phase I.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
aerodynamic and aeroelastic behavior of slender, high tip-speed ratio, highly flexible blades.	the three BAR concepts, 2) Addressing gaps in the modeling capability and validating the advanced engineering design tools to enable the analysis of next generation concepts, and 3) Conducting experiments to demonstrate the concepts and collect validation data for the new suite of advanced engineering design tools.	
Environmental and Siting R&D $5,961,000	$16,896,000	+$10,935,000
• Build upon National Laboratory research to characterize the environmental performance of land-based wind projects, by focusing on identifying potential bat deterrent signals and to better understand drivers of risk for bat species at wind farms.	• Continue research efforts aimed at understanding environmental impacts and develop siting solutions for a range of species.	• Expand research on grouse species, to augment prior year investments in bat and eagle research and solution development. DOE will support research efforts to increase understanding of impacts of wind development on grouse species, as well as validation of siting and compensatory mitigation options.
• Development and validation of environmental monitoring and mitigation technologies, with an emphasis on developing and optimizing bat deterrent technologies.	• Development and validation of environmental monitoring and mitigation technologies.	• Focus work on technologies that increase understanding of and minimize risk to bats at wind farms.
• Continue international research sharing and dissemination through IEA Wind Energy Task 34 (WREN) and the Tethys database.	• Continue international research sharing and dissemination through IEA Wind Energy Task 34 (WREN) and the Tethys database.	• Support the continued development of a database that provides information on capabilities of environmental monitoring and mitigation technologies.
• In partnership with DOD, DHS, DOT, DOI and DOC, validate one or more mitigation measures at a radar site where the mission is currently impacted by wind turbine interference.	• Co-fund development and deployment of approaches to wind turbine radar interference mitigation. In partnership with DOD, DHS, DOT, DOI and DOC, test and validate one or more mitigation measures at a radar site where the mission is currently impacted by wind turbine interference.	• Increased emphasis on final development and deployment of mitigations for systems likely to be impacted by both land-based and offshore wind.
• Support for the National Wind Turbine Database.	• Continue support for the National Wind Turbine Database.	• No significant change
• Maintain WINDExchange to ensure use of the best available science to support wind energy policy and deployment decisions.	• Maintain WINDExchange to ensure use of the best available science to support wind energy policy and deployment decisions.	• No significant change
• No significant efforts	• Support for proactive community planning processes that include consideration of wind	• New effort in FY22 to provide assistance to communities to help plan for energy projects at

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	energy development in the context of broader renewable energy options.	the local level, including energy choice considerations and evaluation of land-use options.
• Continue support for research on community impacts.	• Research on impacts of wind development on wind farm neighbors. Research to understand socioeconomic impacts of wind energy development, with an emphasis better understanding environmental justice implications of wind energy development and the development of solutions to promote equity and benefits from wind energy development for disadvantaged communities.	• Increased research efforts.
STEM and Information Resources $1,116,000	$3,292,000	+$2,176,000
• Support for the Wind for Schools (WFS) project.	• No funding requested	• Transfer funding of WFS to non-profit entity established for this purpose through an FY 2016 National Renewable Energy Lab Request For Proposals.
• Continue support for the Collegiate Wind Competition (CWC), KidWind, and the North American Wind Energy Academy	• Continue support for the Collegiate Wind Competition, KidWind, and the North American Wind Energy Academy	• Expand CWC to include part-time support for associated faculty and staff.
	• Support for new wind energy fellowships and internships, with an emphasis on promoting diversity in the future wind workforce	• Establishment of new programming. Initiate programming to increase wind energy curriculum, fellowships, and internships, at universities and colleges, including an emphasis on ensuring diversity of the future wind workforce.

Wind Energy
Distributed Wind

Description

The Distributed Wind subprogram focuses on achieving breakthroughs in reducing the levelized cost of energy (LCOE) from $.09/kWh today to $0.05/kWh for a reference 100-kilowatt system. Achieving this goal would enable distributed wind to cost-effectively complement and integrate with other distributed energy resources (DERs), such as solar PV and storage, in hybrid plants and microgrids. The subprogram invests in activities to reduce soft costs (i.e. permitting and interconnection processes); increase system power production and grid support capabilities; improve decision support tools for distributed wind project planning, design, and operations; and test next generation technology to national standards to verify performance and safety. Activities to reduce high cost market barriers, such as permitting and interconnection, provide targeted technical assistance to support rural, disadvantaged, and isolated communities with evaluating the benefits of standalone and hybrid distributed wind energy systems.

Science and Technology Innovation

This activity will continue work to improve the science around rapid, computationally-based wind resource and site assessment for standalone and hybrid distributed wind systems, for which traditional meteorological instrumentation and field measurements are cost-prohibitive, and current practices are too uncertain and inaccurate to support the third-party financing, grid planning, and operational tools needed for industry growth.

Testing and Reliability

Testing and Reliability efforts for distributed wind will support U.S. small and medium wind turbine manufacturers through the Competitiveness Improvement Project to reduce turbine costs, improve system performance and grid support capabilities, and test turbine designs and balance of plant components to national and international safety and performance standards to achieve certification. Efforts will also include U.S. and international stakeholder engagement to improve and harmonize national and international wind turbine performance and safety standards to ease export market access.

Balance of Systems

Balance of systems activities will focus on reducing capital costs through standardization of project assessment, permitting, interconnection, system design, and installation of distributed wind systems. New efforts under this activity will include the launch of the Wind Innovations for Rural Economic Development (WIRED) Networks initiative, which will support industry, communities, utilities and other stakeholders in development of best practices to reduce soft costs and remove barriers to distributed wind deployment. The activity will also support the expansion of the EERE funded Energy Transition Initiatives Partnership Program (ETIPP), to provide technical assistance to remote communities in increasing energy resilience and achieving their energy transition objectives. The activity will also continue to fund R&D that enhances accuracy of distributed wind performance assessments in tools used to inform siting and system design, evaluate grid impacts, and reduce project development risk. Efforts will also focus on maximizing and demonstrating the value and resiliency of microgrids powered by wind energy, in combination with other distributed energy resources such as solar and storage.

Distributed Wind

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Distributed Wind $10,000,000	**$17,750,000**	**+$7,750,000**
Science and Technology Innovation $3,238,000	$3,238,000	$0
• Tools Assessing Performance (TAP) work will continue improving and validating the science around rapid, computationally-based wind resource and site assessment for distributed wind systems, for which traditional meteorological instrumentation and field measurements are cost-prohibitive.	• Tools Assessing Performance work will build upon prior year efforts by integrating computationally sourced and field validated wind resource characteristics into simplified, easily accessible models for user facing decision support tools to leverage.	• No significant change.
• Defense and Disaster Deployable Turbine work will complete design guideline and model procurement specifications for military applications.	• Defense and Disaster Deployable Turbine work will focus on engagement with military and disaster response stakeholders to disseminate design guidelines and procurement specifications.	• Shift in emphasis to dissemination of developed products as project ramps down.
Testing & Reliability $4,273,000	$4,273,000	$0
• Support for the Competitiveness Improvement Project (CIP) to reduce turbine costs, improve performance and grid support capabilities, and test designs to national safety and performance standards for achieving certification.	• Continue Competitiveness Improvement Project with 2022 Request for Proposals, to reduce turbine costs, improve performance and grid support capabilities, and test designs to national safety and performance standards for achieving certification.	• No significant change.
• Strategic and technical analysis and engagement activities in support of distributed wind R&D to increase the economic and technical viability of distributed wind energy installations.	• Continue strategic and technical analysis and engagement activities in support of distributed wind R&D, to increase the economic and technical viability of distributed wind energy installations.	• Emphasis of FY 2022 activities will be on development and publication of a distributed wind futures study to assess distributed wind's potential role in reaching a zero-carbon electricity grid by 2035.
Balance of System R&D $2,387,000	$10,137,000	$7,750,000
• Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad (MIRACL) work develops advanced system control capabilities for enhanced resilience and grid support, and improves modeling and valuation tools.	• Continue support for Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad work focusing on the integration and control of distributed wind hybrid systems.	• FY 2022 work will transition from development of models and capabilities to multi-lab hardware testing, and data collection and research on reference systems in the field.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	• Launch Wind Innovations for Rural Economic Development (WIRED) Networks to support the development of permitting and interconnection best practices for wind and wind hybrid projects, new business models, and other work to reduce soft costs and overcome barriers to wind deployment in rural communities.	• Initiation of effort through FOA and lab-based technical assistance to utilities, communities, and industry members.
	• New funding to support the expansion and inclusion of wind in the EERE-funded Energy Transitions Initiative Partnership Project (ETIPP).	• Support expansion of EERE-led National Laboratory technical assistance program to remote communities to aid in energy transition planning and implementation.
STEM and Information Resources $102,000	$102,000	$0
• Maintain WINDExchange to ensure use of the best available science to support wind energy policy and deployment decisions.	• Continue WINDExchange to ensure use of the best available science to support wind energy policy and deployment decisions.	• No significant change

Wind Energy
Grid Integration and Analysis

Description

The Grid Integration and Analysis subprogram aims to enable cost-effective, cyber-secure, reliable, and resilient operation of the energy system with increasing levels of wind in all regions, and provide objective analysis to benchmark technology trends, evaluate and prioritize wind energy technology innovation opportunities, and explore the potential role of wind energy in different energy futures for offshore, land-based, and distributed applications.

The grid integration subprogram will develop new technologies and analytical tools that facilitate transmission access and improve grid reliability and resiliency with increasing levels of wind energy. The research will focus on identifying transmission infrastructure needs for wind deployment and prioritizing industry collaboration to improve electrical hardware performance and reduce wind energy system costs. The research will enable wind to provide a set of stackable grid services with an emphasis on wind plant controls optimization, wind power forecasts improvement, and the validation and demonstration of reliable and resilient grid operation with wind control features and improved plant level forecasts. The subprogram will continue to coordinate through the Grid Modernization Initiative and the Energy Storage Grand Challenge in cross-cutting R&D activities including providing technical assistance to Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) and initiating technical assistance to cities and communities to reach their 100 percent renewable goals.

Specific R&D activities supporting the Energy Storage Grand Challenge include assessing hybrid wind energy storage and conversion options; optimal hybrid plant design and configurations; developing controls, hardware, and models for wind hybrid plants; improving resource forecasting; and conducting validations and field demonstrations.

Informed by the DOE Roadmap for Wind Cybersecurity, cross-cutting cybersecurity research activities will extend from cyber vulnerability assessment to focus on wind plant cyber and physical protection, cyber intrusion detection, and cyber incident response and recovery. The R&D will be conducted in collaboration and coordination with other DOE offices, Federal agencies, and wind industry stakeholders.

In analysis, the subprogram will continue its work to inform, guide, and enable the Wind Program to efficiently plan, prioritize, and communicate on its research and innovation mission. In support of this objective, the subprogram will continue to collect data on U.S. wind energy technology trends in the land-based utility scale, offshore, and distributed wind sectors, to provide a solid baseline both for assessing future technology innovation opportunities, and to give stakeholders a solid objective understanding of U.S. wind energy cost, performance, and technology trends. Second, the subprogram will continue evaluating potential future wind energy innovation opportunities, using and improving on its state-of-the art systems engineering, cost and deployment models, and other tools. Finally, the subprogram will continue to explore wind energy's potential role in different energy futures through robust scenario analysis. These efforts will include support for a new EERE-level effort assessing pathways to achieve a zero-carbon grid by 2035 and a net-zero economy by 2050, collaboration with EERE Strategic Analysis and other EERE offices on products such as the Annual Technology Baseline and Standard Scenarios, and continuation of Wind Program-specific efforts to inform technology development and strategy efforts.

Grid Integration and Analysis

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Grid Integration and Analysis $5,000,000	**$46,860,000**	**+$41,860,000**
Grid Integration $3,517,000	$45,377,000	+41,860,000
• In support for cross-cutting Grid Modernization Initiative and Energy Storage Grand Challenge activities, continue the research and development in renewable hybrid energy storage systems and provide technical assistance to ISOs/RTOs.	• Continue support for cross-cutting Grid Modernization Initiative activities such as wind-hybrid energy storage systems and technical assistance to ISO/RTOs from the Grid.	• No significant change.
• Wind cybersecurity research to compare and evaluate various hardening mechanisms to secure wind power plant • Develop and prototype grid forming control for wind.	• Research and development to increase dispatchability of wind energy and improve wind power forecast for grid services, • Continue wind cyber security research to develop wind plant protection, intrusion detection, and cyber incident response and recovery. • Initiate new research to assess transmission infrastructure requirements to maintain system reliability and ensure cost-effective transmission access for offshore wind, while identifying innovative solutions to provide advanced grid services and reduce costs	• FY 2022 will focus on stackable grid services and improved dispatchability with enhanced grid service forecast. • FY 2022 will transition to wind plant cyber physical protection, intrusion detection, and cyber incident response and recovery. • New effort to identify transmission infrastructure needs for offshore wind and develop innovative solutions to reduce cost.
	• Joint effort with the DOE's Hydrogen and Fuel Cell Program to integrate and demonstrate a multi-megawatt water electrolyzer coupled with wind power generation to produce low-cost, emissions-free hydrogen	• New effort to optimize and validate configuration design for hydrogen production with wind energy and conduct joint industry operational demonstration.
	• Joint effort with DOE's Solar Energy Technologies Office to demonstrate the robustness of grid services provided by utility scale wind and solar plants under various operating conditions and systematically improve processes nationwide to enable faster and simpler interconnection of solar and wind resources to the electric grid.	• New effort to demonstrate reliable grid operation in high renewable energy systems with grid services provided by wind and solar. Develop roadmap and identify solutions for improvement of interconnection process.
	• In support of Energy Storage Grand Challenge, demonstrate and validate energy storage technologies under varying system conditions to	• New cross-office collaboration to develop and demonstrate new energy storage technologies.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	improve electricity service and community resilience. • Cross-office collaboration to initiate technical assistance and demonstration for cities and communities reaching their 100 percent renewable goals and consider important power system attributes including reliability, resilience, security, affordability, flexibility, and energy equity.	• New cross-office collaboration to assist cities and communities reaching their 100 percent renewable goals
Analysis $1,483,000	$1,483,000	$0
• Collect and disseminate data on wind technology cost and performance trends to support GPRA reporting, support other analytical efforts and inform stakeholders.	• Collect and disseminate data on wind technology cost and performance trends to support GPRA reporting, support other analytical efforts and inform stakeholders.	• No significant change.
• Develop and maintain capabilities to evaluate the impacts of innovation in land-based, distributed, and offshore wind technologies.	• Develop and maintain capabilities to evaluate the impacts of innovation in land-based, distributed, and offshore wind technologies.	• No significant change.
• Through collaboration with other Renewable Power offices, conduct electricity system analysis to better understand wind energy's role in the electricity system, both today in the future.	• Through collaboration with other Renewable Power offices, conduct electricity system analysis to better understand wind energy's role in the electricity system, both today in the future.	• No significant change.

Water Power

Overview

The Water Power Technologies Office (WPTO) administers a broad portfolio of research activities to strengthen the body of scientific and engineering knowledge and support industry efforts to develop and deploy new hydropower and marine energy technologies at all scales. These efforts are directly aligned with the Administration's goal of a carbon pollution-free electricity sector by 2035. America has vast marine energy and hydropower resources and there remains enormous potential to both expand into new markets and applications and to increase generation and flexibility across the nation's sizable hydropower and pumped storage fleet. Areas of opportunity include existing hydropower facilities and non-powered dams that can utilize new technologies to cost-effectively increase generation and flexibility; innovating on flexible and more rapidly deployable pumped energy storage systems; and advancing marine energy technology to support new and growing industries utilizing waves, currents, tides, and ocean thermal gradients. The program supports applied research, development, demonstration, and deployment (RDD&D)-focused projects across industry, academia, and the National Laboratories through a wide variety of mechanisms and other innovative partnership approaches to accomplish its objectives.

Hydropower, which currently provides almost seven percent of the electricity on the Nation's grid, offers flexibility in both the short and long-term to support and complement variable renewable energy (VRE), and pumped storage systems are one of the most scalable, cost-effective, and long-lived grid-scale storage assets, both now and likely in the future. The pumped storage hydropower (PSH) fleet provides 22 Gigawatts (GW) of capacity and 550 GW hours of energy storage, making it by far the largest source of long-duration storage currently available. The Program's HydroWIRES (Water Innovation for a Resilient Energy System) initiative invests in R&D that enhances the ability of hydropower and PSH to provide increased flexibility and grid-reliability services and investigates new PSH technologies that can dramatically reduce the capital costs and barriers to new, large-scale, long-duration storage facilities critical to integrating additional VRE resources while maintaining a reliable and resilient grid. The Program also supports the Energy Storage Grand Challenge to validate and demonstrate promising approaches to long-duration energy storage that can help provide the necessary flexibility to operate a high-renewables power system. This includes working closely with other EERE and DOE offices to refine storage performance metrics, validate technologies in the field, and develop new storage demonstration and pilot programs.

Marine energy, with its potential to provide power through precisely predictable tides and the large technical resources in waves and thermal gradients, offers both a future opportunity to supply electricity to a deeply decarbonized national grid and is a near-term solution for distributed energy for isolated and islanded communities, where marine energy might serve as the only viable substitute for fossil fuels. However, marine energy technologies are still relatively nascent and face significant challenges in engineering and operations to fully unlock their potential at both small and large scales.

In addition to its value to large scale renewables integration, water power has important benefits across multiple infrastructure sectors and to the people who depend on them. There are opportunities to evaluate how to harness and deliver water power, including through building more resilient infrastructure, providing power to produce clean water, unlocking the full potential of all ocean resources (Powering the Blue Economy or PBE), and better aligning technology development with end-users and communities. Community-centric development is an increasing emphasis of the Water Power Program's work, particularly in the instances of remote, underserved, tribal, and/or isolated communities. These communities are deeply reliant on and connected to their water systems as part of their economy and culture. Recognizing and being respectful of these factors, the Water Power Program endeavors to build connections to communities and the industries who use the technologies developed through the program's R&D. The Program does this through leveraging the larger innovation ecosystem to support entrepreneurship and technology development incorporating end-user requirements in solicitations, and by working with community-based organizations.

Leveraging technical assistance from the National Laboratories, supporting research and development, and working closely with communities and other end-users can provide catalytic change for the communities and organizations who most benefit from harnessing water power. This includes work to support irrigation modernization, working with municipal utilities and cooperatives to expand their ability to manage systems like storage and hybrid systems, and building out strategies to address multipurpose existing water infrastructure like dams. In FY 2022, the Program will initiate partnerships

with local irrigation districts and municipalities to develop the digital planning tools and advanced water sensors necessary to modernize the Nation's water infrastructure systems for irrigation, water treatment, and consumptive delivery.

To realize the potential of water power it is necessary to understand how it is changing with the climate. Water power technologies can serve as invaluable assets in a decarbonized future and serve the energy needs of climate-impacted communities, but it is necessary to understand how water systems themselves are impacted by changing weather patterns and societal needs. Climate change will affect water control, storage, management, and multiple uses of water by reservoirs, resulting in critical risks and unique opportunities for these water systems. Therefore, hydropower and the broader water infrastructure system must develop analytical tools, infrastructure solutions, and adaptation processes to ensure our current system's reliability and develop adaptive, flexible solutions to drive a productive and climate resilient future. As such, in FY 2022, the Program will dramatically expand efforts to quantify hydrologic and climate change impacts to hydropower by demonstrating and deploying advanced hydrologic sensors in watersheds across the U.S. and assessing the Nation's dams with respect to climate resiliency. The oceans can also serve as assets for resilience against climate change. The Water Power Program plans to explore the potential for how oceans can be a sink for carbon in an environmentally appropriate way, offer pathways to decarbonization through the maritime sector, and explore how marine energy can power emerging markets like kelp farming and other climate mitigation strategies.

The hydropower sector has an aging workforce but offers pathways to well-paying, stable jobs. This potentially includes veterans and the workforce from other industries impacted by a shift to a clean energy economy, particularly since many hydropower plants are operated by utilities who will shift operations away from fossil fuel systems to renewables. Marine energy holds promise for new jobs from ports to remote communities, to developing solutions far out at sea, as well as being an interdisciplinary hard technology field for emerging researchers and scientists. However, both the marine and hydropower industries currently face challenges, such as a lack of diversity and even a lack of awareness of the opportunities within the broader public. There are opportunities in the Water Power Program to expand on work conducted to date in developing effective strategies to support STEM and workforce gaps in water power.

To fund this crosscutting and technology-specific work, the Water Power Program uses funding mechanisms based on technological challenges, end-user needs, programmatic objectives, and intended funding recipients (companies, entrepreneurs, National Laboratories, universities, and other Federal and state agencies). The driving philosophy behind decisions on which mechanisms to use for which end goal is to maximize the impact of funding and to tailor funding mechanisms to best align with activity objectives and recipient needs.

But there is still a need to address the key challenges to commercialization, adoption, and diffusion of technologies. To support both deep tech and near-term deployable solutions to address climate change, increased support for the broader innovation ecosystem that is critical to ensuring commercialization, adoption, and diffusion of climate technologies is needed. The Water Power Program will work with other offices across the Renewable Power portfolio to support an effort to align activities and with the Office of Technology Transitions to support the regional, local, and national innovation ecosystem. The activities under consideration include: supporting incubators/accelerators in the private sector to support commercialization of a broad range of technologies and entrepreneurs, including attracting, recruiting, and training individuals and companies to apply for funding; identifying options to build on National Laboratory-focused commercialization opportunities; and developing metrics to measure, track, and evaluate commercialization strategies.

In support of the Administration's goals of achieving a 100 percent carbon pollution-free electricity system by 2035 and a 100 percent net-zero emission economy by 2050, the Water Power Program will support increased cross-EERE and cross-DOE efforts to provide data, tools, and analysis to support the widespread integration of renewables in a resilient, reliable power system. This includes partnering with the Office of Strategic Programs and the Office of Electricity to significantly expand upon current technical assistance for stakeholders faced with making data-driven decisions and investments, including evaluating technologies, designing clean energy deployment programs, developing market and policy solutions, and planning transmission and distribution upgrades to facilitate the transition to a 100 percent clean electricity system. This will also include designing a program to leverage National Laboratory capabilities to support municipal governments and utilities in developing cost-effective pathways to achieve their own clean energy goals, as well as, to simulate their power systems under various clean energy scenarios to gain operational experience and ensure grid reliability and resilience. Laboratory capabilities will include analysis, demonstrations, evaluation, measurement, and verification; and direct technical assistance, tailored to the needs of individual cities and communities.

Highlights of the FY 2022 Budget Request

The Water Power Program will pursue the following major activities in FY 2022 to support the EERE strategic priority of initiating a path to achieve a carbon pollution-free electricity sector no later than 2035:

- Through HydroWIRES, provide competitive funding to solicit new models, tools, and operational strategies for use by the hydropower fleet, as well as for technology R&D of the most promising novel PSH concepts that can reduce costs or overcome other deployment barriers. Technical assistance via the National Laboratories will apply PSH valuation guidance to inform valuation of additional proposed PSH sites, and to evaluate use cases for hydropower hybrid configurations such as hydropower plus batteries or floating solar photovoltaics.
- The Hydropower Technologies subprogram will increase its efforts to develop technologies designed to lower costs while increasing efficiency of low head hydropower. The subprogram will engage both the National Laboratories and the private sector in developing technologies designed to power non-powered dams, particularly marginal dams where developmental costs currently outweigh the power benefits.
- The Hydropower Technologies subprogram will build on prior-year efforts to develop tools to assist the Nation's irrigation districts in using hydropower as a "building block" toward irrigation modernization: converting canals to pressurized pipes; enabling electrification of farm equipment and elimination of diesel pumps; and helping decarbonize the agricultural sector.
- With respect to climate change effects on watersheds and hydropower, the subprogram will support development of a suite of climate and hydrologic models, advanced hydrologic sensors, and decision-making tools to provide accurate state-of-the-art climate information and diagnostic capabilities for predicting and managing water and power systems. This will also include collaborative efforts with the Advanced Manufacturing Program to initiate development of advanced sensors and data analytics to ensure the continued operability of human-made water systems.
- The Hydropower Technologies subprogram will continue its effort to develop technologies to ensure safe and effective fish passage for migratory species by partnering with the National Laboratories and the private sector to develop higher Technology Readiness Level (TRL) systems with an eye toward field demonstration and deployment.
- They Hydropower Technologies subprogram will support increased cross-EERE and cross-DOE efforts to provide data, tools, analysis, and technical assistance to support the widespread integration of renewables in a resilient, reliable power system, in partnership with the Office of Strategic Programs and the Office of Electricity.
- In Marine Energy Technologies, funding is provided to support the design, fabrication, and testing of marine energy conversion devices at a range of sizes (including grid-scale and PBE technologies); for longer-term demonstrations of wave powered desalination systems for remote communities and disaster relief and recovery; demonstrations of marine energy powered ocean observing systems; and for DOE's Polymers Upcycling and Recycling initiative for National Laboratory R&D to identify promising locations for deploying waterway debris remediation systems that are powered by hydrokinetic energy.
- Marine Energy Technologies will continue support in FY 2022 of the Testing Expertise and Access for Marine Energy Research (TEAMER) initiative, a rolling test campaign developed in collaboration with U.S. universities and National Laboratories to provide technology developers with quick and economical access to marine energy testing facilities and capabilities across the U.S.
- Funding is provided for the Energy Transition Initiative Partnership Project (ETIPP), a program launched in 2020 to establish a new mechanism to both engage with underserved remote and islanded communities, including those that are energy communities, and deliver technical assistance to enable these communities to leverage expertise in evaluation of energy systems. ETIPP provides on-the-ground assistance on resource assessment (water, solar, wind, geothermal), grid integration analyses, and vetting of technology fit to help communities chart pathways to energy resiliency.

Water Power
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Water Power				
Hydropower Technologies	39,000	41,000	84,560	+43,560
Marine Energy Technologies (formerly Marine and Hydrokinetic Technologies)	109,000	109,000	112,000	+3,000
Total, Water Power	**148,000**	**150,000**	**196,560**	**+46,560**

SBIR/STTR:

- FY 2020 Transferred: SBIR $7,062,000; STTR $1,323,000
- FY 2021 Projected: SBIR $4,402,000; STTR $619,000
- FY 2022 Request: SBIR $6,063,000; STTR $853,000

Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted ($)
Water Power	
Hydropower Technologies: The hydropower subprogram is expanding its efforts through optimization of the existing hydropower fleet by: (1) increasing funding of its HydroWIRES initiative to increase the flexibility of hydropower through operational improvements, supporting development and testing of innovative pumped storage hydropower technologies, demonstrating hybrid systems of hydro and storage, and investing in the environmental systems to keep the fleet online; and (2) dramatically expanding analysis to quantify hydrologic and climate change impacts to hydro now and through 2050. The Program is also expanding work in new, low-impact hydropower by investing in demonstration of technologies to power nonpowered dams or infrastructure and demonstrating and deploying irrigation modernization to serve agricultural end-users.	**+43,560**
Marine Energy Technologies: No new funding is requested for the newly established Atlantic Marine Energy Center, though the Center will continue to operate and support developer needs with funds obligated in previous years. This will enable expansion in other subprogram areas, including support of the Energy Storage Grand Challenge's remote communities use case, building off the ETIPP to support device design and fabrication to serve remote coastal and islanded communities, including those that are energy communities, based on outcomes of first cohort of ETIPP. Funding is provided for controls, advancements in materials and manufacturing, access to testing facilities for marine energy developers, and the design, fabrication, and testing of marine energy devices at a range of sizes, including PBE and grid-scale technologies.	**+3,000**
Total, Water Power	**+46,560**

Water Power
Hydropower Technologies

Description

Hydropower has provided clean, low-cost electricity for over a century as the Nation's first renewable source of electricity. Today's evolving power system has created new opportunities for hydropower to play an important role in a 100 percent clean energy future, using existing and new technologies and infrastructure. In 2019, hydropower provided 6.6 percent of the electricity on the grid and accounted for 38 percent of U.S. renewable electricity generation. Hydropower, including pumped storage hydropower (PSH), provides flexibility, inertia, storage, and grid services to support the integration of variable renewable energy (VRE) like wind and solar energy. And while hydropower is well-positioned to serve this integrating role, there are urgent needs to better quantify the value hydropower provides, understand tradeoffs (both power and non-power) associated with hydropower operations, and develop new technologies and operational strategies to enhance hydropower's flexible capabilities.

PSH is the largest contributor to U.S. energy storage with an installed capacity of 21.9 GW, or roughly 93 percent of all commercial storage capacity in the U.S. PSH also provides over 550 GW hours of U.S. energy storage, making it by far the largest source of commercially available long-duration energy storage. While most PSH plants were built decades ago, multiple new large-scale PSH projects have progressed in the development pipeline in recent years.

The vision of the Hydropower Technologies subprogram is a U.S. hydropower and pumped-storage industry that modernizes and safely maintains existing assets; responsibly develops new low-impact hydropower; supports grid reliability, integration of other energy resources; promotes environmental sustainability; and supports energy-water systems resilience. Through modernization of the existing U.S hydropower fleet, adapting to the changing needs our Nation's power system, and meeting the challenges of climate change head-on, hydropower can be the keystone to a fully decarbonized power system by 2035.

New Low Impact Hydropower: Most new hydropower facilities will be smaller scale than existing systems since limited opportunities exist to develop new, large-scale conventional hydropower due to high costs and environmental concerns. These new facilities—including low-impact, small hydropower or with technologies for existing conduits and canals—can integrate multiple social, environmental, and energy benefits, while realizing value and revenue from a variety of sources. Hydropower Technologies subprogram activities support the deployment of these systems with an explicit focus on modernizing irrigation systems and developing technologies that will more cost-effectively power non-powered dams and develop new stream reaches, particularly in remote communities. Scientific advances associated with these technologies can allow developers and operators to more effectively identify and mitigate potential environmental impacts, ultimately allowing for more effective utilization of existing hydropower and reduced regulatory costs.

There are more than 90,000 existing dams across the Nation, of which about 2,500 have hydropower facilities for electricity generation. Retrofitting existing dams and adding generation at non-powered dams can increase renewable energy production. Over the last four years, the Hydropower Technologies subprogram has developed design criteria for more standardized, modular hydropower development that capitalizes on advanced manufacturing and materials, while preserving and enhancing stream functionality for greenfield development and powering non-powered dams.

Dams serve many roles besides power generation, such as flood control, water supply, irrigation, and recreation. Because hydropower occupies a unique position at the intersection of the energy/water nexus, it offers unique benefits through connections to the water supply and associated infrastructure. For example, cost-savings from hydropower project developments have allowed irrigation districts to modernize their irrigation systems[1]. The process of converting unlined, open canals to pressurized pipes saves water, decreases pumping costs for farmers, decreases nutrient loading downstream, and increases on-farm productivity. To facilitate this effort, partnerships with irrigations districts are needed to inform development of digital planning tools and demonstration sites.

[1] https://www.energy.gov/eere/water/articles/new-way-modernize-irrigation-infrastructure-and-generate-renewable-energy

Hydropower combined with water distribution and treatment systems can power behind-the-meter applications for resilience and reliability within water networks or neighboring infrastructure. However, advanced water sensor development and data analytics are necessary to ensure the continued operability of human-made water systems. The hydropower subprogram will partner with the Advanced Manufacturing Program and the National Laboratories to develop these novel monitoring systems for not only hydropower plants, but also water conveyance systems, water treatment, and water storage capabilities. An integrated approach to sensors and data is important; in many cases these face the same challenges of widespread system distribution, diverse legacy systems to monitor, and constrained system budgets.

Grid Integration: Traditionally, much of the hydropower fleet was designed to provide optimal performance and value when operating at a constant output level. Both hydropower and PSH, however, can adjust their output quickly and on demand, providing a highly flexible generation source with critical services that help maintain the reliability and resiliency of the Nation's power grid. Services include quick response dispatchable power that can be used to meet peak demand and balance variable resources, as well as a discrete set of technical capabilities ranging from sub-second frequency response to black-start (restoration) capabilities that can help the grid quickly recover from an outage. PSH provides many of these same services, along with the ability to absorb excess generation during the pumping mode and provide long-term power storage for when it is needed most. These capabilities and flexibility will be increasingly important as the Nation's electric grid evolves; however, the specific design and operational attributes that will prove most valuable are not well understood and remunerated, which leads to potential inefficiencies in how existing power and ancillary services are procured and compensated.

As part of the Energy Storage Grand Challenge, the hydropower subprogram, under the HydroWIRES initiative, continues research to quantify and understand the economic value of the services provided by hydropower and PSH and the additional costs or technical requirements of operating hydropower systems in a changing grid. This research includes understanding the value of hydropower under future electric system conditions, quantifying the effect of flexibility constraints on plant capabilities and performance (e.g., from variations in water flows, plant designs, or license conditions), addressing critical technical barriers to effective operation of hydropower resources for reliability and economic dispatch, and identifying technology solutions that will preserve or enhance hydropower capabilities to deliver services or system benefits competitively. The subprogram will also continue to assess and drive innovation in hydropower flexibility, as well as new PSH configurations that reduce geographic siting limitations, construction costs and timelines, and environmental impacts. These activities drive needed innovation in the design of PSH, as traditional designs are capital intensive, limited in where they can be sited, and difficult to finance. New transformative designs could reduce capital investment requirements, expand siting possibilities, and shorten development timeframes for new facilities, thus incentivizing private investment.

HydroWIRES will expand its efforts to develop new strategies that can enhance hydropower's flexibility for facilitating deployment of wind and solar onto the U.S. electric grid—including faster and more frequent ramping, more frequent starts and stops, and enhanced frequency and voltage control to optimize the highest-value services crucial for the transition to a primarily renewable power system. HydroWIRES will also increase support for the development and testing of novel pumped storage technologies. Finally, coordinated technical assistance efforts will support both PSH and hydropower owners in optimizing operations of their plants, including evaluating use cases for hydropower hybrid energy storage configurations, such as hydropower plus batteries or floating solar PV.

Existing Hydropower: The existing U.S. hydropower fleet faces key challenges including asset modernization, operations optimization, and cybersecurity threats. Efforts to improve the sustainability and environmental performance of the Nation's existing hydropower systems are inherently linked to modernizing the existing fleet. The average hydropower plant is 64 years old,[1] and the aging infrastructure requires fleet modernization. As the fleet ages, maintaining efficient and cost-effective operations and ensuring the security – including cybersecurity – of our critical energy infrastructure becomes increasingly challenging. Modernization of the existing hydropower fleet represents a significant opportunity to restore reliability and performance and add new cutting-edge technologies that can mitigate high operation and maintenance costs associated with balancing tradeoffs associated with compensation for services, impact on machines, and meeting license requirements. In addition, with its range of legacy components and diverse system structure, the hydropower fleet also has

[1] https://www.eia.gov/todayinenergy/detail.php?id=30312# .

unique cyber vulnerabilities, which were catalogued and assessed in the subprogram's FY 2021 "Cybersecurity State of the Hydropower Fleet."

In addition to supporting research to address the challenges faced by the U.S. hydropower fleet, the Hydropower Technologies subprogram also supports the hydropower industry and its stakeholders through its activities to assess and address climate change impacts, environmental sustainability, and relicensing. Hydropower generation is both impacted by climate change and has an important role in climate change mitigation. Climate change impacts on the water system can affect hydropower operations by complicating short- and long-term planning, introducing risk and uncertainty, and compounding other challenges such as managing water quality and species protection measures. Climate change will also disproportionally impact regional water supplies across the U.S. and pose challenges for the multipurpose demands of reservoirs. The subprogram's work on hydropower reservoir management can create opportunities to enhance climate resilience and adaptation for remote or socioeconomically vulnerable communities by advancing climate science and adaptation, analyzing infrastructure design and water management, enhancing environmental sustainability, and ultimately building socioeconomic resilience in communities challenged by climate change

Environmental sustainability is another critical challenge, requiring fundamental research to understand hydropower's effects on the environment, as well as novel monitoring and mitigation technologies. Hydropower's long-term value depends on maintaining a high level of environmental performance across the fleet. New technologies are needed to improve the environmental performance of hydropower facilities, particularly on issues related to fish passage. Since 2005, mandatory fishway prescriptions for upstream or downstream passage have been ordered in approximately 27 percent of hydropower facilities as part of recent Federal Energy Regulatory Commission (FERC) project relicenses. Current fish protections at hydropower projects may include operating dam spillways and turbines to reduce fish mortality during certain times of the day or during migration seasons, installing physical barriers or other deterrents that guide fish to passage routes with the highest survival, and using fishways—engineered structures designed specifically for fish—to allow them a swimming route over or around the dam. High priority needs for fish passage at hydropower dams include fundamental research in fish behavior, movement, and lifecycles; and information and tools to increase fish survival through turbines and other hydropower structures.

Finally, non-federally owned hydropower facilities require a license from the FERC to operate, and license terms typically last for 30-50 years. At the time of licensing or relicensing, the environmental impacts of a hydropower facility are rigorously evaluated. Relicensing provides an opportunity for communities to (1) establish goals for the environment, recreation, energy, and other benefits; (2) evaluate site- and basin-level potential impacts in relation to goals; and (3) define measures to avoid, minimize, or mitigate impacts. In the next decade, approximately 30 percent of U.S. hydropower will need to go through relicensing. Environmental measures can account for up to 30 percent of the federal wholesale rate, and solutions for effective environmental outcomes and cost reductions are essential. Over the past five years, the Hydropower Technologies subprogram has taken an active role in developing tools and analyses that can assist applicants for FERC licenses and other hydropower stakeholders navigate the FERC licensing process and assess the environmental effects of proposed projects.

Data, Modeling, & Analysis: Throughout the course of its funded R&D activities, the Hydropower Technologies subprogram, the National Laboratories, and funding recipients identify and aggregate large amounts of data from across the hydropower industry and hydrologic science disciplines. Non-proprietary data are validated and made publicly available through the program-maintained HydroSource data portal[1]. These data are useful to inform R&D, investment, advocacy, and regulatory decisions for researchers, technology developers, conservation advocates, policymakers, and regulatory agencies. The activity also supports a portal which features hydropower educational resources and will continue to build on its workforce development and STEM activities, including launching a new hydropower-focused collegiate competition.

[1] https://hydrosource.ornl.gov/.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Hydropower Technologies $41,000,000	**$84,560,000**	**+$43,560,000**
New Low Impact Hydropower $8,000,000	$26,310,000	+$18,310,000
• Develop an opportunities strategy for advanced manufacturing technologies to support standard modular hydropower and modernize the hydropower fleet.	• Partner with the Advanced Manufacturing Office to develop a hydropower-specific program at ORNL's Manufacturing Demonstration Facility (MDF) to provide hydropower technology innovators unique access to infrastructure, tools, and expertise to facilitate rapid adoption of additive manufacturing technologies.	• Utilize the FY 2021 efforts to develop an advanced manufacturing opportunities strategy to demonstrate the capabilities of ORNL's MDF leading to cost reductions in the manufacturing of new hydropower technologies.
• Complete design criteria for standard modular hydropower development at non-powered dams (NPD).	• Fund National Labs to develop innovative concepts for NPD development to inform a competitive funding solicitation focused on industry-led technology innovations for powering some of the more than 90,000 non-powered dams.	• Expansion: building on past work in standard modular hydropower for non-powered dams and establishing framework for assessing costs and benefits of adding hydropower to non-powered dams, partner with private sector developers and municipalities to implement concepts to real-world hydropower projects.
• Continuation of National Laboratory projects investigating where small, modular hydropower technologies could complement other water-related objectives like irrigation systems modernization or groundwater recharge.	• Partner with irrigation districts and develop a demonstration program that would accelerate deployment of a new irrigation modernization paradigm that is community-driven and responsive to local needs and opportunities and establish a consortium of technology innovators, infrastructure modernization project funders, and agriculture practitioners to help advise the program.	• Expansion of R&D using digital tools developed in FY 2021, demonstrate and deploy irrigation modernization and small hydropower to serve agricultural end-users in support of a decarbonized agricultural sector.
• Complete National Laboratory work on identifying non-energy benefits of small hydropower. • Complete National Lab scoping study of potential sites for federal hydropower test facility.	• Provide support to industry partners to identify, quantify, and unlock non-energy benefits—such as environmental health, resilience, water use efficiency—at real sites, including facilitating engagement with relevant stakeholders.	• Expanded R&D using the hydropower "value stacks" identified in FY 2021, work with small hydropower developers and municipalities to demonstrate how small hydro can be valued based on both energy and non-energy benefits.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Not funded in FY 2021	• Solicit designs for a federally-supported test facility at existing infrastructure as scoped in the FY 2021 report, and down-select sites.	• Based on the results of the FY 2021 scoping study and design criteria, develop design for a hydropower test facility or facilities capable of field-testing new hydropower technologies at various scales.
• Not funded in FY 2021	• With the Advanced Manufacturing Office, initiate effort to develop novel water infrastructure sensing capabilities to ensure the continued operability of human-made water systems. The scope of this effort includes not only hydropower plants but also water conveyance systems, water treatment, and water storage capabilities.	• New research into the development of novel water infrastructure sensors capable of detecting leakage and evaporative losses is critical to promoting water conservation. Conservation of these resources is going to be increasingly important in an uncertain climatological future and the data provided will allow for the timely assessment and remediation of these losses.
Grid Integration $15,000,000	$26,000,000	+11,000,000
• Under the HydroWIRES initiative, continue National Laboratory-led hydropower value drivers quantification effort to understand the system conditions (e.g., generation mix, market structure, etc.) that provide the greatest value to a decarbonized power system and enable more flexible operation, as well as improve the representation of hydropower in power system models to more accurately capture its unique capabilities.	• R&D efforts in FY 2022 will include a competitive solicitation under the HydroWIRES Initiative and Energy Storage Grand Challenge to solicit new models, tools, and operational strategies for use by the hydropower fleet, building on prior-year National Laboratory efforts. Outcomes of this solicitation would include increased flexibility from improved operation of existing plants, improved reservoir inflow forecasting to enable increased value to the grid, and development of new tools to better balance flexible operation and environmental outcomes.	• Expanded R&D efforts represent more direct focus on providing hydropower owners with tools to increase flexibility. Outcomes of this solicitation would include more flexible operation of the hydropower fleet, which would enable deployment of additional zero-carbon renewable resources.
• The activity will continue support of component level technology R&D to enable increased flexibility of hydropower, including a competitive funding solicitation targeting manufacturers with owners/operators as partners focused on technology innovations that can improve hydropower and PSH flexibility and their value to a decarbonized power system.	• Building on previous PSH funding opportunities and prizes, FY 2022 efforts will include a competitive funding opportunity for technology R&D of the most promising novel PSH concepts that can reduce costs or overcome other deployment barriers. The effort will advance low-TRL concepts to the testing phase so that	• Drawing on results from National Lab PSH innovation studies, FY 2022 efforts will target the PSH concepts with greatest potential to progress rapidly to testing and ultimate deployment. Outcomes include some of these concepts being deployed by 2035 to meet system needs for long-duration storage, in combination with new deployments of existing PSH technologies.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	they can progress further toward demonstration and deployment in future years.	
• Develop an online PSH valuation tool, based on the PSH valuation guidance previously developed under HydroWIRES, to ensure ease of use by developers and other stakeholders.	• National Lab technical assistance to apply the PSH valuation guidance to inform valuation of additional sites, and to evaluate use cases for hydropower hybrid configurations such as hydropower plus batteries or floating solar PV.	• These efforts would expand the valuation methodology developed to additional potential PSH and hydropower hybrid projects, supporting the value proposition for deployment.
Existing Hydropower $6,000,000	$24,400,000	+$18,400,000
• Continuation of congressionally directed study to examine the risks from global climate change associated with water supplies for Federal hydroelectric power generation. Initiation of a national-scale analysis and visualization platform enabling utilities and system operators to evaluate water-related impacts and risks.	• In addition to continued evaluation of effects of climate change on the Federal hydropower fleet and examination of water risks and impacts to hydropower operators, initiation of an effort to use advanced sensors to develop a suite of climate and hydrologic models and decision-making tools to provide accurate state-of-the-art climate information and diagnostic capabilities to inform watershed and reservoir management decisions and to understand the relationship between natural systems and to help community-based, watershed decision-making as a meaningful step towards climate equity.	• Major expansion of efforts to understand climate change effects on hydropower systems, and a more holistic effort to demonstrate advanced sensing techniques to collect real-time hydrologic data from several watersheds across a wide geographic spectrum.
• Continued development of a scientific framework and a user-friendly tool for identifying key factors contributing to environmental impacts of hydropower developed in prior years in a regulatory setting to assess its ability to minimize the time and costs for scientific studies needed for regulatory permitting.	• Upon completion of the science-based tool for identifying environmental impacts of hydropower projects, continue to develop a suite of technical information leading to improved environmental outcomes for new hydropower. This suite will include studies on replicability of site-specific completed environmental studies to other sites, a new comprehensive report on effects of hydropower operations on migrating fish and developing a methodology for valuing environmental mitigation measures provided by hydropower.	• Significant expansion of scientific work to help streamline environmental permitting and lower costs for hydropower developers seeking to permit new hydropower growth.
• The activity initiated significant investments in digitalization and modernization of the existing hydropower fleet by scoping existing capabilities	• Expanded digital twin program with a shifted focus from state-of-the-art assessment to the development of preliminary system models for	• Moving from basic exploration of the "mathematical building blocks" necessary for a functional digital twin to actual "construction" in

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
and mathematical methods and models leading to the development of hydropower turbine digital twins to understand the effects of variable dispatch on a decarbonized grid dominated by variable renewables.	future deployment. In addition, research into the development of novel cost-effective sensors to provide operational data to enable artificial intelligence for a variety of applications including dam safety and condition assessment.	preparation for validation using real hydropower operational data. Expansion of digitalization research to modernize the existing hydropower fleet through the use of advanced sensors and artificial intelligence.
• Completion of a landscape study on the highest priority R&D needs of the hydropower industry to improve the industry's cybersecurity standing. Initiation of cybersecurity investment guidance with respect to the "value" of implementing cybersecurity measures.	• Cybersecurity R&D will focus on attack detection and the production of vital cybersecurity guidance to dam owners by validating simulated data from a "cyber surrogate" digital turbine twin using archived data from an existing operational hydropower plant. Continued development of industry guidance for cybersecurity "value."	• Shift from basic research into the "Cybersecurity State of the Hydropower Fleet" to applied research using digital tools to simulate cyber "attack" and subsequent recovery.
• Completion of work to develop turbine design and evaluation tools that improve both fish passage and turbine efficiency.	• Partnering with the private sector to offer a funding opportunity for climate-ready (adaptable) and multispecies fish passage and protection for new ideas for fish passage (from previous funding opportunities) followed by a down select for demonstration/deployment.	• Building off previous National Lab work and competitive funding solicitations and prizes, shift focus to field demonstrations of new and more cost effective fish passage/protection measures.
Data, Modeling, & Analysis $5,000,000	$7,850,000	+$2,850,000
• Updates to the Hydropower Vision Roadmap, which lays out strategic R&D needs to advance the hydropower industry towards a 100 percent clean energy economy.	• Engaging a wide spectrum of hydropower industry and stakeholders through a series of workshops to establish prioritization of Roadmap activities and goals.	• Conclude two years of preparation to release a consensus-based updated Hydropower Vision Roadmap with hydropower industry priorities and goals for the next five years to advance hydropower growth and sustainability.
• Support for the hydropower industry by building the educational infrastructure to identify and train future hydropower professionals through development of educator resources, water power career profiles, and a STEM portal within existing OpenEI pages for educators, students, and the public to learn about water power technologies and workforce development opportunities.	• Workforce efforts will focus on establishment Water Power Workforce Hubs at existing organizations with clean energy workforce missions and will serve to facilitate regional collaboration, support renewable energy education, and ensure equitable access to workforce training opportunities across the nation. STEM activities will focus on a Hydropower Collegiate Competition for undergraduate students, and establishment of a	• Expansion of Workforce and STEM activities to actively engage the hydropower industry and college graduates/researchers to ensure a well-trained hydropower workforce for the future.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	Hydropower Fellowship program and a hydropower data analysis prize for graduate students.	
• Exploratory scoping work to assess stakeholder needs and value of improved access to many different types of river and water-related data.	• Development of a methodology to improve stakeholder access to data and develop improved and publically-available data on dams and their existing uses, and potential future societal values.	• Shift in work toward developing more easily accessible and publicly-available data, and greater coordination with other Federal agencies engaged in similar work.
• Initiation of work on a user-friendly tool to search the FERC eLibrary database.	• Continued work on FERC eLibrary tool development.	• Focus on FERC eLibrary tool will engage FERC staff and potential tool users for maximum useability.
• Completed National Laboratory development of a user-friendly interface for U.S. Hydro fleet data and a competitive funding solicitation for hydro operational data in order to close gaps in data and information regarding how best to modernize and optimize hydro to support a decarbonized grid dominated by variable renewables.	• Initiation of outreach efforts to introduce new user-friendly interface to the hydropower industry to gather data on use, and practical applications of U.S. Hydro fleet data for potential further improvements.	• Shift from inward focused development of new user interface to outward facing data collection and outreach.
EPAct Section 242 $7,000,000	$0	-$7,000,000
• Funding supports the Congressionally-directed implementation of the Energy Policy Act of 2005, Section 242, Hydropower Production Incentive Payments to owner/operators.	• No funding requested.	• Program funds can be more effectively allocated to RDD&D activities.

Water Power
Marine Energy Technologies (formerly Marine and Hydrokinetic Technologies)[1]

Description

Marine energy technologies convert the energy of waves, tides, river and ocean currents, ocean thermal gradients, and salinity and pressure gradients into electricity and have the potential to provide millions of Americans with locally sourced, clean, and reliable energy. Resource assessments show that the total marine energy technical resource in the 50 U.S. states is 2,300 TWh/yr, equivalent to 57 percent of the electricity generated by those states in 2019. The nation's Pacific and Caribbean territories and freely associated states add an additional 4,100 TWh/yr of ocean thermal energy resource.[2] Developing just one-sixth of the available wave energy in the five Pacific states could power more than five million homes. Marine energy is a predictable, forecastable resource with a generation profile complementary to the seasonal or temporal variations of other resources such as onshore wind and solar, which can enhance its contributions to grid resilience and reliability.

Marine energy offers both a future opportunity to supply electricity to a deeply decarbonized national grid, and as a near-term solution for distributed energy for isolated and islanded communities. Through the Powering the Blue Economy (PBE) initiative, the Water Power Program is demonstrating that marine energy technologies also have the potential to provide cost-effective energy for emerging at-sea and coastal distributed applications, including power for remote coastal communities with high electricity costs, charging for ocean-based sensors and underwater vehicles, and non-electric uses like desalination. Successfully serving these markets provides industry with opportunities to develop and deploy marine energy technologies in the near-term, while reducing costs for larger utility-scale markets that are still developing. These real in-water experiences allow the industry to drive down learning curves and increase near term investment in the sector.[3] In addition, cost-effective energy provision at sea enables major advances in scientific understanding of the ocean and technology innovation and commercial opportunities in the ocean.

However, marine energy technologies are at an early stage of development due to the fundamental scientific and engineering challenges of generating power from dynamic, low-velocity and high-density waves and currents while surviving in corrosive ocean environments, and face significant challenges in engineering and operations to fully unlock their potential at both small and large scales. These challenges are intensified by high costs and lengthy permitting processes associated with in-water testing. To address these challenges, the program invests in RDD&D specific to marine energy applications to generate knowledge relevant for industry to develop innovative components, structures, materials, systems, and approaches to manufacturing. It also supports the development and utilization of testing infrastructure to facilitate systematic technology development and validation by industry at multiple scales. The program works to aggregate, analyze, and disseminate data, enabling industry-led development of cheaper and more effective monitoring instrumentation, ultimately increasing permitting and regulatory process efficiencies. The program's marine energy RDD&D also focuses on those scientific and engineering challenges where breakthroughs likely have the broadest, industry-wide benefits. Industry deployment of marine energy technologies for bulk power generation is nascent, and significant RDD&D is still required to realize cost-competitiveness at the utility-scale for marine energy technologies and reduce levelized costs of energy.

Materials and Components R&D: Marine energy technologies have difficult engineering challenges specific and inherent to the marine energy environment. Marine energy resources have large ranges in intensity and present other fundamental difficulties for designing systems to efficiently capture usable energy, as a result of the unique physics of the systems.

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[1] The Marine and Hydrokinetic Technologies program is being renamed Marine Energy Technologies. This change is being made to be consistent with the definition published in the Energy Act of 2020. https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf.

[2] Kilcher, Levi, Michelle Fogarty, and Michael Lawson. 2021. Marine Energy in the United States: An Overview of Opportunities. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5700-78773. https://www.nrel.gov/docs/fy21osti/78773.pdf.

[3] "Powering the Blue Economy, Exploring Opportunities for Marine Renewable Energy" U.S. Department of Energy. April, 2019. https://www.energy.gov/sites/prod/files/2019/09/f66/73355-v2.pdf.

Marine energy devices must operate in environments with resource characteristics (e.g., high energy-density waves and currents with often complex, low-velocity, highly turbulent characteristics) that vary significantly on timescales ranging from seconds to seasonal cycles, resulting in a complex set of systems design and optimization challenges. The subprogram works to support RDD&D to tackle these difficult engineering challenges to rapidly improve and reduce costs of marine energy generation technologies.

Advanced controls research remains a major programmatic focus, as studies have shown that advanced controls improvements can provide significant increases in energy capture at varying timescales, and recent work has achieved advances doubling the energy capture of previous methods. Controls strategies and technologies are also being leveraged from other industries (e.g., aerospace and defense) that can maximize power production over a range of ocean conditions. Programmatic research will continue to support DOE's commitment to a joint DOE-Navy project targeting advanced controls, and continues with National Laboratory support through technical assistance and partnerships for accessing National Laboratory capabilities for competitively selected industry awards to develop new marine energy control systems.

The activity is also continuing development of the first-ever national wave classification metrics and site-specific wave energy characterization. This work is similar to what DOE has provided historically for the wind and solar industries including national level maps and dynamic resource predictions. These efforts will refine and expand on the high-resolution wave and tidal resource data that assists in identifying project sites, informs design requirements, maximizes energy capture, reduces project uncertainty and risk, and thereby reduces levelized cost of energy (LCOE). This type of national level, unbiased information is essential both to help industry make informed project siting decisions and to inform device design and DOE's own RDD&D priorities.

Few materials are designed or optimized for use in the ocean at a practical cost for the marine energy industry. The activity supports research into cost-competitive materials and coatings designed to function in one of the harshest environments, providing a catalyst for the emerging industries that depend on it.

System Integration and Validation: The activity's strategy to help catalyze marine energy deployment focuses on technology research, design, testing, and validation to reduce cost and improve performance of marine energy technologies at a range of sizes and technology readiness. This work involves testing proof-of-concept systems in laboratory and ocean settings to understand performance characteristics, identifying and mitigate reliability risks, and providing data to inform future RDD&D to improve next-generation designs across the industry. The Marine Energy Technologies subprogram is committed to investment in RDD&D activities that will include a focus on design concepts that have the potential to serve existing or emerging ocean-based technologies that can advance the Nation's military, commercial, and scientific capabilities. These include power for remote coastal communities and Department of Defense installations with high electricity costs, charging for ocean-based sensors and underwater vehicles, and non-electric uses like desalination. Development and testing for these applications will provide critical data and experience that will accelerate design improvements and cost reductions for grid-connected power generation.

The activity will continue to support the Powering the Blue Economy initiative, including desalination systems for remote communities and disaster relief and recovery, demonstration of marine energy powered ocean observing systems, and through ETIPP provide on-the-ground assistance on resource assessment (water, solar, wind, geothermal), grid integration analyses, and vetting of technology fit to help communities chart pathways to energy resiliency. In addition, the activity continues to support deployable systems to address plastics waste in U.S. rivers and waterways. Furthermore, the activity will demonstrate and deploy grid-scale marine energy projects to validate performance towards a fully decarbonized electric grid.

Testing & Reliability: The activity makes strategic investments to support infrastructure at the National Laboratories and other marine energy test sites to enable technology innovations and reduce barriers to testing and validation. Deploying marine energy for coastal and ocean-based applications is crucial towards accelerating marine energy technology development for the grid. These near-term deployments with existing applications will enable the industry to understand the effectiveness of marine energy technologies, their shortcomings, and to rapidly solve technical challenges, while also benefiting coastal communities and the other Blue Economy markets. With time, these deployments will improve the marinization of marine energy systems, i.e., better understand their survival in harsh, highly corrosive, energic environments, and utilize appropriate materials and technologies. In addition, siting marine energy technologies in an

environmentally responsible manner through partnerships between coastal communities, the government, private industry, and technical experts can lead to sustainable and resilient energy technology. For industry to expand deployment of marine energy technologies, in-water validation of prototype performance, efficiency, and reliability across a wide range of sea states including extreme conditions, is needed. The activity partners with industry to enable the development and testing of these prototypes, through programs such as TEAMER (Testing Expertise and Access for Marine Energy Research), as well as enable access to dedicated testing infrastructure to reduce the inefficiency associated with each developer investing in testing cables and permits. The activity also supports modeling and predicting of the environmental effects of marine energy devices through research that simulates device-ecosystem interactions and industry efforts to develop new technologies that more accurately monitor in-water devices.

Data, Modeling, & Analysis: Marine energy technologies are at an early stage of development due to the fundamental scientific and engineering challenges as well as high costs and lengthy permitting processes associated with in-water testing. The activity works to aggregate, analyze, and disseminate data to as wide an audience as possible to ensure project successes and lessons learned are shared throughout the community and the impact of support is maximized. The activity also ensures access to STEM resources and opportunities for students to develop skills needed to enter the marine energy workforce. These efforts include the maintenance of the new PRIMRE system (Portal and Repository for Information on Marine Renewable Energy). This knowledge management system centralizes databases, tools, and educational resources developed by the Marine Energy Technologies subprogram. The activity will continue to support student research fellowships and a collegiate competition for interdisciplinary teams to develop technical designs and Blue Economy business cases for marine energy.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Marine Energy Technologies $109,000,000	**$112,000,000**	**+$3,000,000**
Materials and Components R&D $27,500,000	$31,900,000	+$4,400,000
• Continued National Laboratory R&D into controls and power take-offs for MHK devices following up on the strategy developed in recent FYs to dramatically reduce costs and/or increase energy capture.	• Continue National Laboratory R&D into controls and power take-offs for MHK devices following up on the strategy developed in recent FYs to dramatically reduce costs and/or increase energy capture. These technologies are an integral part of the solution to achieve 100 percent electricity generation from zero carbon sources by 2035, generating economic opportunity and growth through the deployment of new energy technologies, and supplying clean, reliable power to underserved coastal communities.	• No change.
• Building on recent advances in materials and manufacturing and the completion of a significant systems engineering study, FY 2021 increased R&D focused on advanced materials and manufacturing, and initiated a new funding competition focused on generating novel device concepts and testing prototypes of wave energy systems, and partnered with the Navy on a study of emerging technologies with the potential to transform MHK designs.	• Building on recent advances in materials and manufacturing and the completion of a detailed materials strategy, including expert elicitation, FY 2022 will support R&D focused on advanced materials and manufacturing, and initiate a new prize competition focused on generating novel device concepts and testing prototypes of wave energy systems.	• Increased focus and support on advanced materials and manufacturing for the marine energy industry informed by the recently completed materials strategy document.
• Continued support for National Laboratory work on modeling tools and methodologies for device and array performance, R&D of advanced materials, and new approaches for operation and maintenance (O&M) of marine energy projects.	• Continue support for National Laboratory work on modeling tools and methodologies for device and array performance, R&D of advanced materials, and new approaches for O&M of marine energy projects.	• No change.
• Continued development of the first-ever national wave classification metrics and site-specific wave energy characterization.	• Continue development of the first-ever national wave classification metrics and site-specific wave energy characterization, with a focus on new sites and locations applicable to Powering the Blue Economy (PBE) technologies.	• Expanding focus/sites to include locations applicable to PBE technologies, including remote communities.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Systems Integration & Validation $48,800,000	$51,900,000	+$3,100,000
• Support the testing of up to 4 existing wave energy conversion (WEC) devices and testing of up to 5 supporting systems (including components & devices) at PacWave. These projects will quantify WEC technology performance and costs, help validate numerical models in a realistic ocean environment, and help identify high priority R&D needs for the wave energy industry.	• Fund up to 2 additional WEC devices that target testing at PacWave at a range of sizes, including PBE and grid-scale technologies, to quantify WEC technology performance and costs, help validate numerical models in a realistic ocean environment, and help identify high priority RDD&D needs for the wave energy industry.	• Following on efforts from FY 2021, support development of additional WEC technologies, both for PBE and grid-scale end uses, as well as additional system demonstrations planned for testing at PacWave.
• To advance alternative applications for remote communities and other ocean markets, the Powering the Blue Economy initiative will begin to focus on the fabrication and testing of prototype systems for desalination and ocean observing. This includes moving to the next phase of both Waves to Water and OceanObs prizes, as well as the progression of phase II selections from 13 phase I ongoing SBIR awards. In addition, the program will begin implementation of the partnership with the ETIPP to support marine energy in remote communities and finalize the full PBE R&D Roadmap.	• Following on the success of the Waves to Water and OceanObs prizes, fund desalination systems for remote communities and disaster relief and recovery, and in partnership with the National Oceanic and Atmospheric Administration demonstrate and deploy marine energy powered ocean observing systems. Design and fabricate devices based on outcomes of first cohort of ETIPP. SBIR efforts are aimed at stimulating technological innovation using small businesses, to meet federal R&D needs, to foster and encourage participation by minority and disadvantaged persons in technological innovation, and to increase private-sector commercialization derived from federal research and development.	• Increase in funding will continue to advance successful technologies from Waves to Water and OceanObs prizes. New work also includes WaterPACT, which builds on deployable systems to address plastics waste in U.S. rivers and waterways.
• Launch competitive solicitations in partnership with other agencies, including Department of Commerce Economic Development Administration, to support developers entering into non-grid-scale markets. This includes entrepreneurial assistance to developers and technical assistance to remote communities seeking to increase the resiliency of their energy and water systems.	• No funding requested.	• With existing funds, support will continue for developers entering into non-grid-scale markets.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Testing & Reliability $23,700,000	$17,900,000	-$5,800,000
• Continued support of TEAMER, a rolling test campaign supported in collaboration with U.S. universities and National Laboratories for early stage marine energy systems.	• Continue support of TEAMER, a rolling test campaign supported in collaboration with U.S. universities and National Laboratories for early stage marine energy systems.	• No change.
• Continued National Laboratory work begun in FY 2017 on large-scale field study to evaluate environmental effects of marine energy devices, including strike-risk to fish from tidal turbines, and acoustic and other environmental impacts of wave energy devices.	• Continued National Laboratory work on large-scale field study to evaluate environmental effects of marine energy devices, including strike-risk to fish from tidal turbines, and acoustic and other environmental impacts of wave energy devices, resulting in reduced cost and timelines associated with permitting.	• No change.
• Continued support for upgrades to test infrastructure at marine energy technology testing sites, including the development of a testing needs roadmap.	• Continue support for upgrades to test infrastructure at marine energy technology testing sites, based on the testing needs roadmap developed in previous years.	• No change.
• Continued funding for the newly established Atlantic Marine Energy Center (AMEC), focused on advancing marine energy technologies towards commercialization and to develop powering the blue economy (PBE) solutions.	• No funding requested.	• With prior year funds, AMEC will continue to operate and support developer needs.
Data, Modeling, & Analysis $9,000,000	$10,300,000	+$1,300,000
• To advance diversity in STEM and clean energy industries, the subprogram continued the Marine Energy Collegiate Competition, an annual competition established in 2020, which engages student competitors to identify the most promising, near-term blue economy applications for marine energy and develop technically sound, tabletop-scale, marine energy prototypes that are designed based on the end-user needs in their selected market.	• To advance diversity in STEM and clean energy industries, the subprogram will continue the Marine Energy Collegiate Competition, an annual competition established in 2020, which engages student competitors to identify the most promising, near-term blue economy applications for marine energy and develop technically sound, tabletop-scale, marine energy prototypes that are designed based on the end-user needs in their selected market.	• No change.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Continued support for data sharing and results dissemination, including PRIMRE – dissemination database and tool to ensure information from program-funded research and testing results are aggregated and widely accessible.	• Continue to support for data sharing and results dissemination, including PRIMRE – dissemination database and tool to ensure information from program-funded research and testing results are aggregated and widely accessible.	• No change.
• Support National Laboratory analysis of R&D challenges and opportunities for remote and coastal communities (Powering the Blue Economy).	• Continue to support National Laboratory analysis of R&D challenges and opportunities for remote and coastal communities (Powering the Blue Economy), and expand focus into additional end use markets.	• Expanded focus into additional PBE markets, including follow on work to address plastics in waterways, based on a scoping activity completed in previous years.

Geothermal Technologies

Overview

Geothermal energy is a domestic energy resource from the heat of the earth, which represents a reliable, secure, clean, and nearly inexhaustible baseload energy source. Increasing the deployment of carbon-free, flexible geothermal energy in both the electric and non-electric sectors will help reach a carbon pollution-free electric grid by 2035 and achieve a net-zero economy by 2050, while ensuring that the benefits accrue equitably to all Americans. Geothermal addresses environmental justice issues because its high capacity factor, small physical footprint, and wide-ranging application in the built environment ensure that it can be utilized in urban centers, rural areas, and remote and energy communities where geothermal has high technical and economic potential and can reduce dependence on fossil fuels.

The current domestic installed geothermal capacity is over 3.8 gigawatts (GW).[1] The 2019 DOE study, *GeoVision: Harnessing the Heat Beneath Our Feet,* showed that with improved technologies, reduced permitting timelines, and increased public awareness of geothermal and its benefits, geothermal power capacity could reach 60 gigawatt electricity (GWe) by 2050, a 26-fold increase from today's levels, and geothermal heating could be used in up to 17,500 district heating systems and in 28 million geothermal heat pumps installations.[2] The mission of the Geothermal Technologies Program is to drive increased utilization of geothermal energy through research and development in innovative technologies that enhance exploration and production.

The Geothermal Technologies Office's (GTO) technology portfolio prioritizes research, development, demonstration, and deployment (RDD&D) in three closely related geothermal categories: Hydrothermal, Enhanced Geothermal Systems (EGS), and Low Temperature.[3] This research addresses technology barriers in RDD&D that industry may not have the technical capabilities or institutional knowledge to conduct. The geothermal industry operates in a harsh subsurface environment with unique technical and operational challenges. Foremost among those challenges is that the resource is "out of sight" at a depth of approximately two to five kilometers, in hard, abrasive rock formations at elevated temperatures and pressures well beyond those typically encountered in oil, gas, or other subsurface operations. Consequently, DOE involvement in RDD&D supports efforts in the geothermal sector to develop innovative technologies that will help harness American geothermal energy resources safely and efficiently.

Highlights of the FY 2022 Budget Request

The Geothermal Technologies Program will pursue the following major activities in FY 2022:

- Frontier Observatory in Research in Geothermal Energy (FORGE): This flagship initiative, started in FY 2014, has drilled several major wells on the Utah site, including the first-ever highly deviated geothermal well, drilled at 8000+ foot depth at a rate twice the industry standard. Utah FORGE made 17 awards for $46 million in five topic areas with its first R&D solicitation in FY 2021. In FY 2022, GTO will significantly increase its support for the next R&D solicitation to take advantage of the momentum at the FORGE site and provide additional technological progress toward ensuring EGS viability in the commercial space, contributing to meeting Administration goals for a carbon pollution-free electric grid by 2035.
- Wells of Opportunity – Amplify: GTO will make a major investment for the third year in a row in near-field EGS demonstration projects. Because these projects are at the margins of existing geothermal production fields, teams can

[1] Net Generation by State by Type of Producer by Energy Source (EIA-906, EIA-920, and EIA-923) - 2015, https://www.eia.gov/electricity/data/state/, released Oct. 12, 2016 and EIA Electric Power Monthly March 2017.

[2] GeoVision: Harnessing the Heat Beneath Our Feet (DOE 2019); www.energy.gov/GeoVision. The *GeoVision* Roadmap outlines a compilation of technical, economic, and institutional actions that the entire geothermal community including DOE, other government agencies, industry, and academia must address in order for geothermal technologies to play a larger role in the Nation's energy mix.

[3] Hydrothermal resources exist where there is sufficient temperature, permeability, and fluid in the subsurface such that fluids can flow naturally at economic rates for power generation. EGS reservoirs require rock stimulation for permeability enhancement and fluid injection to allow commercial-scale fluid flow. Low Temperature resources leverage moderate temperatures found in both shallow and deep subsurface regimes for heating, cooling, and energy storage applications.

leverage existing infrastructure and add new, low-cost, clean power to the grid from wells that would otherwise sit idle. The projects also demonstrate for the geothermal industry what EGS technologies are coming online each year.

- Drilling Technology Demonstration Campaign: R&D on drilling technologies over the past decade has resulted in numerous technologies and methods that are now ready for field demonstration, can reduce the costs and risks of drilling, and lead to increased deployment of geothermal. DOE-sponsored field development is needed because thinly-capitalized geothermal developers will not accept risks associated with the implementation of innovative well construction technologies, including those adapted from the oil and gas (O&G) industry. This drilling technology demonstration campaign will enable field demonstration to prove utility and efficacy and attract future private investment and use as well as serve to quantifiably demonstrate technology driven drilling cost reductions in geothermal well development and further the Nation's goal to a 100 percent clean energy economy.
- Community Geothermal Heating & Cooling Technical Assistance & Deployment: This initiative funds technical assistance to demonstrate and deploy community-scale direct use geothermal. The initiative will provide funds to competitively-selected geographic coalitions, especially in the northeast corridor, to implement geothermal district energy systems through installation of geothermal heat pumps (GHP) and/or direct use of geothermal fluids. Target areas include urban centers, rural areas, energy communities, and remote communities where geothermal has high technical and economic potential and can reduce dependence on fossil fuels (such as natural gas and heating oil). A major objective of the initiative is to develop a set of “proven test cases” that can be duplicated by communities throughout the U.S. The funded coalitions would provide technical and economic data back to DOE and develop case studies (“test beds”) that can be used to demonstrate applicability to other communities.
- Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): This is a new consortium in FY 2022 designed to leverage oil & gas subsurface assets, technologies, and expertise to help solve geothermal energy’s toughest challenges while providing clean energy employment opportunities and environmental benefits for communities adversely impacted by the fossil energy sector decline. GEODE will accelerate the fossil energy sector’s carbon pollution-free strategies while adding clean, renewable, baseload geothermal to the grid via technology development, demonstration, and workforce transition. This initiative will: (1) Identify and facilitate technology transfer opportunities between the oil and gas and geothermal industries; (2) Assess opportunities for the oil and gas industry to deploy geothermal technologies nationwide, including the use of geothermal energy for onsite power production at operating oil and gas fields (coproduction), and the transition of retired oil & gas wells to flexible, carbon pollution-free geothermal energy; (3) Evaluate and address the barriers to the O&G industry’s expansion into the geothermal sector; and (4) Leverage the expertise of skilled oil and gas workers especially in energy communities currently seeking employment to tackle geothermal challenges and fill gaps in the growing geothermal workforce through education, outreach, community engagement, and technology transfer demonstrations. Such efforts would provide good paying jobs that would benefit energy communities.
- Federal Partnerships for Geothermal Installations: Through this initiative, GTO and FEMP will make it possible for Federal agencies to seriously consider geothermal energy to heat/cool (and in some limited cases, potentially power) their installations. In particular, work will focus on Defense, State, National Park Service, NASA, and the General Services Administration. This Federal Partners initiative will fund critical research and characterization activities in FY 2022, driving the selected sites to demonstration and deployment of on-site geothermal projects. GTO support will fund advanced feasibility studies on shovel-ready sites and then develop on-site geothermal projects on Federal sites via FEMP performance contracting mechanisms.
- Next Generation Connected Communities: GTO will collaborate with the Building Technologies Office to demonstrate the market viability of highly energy-efficient, demand-flexible, low-carbon buildings integrated with distributed energy resources (DERs) and related infrastructure (e.g. EV charging, thermal energy sources) to reliably and cost‐effectively contribute to America’s transition to a carbon pollution-free grid. Specifically, the GTO will contribute funds for the demonstration of geothermal energy storage and/or community geothermal energy resources. GTO will competitively select projects that demonstrate how low-carbon pollution buildings integrated with DERs and infrastructure (e.g. EV charging, thermal energy sources), can reliably and cost‐effectively contribute to America’s transition to a carbon pollution-free grid by 2035 and net-zero economy by 2050.

Geothermal Technologies
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Geothermal Technologies				
Enhanced Geothermal Systems	69,000	65,000	70,380	+5,380
Hydrothermal Resources	20,000	20,000	39,100	+19,100
Low Temperature and Coproduced Resources	15,000	15,000	34,700	+19,700
Data, Modeling, and Analysis	6,000	6,000	19,580	+13,580
Total, Geothermal Technologies	**110,000**	**106,000**	**163,760**	**+57,760**

SBIR/STTR:

- FY 2020 Transferred: SBIR: $3,426,000; STTR: $580,000
- FY 2021 Projected: SBIR: $3,344,000; STTR: $470,000
- FY 2022 Request: SBIR: $4,860,000; STTR: $683,000

Geothermal Technologies
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted ($)
Geothermal Technologies	
Enhanced Geothermal Systems: Under the EGS subprogram, the Budget prioritizes additional funding for the highly-successful Frontier Observatory for Research in Geothermal Energy (FORGE) initiative under the FORGE activity, which decreases by $10,552,700 from FY 2021. Within Subsurface Enhancement and Sustainability R&D, the Budget increases $1,680,000 from FY 2021 to provide a third year of near-field EGS demonstration projects and a new funding opportunity in high temperature casing R&D. Within the $14,632,770 increase in the Exploration and Characterization activity, EGS will sponsor a major prize for the development of state-of-the-art geophone technologies. Within Subsurface Accessibility, EGS will provide half of the funding for GEODE, intended to help transition and transfer between the oil and gas and geothermal sectors and accelerate development of geothermal resources.	**+5,380**
Hydrothermal Resources: The Budget prioritizes funding for R&D under the Hydrothermal Resources Subsurface Accessibility R&D Activity in FY 2022 to focus on a major Drilling Technology Demonstration Campaign and the GEODE initiative (an increase of $21,500,000 over FY 2021). Funding is requested for work in Exploration and Characterization R&D (decrease of $4,550,000) for collection of data that will help characterize geothermal resources, additional machine learning projects, and additional National Laboratory projects on dark fiber and subsurface imaging. The Budget also requests funding for critical materials research, specifically follow-on research for lithium extraction from geothermal brines, under the Resource Maximization R&D activity (an increase of $2,150,000).	**+19,100**
Low Temperature and Coproduced Resources: In FY 2022, the Budget prioritizes funding for efforts under the Resource Maximization R&D Activity in the Low Temperature & Coproduced Resources subprogram with an increase of $17,450,000 for a strong focus on technical assistance in the Community Geothermal Heating and Cooling initiative and on demonstrating the benefits of geothermal energy on Federal installations, as well as continuing work in the DOE Energy Storage Grand Challenge and particularly in thermal energy storage R&D. The Budget also requests funding in Exploration and Characterization R&D of $2,250,000 for collaboration with the U.S. Geological Survey.	**+19,700**
Data, Modeling, and Analysis The Data, Modeling, and Analysis (DMA) subprogram in FY 2022 will focus on cross-EERE analysis and demonstration, with a strong focus on geothermal grid valuation through grid policy and regulatory support, Energy Transitions Initiative Partnership Program (ETIPP), and other related work. DMA will also conduct geothermal-specific grid research and analysis, along with continuing support for geothermal metric development and data repositories; the Budget requests an increase of $13,580,000 over FY 2021 in this activity.	**+13,580**
Total, Geothermal Technologies	**+57,760**

Geothermal Technologies
Enhanced Geothermal Systems

Description

Enhanced Geothermal Systems (EGS) are engineered reservoirs, created where there is hot rock but little to no natural permeability or fluid saturation present in the subsurface. Underpinning the EGS subprogram's major technical thrusts are fundamental geoscience challenges whose resolution hinge on collaborative R&D. The focus of the EGS subprogram is to gain an evidence-based understanding of these basic science challenges surrounding long-term subsurface heat flow, permeability enhancement, and stress evolution to enable development of sustainable, man-made heat exchangers. In the long term, strengthening the body of EGS knowledge through early-stage R&D will enable industry to develop a baseload energy resource as shown in the *GeoVision* report, which can be the major contributor to achieving a potential geothermal power capacity of 60 GWe by 2050.

EGS research is in a relatively early stage, yet it shares common challenges with other subsurface industries. Critical to advancing EGS are technologies that facilitate characterization of local stress, chemical constituents, and evolution of fluid and thermal pathways through space and over time. A final overarching hurdle is sustainable operation, which requires sufficient productivity for power generation without excessive flow localization or reduced flow rates. Inherent in this valuable multi-disciplinary approach is collaboration across the government, academic, and private sectors such as the research that is underway in the EGS subprogram's flagship initiative, the Frontier Observatory for Research in Geothermal Energy (FORGE). In addition to FORGE, all other research in the EGS subprogram is categorized into the following activities: Resource Characterization R&D, Subsurface Accessibility R&D, Subsurface Enhancement & Sustainability R&D, and Resource Maximization R&D.

The research supported under these activities will address the goal of meeting $0.06/kWh by 2050 from newly developed enhanced geothermal systems.

Resource Characterization R&D: EGS site characterization technologies focus on assessing the subtle subsurface properties that are paramount to EGS success: temperature, state of stress, fracture morphology, permeability, and thermal-hydrologic-mechanical-chemical (THMC) parameters. Assessing these parameters at the outset can inform well placement and the design of stimulation programs and tracking their evolution over time can improve the likelihood of successful long-term flow through EGS reservoirs. Characterization technologies seek to fully understand the conditions in the subsurface such that reservoir development and operation can be optimized to maximize heat extraction, thereby reducing risks and costs of EGS development and the final levelized cost of energy (LCOE) of produced energy. Ultimately, success in this space includes remote assessment capabilities for this suite of characterization technologies incorporated in real-time into fully coupled, 3D stress and reservoir models. The EGS Near-Field Monitoring & Characterization R&D Partnerships with the National Laboratories and the U.S. Geological Survey (USGS), for example, conduct R&D to develop a state-of-the-art subsurface monitoring system for EGS to be deployed at the Near-Field EGS Demonstration (Amplify) project sites. Lower costs will enable deployment of carbon pollution-free EGS energy production, contributing energy to the grid, avoiding significant CO_2e, and creating an estimated 250,000+ "gross" full-time mid-tech jobs.

Subsurface Accessibility R&D: Technical challenges in accessing EGS resources include a need for more efficient and cost-effective drilling in high temperature environments and hard-rock formations. Opportunities exist for using real-time surface and down-hole data to better control well profiles, adapting and creating drilling technologies and techniques for cost-effective subsurface access, and designing effective completions that will facilitate multi-zone stimulations. EGS efforts in accessing the subsurface aim to reduce the cost of development, which reduces the final LCOE. Efforts culminating in FY 2022 at the EGS Collab project, for example, will directly enable deployment of carbon pollution-free EGS energy production, contributing 60 GWe by 2050, facilitating 516 million (MMT) of avoided CO_2e and creating 262,000 "gross" full-time jobs.

Subsurface Enhancement & Sustainability R&D: Engineering the subsurface is paramount to the commercial and technological success of EGS. For EGS to be sustainable and commercial, fracture stimulation at depth must be reliable, reproducible, zone-specific, and tailorable (meaning that flow can be optimized by directing fluid through specific fractures depending on where heat is available). Advancements are necessary to understand the complex interactions and impacts of chemical, biological, and physical properties on permeability, pressure, and heat flow and provide predictive capabilities to

tailor stimulation plans to site-specific conditions. Effective geothermal field management requires identifying and understanding the long-term evolution and real-time changes in these properties. Research in these areas will reduce the costs and risks of EGS resulting in a lower ultimate LCOE for these energy sources and is paramount to the commercial and technological success of EGS. For example, addressing critical technology gaps through the in the Wells of Opportunity (WOO) – Innovative Methods to Control Hydraulic Properties of Enhanced Geothermal Systems subactivity will facilitate advancements towards more sustainable EGS reservoirs and will directly enable deployment of carbon-free EGS energy production, contributing 60 GWe by 2050, facilitating 516 million (MMT) of avoided CO2e and creating 262,000 "gross" full-time jobs. In another example, focused attention on leveraging technology for EGS applications will directly enable deployment of carbon pollution-free EGS energy production, contributing 60 GWe by 2050, facilitating 516 million (MMT) of avoided CO2e and creating 262,000 "gross" full-time jobs. In the medium term, this can also enable transitioning a portion of O&G technologies, workforce, and assets to geothermal energy production via employing some of the recently unemployed 100,000+ fossil energy workforce, enabling emissions reductions from otherwise idle O&G wells, and add more carbon pollution-free energy to the U.S. grid.

Resource Maximization R&D: Geothermal resources can provide a range of benefits, including grid stability, reliability, and resiliency; thermal and reservoir energy storage; the ability to harvest critical minerals from its brines; and partnering with other energy resources for even greater return. Maximizing the value of the country's geothermal resources will include R&D in these and related areas.

Frontier Observatory for Research in Geothermal Energy (FORGE): By enabling transformative and high-risk science and engineering, FORGE is an essential step toward establishing the capability to improve our understanding of EGS concepts. FORGE is a collaborative and inclusive effort involving a diverse group of geothermal and subsurface stakeholders; participation and contribution from industry, DOE National Laboratories, and academia are integral to its success. Furthermore, testing of new technologies and methodologies in the deep rock environment accessed at FORGE will facilitate a fundamental understanding of the key mechanisms controlling processes at depth at full operational scale. Advancement of these R&D technologies will directly enable deployment of carbon pollution-free EGS energy production, contributing 60 GWe by 2050, facilitating 516 million (MMT) of avoided CO2e and creating 262,000 "gross" full-time jobs. In addition, transitioning a portion of O&G technologies, workforce, and assets to geothermal energy production can help re-employ some of the recently unemployed 100,000+ fossil energy workforce, can enable emissions reductions from utilizing otherwise idle O&G wells and add more carbon pollution-free energy to the U.S. grid.

Enhanced Geothermal Systems

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Enhanced Geothermal Systems $65,000,000	**$ 70,380,000**	**+$5,380,000**
Frontier Observatory for Research in Geothermal Energy (FORGE) $30,552,700	$20,000,000	-$10,552,700
• FORGE Competitive R&D Solicitations: This R&D focus addresses developing alternative completion techniques, adoption of relevant unconventional oil and gas stimulation methods, and identifying links between completion techniques and reservoir development and operation.	• FORGE Competitive R&D Solicitations: Funding is requested for an additional R&D solicitation on topics to be determined by FORGE's Science and Technology Analysis Team and DOE in FY 2022.	• FORGE Competitive R&D Solicitations: A FORGE R&D solicitation is expected to be released at the start of calendar year 2022; additional funding will allow the program to increase the award size and number of awards for this critical research into EGS technologies and techniques.
• FORGE Advanced Wellbore Completions for EGS Longevity: This R&D focus addresses developing alternative completion techniques, adoption of relevant unconventional oil and gas stimulation methods, and identifying links between completion techniques and reservoir development and operation.	• FORGE Advanced Wellbore Completions for EGS Longevity: No funding is requested in FY 2022.	• FORGE Advanced Wellbore Completions for EGS Longevity: FORGE Advanced Wellbore Completions for EGS Longevity: The Budget Request in FY 2022 prioritizes funding for other EGS technology R&D areas and specifically covers wellbore completions in the Subsurface Enhancement & Sustainability R&D category.
Subsurface Enhancement & Sustainability R&D $26,700,000	$28,380,000	+$1,680,000
• Innovative Methods to Control Hydraulic Properties of Enhanced Geothermal Systems: This R&D focus addresses solutions for assessing fluid residence time, fracture connectivity, and reservoir volume critical to determining reservoir performance. New technologies and new real-time data collection and processing methods to be developed under this effort will facilitate the collection of these critical data, which will help operators understand and address changes that occur in the subsurface before, during, and after stimulation and will aid in designing more efficient, sustainable reservoirs.	• Innovative Methods to Control Hydraulic Properties of Enhanced Geothermal Systems: No funding is requested in FY 2022.	• Wells of Opportunity (WOO) – Innovative Methods to Control Hydraulic Properties of Enhanced Geothermal Systems: The Budget Request in FY 2022 prioritizes funding for other critical areas of EGS technology R&D. Work on this important effort will continue in FY 2022 with prior year appropriations.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Wells of Opportunity – Amplify Topic Area 1 – Amplify (EGS Near-Field RD&D): This field validation effort will culminate in new power production, adding to the commercial viability of existing geothermal fields. The goal of Amplify is to illustrate that near-field and in-field EGS can be successfully deployed now as a result of recent technology advancements and that low permeability/underproductive wells near and in existing hydrothermal fields can be turned into valuable assets using EGS techniques.	• Wells of Opportunity (WOO) – Amplify: Funding is requested in FY 2022 to provide a third set of near-field EGS demonstration projects. This third set of near-field EGS demonstration projects will build on the lessons learned from the first two years of demonstration, while adding tens of MW of clean, geothermal energy to the electric grid in the near-term. The projects also demonstrate that near-term EGS is feasible and can add capacity while turning idle wells into productive assets.	• Wells of Opportunity (WOO) – Amplify: The Request includes funding to provide a third set of near-field EGS demonstration projects.
• Topic Area 2 – ReAmplify (Geothermal production from hydrocarbon wells): The objective of this initiative is to establish the commercial viability of geothermal energy production from existing hydrocarbon fields. The goal of ReAmplify is to establish a pilot program where the production of geothermal heat from existing hydrocarbon fields can be demonstrated for electricity production or direct use applications.	• ReAmplify (Geothermal production from hydrocarbon wells): No funding requested.	• ReAmplify will be incorporated into outyears of GEODE, as current funding levels for GEODE do not permit full-scale demonstrations.
• EGS Workforce Training: FY 2021 includes engagement with the community to speed the adoption of advanced concepts and capabilities, including the subsurface workforce, into the EGS field. A major goal of this effort is engagement of a broader swath of the U.S. population to increase geothermal literacy – which can facilitate technically savvy workforce and also a community interested in advocating for geothermal energy as their clean-energy of choice.	• No funding is requested in FY 2022.	• EGS workforce efforts in FY 2022 will be concentrated in the GEODE initiative. Work on this effort will continue in FY 2022 with prior year appropriations.
• EGS STEM Early Career Awards: This effort includes a program for early career researchers to receive seed funding to explore EGS concepts and widen the breadth of contributors to the EGS community. A major goal of this effort is engagement of a broader swath of the US	• EGS STEM Early Career Awards: Funding is requested for this program in FY 2022 to use lessons learned from the first year to attract the highest quality researchers into the geothermal field.	• The Request includes funding for a second cohort of early career awards in EGS, using lessons learned from the first year to attract the highest quality researchers into the geothermal field.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
population to increase geothermal literacy – which can facilitate technically savvy workforce and also a community interested in advocating for geothermal energy as their clean-energy of choice.		
• High Temperature Smart Casing Working Group for Funding Opportunity. No funds were requested.	• High Temperature Smart Casing Working Group for Funding Opportunity: Funding is requested to form a working group to identify promising research directions associated with reducing the cost of casing. Completing a well – casing and cementing – is responsible for up to half the cost of drilling a geothermal well and hence lowering the cost of casing, creating dual purpose casing (for monitoring and wellbore stability), or eliminating the need for casing altogether could dramatically lower the overall costs of geothermal drilling and EGS development. This National Lab-driven scoping effort and the Funding Opportunity Announcement (FOA) that will ultimately be produced from it, will seek to develop new technologies and leverage advances in additive and other areas to address these challenges.	• High Temperature Smart Casing Working Group for Funding Opportunity: Funding is requested to form a working group to identify promising research directions associated with reducing the cost of casing.
Subsurface Accessibility R&D $5,380,070	$5,000,000	-$380,070
• EGS Collab: The EGS Collab project continues stimulation and flow experiments in highly-monitored and well characterized intermediate-scale (~10-20 m) field test beds. In FY 2021 a new test bed, in a different rock type 4,100 feet below the surface will be developed. Fracture creation, stimulation, and interwell flow tests are repeatedly performed to better understand processes that control formation of effective subsurface heat exchangers useful in EGS. EGS Collab also provides a means of testing models, tools, and concepts that can later be employed	• EGS Collab: No funding is requested in FY 2022.	• EGS Collab: The EGS Collab project will be finished after the FY 2021 funding is expended, although work on this effort will continue in FY 2022 with prior year appropriations.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
under geothermal reservoir conditions at FORGE or other enhanced geothermal systems to improve reservoir creation and connectivity. The intermediate scale field testing underway at EGS Collab is a critical step to enable full scale field deployment of EGS nationwide. Efforts culminating in FY2022 at EGS Collab will directly enable deployment of carbon-free EGS energy production, contributing 60 GWe by 2050, facilitating 516 million (MMT) of avoided CO2e and creating 262,000 "gross" full-time jobs.	• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): As a major investment split between EGS and Hydrothermal Resources, GEODE aims to accelerate the fossil energy sector's carbon pollution-free strategies and accelerate development of geothermal resources through mission critical technology development, demonstration, and workforce transition. This initiative will: (1) Identify and facilitate technology transfer opportunities between the Oil and Gas and Geothermal industries; (2) Assess opportunities for the oil and gas industry to deploy geothermal technologies nationwide, especially in energy communities, including the use of geothermal energy for onsite power production at operating oil and gas fields (coproduction), and the transition of retired oil & gas wells to flexible, carbon pollution-free geothermal energy; (3) Evaluate and address the barriers to the O&G industry's expansion into the geothermal sector; and (4) Leverage the expertise of skilled oil and gas workers, including those in energy communities currently seeking employment to tackle geothermal challenges and fill gaps in the growing geothermal workforce through education, outreach, community	• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): The Request includes funding to initiate this effort, which will bring oil and gas technology, tools, and talents into the geothermal field.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	engagement, and technology transfer demonstrations.	
Exploration and Characterization R&D $2,367,230	$17,000,000	+$14,632,770
• EGS Near-Field Monitoring & Characterization R&D: Partnerships with the National Laboratories and USGS will continue R&D to develop a state-of-the-art subsurface monitoring system for Enhanced Geothermal Systems (EGS) to be deployed at the Near-Field EGS Demonstration (Amplify) project sites. A successful outcome of this effort will include lower-cost, faster deployed wells that are capable of monitoring in situ reservoir evolution and properties at higher resolution than existing systems. The EGS Near Field Monitoring goals, as stated above, impact the economics of EGS deployment dramatically, and when successful will enable reduction of one portion of the EGS deployment costs (monitoring for regulatory compliance).	• EGS Near-Field Monitoring & Characterization R&D: Additional funding is requested in FY 2022 to support the new near-field EGS demonstration projects.	• EGS Near-Field Monitoring & Characterization R&D: This critical work supports the previous and the new near-field EGS demonstration sites. While work on this effort will continue in FY 2022 with prior year appropriations, the additional funding will continue GTO's strategic emphasis on developing more cost-effective methods for developing sustainable, economic EGS reservoirs.
	• High Temperature Geophone Prize: The EGS Subprogram includes funding for a prize to develop state-of-the-art high-temperature geophones for use in EGS monitoring. A geophone converts ground movement (velocity) into voltage to analyze the structure of the earth and to track reservoir growth during EGS stimulations. Current geophones cannot survive the temperatures encountered downhole in EGS environments; this prize will focus on increasing the temperatures at which geophones can reliably track subsurface reservoir data.	• High Temperature Geophone Prize: The Request includes funding for a prize to develop state-of-the-art high-temperature geophones for use in EGS monitoring. This work continues GTO's strategic emphasis on developing cost-effective methods for developing and monitoring sustainable, economic EGS reservoirs while ensuring safe operations.

Description

Hydrothermal resources are currently the primary source of geothermal power and heat worldwide, and the *GeoVision* study indicates that technology innovation can help unlock additional hydrothermal resources to contribute to the potential 60 GWe of geothermal power capacity by 2050. Hydrothermal resources can also be utilized to hit the nearer-term Administration goal of a carbon pollution-free electricity sector by 2035. The program sponsors R&D that can lower cost and risk throughout the lifecycle of a hydrothermal project to bring more hydrothermal power on line: from exploration and resource confirmation, to drilling and field development, to reservoir management over multi-decadal timescales.

Because cost and risk are both concentrated in the early phases of a geothermal resource development, many of the biggest opportunities for advancement relate to the exploration and drilling phases of a project (both pre- and post-confirmation drilling). Improving capabilities for characterization of both known and "hidden" hydrothermal resources will encourage geothermal development by reducing project cost and risk through improved drilling success rates. New and innovative exploration technologies can improve a geothermal developer's ability to infer reservoir properties, map out major geologic structures, and understand the subsurface stress state prior to drilling. These technologies can reduce project risk by greatly reducing the number of unsuccessful wells that are drilled.

Following initial reconnaissance and exploration, resource confirmation (understanding the location, extent, and quality of a geothermal resource) and field development ultimately require extensive drilling. Advanced drilling technologies have the potential to improve project economics significantly by attaining improved rates of penetration, reducing delays, avoiding problems with surface and downhole equipment, and offering low-cost, high-performance materials for well construction.

Reducing the risk in the exploration and development stages of geothermal projects will lower the LCOE of the geothermal energy produced by reducing the number of expensive wells that are required; shortening the length of time spent developing the field, and enhancing access to capital for geothermal developers. Improved subsurface characterization and drilling technologies yield improved economics in the operational phase of a project by lowering operations and maintenance (O&M) costs and extending resource life. Other paths to improved O&M economics focus on sustaining the resource and maximizing its value; efforts include the application of machine learning and artificial intelligence (e.g., big-data techniques and autonomous systems) in field management, and the implementation of newer energy applications and business models, e. g. mineral recovery, grid-scale energy storage, and dispatchable power generation. The subprogram also supports R&D for harvesting critical materials or other strategic minerals from geothermal brines to maximize the ancillary benefits of geothermal resources. Research in the Hydrothermal Resources subprogram is categorized into the following activities: Exploration and Characterization R&D, Resource Characterization R&D, Subsurface Accessibility R&D, Subsurface Enhancement & Sustainability R&D, and Resource Maximization R&D.

Exploration and Characterization R&D: Hydrothermal resources are typically discovered through the application of conventional exploration technologies and methods, or because of the presence of some surface expression such as a geyser, hot spring, fumarole, or other indication that a hydrothermal resource may exist at depth. However, most of the remaining undiscovered hydrothermal resources in the U. S. are difficult to identify with existing exploration technologies and methods, largely because these resources lack the traditional surface manifestations that indicate resource potential. Advanced techniques that work reliably in oil and gas exploration do not yet perform similarly in a geothermal setting but are of high interest for technology transfer efforts. Hydrothermal exploration and characterization R&D therefore focuses largely on capabilities for locating and mapping the extent of the requisite components of a resource: heat, fluids, and permeable pathways; as well as high-resolution subsurface imaging that is needed to develop an identified resource. These technologies can reduce LCOE primarily by lowering the capital cost of a geothermal project.

Subsurface Accessibility R&D: The ability to access the subsurface effectively is critical to hydrothermal development. Integrating improved drilling and well-completion technology, better well designs and construction materials, and improved decision-making can help industry realize better drilling efficiencies and effectiveness. Additionally, as the most commercialized geothermal resource setting, newly developed drilling techniques deployed in a hydrothermal setting can have spillover benefits to the development of less commercialized EGS and low-temperature systems. Hydrothermal efforts in accessing the subsurface aim to reduce the cost of field development, which is a large component of LCOE.

Subsurface Enhancement and Sustainability R&D: Long-term stability of hydrothermal systems relies on the maintenance of fluid flow pathways as related to sustaining temperature and flow rate of the resource. Furthermore, stability also depends on controlled interaction of geothermal brines with surface equipment and advanced operational strategies to divert flow to maximize production. Significant opportunities exist to optimize hydrothermal reservoir management through the application of machine learning and artificial intelligence, which can augment existing modeling tools and provide a basis for developing autonomous systems for field management.

The overall goal for operations in the hydrothermal sector is to reduce operating costs ($/kWh) and optimize and maximize heat extraction. The ability to sustain a hydrothermal resource over time will reduce the costs and risks of geothermal energy, resulting in a lower ultimate LCOE for these energy sources.

Resource Maximization R&D: Geothermal resources can provide a range of benefits, including grid stability, reliability, and resiliency; thermal and reservoir energy storage; the ability to harvest critical minerals from its brines; and partnering with other energy resources for even greater return. In particular, the ability to harvest critical minerals such as lithium and manganese, as well as other valuable minerals such as zinc and silica, from geothermal brines can help maximize the value of the country's geothermal resources. R&D can help overcome challenges of proving extracting technologies and scaling them up to commercial level; R&D can improve tools and techniques for characterizing provenance and sustainability of these types of mineral resources.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Hydrothermal Resources $20,000,000	**$39,100,000**	**+$19,100,000**
Subsurface Accessibility R&D $3,500,000	$25,000,000	+$21,500,000
• Drilling Improvements in Geothermal (DIG) FOA: This effort, which will be combined with FY 2022 funds in the Drilling Technology Demonstration Campaign, continues to build on the success of the FY 2018 EDGE FOA in this new funding opportunity to move to the next phase of development for efficient drilling technologies by moving them to field demonstrations that will generate repeatable, sustainable drilling efficiency improvements to produce a systematic approach to addressing the needs of geothermal drilling in a variety of play types. DIG FOA's goal will be to reduce the time required to drill geothermal wells in active geothermal fields by leveraging oil and gas expertise and technologies. This will directly enable deployment of carbon-free geothermal energy production, contributing 30 GWe by 2050.	• Drilling Technology Demonstration Campaign: R&D on drilling technologies over the past decade has resulted in several technologies and methods ready for field demonstration that can reduce the costs and risks of drilling and, therefore, lead to increased deployment of geothermal. GTO will fund a major drilling technology demonstration campaign to prove the utility and efficacy of innovative well construction technologies and to attract future private investment. DOE-sponsored field development is needed, because thinly-capitalized geothermal developers will not accept risks associated with the implementation of such innovative well construction technologies, including those adapted from the oil and gas industry.	• Drilling Technology Demonstration Campaign: The increased funding request for this drilling technology demonstration campaign will enable field demonstration to prove utility and efficacy and attract future private investment and use. The drilling demonstration campaign will serve to quantifiably demonstrate technology driven drilling cost reductions in geothermal well development and further the Nation's goal to a 100 percent clean energy economy.
	• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): As a major investment split between EGS and Hydrothermal Resources, GEODE aims to accelerate the fossil energy sector's carbon pollution-free strategies through mission critical technology development, demonstration, and workforce transition. This initiative will: (1) Identify and facilitate technology transfer opportunities between the Oil and Gas and Geothermal industries; (2) Assess opportunities for the oil and gas industry to deploy geothermal technologies nationwide, including the use of geothermal energy for onsite	• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): The Request includes funding to initiate this activity, which will bring oil and gas technology, tools, and talents into the geothermal field and assist with just transitions for fossil energy workers and communities as we move towards the Nation's goal of a 100 percent clean energy economy.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	power production at operating oil and gas fields (coproduction), and the transition of retired oil & gas wells to flexible, carbon-free geothermal energy; (3) Evaluate and address the barriers to the O&G industry's expansion into the geothermal sector; and (4) Leverage the expertise of this industry, including that which exists in energy communities. • Geothermal Energy from Oil and gas. Demonstrated Engineering (GEODE): As a major investment split between EGS and Hydrothermal Resources, GEODE aims to accelerate the fossil energy sector's carbon pollution-free strategies through mission critical technology development, demonstration, and workforce transition. This initiative will: (1) Identify and facilitate technology transfer opportunities between the Oil and Gas and Geothermal industries; (2) Assess opportunities for the oil and gas industry to deploy geothermal technologies nationwide, including the use of geothermal energy for onsite power production at operating oil and gas fields; and (3) Leverage the expertise of skilled oil and gas workers currently seeking employment including those in energy communities to tackle geothermal challenges and fill gaps in the growing geothermal workforce through education, outreach, community engagement, and technology transfer demonstrations.	
Exploration and Characterization R&D $16,500,000	$11,950,000	-$4,550,000
• Machine Learning for Geothermal: Projects awarded under the FY 2018 Machine Learning for Geothermal Energy FOA will undergo a downselect. 1-3 projects will continue into the	• Machine Learning for Geothermal: Initiate new research activities based on feedback and learnings from the FY 2021 review of FY 2018 Machine Learning FOA projects and the FY 2021	• Machine Learning for Geothermal: The Budget Request continues to prioritize funding for this critical priority and related departmental crosscutting activity. Further leveraging machine

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
next phase of research which will focus on scaling up from early stage R&D and may involve expanded study areas, new data acquisition, and additional market transformation activities. Further leveraging machine learning research to identify geothermal resources and improve hydrothermal operations and methods will help meet Administration carbon pollution-free goals by directly enabling deployment of carbon-free geothermal energy production, contributing 30 GWe by 2050.	downselect, as well as from continued GTO participation in DOE's Intra-agency Artificial Intelligence (AI) collaboration team. Research may include areas such as automation in field operations or data management, among others. Machine learning analyses of recent, rich, geothermal-relevant data sets (such as the GeoDAWN data collection effort) will also be prioritized.	learning research to identify geothermal resources and improve hydrothermal operations and methods will help meet Administration carbon pollution-free goals by directly enabling deployment of carbon-free geothermal energy production, contributing 30 GWe by 2050.
• Hidden Systems Award: To stimulate the continued discovery and development of hidden geothermal resources in the Basin and Range Province of the western U.S. by expanding the public body of exploration tools and knowledge, the project selected will design, apply, and validate a complete workflow for discovering hidden geothermal resources in the selected study area. The team will optimize the allocation of award funds across the project activities, with the concurrent goals of maximizing the identification of undiscovered resources, lowering risk and uncertainty for the overall resource portfolio, and validating the specific exploration methods and approach for the study area through some level of site-specific drilling. This award will directly enable identification of geothermal systems that will lead to deployment of carbon-free geothermal energy production, contributing 30 additional GWe by 2050, and aiding the U.S. transition to 100 percent clean energy economy.	• Hidden Systems Application: No funding is requested in FY 2022.	• Hidden Systems Application: The Request prioritizes RDD&D in other areas within Hydrothermal Resources to continue to harness hydrothermal resources toward a carbon-free grid for 2035. Work on Hidden Systems will continue in FY 2022 with prior year appropriations.
• Hydrothermal Lab R&D – Dark Fiber: Pending the outcome of a Go / No Go review, the next phase	• Hydrothermal Lab R&D – Dark Fiber: The final increment of funding for this critical lab project	• Hydrothermal Lab R&D – Dark Fiber: This is the final increment of funding for this critical lab

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
of work for a Lawrence Berkeley National Lab project, which explores the use of dark fiber (unused optical fiber that has been laid but is not currently being used in fiber-optic communications) and distributed acoustic sensing to map and monitor geothermal resources in the Imperial Valley, will begin. This project will provide unique insights into the Imperial Valley in California, where known geothermal resource areas exist, which will directly enable deployment of additional carbon-free geothermal energy production in the Imperial Valley. It will also provide a method for increased discovery of hidden geothermal resources in the U.S.	will be funded in FY 2022, pending a final Go / No Go review in FY 2021.	project, which has passed its Go/No Go review, pending a final Go / No Go review in FY 2021.
	• Interagency Collaboration with Department of Interior/USGS: GTO and USGS collaborated in FY 2020 and FY 2021 on the Geoscience Data Acquisition for Western Nevada (GeoDAWN). In FY 2022, GTO will expand its work with USGS for resource mapping and assessments as well as additional data acquisition collaborations that serve the missions of both agencies. • Subsurface Imaging Follow-on (Laboratory Project): GTO will fund the final increment on an FY 2020 lab award to the National Renewable Energy Laboratory for exploration and characterization research in Hawaii. This project leverages abundant existing Hawaii Volcano Observatory data for Kilauea and the associated rifts along with planned surface and airborne surveys to gather additional, subsurface data. This project is expected to improve subsurface confidence and understanding of the unique integrated geophysical signature of a	• Interagency Collaboration with Department of Interior/U.S. Geological Survey: The Request includes funding to continue this activity, which furthers the goals of both agencies while avoiding duplicative research. The resource mapping and assessments in particular are something needed throughout the U.S. to increase deployment of geothermal energy. • Subsurface Imaging Follow-on (Laboratory Project): The Request funds the final increment on the FY 2020 award.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	commercially productive geothermal system in Hawaii.	
Resource Maximization R&D $0	$2,150,000	+$2,150,000
• Critical Materials: No funding was requested in FY 2021 through the Hydrothermal Resources subprogram; until FY 2022, critical materials research was funded through Low-Temperature and CoProduced Resources.	• Critical Materials: Starting in FY 2022, funding critical materials is being requested through the Hydrothermal Resources subprogram, as the work is being conducted exclusively in higher-temperature resources. Provided that techno-economic studies on this topic justify additional R&D spending in this area, GTO will build on the FY 2021 Geothermal Lithium Extraction Prize to fund additional research and/or technologies that complement, but do not duplicate, prize efforts to separate lithium or other critical minerals from geothermal brines. The focus of this effort will be better understanding of the resources, environment, and operations of geothermal power generation sites with potential mineral coproduction.	• Critical Materials: The Request prioritizes funding for the Administration's Critical Materials effort under the Resource Maximization R&D activity. Provided that techno-economic studies on this topic justify additional R&D spending in this area, GTO will build on the FY 2021 Geothermal Lithium Extraction Prize to fund additional research and/or technologies that complement, but do not duplicate, prize efforts to separate lithium or other critical minerals from geothermal brines.

Geothermal Technologies
Low Temperature and Coproduced Resources

Description

The Low Temperature and Coproduced Resources subprogram supports targeted R&D on technologies applicable to geothermal resources below a temperature of 300°F (150°C) as well as geothermal resources, including hybrid power designs, that can be co-developed with existing well-field infrastructure and other clean energy technologies. These low-temperature resources have a lower power conversion efficiency than other geothermal resources, so, while these resources are abundant throughout the country, it will require EGS tools and techniques to unlock their full potential. The subprogram also supports R&D including the direct use of thermal resources for process and space heating applications. These technologies have the potential to provide cost-effective, renewable thermal energy in large portions of the U.S.

A USGS assessment estimates 46,500 MW thermal (MWth) of total beneficial heat could be extracted from geothermal resources below 90°C in the U. S. using currently available technologies.[1] The recently published *GeoVision* study estimates that through the adoption of advanced technology scenarios, geothermal district-heating installations could increase to 17,500 nationwide and 28 million U. S. households could realize cost-effective heating and cooling solutions through geothermal heat pumps.

Whether used to produce distributed power or directly for heating and cooling, low-temperature resources may have much of the necessary infrastructure already in place, lowering the effective levelized cost of electricity or heat. Improving the efficiency of low-temperature geothermal systems, and expanding their utility through value-added commercial opportunities (i.e., reservoir thermal energy storage, borehole thermal energy storage, geothermal heat pumps, and distributed low-temperature power production) can facilitate near-term development of innovative geothermal technologies in geographically diverse areas of the U.S.

Exploration and Characterization R&D: Characterization of the subsurface for low-temperature power production and direct use applications, including temperature gradients at varying depths and in varying environments (urban/rural, residential/industrial, etc.), is critical for understanding where these low-temperature resources can most effectively be harnessed.

The overall goal of exploration and characterization in the Low-Temperature and Coproduced Resources subprogram is to understand the conditions in the subsurface such that both low-temperature power production and direct use systems are effective and affordable to contribute to the thermal capacity on line and facilitate nationwide deployment of low-temperature power production.

Subsurface Accessibility R&D: Drilling wells and boreholes, along with trenching, are critical to enable direct use and power-producing low-temperature geothermal systems. Challenges in accessing low-temperature resources are similar to those in EGS and hydrothermal because of the depths at which these resources may be located, especially outside of the West where higher temperature resources are concentrated, with additional challenges associated with thermal storage systems.

Low Temperature & Coproduced Resources efforts in accessing the subsurface aim to reduce the cost of development, which reduces the final Levelized Cost of Heat (LCOH) and LCOE for low-temperature resources. A lower LCOH and LCOE will result in increased thermal capacity on line and facilitating nationwide deployment of low-temperature power production.

Subsurface Enhancement and Sustainability R&D: Enabling cost-effective subsurface engineering technologies, specifically the ability to increase permeability at depth, can facilitate geothermal district heating and cooling throughout the U.S. Currently, inefficient injection strategies limit the ability to produce at high volumes for direct use or storage purposes. Likewise, subsurface engineering is critical to developing synthetic geothermal reservoirs for advanced energy storage.

[1] Williams, et al., Revisiting the Assessment of Geothermal Resources <90°C in the U.S. April 10, 2015.

Increasing production of low-temperature resources at depth (Deep Direct Use) will reduce the LCOH for these district heating and cooling systems. A lower LCOH can result in increased thermal capacity on line.

Coupled thermal, hydraulic, mechanical, and chemical (THMC) modeling and testing are needed to optimize and balance low-temperature injection and production temperatures against heating and cooling demands to prevent well fields and systems from being depleted. Another challenge to sustainability of low-temperature and storage systems is related to restricted flow rates because of mineral and solid particle deposition. Sustaining production from low-temperature resources for direct use and power production will reduce the LCOH and LCOE for these systems. A lower LCOH and LCOE will result in increased thermal capacity on line and facilitating nationwide deployment of low-temperature power production.

Resource Maximization R&D: Geothermal resources can provide a range of benefits, including grid stability, reliability, and resiliency; thermal and reservoir energy storage; and partnering with other energy resources for even greater return. There is ubiquitous thermal energy storage available in the Earth for a variety of direct-use and grid applications that can significantly enable new, more resilient energy services that not only provide an effective alternative to grid-dependent heating and cooling but that also add resilience to the broader energy system. GTO continues to support this potential in partnership with the DOE Energy Storage Grand Challenge and through standalone funding opportunities for large-scale resource assessment and feasibility research across a diverse group of institutions pursuing geothermal system installation. This program includes maximizing the benefits of coproduced energy sources, such as coproduction of oil/gas and geothermal energy using heated fluids sourced from nearby oil and gas fields. The geothermal component of these systems may generate power/electricity, or it may be directly used for heating applications

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Low Temperature and Coproduced Resources $15,000,000	**$34,700,000**	**+$19,700,000**
Resource Maximization R&D $15,000,000	$32,450,000	+$17,450,000
• Energy Storage Grand Challenge: The selected project in Direct Use Applications will enable new, more resilient energy services that not only provide an alternative to grid-dependent heating and cooling but that also add resilience to the larger energy system. The engineering design and testing of low-temperature geothermal fluids in district heating and cooling systems will enable the development of needed low-temperature system components and infrastructure resulting in the next generation of district heating and cooling in America. This initiative will help transition the U.S. to a 100 percent clean energy economy as well as develop technology that will transition underserved communities to clean, geothermal energy through the addition of 17,500 district heating systems nationwide by 2050.	• Energy Storage Grand Challenge: GTO will support the Energy Storage Grand Challenge to validate and demonstrate promising approaches to long-duration thermal energy storage that can help provide the necessary flexibility to operate a renewable energy-based power system. This includes working closely with other EERE and DOE offices to refine storage performance metrics, validate thermal energy storage technologies in the field, and develop new storage demonstration and pilot programs. This initiative will help transition the U.S. to a 100 percent clean energy economy as well as develop technology that will transition underserved communities to clean, geothermal energy through the addition of 17,500 district heating systems nationwide by 2050.	• Energy Storage Grand Challenge: The Budget Request includes funding for the DOE Energy Storage Grand Challenge and thermal energy storage research and demonstrations.
• Energyshed Management System: This effort includes the development and demonstration of an "energyshed" management system that addresses a discrete geographic area in which renewable sources currently provide a large portion of electric energy needs, where grid capacity constraints result in curtailment of renewable generation, and with very substantial existing deployment of interactive smart meters. The "energysheds" design should achieve a high level of integration resilience and reliability among all energy uses, including both on-demand and long-time energy scales, transmission and distribution of electricity. “Energysheds” will	• Energyshed Management System: No funding requested in FY 2022.	• Energyshed Management System: Work on this effort will continue in FY 2022 with prior year appropriations.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
provide information and transparency to key stakeholders and the public regarding the sources, reliability, and sustainability of their electricity to encourage accountability and environmental justice as we move towards a future with 100 percent clean energy.		
	• Community Geothermal Heating & Cooling Technical Assistance & Deployment: This initiative funds technical assistance to demonstrate and deploy community-scale direct use geothermal. The initiative will provide funds to competitively-selected geographic coalitions, especially in the northeast corridor, to implement geothermal district energy systems through installation of geothermal heat pumps (GHP) or direct use of geothermal fluids. Target areas include urban centers, rural areas, and remote communities where geothermal has high technical and economic potential and can reduce dependence on fossil fuels (such as natural gas and heating oil). A major objective of the initiative is to develop a set of "proven test cases" that can be duplicated by communities throughout the U.S. The funded coalitions would provide technical and economic data back to DOE and develop case studies ("test beds") that can be used to demonstrate applicability to other communities.	• Community Geothermal Heating & Cooling Technical Assistance & Deployment: The Request includes initial funding for this high-priority investment area. This initiative addresses carbon pollution-free of the built environment while focusing on environmental justice issues, ensuring that the benefits of geothermal energy are accrued to those in urban centers, rural areas, and remote communities.
	• Federal Partnerships for Geothermal Installations: Through this initiative, GTO and FEMP will make it possible for Federal agencies to seriously consider geothermal energy to heat/cool (and in some limited cases, potentially power) their installations. In particular, work will focus on Defense, State, National Park Service, NASA, and the General Services Administration. This Federal Partners initiative will fund critical research and characterization activities in FY 2022, driving the	• Federal Partnerships for Geothermal Installations: The Request includes initial funding within this subprogram for this high-priority collaborative initiative; additional funding is requested in the Data, Modeling, and Analysis subprogram. This work helps to decarbonize the built environment, looking to replace the use of fossil fuels for heating and cooling with carbon-free geothermal energy.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	selected sites to demonstration and deployment of on-site geothermal projects. GTO support will fund advanced feasibility studies on shovel-ready sites and then develop on-site geothermal projects on Federal sites via FEMP performance contracting mechanisms. • Next Generation Connected Communities: GTO will collaborate with the Building Technologies Office to demonstrate the market viability of highly energy-efficient, demand-flexible, low-carbon buildings integrated with distributed energy resources (DERs) and related infrastructure (e.g., EV charging, thermal energy sources) to reliably and cost‑effectively contribute to America's transition to a zero-carbon grid. Specifically, the GTO will contribute funds for the demonstration of geothermal energy storage and/or community geothermal energy resources.	• Next Generation Connected Communities: The Request includes initial funding within this activity for this high-priority collaborative initiative. This activity will competitively select projects that demonstrate how low-carbon buildings integrated with distributed energy resources (DERs) and infrastructure (e.g., EV charging, thermal energy sources), can reliably and cost‑effectively contribute to America's transition to a zero-carbon grid by 2035 and net-zero full economy by 2050.
Exploration and Characterization R&D $0	$2,250,000	+$2,250,000
	• Interagency Collaboration with Department of Interior/U.S. Geological Survey: In FY 2022, GTO will expand its work with USGS for resource mapping and assessments to include low temperature resources as well as underground thermal energy storage resources. This will enable more accurate subsurface assessment of low temperature applications.	• Interagency Collaboration with Department of Interior/U.S. Geological Survey: The Request includes funds to expand this partnership, which furthers the goals of both agencies while avoiding duplicative research. The low temperature resource mapping and thermal storage assessments in particular are needed throughout the U.S. to increase the deployment of geothermal energy, including low-temperature resources for District Heating and Cooling.

Geothermal Technologies
Data, Modeling, and Analysis

Description

The goal of the Data, Modeling, and Analysis subprogram is to identify and address barriers to geothermal adoption in the U. S. and validate and assess technical progress across the geothermal sector primarily to inform the direction and prioritization of early-stage R&D. The Data, Modeling, and Analysis subprogram takes a holistic analytical approach across the program's technology portfolio to evaluate trends, conduct impact analyses, undertake geothermal resource assessments, identify best practices, and identify key investments needed to refine the Geothermal R&D portfolio aimed at increasing knowledge and understanding of complex geothermal systems and technologies to convert geothermal resources into useful energy.

The Data, Modeling, and Analysis subprogram conducts analyses in the following areas: the environmental impacts of geothermal, the policy and regulatory barriers to geothermal development and deployment, techno-economic modeling and validation of geothermal technologies, and collecting and disseminating data for stakeholder use to spur geothermal development. Lessons learned resulting from these analyses are subsequently incorporated into the program's strategic planning and either validate or refine the program's overall direction of early-stage R&D. The Data, Modeling, and Analysis subprogram conducts these activities in partnership with the DOE National Laboratories, Federal agencies, academic institutions, and industry stakeholders to maximize interagency coordination to provide greater impact than that of individual agency activities.

In FY 2019, the program released *GeoVision*: *Harnessing the Heat Beneath Our Feet*. Based on rigorous modeling and simulation, the *GeoVision* analysis addresses gaps in understanding the potential of geothermal resources and provides a case for geothermal energy to have a sizable role in meeting the Nation's 21st-century energy demands. Leveraging the results from the *GeoVision* analysis, in FY 2019, the program initiated development of a Multi-Year Program Plan, slated to be completed in FY 2021. The Multi-Year Program Plan will provide additional R&D objectives and associated performance goals for achieving the outcomes identified in the *GeoVision* analysis.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Data, Modeling, and Analysis $6,000,000	**$19,580,000**	**+$13,580,000**
Data, Modeling, and Analysis $6,000,000	$19,580,000	+$13,580,000
• Techno-Economic Tools & Data: Funding supports continued maintenance of techno-economic tools, data, and National Laboratory expertise. Geothermal Electricity Technology Evaluation Model (GETEM): In its current form, GETEM is a robust open source techno-economic analysis tool used by industry and DOE to evaluate the levelized costs of prospective geothermal power generation developments. There are opportunities to improve and enhance GETEM's capabilities by incorporating relevant datasets that are rigorously tied to the underlying physics and thermodynamics of geothermal systems. Through a multi-lab collaboration, a framework of enhancements will upgrade model sophistication, minimize data uncertainties, and expand data inputs leveraging the results of key initiatives such as FORGE. These improvements will allow GETEM to better directly represent technology advancements and their ability to lower geothermal LCOE accurately value geothermal project costs, and provide critical inputs for a variety of energy system planning models to better accurately capture geothermal's important deployment potential in the transition to a 100 percent clean energy economy. Geothermal Data Repository (GDR): GDR is the submission portal for data generated by GTO funded projects. Data collected will continue to be collected and curated, and NREL will continue to maintain the repository as well as implement	• Techno-Economic Tools & Data: Funding is requested to continue critical analysis, modeling, and data repository maintenance for GTO. In particular, FY 2022 will continue the GETEM upgrade based on information obtained through an FY 2021 RFI due out in May 2021; this upgrade will provide critical underpinning geothermal cost and project performance data and assumptions critical for accurately representing geothermal energy in a variety of resource and energy planning activities at local, state, and federal levels.	• Techno-Economic Tools & Data: The Request includes funding for DMA analysis, which underpins the rest of the GTO program and allows geothermal to contribute to the Administration goals for deployment by 2035 and 2050.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
improvements that can streamline submission practices to enable new GTO analysis capabilities. Data is accessible to everyone in order to fuel innovation, promote scientific discovery in the geothermal sector, and empower a diverse group of stakeholders to engage with cutting-edge geothermal data. Technical Monitoring Team (TMT): Independent expertise will continue to be provided by the DOE National Laboratories on the Program's major investments.		
• Feasibility of Geothermal on Federal Installations: In collaboration with the DOE Federal Energy Management Program (FEMP), the Program will conduct feasibility analyses and research to identify promising Federal installations (e.g., DoD, National Park Service, the Department of Veterans Affairs) for developing on-site geothermal projects. This effort will leverage existing data and analytical tools, identify approaches to enhance analytical tool capabilities, as well as leverage FEMP Federal partnerships and networks. The result of this collaboration will be a suite of sites with demonstrated promise for additional research and characterization activities for developing on-site geothermal projects that can provide significant contributions to Federal clean energy goals and highlight Federal leadership in transitioning to a 100 percent clean energy economy.	• (Renamed) Federal Partnerships for Geothermal Installations: Through this initiative, GTO and FEMP will make it possible for Federal agencies to seriously consider geothermal energy to heat/cool (and in some limited cases, potentially power) their installations. In particular, DMA work will focus on continuing feasibility studies from FY 2021 in partnership with Federal agencies and contributing to the critical research and characterization activities in FY 2022, driving the selected sites to demonstration and deployment of on-site geothermal projects. GTO support will fund advanced feasibility studies on shovel-ready sites and then develop on-site geothermal projects on Federal sites via FEMP performance contracting mechanisms.	• Federal Partnerships for Geothermal Installations: The Request includes initial funding within this subprogram for this high-priority collaborative initiative; additional funding is requested in the Low Temperature and Coproduced Resources subprogram. This work helps to reduce carbon pollution in the built environment, looking to replace the use of fossil fuels for heating and cooling with carbon-free geothermal energy.
• Closed-loop Geothermal System Performance Modeling: A multi-laboratory working group will numerically investigate the potential of closed-loop type geothermal systems, considering variations in well geometries, geothermal	• Closed-loop Geothermal System Performance Modeling: GTO will fund the second half of this closed-loop geothermal modeling project, leading to a comprehensive understanding of techno-economic and performance considerations	• Closed-loop Geothermal System Performance Modeling: The Request will support the second half of the Closed-Loop Geothermal modeling project.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
reservoirs working fluids, enhancement technology, and other operational parameters. Results will focus on quantifying thermal power generation, heat quality yields across these variations, and system longevity among other considerations. This analysis project represents continued focus from GTO on a variety of geothermal technologies that can support transitioning to a 100 percent clean energy economy.	required to achieve viability for the closed-loop geothermal application space. The second project year will introduce new well geometries, working fluids, and enhancement technologies into computational modeling to understand how the full suite of potential geothermal technologies can contribute to the Administration goals for deployment by 2035 and 2050.	
	• Cross-EERE Analysis and Demonstration: In support of the Administration's goals of achieving a 100 percent clean electricity system by 2035 and a 100 percent net-zero emission economy by 2050, GTO will support increased cross-EERE and cross-DOE efforts to provide data, tools, analysis to support the widespread integration of renewables in a resilient, reliable power system. This includes partnering with the Office of Strategic Programs and the Office of Electricity to significantly expand upon current technical assistance for stakeholders faced with making data-driven decisions and investments, including evaluating technologies, designing clean energy deployment programs, developing market and policy solutions, and planning transmission and distribution upgrades to facilitate the transition to a 100 percent clean electricity system. This will also include designing a program to leverage National Laboratory capabilities to support municipal governments and utilities in developing cost-effective pathways to achieve their own clean energy goals, and to simulate their power systems under various clean energy scenarios to gain operational experience and ensure grid reliability and resilience. Laboratory capabilities	• Cross-EERE Analysis and Demonstration: The Request includes funding to initiate these high-priority analysis and demonstration programs.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	will include analysis, demonstrations, evaluation, measurement, and verification; and direct technical assistance, tailored to the needs of individual cities and communities.	

Advanced Manufacturing

Overview

A resilient and competitive American manufacturing sector is critical for the economy. Manufacturing generates 11 percent of U.S. gross domestic product (GDP)[1] and employs more than 12 million Americans[2]. Significant decarbonization of the manufacturing sector is essential to achieving the overall goal of economy-wide decarbonization by 2050 and creating good paying jobs with a free and fair chance to join a union and collectively bargain. The U.S. manufacturing sector has an annual energy bill of about $200 billion, consumes roughly one-third of primary energy in the U.S., and produces 28 percent of the Nation's carbon emissions.[3] Innovations in the manufacturing sector are required to improve the energy efficiency and reduce carbon emissions of U.S. manufacturers and support manufacturers of all kinds to be more competitive in the global marketplace.

The Advanced Manufacturing Office (AMO) plays a leading role to decarbonize the industrial sector and address the climate crisis by driving the innovation that can lead to a more resilient and competitive domestic manufacturing sector that also provides economic opportunities across diverse communities. In addition, manufacturing innovations are required to deliver the clean energy technologies needed to decarbonize other sectors, including transportation, buildings, and the electric grid. AMO accomplishes this by focusing on applied research, development, and demonstration (RD&D) in crosscutting, platform technologies to reduce manufacturing energy intensity and carbon emissions within existing manufacturing processes and promote the development and growth of manufacturing in multiple emerging energy fields. In addition, AMO actively partners with industry to lower scientific uncertainty that would otherwise limit the subsequent demonstration, adoption, and use of the new knowledge gained through R&D, to ensure that new energy technologies invented in the U.S. ultimately result in the manufacture of products in the U.S. in support of the Administration priority to deliver an equitable, clean energy future for all Americans. Through its technical assistance and workforce development programs, AMO ensures that resources are available to diverse manufacturing organizations and career opportunities to a diverse workforce. With this approach, AMO will drive the manufacturing innovations needed to support the Biden Administration goal of net-zero greenhouse gas emissions, economy-wide, by 2050, while also investing in the economic engine of American-made energy technology that brings economic prosperity and jobs at a local community level.

Through strategic investments in RD&D activities, AMO works with universities, laboratories, companies (for-profit and not-for profit), state/local governments, and consortia. AMO activities depend on merit-based selection and peer-reviewed results.

Over the past year, AMO developed a new budget structure in response to feedback from stakeholders and program peer reviewers. The historical subprogram structure through FY 2021 had been based on operational categories – R&D Projects, R&D Consortia, and Technical Partnerships. The FY 2022 Budget is presented in the new structure across four technical subprograms Materials, Manufacturing Innovations, Energy Systems, and Manufacturing Enterprise. The new structure was developed based on the following principles:

- Align with capabilities, mission, goals, and authorizing language so that the budget structure can withstand over time;
- Communicate simplified technical areas in a way that is understandable to stakeholders;
- Accommodate emerging priorities and enable accounting for Departmental crosscuts;
- Strengthen connections across the current operational pillars; and
- Decarbonize the industrial sector.

[1] "GDP by Industry / VA, GO, II, EMP," 2021, Bureau of Economic Analysis; available from: https://apps.bea.gov/industry/factsheet/factsheet.cfm.

[2] National Income and Product Accounts Tables – Section 6: Income and Employment History, Table 6.4D: Full-Time and Part-Time Employees by Industry (A)." U.S. Bureau of Economic Analysis. Available online at: https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2&isuri=1&1921=survey.

[3] Annual Energy Outlook 2021: Reference Case Data, U.S. Energy Information Administration, available from: http://www.eia.gov/forecasts/aeo/data.cfm.

Through the new budget structure, AMO is addressing both industrial decarbonization and manufacturing innovation needed to decarbonize other sectors. AMO is also supporting equitable access to technical assistance and career opportunities, with a particular focus on underserved communities, energy communities, and tribal communities.

The Materials subprogram focuses on developing novel materials with improved properties, as well as the materials' production processes. It also focuses on sustainable use of materials and resources through resilient and secure supply chains and across product lifecycles, contributing to economy-wide decarbonization. Manufacturing Innovations focuses on advancing new manufacturing technologies and improving energy efficiency and reducing carbon emissions in existing manufacturing processes and operations. It also focuses on enabling value chains to be nimble, responsive, and adaptive to disruption, change, and opportunity. Energy Systems focuses on advancing both 1) systems related to energy conversion, utilization, storage, and management within industrial facilities, and 2) production processes of these energy systems to be used in manufacturing and other sectors. Finally, Manufacturing Enterprise focuses on making knowledge and transformational tools accessible across manufacturing organizations and developing the future manufacturing workforce with an emphasis on benefiting disadvantaged communities underrepresented populations. The technical subprograms will support secure and resilient decarbonized manufacturing supply chains and improvements in energy and resource efficiency in manufacturing and across product lifecycles for the manufacturing enterprise of today and tomorrow. Moreover, AMO supports the Administration's commitment to ensuring the future is Made in America by workers who have a fair and free choice to join a union and collectively bargain.

Within each subprogram, AMO focuses on technical areas with high potential for impact. The AMO technical focus areas are developed through engagement with stakeholders and targeted toward knowledge gaps that, if addressed through R&D or other investments, can be further developed by industry to improve productivity through advanced manufacturing processes.

AMO technology areas address scientific knowledge gaps related to manufacturing and energy. With the crosscutting (i.e., applicable to multiple industries) and platform (i.e., provides a foundation for successive iterations of technological innovation) nature of this R&D, the new knowledge discovered will be broadly applicable to two or more sectors in energy technology and manufacturing. AMO does not work on single industry specific manufacturing challenges more appropriate for the respective technology offices. The research supported by AMO is targeted at processes and technological challenges that present a significant degree of scientific or technical uncertainty and require longer term investments. In contrast, industry R&D is typically focused on near-term cost reduction and process improvements, which provide a competitive advantage and faster return on investments. AMO investments are targeted at both established energy-intensive industries and emerging industries. Targeted investments in demonstration activities are used to address key scale-up and manufacturing challenges in order to accelerate adoption and deployment to enable American made energy technologies.

Examples of AMO focus areas within the technical subprograms include:

<u>Materials</u>:

- Advanced Industrial Materials: The identification, development, and production of advanced materials broadly applicable to energy products including energy conversion materials, materials for extreme or harsh conditions, and nanomaterials.
- Advanced Materials for Lifecycle Energy Impact: The identification, development, and production of advanced materials that reduce the life cycle energy impacts of the material or its manufacturing process, including novel polymers, and high-strength and low-weight materials for energy conversion or end-use efficiency applications.
- Critical Materials: Diversification of supply, recycling, more efficient use, and substitution for critical materials (e.g., rare-earth materials) essential to manufacturing energy technologies for which there is potential for supply chain disruption.
- Sustainable Manufacturing: Technologies to advance more sustainable product design, including design for recyclability. Also includes technologies for the efficient use, recycling, and reuse of raw materials in manufacturing.

Manufacturing Innovations:

- Industrial Decarbonization: Applied research and limited demonstration activities to accelerate the commercial readiness of emerging, net-zero carbon, process technologies for the most carbon-intensive industrial sectors such as cement, chemicals, and steel.
- Additive Manufacturing Processes: Processes capable of direct net-shape formation of metals, polymers, and ceramic materials for application in energy efficient manufacturing and manufacturing of energy technologies.
- Chemical and Thermal Process Intensification: Chemical and thermal process intensification to reduce the equipment size and energy intensity for manufacturing processes through higher reaction efficiency, novel mixing and separations, and low thermal budget heating and cooling.
- Roll-to-Roll Processes: Roll-to-roll processes with potential to form complex two-dimensional multi-material assemblies and functional structures, including batteries, membranes, and fuel cells.
- Energy-Water: Technologies to improve the treatment, processing, and recovery of water and the recovery of energy from a variety of nontraditional water sources.
- Smart Manufacturing: Technologies that leverage advanced sensors, controls, artificial intelligence, platforms, and models to facilitate real-time, secure, operational energy efficiency improvements in materials and manufacturing process technologies.
- Cybersecurity: Cost-effective and widely applicable technologies and methods to address the cybersecurity challenges that limit adoption of energy-efficient manufacturing technologies.
- Agile Manufacturing: Integrated advances in information technology, analytics, controls, modular processes, and manufacturing equipment design that contribute to a more resilient manufacturing supply chain to enable U.S. manufacturers to address current market needs and respond to emerging market opportunities while continuing to reduce energy use and costs and enable industrial decarbonization.

Energy Systems:

- Grid and Resource Integration in Manufacturing: Grid and resource integration, including new technologies for high efficiency Combined Heat and Power (CHP), waste heat to power, distributed generation, and real-time manufacturing demand response.
- Technical Assistance: Assistance for manufacturers and other large energy users in screening renewably fueled CHP systems for cost-effectiveness and provide resources to support project implementation.
- Energy Storage: Manufacturing innovations to improve performance of energy storage systems and to address technical challenges and manufacturing barriers to achieve lower manufacturing cost.
- Integrated Flexible Systems: Flexible manufacturing processes integrated with storage systems that provide increased control of electricity demand for enhanced grid stability and resilience.
- Wide Bandgap Power Electronics: Wide bandgap semiconductors to reduce energy losses and improve reliability in electric power systems.

Manufacturing Enterprise:

- Technical Assistance: Assistance for diverse manufacturers in reducing their energy use intensity, adopting energy management programs, incorporating resilience into their operating systems, and providing targets for energy efficiency, productivity, waste reduction, and water use reduction practices.
- Workforce Development: A multi-level manufacturing workforce development program that engages participants at varying career levels and integrates activities across AMO programs and partner offices to expand impact, especially in energy communities, underserved communities, and tribal communities.

Highlights of the FY 2022 Budget Request

FY 2022 activities support Administration, Department, and programmatic goals. Highlights include support for the following Departmental Crosscuts:

- Critical Minerals ($70,000,000) – Support new lab-industry consortium to de-risk and validate successful technology innovations for critical minerals, including test-bed facilities to scale up technology solutions around identified gaps such as metal conversion or magnet manufacturing. Additionally, a portfolio of new early-stage projects to address emerging critical materials needs for the Nation based on an updated materials criticality assessment. In FY 2022, AMO will continue funding high priority critical materials RD&D in an integrated and coordinated program executed through Annual Operating Plans (AOP), Lab Calls, and Funding Opportunity Announcements (FOAs).
- Energy Storage Grand Challenge ($41,000,000) – Collaborate with multiple offices, including the Office of Electricity and the Vehicle Technologies Office, on projects to overcome the manufacturing barriers of innovative integrated energy storage systems that meet the performance requirements for multiple applications, including grid and vehicles. In collaboration with the Hydrogen Fuel Cell Technologies Office (HFTO), AMO will also support electrolyzer manufacturing RD&D. AMO will also support strategic analysis to understand supply chain vulnerabilities and adoption behavior for energy storage systems.
- Workforce Development ($33,500,000) - Strengthen / expand existing workforce development programming to increase diversity at all levels, improve career paths, and further support entrepreneurship with a focus on activities in energy communities, underserved communities, and tribal communities.

Advanced Manufacturing
Funding ($K)
(Comparable)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Advanced Manufacturing				
Materials	124,000	80,559	85,059	+4,500
Manufacturing Innovations	177,700	233,644	367,643	+133,999
Energy Systems	48,800	46,500	50,500	+4,000
Manufacturing Enterprise	44,500	35,297	47,298	+12,001
Total, Advanced Manufacturing	**395,000**	**396,000**	**550,500**	**+154,500**

Advanced Manufacturing
Funding ($K)
(Non-Comparable)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Advanced Manufacturing				
R&D Projects	151,135	217,672	0	-217,672
R&D Consortia	198,865	133,328	0	-133,328
Technical Partnerships	45,000	45,000	0	-45,000
Materials	0	0	85,059	+85,059
Manufacturing Innovations	0	0	367,643	+367,643
Energy Systems	0	0	50,500	+50,500
Manufacturing Enterprise	0	0	47,298	+47,298
Total, Advanced Manufacturing	**395,000**	**396,000**	**550,500**	**+154,500**

SBIR/STTR:
FY 2020 Transferred: SBIR: $10,926,000; STTR: $1,849,000
FY 2021 Projected: SBIR $11,232,000; STTR $1,580,000
FY 2022 Request: SBIR: $15,622,000 ; STTR: $2,197,000

Budget Structure Crosswalk ($K)

	Proposed FY 2022 Budget Structure				
FY 2021 Budget Structure	**Energy Systems**	**Manufacturing Enterprise**	**Manufacturing Innovations**	**Materials**	**Total**
R&D Consortia	0	2,000	100,639	30,000	**132,639**
R&D Projects	38,500	8,000	264,701	55,059	**366,260**
Technical Partnerships	12,000	37,298	2,303	0	**51,601**
Total, Advanced Manufacturing	**50,500**	**47,298**	**367,643**	**85,059**	**550,500**

	FY 2022 Request Level vs FY 2021 Enacted
Materials: New subprogram will focus on domestic availability of materials and resources through resilient and secure supply chains. Key activities include sustainable manufacturing and critical materials supply, substitution, and reuse, as well as advanced materials broadly applicable to energy technologies including energy conversion materials, materials for extreme or harsh conditions, and nanomaterials. In FY 2022 AMO efforts will focus on establishing a new lab-industry consortium to validate technology innovations relating to critical materials and soliciting new projects to address emerging critical materials needs.	**+$4,500**
Manufacturing Innovations: New subprogram will focus on advancing new manufacturing technologies and improving energy efficiency and reducing carbon emissions in existing manufacturing processes and operations, as well as enabling the value chains to be nimble, responsive, and adaptive to disruption, change and opportunity; making knowledge and transformational tools accessible across manufacturing organizations. Key activities include the development of new manufacturing technologies and next-generation processes for existing industries. In FY 2022 AMO will focus efforts on industrial decarbonization activities, including research and demonstrations, to address large opportunities and enable an accelerated timeline for achieving carbon emission reductions.	**+133,999**
Energy Systems: New subprogram will focus on both advancing systems related to energy conversion, utilization, storage, and technologies for management within industrial facilities, and advancing production processes of these systems to be used across all sectors, including manufacturing. Key activities include renewably-fueled combined heat and power, system approaches for efficient facility energy use, and energy storage system manufacturing. In FY 2022 AMO will eliminate funding for district energy systems that are fossil-fueled and increase funding for research efforts to address manufacturing barriers for innovative energy storage and conversion technology solutions, and advance integrated high temperature electrolyzer manufacturing capabilities.	**+4,000**
Manufacturing Enterprise: New subprogram will focus on providing technical assistance for the implementation of energy and water efficiency projects and practices, as well as making transformational tools accessible across manufacturing organizations and developing the future manufacturing workforce. Technical areas include energy and water efficiency, waste reduction, decarbonization, workforce development, and technical assistance for energy management. In FY 2022 AMO will increase funding for multi-level workforce development activities and focused assistance to energy-intensive manufacturing sectors, including those in energy communities, underserved communities, and tribal communities.	**+12,001**
Total, Advanced Manufacturing	**+154,500**

Advanced Manufacturing
Materials

Description

Materials will focus on domestic availability of materials for energy systems and developing novel materials with improved properties and reduced life cycle energy and carbon impacts. Key activities include the development of materials for energy systems, as well as materials and processes that will enable decarbonization and a circular economy. The Materials subprogram will support applied research projects, cost-shared with companies and research organizations, that focus on generating solutions to specific technology challenges to enable of American manufacturing of energy technologies. These RD&D projects will be selected through a combination of merit-based, competitive solicitations and peer-reviewed National Laboratory-based activities (in partnership with industry), and the results of these RD&D efforts will support industry development and manufacturing of next-generation advanced materials to meet national needs. Example R&D topic areas include critical materials, harsh environment materials, and sustainable manufacturing. The subprogram will identify the specific research challenges based on stakeholder input, alignment with the program's technology thrust areas, and potential energy, carbon, and economic impacts.

Materials for Energy Systems: RD&D will enable a secure and reliable supply chain of critical materials for clean energy, national security, and economic growth. Efforts will include diversification of supply, recycling, more efficient use, and substitution for critical materials (e.g., rare-earth materials) essential to manufacturing zero-emission energy technologies. Opportunities exist to develop and enable manufacturing of advanced materials broadly applicable to energy products including energy conversion materials, materials for extreme or harsh conditions, and nanomaterials.

Circular Economy: Significant opportunities exist to reduce the life-cycle carbon emissions of materials manufacturing by developing new materials and processes that enable the more efficient use, reuse, and recycling of raw materials, manufacturing waste, and end-of-life products. Opportunities exist to advance more sustainable product design, including design for recyclability, as well as to de-risk and validate novel recycling and upcycling technology that increases secondary material use.

AMO will focus on advanced materials that reduce the life cycle energy and enable decarbonization of the material or its manufacturing process, including polymers, metals, fibers, and other energy intensive materials.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Materials $80,559,000	**$85,059,000**	**+$4,500,000**
Materials for Energy Systems $65,059,000	Materials for Energy Systems $ 80,059,000	+15,000,000
• The tenth of ten years of funding for the Critical Materials Institute (CMI) is dedicated to finding innovative solutions and carving creative, transformational paths to eliminate criticality of certain rare earth and other elements through the diversification of supplies, development of substitutes, and improvement of usage efficiency, reuse, and recycling.	• Continue funding high priority critical materials RD&D in an integrated and coordinated program executed through AOP, Lab Calls, and FOAs.	• Finish close-out of the existing Energy Innovation Hub led by Ames Laboratory. Critical materials RD&D at CMI and Ames National Laboratory will continue to be supported to the extent it is aligned with the goals of directed and competed funding.
• Support validation and verification of improved upstream extraction and midstream separation and processing technologies of critical materials. Additionally, support FY 2021 Congressional direction for a Lithium Research Center to convert lithium chloride to lithium hydroxide and lithium ion (Li-ion) extraction from unconventional sources.	• Conduct competitive solicitation to establish and support a new lab-industry consortium to validate technology innovations relating to critical materials and drive the innovations toward adoption by industry.	• Increase in funding to enable accelerated validation and adoption of critical material technology solutions in support of the Critical Minerals Initiative.
• Support the Harsh Environment Materials Initiative, in collaboration with the Offices of Fossil Energy and Nuclear Energy, through competitively selected, merit-based, early-stage applied R&D projects at National Laboratories, universities, and companies. Specifically, projects will focus on increasing durability and capability, and reducing the cost of materials and components operating in harsh and extreme environments such as those found in high efficiency power plants and industrial operations.	• Fund competitively selected, merit-based applied R&D projects at National Laboratories, universities, and companies focused on increasing durability and capability, and reducing the cost of materials and components operating in harsh and extreme environments found in industrial operations.	• Funding will be limited to focus on the highest quality merit-based projects.
• Support a prize for conductivity-enhanced nanocarbon-metal-matrix composites for	• Support CABLE prize activities to help build an equitable, clean-energy future.	• No significant change.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
affordable, breakthrough, leapfrog, electric and thermal applications (CABLE). • Support up to 5 projects to advance the development of aluminum-cerium alloys.	• No funds requested.	• No funding is requested to allow time to assess progress from previously selected awards and address higher priority program activities.
Circular Economy $15,500,000	$5,000,000	-$10,500,000
• Support efforts to apply principles of materials reuse and recycling with emphasis on plastics as part of Plastics Innovation Challenge activities, including the continuation of the BOTTLE Consortium and R&D projects to recycle and upcycle plastics films; along with efforts to apply circular economy principles to polymers and fiber reinforced polymer (FRP) composite materials.	• Support the Plastics Innovation Challenge by funding continuation of the BOTTLE Consortium to develop new chemical upcycling strategies for current plastics and designing new plastics to be recyclable-by-design.	• Decrease in funding to focus efforts on BOTTLE Consortium activities.
• Support up to 5 competitively selected, merit-based projects on sustainable chemistry R&D.	• No funds requested.	• No funding is requested to allow time to assess progress from previously selected awards and address higher priority program activities.

Advanced Manufacturing
Manufacturing Innovations

Description

Manufacturing Innovations will focus on improving energy efficiency while enabling significant decarbonization of manufacturing processes and operations and advancing new manufacturing approaches and technologies. Key activities include the development of significantly improved manufacturing processes for existing industries, as well as thoroughly new manufacturing technologies that can transform the industrial sector. An additional key activity is the development of advanced processes and technologies that can improve utilization of water and the associated energy demands. The Manufacturing Innovations subprogram will support applied research projects, cost-shared with companies and research organizations that focus on generating solutions to specific manufacturing technology challenges, and a limited number of demonstration projects. These RD&D projects will be selected through a combination of merit-based, competitive solicitations and peer-reviewed National Laboratory-based activities (in partnership with industry), and the results of these RD&D efforts will support industry development of next-generation manufacturing innovations to meet national needs. Example R&DD topic areas include industrial decarbonization, carbon-free manufacturing, additive manufacturing, high-performance computing for manufacturing, smart manufacturing, cyber security, and process intensification. The subprogram will identify the specific research challenges based on stakeholder input, alignment with the program's technology thrust areas, and potential energy, carbon, and economic impacts.

Improved Manufacturing Processes: Energy efficient manufacturing processes for existing products including decarbonization, process intensification, process heating using carbon-free energy sources, and high-performance computing for energy related manufacturing challenges. Opportunities exist to address major sources of energy consumption and carbon emissions in large energy and carbon intensive industries like steel, chemicals, and cement, along with associated process operations such as melting, drying, and calcining. Improved reactions and separations can enable energy and cost savings, reduced water usage and a lower carbon footprint in energy-intensive industries such as chemical production and food processing. Efforts in smart manufacturing and cybersecurity will facilitate real-time, cybersecure, operational energy efficiency improvements in manufacturing processes. A strong analytical program will conduct efforts to assess life-cycle energy and carbon requirements to determine the cross-sector impacts of process improvements from potential program investments.

Energy Water: Research and development for the energy efficient and resource efficient treatment of nontraditional water sources for beneficial end use applications including energy-efficient and low–cost desalination technologies and technical assistance for waste-water treatment facilities. Efforts include development of technologies that treat seawater, brackish water, and produced waters, for use in municipal, industrial, agricultural, utility, and other water supply needs. These technology advancements will help domestic suppliers of water desalination systems to manufacture critical components and parts—including the design and manufacture of small-modular and large-scale systems. Investments will contribute to the Nation's transition to more resilient energy and coupled energy-water systems.

New Manufacturing Technologies: New ways to manufacture products including hydrogen-based manufacturing processes, electrification, additive manufacturing, and the manufacture of carbon fiber from low cost precursors. Research efforts include crosscutting technologies for use across a variety of industries, entirely new processing routes relevant to existing industries, and innovations for emerging industries to improve U.S. competitive advantage. Provide support to key facilities such as the Manufacturing Demonstration Facility (MDF) and Carbon Fiber Technology Facility (CFTF) to enable robust technology ecosystems.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Manufacturing Innovations $233,644,000	**$367,643,000**	**+$133,999,000**
Improved Manufacturing Processes $107,227,000	$226,031,000	+$118,804,000
• Fund the fifth and final year of the Cybersecurity in Energy Efficient Manufacturing Institute, along with one new Clean Energy Manufacturing Innovation (CEMI) Institute (Institute #7).	• Fund the second year of CEMI Institute #7. Launch two additional CEMI Institutes.	• Increase in funding to establish additional CEMI Institutes to support the U.S. manufacturing sector in industrial decarbonization, reducing their energy use intensity, and incorporating resilience into their operations.
• Support competitively selected, merit-reviewed projects focused on improved manufacturing processes including electrochemical manufacturing, enhanced drying, and direct air capture.	• Support the Decarbonizing Industry Initiative through competitively selected, merit-reviewed projects focused on transformative zero-carbon production technologies, electrification, electrochemical manufacturing, enhanced drying, direct air capture, and other opportunities; along with supporting industrially-relevant testbeds and demonstrations in energy- and carbon-intensive sectors (e.g., steel, cement, chemicals), and collaborating with HFTO on the use of green hydrogen to decarbonize energy intensive industries.	• Significantly increased funding for industrial decarbonization activities, including research and demonstrations, to address large opportunities and enable an accelerated timeline for achieving carbon emission reductions.
• Support the HPC4MFG program including the funding of up to 15 competitively selected projects that apply modeling, simulation, and data analysis to industrial processes and products to reduce energy and carbon intensity, lower production costs and shorten the time to market; and conduct quantitative analysis research to identify research gaps and potential new research activities.	• Support the HPC4MFG program including the funding of up to 15 competitively selected projects that apply modeling, simulation, and data analysis to industrial processes and products; and conduct quantitative analysis research.	• No significant change.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Support competitively selected, merit-reviewed projects focused on improved manufacturing processes including dynamic catalyst science, steel industry improvements, large-scale aerostructures, and silicon carbide component fabrication.	• No funds requested.	• No funding is requested to allow time to assess progress from previously selected awards and address higher priority program activities.
Energy Water $45,000,000	$45,000,000	$0
• Fund the fifth and final year of the first five-year phase of the Energy Water Hub that serves as a center of research focused on developing integrated technological system solutions and enabling technologies for de-energizing, de-carbonizing, and commercializing desalination advancements.	• Fund the first year of the second and final five-year phase of the Energy Water Hub.	• No significant change.
• Support up to 10 competitively selected, merit-based research projects to achieve energy efficiency at water and wastewater treatment plants, including the use of alternative energy sources and the use of biosolids or algae treatment.	• Fund up to 10 competitively selected, merit-based research projects to achieve energy efficiency and energy recovery at water and wastewater treatment plants, with a focus on decarbonization of water infrastructure.	• No significant change.
New Manufacturing Technologies $81,417,000	$96,612,000	+15,195,000
• Conduct high-priority public-private projects related to additive manufacturing and carbon fiber materials research through the MDF/CFTF.	• Continue selected additive manufacturing projects and carbon fiber materials research through the MDF/CFTF; pursue zero carbon technologies to manufacture products including hydrogen-based manufacturing processes.	• Reduce additive manufacturing activities and increase zero carbon manufacturing technologies in support of the Decarbonizing Industry Initiative.
• Support competitively selected, merit-based projects addressing advanced tooling for lightweight automotive components.	• Fund competitive opportunity for innovative advanced manufacturing technologies to enable manufacturing supply chains to be nimble, responsive, and adaptive to disruption, change and opportunity; and support competitively selected, merit-based projects addressing innovations in emerging industries and advanced tooling for lightweight automotive components.	• Increase in funding to address agile manufacturing opportunities to support manufacturing innovations in emerging industries.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Develop additive manufacturing involving nanocellulosic feedstock materials made from forest products; and collaborate with the Wind Energy Technologies Office on additive manufacturing work on large offshore wind blades and other wind turbine components including thermoplastic resin systems.	• No funds requested.	• No funding is requested to allow time to assess progress from previously selected awards and address higher priority program activities.

Advanced Manufacturing
Energy Systems

Description

Energy Systems will focus on both manufacturing RDD&D advances for energy conversion, utilization, and storage technologies used across all sectors and innovative use of these energy system technologies within industrial facilities. Key activities include combined heat and power, system approaches for efficient and flexible facility energy use, and energy storage systems. The Energy Systems subprogram will support applied research into the optimization of energy system operations at manufacturing facilities to minimize energy use and maximize decarbonization. These activities will be supported through a combination of merit-based, competitive solicitations and peer-reviewed National Laboratory-based activities (in partnership with industry), and the results of these research and technical assistance efforts will support industry development and use of next-generation energy systems to meet national needs. Example RDD&D topic areas include combined heat and power for flexible manufacturing, renewable or hydrogen-fueled combined heat and power systems, power electronics, microgrid operations, electric or thermal storage integration, electrolyzer manufacturing, thermal storage system manufacturing and battery system manufacturing. Example technical assistance areas include screening analyses for renewably fueled combined heat and power and energy storage systems at manufacturing facilities, continued efforts by Technical Assistance Partnerships (TAPs), development of resources on implementation strategies, and stakeholder engagement to encourage new technology deployment and American manufacturing of energy technologies. The subprogram will identify the specific research and deployment challenges based on stakeholder input, alignment with the program's technology areas, and potential energy, carbon, and economic impacts.

Combined Heat and Power: Combined Heat and Power (CHP) systems generate electricity and heat, capturing energy that would normally be lost in power generation, transmission, and distribution and use it to provide heating, cooling and other thermal energy at or near the site. Opportunities exist to improve system performance, heat recovery efficacy, and system installed costs. Demonstration of packaged CHP systems that use pre-engineered components that are packaged together in discrete sizes offer the opportunity to reduce installation costs and accelerate project development timelines. Research into the use of hydrogen or renewable fuels in CHP will show the potential that they can contribute to decarbonization of the manufacturing sector. Additional research areas include development of high power-to-heat ratio systems that enable flexible manufacturing, and the integration of CHP systems along with other technologies like on-site renewable generation, battery storage, and thermal energy storage into microgrid configurations that use advanced controls schemes. Technical assistance opportunities exist to overcome significant economic, regulatory, and informational barriers that limit deployment of CHP systems. Example technical assistance areas include screening analyses for combined heat and power and energy storage systems at manufacturing facilities, continued efforts by Technical Assistance Partnerships (TAPs), development of resources on implementation strategies, and stakeholder engagement to encourage new technology deployment.

Resiliency Systems: Resiliency Systems include technologies that increase the ability of manufacturers and other users to better manage energy through energy storage technologies and systems. There are opportunities to pursue manufacturing innovations to improve performance of energy storage systems and to address technical challenges and manufacturing barriers to achieve lower manufacturing cost to make storage systems more accessible to transportation, grid, and other applications across the economy. In addition, there are opportunities to develop and apply flexible manufacturing processes, storage systems, and microgrids that provide increased control of electricity demand for enhanced grid stability and resiliency. Technical assistance opportunities exist to educate manufacturers on how they can incorporate resiliency systems into their operations as well as provide resources that highlight best practices for deployment.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Energy Systems $46,500,000	**$50,500,000**	**+4,000,000**
Combined Heat and Power $23,000,000	$12,000,000	-11,000,000
• R&D for flexible CHP and district energy systems that utilize hydrogen or renewable fuels.	• R&D for hydrogen or renewably fueled CHP that enables flexible manufacturing	• Decrease for District Energy demonstration and deployment activities.
• Technical assistance to support screening analyses, development of resources on implementation strategies, and stakeholder engagement to encourage new technology deployment.	• Technical assistance to support screening analyses, development of resources on implementation strategies, and stakeholder engagement to encourage new technology deployment.	• No significant change.
Resiliency Systems $23,500,000	$38,500,000	+15,000,000
• Support of the Energy Storage Grand Challenge for R&D projects focused on improving manufacturing processes for energy storage systems resulting in lower manufactured cost and flexible manufacturing plants with increased electricity dispatch ability for enhanced grid stability and resiliency.	• Strengthening the domestic production of energy storage technologies by designing new technologies, enhancing materials used in energy storage systems, and improving the manufacturing methods for system components.	• Increased investment in storage manufacturing R&D.
• Technical assistance to support screening analyses for resiliency systems and development of educational resources to support technology deployment.	• Collaborate with HFTO on a funding opportunity to increase focus on electrolyzer manufacturing.	• Increased investment in integrated high temperature electrolyzer manufacturing capabilities.
	• Technical assistance to support screening analyses for resiliency systems and development of educational resources to support technology deployment.	• No significant change.

Advanced Manufacturing
Manufacturing Enterprise

Description

Manufacturing Enterprise will focus on enabling value chains to be nimble, responsive, and adaptive to disruption, change and opportunity; making knowledge and transformational tools accessible across manufacturing organizations; and developing the future manufacturing workforce. The Manufacturing Enterprise subprogram will support technical assistance and stakeholder engagement to encourage the deployment of energy and water efficient technologies and processes. Through a combination of merit-based, competitive solicitations and peer-reviewed National Laboratory-based activities (in partnership with industry), the technical assistance efforts will support manufacturers in increasing their operational efficiency so they can save money and reduce carbon emissions. Technical areas include technologies for flexible and adaptable manufacturing, waste reduction, water efficiency, workforce development, secure digital and cyber-physical systems, and technical assistance for energy management. Example programs include Better Plants, Industrial Assessment Centers, Energy Management Programs (50001 Ready and Superior Energy Performance), Technologist in Residence, and Lab Embedded Entrepreneurship Programs. Example topics include energy and water efficiency, waste reduction, decarbonization, workforce development, resiliency, cybersecurity, and smart manufacturing. The subprogram will identify the specific research and deployment challenges based on stakeholder input, alignment with the program's technology areas, and potential energy, carbon, and economic impacts.

Technical Assistance: Technical assistance is needed to increase the adoption of advanced energy and water efficiency technologies and practices across the industrial sector. Opportunities exist to provide resources to assist manufacturers in reducing their energy use intensity, promote the adoption of energy management programs and provide targets for energy efficiency, productivity, carbon reductions, and waste/water use reduction practices. Activities include the expansion of the Better Plants program to include new initiatives related to energy-intensive manufacturers, carbon reduction, technology validation, and training opportunities. Additional activities include the expansion of existing tools like the 50001 Ready Navigator and MEASUR tool suite to address emerging topics such as carbon reduction, resiliency, and cybersecurity, and enable manufacturing companies to easily access state-of-the-art tools to conduct analysis. By focusing in areas with high industrial environmental emissions and energy communities, this technical assistance work will also support the Justice40 initiative.

Workforce Development: Advanced manufacturing processes are demanding more from workers in the form of technical skills, experience with computer automated processes, and energy information management systems and create good paying jobs with the free and fair chance to join a union and collectively bargain. This subprogram will include a multi-level manufacturing workforce development program that supports participants at varying career levels, engages underserved communities and integrates activities across AMO programs and partner offices to expand impact. Opportunities exist to provide educational resources for primary, high school, community colleges, and university students as well as mentoring and on the job training opportunities to increase the number of qualified technical employees in advanced manufacturing. All educational activities will include a focus on diversity and inclusion, and reskilling programs will be specifically targeted toward underserved communities, energy communities, and tribal communities to aid in their transition to the clean energy economy. The workforce development activities will increase focus on energy communities and disadvantaged communities and building partnerships with labor unions. The activities will also address the Justice40 initiative by improving industrial hygiene and reducing workplace exposures. By developing a more flexible and resilient manufacturing workforce, U.S. manufacturers can be more agile in reacting to market needs, while focusing on innovation. Activities include the expansion of the Industrial Assessment Center (IAC) program to include community colleges and technical schools, especially those in energy communities; enlargement of student mentoring programs with specific emphasis placed on student diversity; creation of training courses that provide participants with continuing education units (CEUs); and development of internship networks.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Manufacturing Enterprise $35,297,000	**$47,298,000**	**+12,001,000**
Technical Assistance $11,797,000	$15,797,000	+$4,000,000
• Fund competitively selected partnerships between National Laboratories, universities, and the private sector that emphasize student-led projects to develop new tools and processes that address energy management and advanced manufacturing challenges identified by private sector partners.	• Provide technical assistance to manufacturers on energy and water efficiency, waste reduction, technology validation, and energy management processes.	• Increase emphasis on energy and carbon reduction.
• Support educational resource development to encourage energy/water efficiency, waste reduction, and carbon reduction technologies and practices.	• Support educational resource development to encourage energy/water efficiency, waste reduction, and carbon reduction technologies and practices, especially in energy communities, underserved communities, and tribal communities.	• No significant change.
	• Provide focused technical assistance to energy intensive manufacturing sectors related to energy and carbon reduction.	• Increase in funding related to energy intensive manufacturing sectors and stakeholder engagement activities through a Better Plants Accelerator.
Workforce Development $23,500,000	$31,501,000	+8,001,000
• Support a manufacturing training program that engages students, entry-level, currently-employed and dislocated candidates to develop career pathways and resources to strengthen the manufacturing workforce and enable candidates to seek and secure employment. Targeted efforts will include training community college/technical school students and developing training options that help employees retain professional certifications and earn certifications in new advanced manufacturing technology areas.	• Fund competitively selected partnerships between National Laboratories, universities, and the private sector that emphasize student-led projects to develop new tools and processes that address energy management and advanced manufacturing challenges.	• Increase focus on energy communities and disadvantaged communities and building partnerships with labor unions. Address environmental justice.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Support projects led by early-career post-doctoral researchers to address fundamental manufacturing challenges identified by industry through competitive solicitations.	• Fund multi-level training program that supports participants at varying career levels (i.e. Students, skilled trades workers, energy managers, corporate managers, etc.).	• Increase funding for workforce development activities to provide additional resources and trainings and increase the impact of existing workforce related programs, including within energy communities, underserved communities, and tribal communities.

Federal Energy Management Program

Overview

The Federal Government is the single largest U.S. energy consumer with more than 360,000 buildings and 600,000 vehicles. The Federal Energy Management Program (FEMP) mission, in accordance with the Energy Act of 2020, Section 1012, is to facilitate the implementation by the Federal Government of cost-effective energy and water management and energy-related investment practices: (A) to coordinate and strengthen Federal energy and water efficiency and resilience; and (B) to promote environmental stewardship.

FEMP works with Federal agencies to ensure the Federal government's energy and water management infrastructure is efficient, resilient, and secure in support of continuous mission operations. FEMP's activities are focused on developing resources and tools, providing technical assistance and replicable solution sets, issuing guidance, facilitating public-private partnerships for project financing, tracking agency performance, and collaborating with agencies to implement required training.

In FY 2019, the Federal Government used 1.3 quads of primary energy at a cost of $18.4 billion.[1] Energy used in buildings and facilities represents about 58 percent of the total energy use of the Federal Government. Vehicle and equipment energy use accounts for 42 percent.[2] Currently there is an estimated $161 billion of deferred maintenance and infrastructure repairs required across the Federal Government.[3] Agencies estimated and reported almost $7 billion[4] of potential cost-effective investments that would result in energy savings.

There is a significant opportunity and responsibility for the Federal Government to cut its energy costs, ensure resilient and reliable operations, leading by example by leveraging the U.S. Government (USG) facilities footprint to drive electrification and decarbonization goals through implementation of portfolio-wide strategies and integration of energy efficient technologies. FEMP will use its resources to turn the threat of climate change into an opportunity by catalyzing our partners across the Federal Government to lead through the power of collaboration and implementation of innovation to make progress toward the goal of building a 100 percent clean energy economy with net-zero emissions.

FEMP strengthens agencies' ability and agility to strategically manage their energy and water infrastructure by focusing activities within five focus areas:

Strategic Programming and Integration Planning: Providing agencies with information and resources to help them develop strategic plans to successfully reduce Federal energy and water use. This includes assembling, analyzing, and sharing information about Federal laws and requirements. FEMP partners with the Executive Office of the President–Council on Environmental Quality and the Office of Management and Budget to develop guidance.

Facility and Fleet Optimization: Providing technical assistance, tools, guidance, and training to optimize facility operations, integrate strategic energy management, and decarbonize Federal fleet and facilities through electrification and grid enabled smart buildings.

Energy and Water Resilience and Security: Providing technical assistance, guidance, and onsite training for risk-informed resilience and cybersecurity assessments, tools, and best practices to support climate adaptation and mitigation planning.

Energy and Project Procurement Development Services: Supporting Federal energy and water projects with technical expertise, leveraging public-private partnerships through life of contract support, quality assurance, oversight, contract management, procurement policy, and technical assistance.

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[1] Table A-4 and Table A-2 http://ctsedwweb.ee.doe.gov/Annual/Report/Report.aspx.

[2] In terms of primary (source) energy use.

[3] https://fiscal.treasury.gov/files/reports-statements/financial-report/2019/deferred-maintenance-repairs.pdf.

[4] $6.7 billion identified by agencies in their evaluations of facilities comprising 75 percent of Federal facility square footage; https://ctsedwweb.ee.doe.gov/CTSDataAnalysis/Reports/PublicAgencyReport_ComprehensiveEvaluationFindings.aspx.

Federal Leadership and Engagement: Fostering interagency collaboration, accountability through tracking of agency performance, and providing training and recognition to the Federal energy and water management workforce.

Highlights of the FY 2022 Budget Request

The FEMP FY 2022 Budget Request of $438.15 million supports implementation of energy and water efficiency, fleet electrification, and decarbonization strategies across the Federal government in support of Executive Order (EO) and statutory energy and water management related goals and objectives.

In FY 2022, FEMP will significantly increase support for the Federal Energy Efficiency Fund (FEEF) Program (+ $387 million to a total of $400 million) providing direct funding to Federal agencies for the development of energy and water efficiency projects and processes that address climate change mitigation and/or adaptation. FEMP will utilize Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) grants to increase the viability and adoption of climate change mitigation and adaptation actions entailing energy efficiency, clean energy, and operational resilience at U.S. Federal government-owned facilities through adoption of energy and water conservation measures and deep retrofits. FEMP will leverage the use of a privately financed performance contract in the form of an Energy Savings Performance Contract (ESPC), ENABLE contract, or Utility Energy Service Contract (UESC) to enhance Federal agency climate change mitigation via energy efficiency, clean energy, and adaptation at mission critical sites. These projects will generate private sector resources that will significantly exceed the initial grant investment, help the government lead by example on climate and sustainability, and create good-paying jobs with a free and fair choice to join a union.

Federal Energy Management Program
Funding ($K)

	FY 2021 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Federal Energy Management Program				
Federal Energy Management	40,000	40,000	438,150	+398,150
Total, Federal Energy Management Program	**40,000**	**40,000**	**438,150**	**+398,150**

Federal Energy Management Program
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Federal Energy Management Program: Funding increase driven by Federal Energy Efficiency Fund (FEEF) Program. In FY 2022 FEMP will award $400,000,000 in AFFECT grants (+$387,000,000). FEMP will increase technical assistance, guidance, and on-site training across all focus areas to facilitate implementation of energy and water electrification and decarbonization strategies across the Federal government in support of EO and statutory energy and water management related goals and objectives (+$11,275,000).	**+398,150**
Total, Federal Energy Management Program	**+398,150**

Federal Energy Management Program

Description

As part of the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE), the Federal Energy Management Program's (FEMP) priority is to help Federal agencies advance the energy efficiency and resilience of their operations, while addressing climate change, increasing electrification, and minimizing the carbon footprint. FEMP assists Federal agencies in meeting energy-, sustainability-, and climate change-related goals by bringing expertise from all levels of project and policy implementation to identify affordable solutions and facilitate public-private partnerships.

FEMP supports Federal agencies efforts to meet EO and statutory energy and water management-related objectives. FEMP is authorized per Sec. 1012 of the Energy Act 2020 (EA 2020) to facilitate the implementation by the Federal Government of cost-effective energy and water management and energy-related investment practices to coordinate and strengthen Federal energy and water resilience and promote environmental stewardship. In addition, FEMP collaborates with and provides the tools, resources, and guidance needed by agencies to implement Executive Order (EO) 13990, *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis*, EO 14008, *Tackling the Climate Crisis at Home and Abroad* and the *Energy Act of 2020*, the first comprehensive energy legislation in 13 years. FEMP collaborates with the Executive Office of the President–Council on Environmental Quality and the Office of Management and Budget to develop Federally focused Executive Orders, implementation guidance, and agency performance targets.

Federal Energy Efficiency Fund (FEEF) Program: AFFECT is authorized under Section 152 (f) of the Energy Policy Act of 1992 (EPAct 1992), Public Law 102-486, as codified in 42 USC § 8256 (b). This statute authorized a Federal Energy Efficiency Fund (FEEF) to provide competitive grants to Federal agencies to help meet requirements of the National Energy Conservation Policy Act (NECPA), 42 USC § 8253(a)-(b). AFFECT grants have been provided most years since 2014.

In FY 2022, FEMP is requesting $400 million in AFFECT grant funding for Federal agencies to drive infrastructure improvements at Federal sites that leverages additional private sector investment and specialized expertise through Energy Savings Performance Contracts (ESPCs) and Utility Energy Service Contracts (UESCs) to stimulate energy efficient and clean energy projects and create jobs that directly address climate change mitigation to lower the Federal carbon footprint and move toward a clean energy economy.

FY 2022 projects will require the leveraging of private sector funds and will focus on implementation of deep retrofits across the Federal government as well as other identified energy and water conservation measures. AFFECT funds can be spent on any of the equipment or services related to the planning, development, or implementation of a project. AFFECT recipients are asked to demonstrate why the grant is needed to implement the project, or to include energy conservation measures that would not be possible without the grant. In many cases the infusion of AFFECT funds is expected to help enable critical energy conservation measures that may have longer paybacks to be included in the project. These measures will likely relate to climate resilience, electrification, and other key areas of AFFECT focus that allow agencies to expand projects to include deep energy retrofits or possible net-zero emission facilities.

Projects will be significantly larger in scope then prior year awards and will provide an option to bundle resilience and mobility conservation measures where appropriate. These projects will generate private sector resources that will significantly exceed the initial grant investments. Historically, AFFECT funds have resulted in a public to private gross investment ratio of 1:30 respectively. Projects will leverage performance contracting and align with Administration electrification and decarbonization and infrastructure improvement goals and objectives. Recipients are encouraged to identify Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses and Veteran Owned Businesses for participation and/or to solicit as vendors and sub-contractors in support of building an inclusive clean energy economy.

Technical Assistance**:** FEMP provides technical assistance that addresses specific agency facility, site, and fleet needs by assisting Federal agencies in identifying, designing, and implementing energy-saving and decarbonization projects and practices. In FY 2022 FEMP is requesting $31.688 million for technical assistance to Federal agencies, including $5.0 million in funding for technical assistance for charging and fleet electrification. FEMP utilizes the Department of Energy's (DOE) National Laboratory subject matter experts to support the development of tools and resources needed to overcome barriers, and share lessons learned and best practices regarding implementation of energy and water efficiency, fleet electrification, and decarbonation projects and strategies, resulting in viable, replicable, energy and water projects.

FEMP will share technical solution sets including performance contracting models and business case methodologies that optimize facilities and fleets increasing energy efficiency and decreasing emissions. FEMP will provide technical project development assistance for energy savings performance contracts (ESPCs), utility energy service contracts (UESCs), and other project financing options in pursuit of energy and water efficiency improvements, distributed energy projects, and demand reduction strategies.

FEMP will provide technical assistance to Federal agencies around facility and fleet optimization to enhance execution of strategic energy and water management approaches in support of facility and fleet electrification and decarbonization strategies. Areas of focus include: training and onsite assistance surrounding 50001 energy management initiatives, auditing and building commissioning, energy information management systems, healthy buildings, and fleet electrification.

FEMP will continue to provide the tools and resources that Federal agencies will need to meet implementation of required Climate Action Plans. Focus will support technical assistance around implementation and enhancement of risk-informed resilience and cyber energy and water climate mitigation/adaptation strategies and approaches across the Federal Government.

In FY 2022 FEMP will launch new initiatives in the following areas:

- Federal Agency Fleet Electrification. This effort is designed to jump start the transition from fossil fuel to electric vehicles through the development, validation, and deployment of an Electric Vehicle (EV) Planning Tool that supports fleet electrification conversion. This activity will provide 18 Federal agencies with replicable technical and financial solutions for fleet electrification and grid-interactive technology solutions will jumpstart the transition from fossil fuel to electric vehicles.
- Federal Smart Buildings. This program will leverage existing smart and active energy building technologies and practices developed for the commercial and institutional sectors in support of Federal facility evaluation and retrofits that promote grid enabled and grid responsive technologies. This program will be modeled after the Better Buildings "accelerator" concept that has proven effective in articulating the value proposition for deploying energy efficient technologies, providing the resources necessary for adoption of technologies, and sharing best practices and replicable models of success.
- Federal Partnerships for Geothermal Installations. Through this initiative, the Geothermal Technologies Office (GTO) will work with FEMP to utilize performance contracting vehicles to develop project action plans ready for implementation as part of viable business cases to deploy geothermal space heating and cooling solutions.
- Generation Four of the DOE ESPC Indefinite Delivery Indefinite Quantity (IDIQ) contract. In FY 2022 DOE expects to award the fourth generation of its IDIQ contract, which has been the most widely used ESPC multiple-award contract in the Federal Government. The new IDIQ contract will help drive increased work and engagement with small business subcontractors, requiring good labor standards such as locally prevailing wages, and will be an important tool for Federal agencies to implement the performance contracting requirements included in EA 2020. FEMP provides extensive training, project development tools and support, as well as life of contract monitoring in support of Federal agencies using the DOE ESPC.

Reporting and Statutory Requirements: In FY 2022 FEMP is requesting $4.15 million to support statutory and EO reporting requirements, DOE is statutorily required to carry out specific functions related to tracking and implementing effective energy and water management throughout the Federal Government. FY 2022 efforts will continue to focus on implementation of Energy Act 2020 requirements for tracking multi-year project-level performance contracting data. FEMP will enhance current reporting system capabilities to achieve these requirements as well as develop required resources necessary to support Energy Act 2020 implementation.

FEMP develops analytical reports for the Office of Management and Budget and Congress annually which track Federal progress towards goals on energy efficiency (42 U.S.C. § 8258(a)), renewable energy use (42 U.S.C. § 15852(d)), and vehicles (42 U.S.C. § 6374e(a)); track agency compliance with the requirements of Section 432 of the Energy Independence and Security Act of 2007 (EISA), Management of Energy and Water Efficiency in Federal Buildings, including the completion of comprehensive evaluations of designated covered facilities and reporting potential and initiated efficiency measures, and annually benchmarking metered buildings.

DOE is authorized to develop training and resources; develop energy efficiency design requirements for new Federal buildings and buildings undergoing major renovations through updates to rules under 10 CFR 433 and 10 CFR 435; develop comprehensive guidance and resources to help agencies achieve targets, and; track performance of agencies with regards to meeting 10 CFR 433 & 10 CFR 435 (42 U.S.C. § 6834(a)(3)(A)).

Furthermore, FEMP develops, in consultation with the Secretary of Defense and the Administrator of the General Services Administration, and issues a report on, best practices for the use of advanced metering of energy use in Federal facilities, buildings, and equipment by Federal agencies. (42 U.S.C. § 8253(e)) and establishes the technical performance requirements for applicable technologies (42 U.S.C. § 8259b(b)). The term "FEMP designated product" means a product that is designated under the Federal Energy Management Program of the Department of Energy as being among the highest 25 percent of equivalent products for energy efficiency. DOE's requirement is to establish the technical performance requirements for the applicable technologies; promote procurement practices which facilitate the purchase of energy efficient products (42 U.S.C. § 8259b(b)); and establish appropriate procedures, methods, and clarifications and guidance for use by Federal agencies with regard to the administration and award of energy savings performance contracts (ESPCs 42 U.S.C. § 8287 et seq.).

Workforce Development: In FY 2022, FEMP is requesting $2.312 million to improve the agility and skills of the Federal energy and water management workforce through training aligned with agency core competency needs and Federal Building Personnel Training Act requirements through its internationally accredited training program for energy and water management professionals via on-demand and in person (currently virtual) training sessions, including the annual Energy Exchange training workshop. In addition, FEMP will assess opportunities to leverage the EERE Education Material for Professional Organizations Working on Efficiency and Renewable Energy Developments. (EMPOWERED) workforce FOA to develop training content for the Federal energy and water management communities.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Federal Energy Management $40,000,000	**$438,150,000**	**+$398,150,000**
Technical Assistance $20,413,500	**$31,688,000**	**+$11,274,500**
• Energy & Project Procurement Development: Complete establishment of the Performance Contracting National Resource Center (PCNRC) which will establish a PCNRC web resources center with technical and best practice guides, a training series and certificate program for owner's representatives, related model procurement criteria, and enhancements to the eProject Builder database to facilitate project development and performance tracking for the State and Local sectors facilities.	• PCNRC will be operational, providing training and resources to State and Local governments to expand performance-based contracting in their respective markets.	• PCNRC will only incur operation and maintenance costs in FY 2022.
• Energy & Project Procurement Development: Provide technical project development assistance for energy savings performance contracts (ESPCs), utility energy service contracts (UESCs), and other contract structures in pursuit of energy and water efficiency improvements, distributed energy projects, energy storage, energy efficient product procurement, and demand reduction strategies.	• Continue to provide technical project development assistance for energy savings performance contracts (ESPCs), utility energy service contracts (UESCs), and other contract structures in pursuit of energy and water efficiency improvements, distributed energy projects, energy storage, energy efficient product procurement, and demand reduction strategies.	• Increased funding will support additional technical assistance in the development and execution of AFFECT grant funding to Federal agencies utilizing performance contracting mechanisms, Federal Partnerships for Geothermal Installations utilizing performance contracting mechanisms, and implementation of EO 140008 and EA 2020 goals and objectives.
• Energy/Water Resilience & Security: Address the identified Federal agency cybersecurity and resilience gaps. Develop and validate agency-universal systematic prioritized approach to energy and water portfolio planning	• Continue to support development of risk-informed resilience and cyber energy and water climate mitigation/adaptation strategies and approaches across the Federal government.	• Increased funding will support additional technical assistance to Federal agencies regarding implementation of EO required Federal agency specific Climate Action Plans.
• Facility & Fleet optimization: Provide technical assistance to Federal agencies in support of	• Provide technical assistance to Federal agencies in support of facility and fleet decarbonization	• Increased funding will support technical assistance for charging and fleet electrification

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
facility and fleet optimization to include development of tools and resources to enable strategic energy management through deployment of energy efficient technologies and best practices.	and electrification to include development of tools and resources needed to implement EO 140008 and EA 2020 goals and objectives.	including development, validation, and deployment of an EV Planning Tool that supports fleet electrification conversion providing Federal agencies with replicable technical and financial solutions for fleet electrification and establishment of a Federal Smart Buildings program to facilitate the adoption of use of smart building technologies and practices through validation, demonstration, and deployment across the Federal building stock.
• Federal Leadership & Engagement: Establish strategic partnerships with 1-3 specific agencies to develop resilience and security solution sets that will yield application benefits across the Federal government.	• Partner with the National Park Service and the Department of Energy to demonstrate viability of electrification and decarbonization energy and water management strategies utilizing integrated FEMP services approach.	• Increased funding will support technical assistance to enable the Federal government to lead by example by demonstrating the viability of deploying energy efficient technologies and best practices.
Reporting and Statutory Requirements $4,930,000	**$4,150,000**	**-$780,000**
• Provide statutorily required reporting and technical guidance. Complete reporting requirements for Agency-level energy intensity, EISA 432 CTS Support, GHG Annual Reporting, FEMP Project Tracking System (PTS), FAST Fleet Reporting, and Renewable Energy Reporting	• Provide statutorily required reporting and technical guidance. Complete reporting requirements for Agency-level energy intensity, EISA 432 CTS Support, GHG Annual Reporting, FEMP Project Tracking (PTS), FAST Fleet Reporting, and Renewable Energy Reporting.	• Develop enhanced reporting capabilities for performance contracting projects to achieve requirements of the Energy Act of 2020**.**
• Evaluate Federal rulemaking and support development and execution. Coordinate with Council on Environmental Quality (CEQ) and Office of Management & Budget (OMB) on Executive Order implementation.	• Evaluate Federal rulemaking and support development and execution and develop comprehensive resources for agencies. Coordinate with Council on Environmental Quality (CEQ) and Office of Management & Budget (OMB) on Executive Order implementation.	• No significant change.
Workforce Development $1,656,500	**$2,312,000**	**+$655,500**
• Federal Leadership & Engagement: Provide training content through free internationally accredited training program for energy and water management professionals via on-demand and in person (virtual) training sessions,	• Continue to provide free accredited training to energy and management professionals and participate in the EERE wide workforce EMPOWER FOA.	• Increased funding supports updating existing training portfolio to align with best practices, including training content that will support electrification and decarbonization objectives in

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
including the annual Energy Exchange training workshop.		support of EERE program workforce development and energy justice priorities.
FEEF – AFFECT $13,000,000	**$400,000,000**	**+$387,000,000**
• Award $13 million in funding under the Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) grant program to catalyze the adoption renewable energy and efficiency strategies in areas with carbon-intensive utilities, and electrification at sites served by utilities with low-carbon fuel mix through privately financed performance contract projects. Anticipate 13-20 projects will be selected.	Award $400 million in funding under the Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) grant program to catalyze the adoption renewable energy and efficiency strategies in areas with carbon-intensive utilities, and electrification at sites served by utilities with low-carbon fuel mix through leveraging of privately financed performance contract projects.	• Increased funding supports EO and statutory energy efficiency electrification, decarbonization and infrastructure improvement goals and objectives. Projects will be significantly larger in scope and will bundle resilience and mobility conservation measures where appropriate. Projects will leverage performance contracting which include significant small and minority business subcontracting goals. These projects will generate private sector resources that will significantly exceed the initial grant investment.

Building Technologies

Overview

Residential and commercial buildings are the single largest energy-consuming sector in the U.S. economy, representing approximately 39 percent of its total energy consumption, 75 percent of the Nation's electricity use, an even greater share of peak power demand, and are responsible for 36 percent of energy-related carbon dioxide emissions.[1,2] As a result, Americans spend over $400 billion annually to power and otherwise energize our 129 million homes, offices, schools, hospitals, and other commercial and residential buildings.[3] However, these energy bills are not equally felt by all. The energy burden for low-income households is on average three times that of non-low-income households and low-income households typically receive a lower quality of energy services.[4] The Building Technologies Office's (BTO) long-term goal is to reduce the energy intensity of homes and commercial buildings – and thus significantly decarbonize them through the application of cost-effective energy efficiency technologies and practices. Beyond reducing energy waste for consumers and supporting an affordable and reliable grid by reducing overall demand, BTO is committed to seeing buildings play a critical role in decarbonizing the economy by helping to integrate higher levels of renewable resources through demand flexibility, supporting affordable alternatives to pollution-emitting energy equipment, and other approaches.

Reducing building energy use intensity not only helps conserve valuable natural resources but greatly strengthens the U.S. economy and labor force by improving the productivity of businesses and helping save money by making energy services (e.g., lighting, heating, and cooling) more affordable for all consumers. Increasing the demand flexibility of buildings helps reduce consumers' costs, improves reliability, and helps make better use of variable renewable resources such as solar and wind. Government investment in research, development, demonstration, and deployment (RDD&D) supports the efforts of the building sector to adopt technologies that can improve energy efficiency and demand flexibility for all communities while also reducing emissions–without sacrificing the comfort or productivity of people inside buildings or the performance of labor-saving devices, appliances, and equipment.

The building sector is fragmented in multiple (and overlapping) ways: residential and commercial sectors, new construction and existing buildings, building use types, ownership, occupancy status, climate zones, energy costs and options, etc. Within any given building, there are numerous building sub-systems and technologies (lighting, heating, building envelope, controls, etc.), with their own technological and market complexities that often inhibit the adoption of even the most cost-effective efficiency measures. The market actors that sell, install, own, use, and/or pay the energy bills for each are generally distinct from one another. This also makes it difficult for any single firm to be able to aggregate sufficient information to address the complexity of the integration challenges necessary to improve efficiency at the scale of the whole building. Furthermore, renters are typically responsible for paying their monthly energy bills but have little control over the energy efficiency of the building envelope or major appliances in their homes or buildings, and landlords have little to no incentive to improve the energy efficiency of their properties (unless they can recoup the expenses of an efficiency upgrade through higher rents).

BTO-sponsored RDD&D activities focus on breaking down these barriers and identifying opportunities to innovate the energy efficient technologies that impact the largest energy demands within buildings: lighting, space conditioning and refrigeration, water heating, appliances, and miscellaneous electric loads, as well as the building envelopes (including windows, insulation, etc.) themselves. Additionally, BTO's RDD&D on advanced and grid-interactive controls and thermal energy storage will help strengthen the body of knowledge to support industry to develop and deploy grid-interactive efficient buildings capable of connecting with the power grid in new and increasingly adaptive manners to help with overall energy system efficiency, resilience, reliability, environmental performance and energy affordability; these capabilities are an integral part of a decarbonized power system. BTO will place a new emphasis on developing market transformation

[1] https://www.eia.gov/environment/emissions/carbon/.
[2] U.S. Energy Information Administration. *Annual Energy Outlook 2019 with projections to 2050*. Washington, DC: U.S. Department of Energy, January 2019. https://www.eia.gov/outlooks/archive/aeo19/pdf/aeo2019.pdf
[3] Spending derived from the U.S. Energy Information Administration Monthly Energy Review. https://www.eia.gov/totalenergy/data/monthly/.
[4] https://www.energy.gov/eere/slsc/low-income-community-energy-solutions#:~:text=According%20to%20the%20U.S.%20Department,which%20is%20estimated%20at%203%25.

initiatives focused on the highest impact areas to accelerate the transition to a net-zero emission economy by no later than 2050. BTO is also investing in "locking in" savings that have been realized by RDD&D and market transformation via appliance and equipment standards and building energy codes.

BTO not only catalyzes innovation, but spurs energy equity by developing and deploying solutions that address some of the needs of our most distressed populations. Nearly 31 million U.S. households face high energy burdens (i.e., spend more than 6 percent of their income on utility bills, roughly double the national average), while 16 million U.S. households face more severe energy burdens (i.e., spend more than 10 percent of their income on energy).[1] With cost reductions – both for the utility bills to operate equipment and for the first cost of energy-saving technologies–serving as one of BTO's primary strategies, this work is essential to ensuring that all Americans can benefit from affordable, high-performing, healthy and comfortable homes and buildings.

BTO-wide Priorities: In FY 2022, BTO will conduct several major cross-cutting initiatives on an Office-wide basis. These initiatives will contribute significantly to top Administration climate and clean energy objectives, including: sharply mitigating carbon dioxide emissions; rapidly deploying energy efficiency; decarbonizing the electric power grid; creating quality jobs for American workers with a free and fair choice to join a union; equitably distributing the benefits of clean energy to all Americans, including disadvantaged and diverse communities; maintaining U.S. innovation competitiveness; and reducing the energy bills of U.S. households and businesses. BTO initiatives include the following:

Advanced Building Construction (ABC) Initiative: The ABC Initiative, launched in FY 2019, is helping lay the foundation for the U.S. to become a leader in modernized, low-carbon building construction and renovation, by scaling highly efficient modular new construction and developing easy to install, appealing retrofit solutions. BTO's work on ABC includes R&D and strategic partnerships aimed at integrating new technologies and approaches for quickly deploying high efficiency and low-carbon solutions into both new building construction and renovation. BTO's investments focus on developing efficiency-related building technologies that require significantly reduced onsite construction and installation time, are affordable and appealing to the market, and leverage related efforts to increase the productivity of the construction and renovation industry. In addition to funding research on technologies, software, and digitization, ABC brings together key building sector stakeholders to tackle efficiency-related challenges, including workforce training, business models, demand growth, and service delivery. In FY 2022, BTO will expand investments in ABC to focus on developing solutions for targeted building sectors (e.g., multifamily) that demonstrate great opportunities for energy and cost savings as well as ancillary benefits (e.g., resilience, speed of construction/installation, affordability). BTO will continue to work with other EERE offices as well as other Federal agencies to ensure that ABC provides an avenue to dramatically expand U.S. leadership in the manufacturing of modular construction, development of low-carbon materials, development and use of low-embodied carbon materials and practices, and pre-fabrication of building components (e.g., facades) that can achieve zero, or near-zero, energy retrofits of existing buildings with less disruption and greater performance.

E3 Heat Pump Initiative for Better Energy, Emissions, and Equity (E3): The E3 Initiative will provide new, affordable solutions for clean heating and cooling systems in buildings to better align comfort, economic productivity, and environmental performance to communities around the country while generating good-paying jobs with a free and fair choice to join a union. This initiative will initially focus on accelerating the adoption of grid-interactive heat pump technologies and provide compelling high-performance alternatives to fossil-fueled building equipment. E3 will advance both research innovation and market adoption of highly efficient cost-effective heat pumps for both space heating and water heating systems in residential and commercial buildings, working to make these technologies affordable for all Americans and easy to install. The initiative prioritizes advancing research on low- to no-global warming potential (GWP) refrigerants, validating and accelerating cold climate heat pump performance, and developing workforce training that will address new and expanded skills required for grid-interactive heat pump installations, so that newly efficient heating and cooling doesn't literally go "out the window". E3 will also integrate opportunities for building envelope with high-R (highly efficient) windows and other measures, especially in cold climates and older buildings. E3 will demonstrate the market viability of highly energy-efficient, grid-interactive heat pump technologies in residential, commercial, and multifamily buildings. Specific areas of

[1] Rita Ballesteros, Build Back Better Homes: How to Unlock America's Single-Family Green Mortgage Market, 2021 https://rmi.org/insight/build-back-better-homes/

focus include: technology challenges focused on working with industry and utilities on new specifications and performance measures and associated field validation, user-centered research to ensure heat pump products support consumer needs for heating and cooling, integration of advanced diagnostics to improve long-term electric optimization solutions to address control panel upgrades, and up-skilling the HVAC workforce through training programs with trade organizations and installers around the country. BTO will test products and develop a test procedure for cold climate heat pumps.

Grid-interactive Efficient Buildings (GEB) Initiative: BTO's GEB Initiative is helping make buildings become smarter about the amount and timing of energy they consume (and avoid consuming). In addition to improving the energy efficiency of the overall building, this research focuses on the ability of a building to provide demand flexibility – the capability provided by onsite distributed energy resources to reduce, shed, shift, modulate, or generate electricity. Building demand flexibility specifically represents the capability of controls and end-uses that can be used, typically in response to price changes or direct signals, to provide benefits to buildings' owners, occupants, and to the grid. BTO's research focuses on next-generation sensors, controls, connectivity, and communication and the main demonstration thrust is through Connected Communities –a collaboration across multiple DOE offices to demonstrate a number of grid-service options that can be provided by the aggregation of grid-interactive efficient buildings with multiple distributed energy resources (DERs). Furthermore, by shifting demand across the hours of the day, GEBs function as de facto energy storage. (In fact, both GEBs and BTO's thermal energy storage RDD&D can greatly expand the amount of distributed inexpensive energy storage available. For example, office buildings can be "pre-cooled" overnight or in the morning when it is more efficient to run air conditioners and then turned off for a portion of the day while the cool indoor temperatures are maintained by a building's thermal mass.)

Highlights of the FY 2022 Budget Request

FY 2022 activities support Administration and Departmental decarbonization goals and objectives. Highlights include:

- Appliance & Equipment Standards and Building Codes: BTO works with industry and stakeholders to test and implement statutorily mandated energy and water conservation standards and test procedures. Similarly, as required by statute, BTO supports the advancement and adoption of building energy codes, including participating in processes to update model energy codes, making a formal determination as to whether new editions increase energy efficiency in residential and commercial buildings, and providing technical assistance to states and local governments to support energy code implementation.
- Grid Modernization Initiative: BTO's Buildings-to-Grid activities support this Departmental crosscutting initiative by focusing on research and development to improve the state of technology, deploy data and best practices, and demonstrate examples that support industry efforts to connect with the power grid in new and increasingly adaptive manners.
- Advanced Building Construction (ABC): Projects supported through the ABC Initiative will transform the U.S. market for modern, modular, and prefabricated, low carbon building construction and renovation. BTO will continue engagement and collaboration with key industry stakeholders to inform ongoing research and development projects, and to prime the market for the integration of high efficiency solutions and evolving approaches in new construction and renovation.
- E3 Initiative for Better Energy, Emissions, and Equity: This technology-focused initiative will support research, development and demonstration (RD&D) for new and existing, affordable greenhouse gas (GHG)-free heating and cooling solutions. BTO will support market transformation activities to accelerate the adoption of grid-interactive heat pump (HP) technologies and deploy strategies and resources to reduce emissions attributed to building equipment including fossil-fueled equipment and refrigerants.
- Climate and Clean Energy Partnerships for Local Governments: This new initiative will empower American cities and counties, including those that are energy communities to accelerate high-impact solutions tailored to their distinct clean energy goals and via their localized workforce. Through a partnership with the Weatherization and Intergovernmental Programs Office (WIP), BTO will provide competitive awards and various types of technical assistance (e.g., onsite capacity, peer exchanges) to local governments to support the development and deployment of transformative clean energy programs, with an emphasis on small to medium jurisdictions and disadvantaged communities. Topics will be coordinated across EERE, DOE program offices, and National Laboratories. BTO's efforts will include a focus on support for local governments' analysis and adoption of building energy codes.
- Grid-Interactive Efficient Buildings (GEB): BTO will continue work supporting the development and adoption of technologies and strategies to improve demand flexibility, energy efficiency, emissions mitigation, and grid-interactivity in residential and commercial buildings.

- Next-Generation Connected Communities: BTO will stand up a new cohort of multi-building and community-level pilots focused on scaling low-carbon building solutions that support renewables integration and provide demand flexibility. With this cohort, BTO will support the measurement, verification, and deployment of data, best practices, and learnings associated with these multi-building, district and community-based approaches and ensure that existing buildings and disadvantaged communities are adequately represented.
- Small Commercial Assessment Centers: Modeled after the well-established Industrial Assessment Centers, BTO will pilot new small building assessment Centers at Accreditation Board for Engineering and Technology, Inc. (ABET)-accredited universities (via the traditional model) and initiate direct-funding for training and jobs development programs offered through community colleges and technical programs, specifically focusing on programs with diverse student participation and those in disadvantaged communities.
- Workforce Development & Education: BTO will support efforts to prepare the next generation of professionals, tradespersons and other workers needed to create a low-carbon, modernized U.S. building stock. BTO will build interest in these careers among underrepresented groups, augment training programs to improve the skills of existing tradespersons and professionals and streamline pathways from education and training to viable careers. Support for Solar Decathlon and JUMP (Join the discussion, Unveil innovation, Make connections, Promote tech-to-market) into STEM by developing "drop in" educational content and curricula. BTO is committed to providing opportunities to those in communities with greatest employment needs, including those from legacy energy jobs.

BTO activities are implemented through partnerships with National Laboratories and competitively selected, cost-shared projects. Equipment and Building Standards activities will be carried out with technical assistance from established contracts and National Laboratories. Building energy codes work does include competitively selected, cost-shared projects. In addition, FY 2022 funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, and economic research studies and other analyses across the BTO portfolio.

Building Technologies
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Building Technologies				
Emerging Technologies (formerly Building Energy Research & Development)	140,000	145,000	174,000	+29,000
Commercial Buildings Integration	50,000	50,000	74,000	+24,000
Residential Buildings Integration	40,000	40,000	72,000	+32,000
Equipment and Buildings Standards	55,000	55,000	62,000	+7,000
Total, Building Technologies	**285,000**	**290,000**	**382,000**	**+92,000**

SBIR/STTR:

- FY 2020 Transferred: SBIR $9,229,000; STTR $1,814,000
- FY 2021 Projected: SBIR $6,440,000; STTR $906,000
- FY 2022 Request: SBIR $7,679,000; STTR $1,080,000

Building Technologies
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Emerging Technologies (Building Energy Research & Development): The FY 2022 Budget Request will support RDD&D of buildings-to-grid. This program area will support next generation Connected Communities and the E3 Initiative. Work on low global warming potential refrigerants and heat-pumps will be significantly expanded. Natural gas and other fossil fuel-fired appliance work will be phased out in favor of zero-emission alternatives. Work on envelope technologies will be expanded in support of ABC with a focus on high performance, scalability, and ease of installation – particularly for retrofit applications. The program will continue work on highly efficient lighting technologies and on building energy modeling. In addition, this Request supports an expansion of the program's work in STEM and workforce development for the building research and development (R&D) sector.	**+29,000**
Commercial Buildings Integration (CBI): The FY 2022 Budget Request continues support for the Better Buildings Initiative, including new work on zero carbon goals and deploying pathways to achieve zero carbon existing buildings. CBI will support the strategic deployment of technologies and solutions produced through the ABC Initiative and Connected Communities, and engagement with state and local governments and to reduce emissions from commercial equipment. Additionally, CBI will significantly grow its portfolio of efficiency work with small businesses through testing, demonstration, and deployment of turnkey energy efficiency and climate-responsive technology packages, scaled in partnership with community-level organizations. Finally, CBI will continue to expand support for growth in skilled jobs and training provided through small commercial assessment centers where training programs target underserved and diverse students participating through community colleges and technical programs.	**+24,000**
Residential Buildings Integration (RBI): The FY 2022 Budget Request supports a combination of RDD&D, technical assistance, partnerships, modeling and analysis aimed at creating a U.S. residential building stock–both existing and new construction – that is affordable, decarbonized, energy efficient, high-performing, and grid-interactive. Partnerships with state and local governments and industry will focus on dramatically expanding use of high efficiency equipment (e.g., heat pumps, low e windows) in single family, multifamily, and manufactured housing. Targeted challenges, prizes, or other strategies will be designed to drive down costs and make important performance features (e.g., automated fault detection and diagnostics that deliver benefits similar to check engine lights in cars) ubiquitous, rather than only niche.	**+32,000**
Equipment and Buildings Standards: Energy efficiency standards compliance activities will maintain compliance with statute. Building Codes technical assistance will emphasize advancement of the national model codes, as well as stretch codes which can be considered and adopted by state and local governments, including a focus on zero net energy and low-carbon solutions. Technical assistance activities will also expand support for workforce education and training initiatives, helping states, local governments, and design, homebuilding and construction professionals adapt to evolving technologies and construction practices, with an emphasis on the latest building energy codes and standards.	**+7,000**
Total, Building Technologies	**+92,000**

Description

The Emerging Technology (ET) program sponsors applied R&D and demonstration in energy-efficient, demand-flexible low-carbon building technologies, enabling innovation and job creation in a range of U.S. industries from building design, construction, and renovation to building equipment and component manufacturing to building commissioning and operation. ET conducts applied research and development at the component, system, and building integration levels in the following technology areas: Buildings-to-Grid R&D, Lighting, HVAC & Refrigeration, Building Envelope, and Building Energy Modeling. In addition, BTO collaborates with industry, academia, and other leaders across the building sector to conduct develop, demonstrate, and validate the performance of connected, energy-efficient building components and sub-systems into efficient and flexible building systems. Through the ET program, BTO also advances building construction and retrofit technologies that help building owners and occupants reduce energy costs and related pollution while providing load flexibility to support rapidly increasing variable renewables on the electricity grid. This applied RD&D portfolio leverages the National Laboratories' researchers, computing capabilities, and other unique facilities that are critical for BTO to support efforts to significantly reduce carbon emissions from buildings.

The innovations supported through BTO's RD&D portfolio are critical to support R&D in the private sector to develop the next generation of energy-efficient and flexible load building technologies. The building sector can be divided in numerous ways and, within any given building, there are numerous building sub-systems or technologies (lighting, heating, building envelope, controls, etc.), many with their own complexities. For a building to operate efficiently and flexibly while ensuring the quality of the occupant experience, these diverse technologies must be integrated. The RD&D supported by BTO leads to an improved understanding of physical properties and phenomena relevant to building materials and building equipment within the context of the building as a whole. This supports industry's ability to innovate and develop novel technologies that reduce global warming emissions and lower energy costs to the consumer.

The ET program plans to support Next Generation Connected Communities to demonstrate the market viability of highly energy-efficient, demand-flexible, low-carbon buildings integrated with distributed energy resources (DERs) and related infrastructure (e.g. EV charging, thermal energy sources) to reliably and cost-effectively contribute to America's transition to a net-zero emission economy by no later than 2050. Specifically, ET will provide funds for communities to scale and demonstrate grid-interactive efficient building technologies such as thermal energy storage, next generation envelope technologies, electrochromic windows, connected lighting, and advanced controls.

BTO's ET program will collaborate with Solar Energy Technologies Office (SETO), Office of Electricity (OE) and Vehicle Technologies Office (VTO) to develop and validate innovative and sustainable approaches to enhance community resilience using DERs. Technological advancements include control/coordination strategies across infrastructure domains, real-time system monitoring, robust communications, grid planning and analytical platforms, and unique capabilities provided by DER technologies. BTO's effort will focus on optimizing building load management to enable a critical load state to minimize power while ensuring occupant safety during a grid outage when using electricity from back-up power sources.

The ET program plans to support the E3 Initiative with a focus on new research supporting low- to no-GWP refrigerants, cold climate HP performance validation, advanced controls, and electric optimization solutions to address control panel upgrades.

BENEFIT (Buildings Energy Efficiency Frontiers & Innovation Technologies), an annual competitive funding opportunity announcement (FOA) that includes topics from across ET's research portfolio, will address RD&D challenges at the intersection of building-energy modeling and advanced building controls as they relate to technologies that enable transactions among buildings, building systems, and the electricity grid. This FOA leverages previous FOAs and builds upon buildings-to-grid R&D.

Research areas of interest for the FY 2022 BENEFIT FOA include:

- Innovation in heating, ventilation, air conditioning, and refrigeration (HVAC&R) and lower-GWP refrigerant technologies that enable increased market penetration of heat pump systems across all climate regions, and push the state of the art for reducing refrigerant leakage in existing supermarket systems to reduce GHG emissions;
- Applied research into integrated virtual and thermal storage solutions and their interaction with, and impact on, existing dynamic building systems; and
- Development of new or enhanced approaches to modeling and analyzing energy use and emissions in buildings, building portfolios, and communities.

In addition to the annual FOA, BTO directly funds DOE National Laboratory R&D that leverages their unique facilities and expertise and fosters collaboration and accessibility. This is encouraged through private sector and university engagement using mechanisms such as Cooperative Research and Development Agreements (CRADAs) to directly support industry RD&D activities and increase the rate of commercialization. BTO will continue to fund research in the following areas:

Buildings-to-Grid (B2G) RD&D: The B2G RD&D includes flexible building loads, thermal energy storage technologies, and control and coordination strategies to provide grid services that enable increased integration of variable renewable generation. This RD&D will enable a zero-carbon electric grid by making building loads more dynamic and flexible while meeting the needs of building occupants and improving building operation and maintenance. B2G RD&D activities support Grid-interactive Efficient Buildings (GEBs), Connected Communities, and DOE's Energy Storage Grand Challenge.

Flexible building loads research includes advanced communication platforms and data management systems; advanced sensing, monitoring, fault detection and control capabilities; and interoperability, cybersecurity, user-centered research, and data analytics to maximize zero-carbon energy use and optimize productivity and occupant comfort. Research and development areas of interest include:

- Deploying integrated building control schemes at the whole-building and multi-building levels with multi-objective optimization across building subsystems including on-site generation and storage, using predictive analytics to respond to changing weather, building, and grid conditions to reduce energy and carbon intensity and support grid stability;
- Reducing the cost and increasing the reliability of device-specific grid-interactive controls and communication, with a priority on thermal systems that provide the greatest potential for demand flexibility. Activities will focus on grid-interactive heat pump heating and cooling systems, given the importance of this technology in meeting decarbonization goals through efficiency and electrification;
- Integrating detection and diagnostics for whole-building level faults (both software and hardware) with analytics for other complementary distributed energy resources at the grid edge;
- Streamlining delivery of grid-interactive applications and capabilities by providing standard solutions for data interpretability by complementing technical interoperability with semantic interoperability so data can be understood with minimal human effort; and
- Applying data models and analytics to intelligently shut down devices or place devices into sleep mode to improve efficiency and provide demand response, without reducing occupant productivity or building services.

Building sector thermal energy storage research and development includes technologies that either provide dedicated standalone storage or integrate storage into building equipment or envelope. Thermal energy storage at the building and/or campus/district scale is a compelling approach to meeting thermal end-use demand in a way that maximizes available renewable generation. Areas of interest include:

- RD&D into materials capable of storing thermal energy (both heat and cold) and controlling and directing their charge and discharge, directing, and controlling thermal energy for buildings applications;
- RD&D to enhance the thermal storage capabilities of existing building components – water heaters, HVAC, building envelope; and
- RD&D and field testing of the algorithms to control these integrated systems, as well as measurement protocols and standards to evaluate these thermal energy storage systems and devices.

These efforts will be coordinated through the launch of a Thermal Energy Storage (TES) consortium. The consortium will help industry move concepts from R&D to demonstration and deployment in an accelerated way that will transform buildings' thermal energy management. Consortium members will include National Laboratories, academia, research institutions, industry, and government agencies. The vision will focus on what is needed at the system/operation level to

align efforts at the materials and components levels, curbing the development time and accelerating the market transformation by having all TES research, development, demonstration, and deployment for buildings in one collaborative place.

Lighting R&D: The focus of BTO's Lighting Program is on applied R&D, as well as field validation and high-impact deployment activities, with the aim of converting most lighting installations to solid-state lighting (SSL) by 2035. If successful, SSL technologies will enable 62 quads of cumulative energy savings versus legacy technologies over the 18 year period from 2017 to 2035—and an additional 16 quads if DOE targets for efficiency, controls, and connected lighting are met. [1] The total cumulative energy savings of 78 quads would be equivalent to $890 billion in avoided energy costs and 5.9 billion tons of avoided CO_2 emissions. [2] This program expands on controllable lighting loads, by emphasizing innovations that improve efficiency while simultaneously improving health, productivity, and well-being. Research areas of interest include:

- Applied semiconductor physics of LED and Organic LED (OLED) devices, to improve efficiency of source technologies;
- R&D and analysis on total light application efficiency beyond source efficacy, including optical control, intensity effectiveness, and spectral efficiency, to controllably deliver the right light, in the right way;
- Cross-cutting research into lighting utilization and its effects on health and wellness;
- Energy reporting accuracy, system-level energy performance, interoperability and system integration, cybersecurity vulnerability, and grid integration of connected lighting systems;
- Quantitative analysis of lighting supply chains and their economic impact; and on potential to provide grid services;
- Development of resources for installers and tradespeople; and
- Development of non-visual and system level metrics for emerging lighting applications.

Building HVAC and Refrigeration R&D: R&D targets fundamental and applied research that supports performance advances and cost reductions in HVAC&R technologies. This research will support industry to achieve a significant reduction in HVAC energy consumption and savings in water heating energy consumption. This work will support thermal storage, variable speed drives, and more sophisticated interactions between building equipment, such as water heaters, HVAC, and appliances, with the electricity grid. This ongoing research will supplement the new E3 Initiative and research oriented towards accelerating clean heating and cooling systems in buildings. In particular, ET R&D will explore low- to no-GWP refrigerant options and validation of cold climate heat pump performance. The following activities will be a continuation of BTO's ongoing R&D:

- Exploring methods for enhancing the heat transfer rate, including across solid/liquid interfaces;
- Transformational heat pumping and non-vapor compression technologies for water heating and space conditioning applications;
- High part-load efficiency building equipment needed to facilitate building-to-grid integration; and
- Advanced controls critical to the successful implementation of grid-interactivity and electrification.

Building Envelope R&D: The building envelope (e.g., walls, roofs, foundations, and windows) is arguably the single largest contributor to primary energy use in buildings. Building Envelope R&D supports the development of next-generation technologies and solutions that reduce the energy required to heat and cool a building, contribute to improved occupant comfort, building flexibility, and resilience, and have competitive installed product costs to enable widespread market adoption. This is expected to make significant contributions to the Administration's goals of decarbonizing buildings, reducing building energy waste, strengthening the U.S. economy and labor force, helping make buildings' operations more affordable, and helping make better use of variable renewables.

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[1] Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, U.S. DOE, Dec. 2019.

[2] Forecast savings of energy and dollars here are as noted in the most recent Energy Savings Forecast of Solid State Lighting in General Illumination Applications (footnote 1).To estimate potential carbon savings, we use the this forecast, along with an average site/source ratio of 2.80 (from Energy Star Portfolio Manager technical reference, https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf, carbon emissions factor of 7.09 x 10-4 metric tons CO2/kWh (from EPA (2020) AVERT, U.S. national weighted average CO2 marginal emission rate, year 2019 data. U.S. Environmental Protection Agency, Washington, DC), and a conversion factor of 3412 Btu/kWh.

Areas of interest include:

- Envelope diagnostics and air sealing technologies;
- Improved R/Inch insulation materials and high-throughput manufacturing processes;
- New heat management solutions that go beyond static insulation;
- Innovative techniques to enable faster and scalable retrofits;
- Low conductive, highly insulating materials such as aerogels or vacuum insulated glazings achieving whole window performance of R10 (equal to most existing homes walls);
- Support for market transformation activities;
- Materials that can independently modulate near infrared and visible light; and
- Low embodied carbon construction materials.

Building Energy Modeling R&D: Physics-based whole-Building Energy Modeling (BEM) supports building energy efficiency in a number of ways. BEM supports integrated, performance-driven design in new construction and major retrofits, which yields lower energy use in buildings. BEM forms the basis of whole-building energy-efficiency standards like ASHRAE 90.1 and IECC, energy-efficiency rating systems like LEED and GreenGlobes, and Federal and utility incentive programs—large scale analysis on prototype models is used to design the code or program while modeling is often used to demonstrate and document performance levels required to achieve compliance, or obtain a label or incentive. BTO uses simulation on prototype models to evaluate potential national impacts of new technologies, to set technology performance targets, and to inform its investment portfolio. An emerging use case of BEM is design; optimization, and implementation of control systems for buildings and multi-building systems like district systems and microgrids that target energy and carbon minimization in addition to occupant comfort. Other emerging use cases leverage BEM in a "digital twin" capacity to perform ongoing commissioning and fault-detection and diagnosis for building HVAC systems, dynamic predictive building control and demand-response.

BTO funds the development of a number of BEM engines and toolkits that directly support analyses for "public good" products like codes and utility programs, and are also embedded in a number of commercial applications and services for architects, engineers, energy auditors, and code officials. Activities include:

- Support for EnergyPlus, BTO's state-of-the-art open-source BEM engine;
- Development of Spawn, the next-generation BEM tool that targets control design and implementation workflows;
- Support for OpenStudio,™ a software development kit that facilitates the integration of EnergyPlus and Spawn into commercial tools and supports automation for large scale analysis;
- Support for BEM education and training; and
- Modeling support for standards for performance-based code-compliance as well as comparable programs such as LEED and new construction utility incentive programs.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Emerging Technologies $145,000,000	**$174,000,000**	**$29,000,000**
Buildings-to-Grid R&D $51,440,000	$83,000,000	+$31,560,000
• Five to six projects focused on autonomous control, pattern matching, and integrated multi-scale data analytics for grid-interactive efficient buildings to help enable a carbon-free electricity sector.	• Five to six projects focused on integrated scaling of advanced building energy management systems, improving building sector cybersecurity, interoperability, and multi-scale data analytics for grid-interactive efficient buildings to help enable a carbon-free electricity sector.	• Increased funding for R&D to address barriers to adoption of energy saving and grid interactive control technologies to reduce carbon emissions.
• Support three to five national laboratory projects in thermal energy storage materials research for advanced salt hydrate and advanced phase-change materials development to enable load shifting and climate resilience.	• Support three to five national laboratory projects in thermal energy storage and launch a Building Thermal Energy Storage Consortium centered on materials discovery, characterization, performance evaluation, scaling/ manufacturability, and systems integration. The Consortium will establish an innovate and deploy ecosystem to help accelerate the pace of transformational thermal energy storage (TES) sciences and technologies with a goal of $15/kWh thermal systems cost and 10,000 TES cycles.	• Initiate new Building Thermal Energy Storage Consortium leveraging the world-class capabilities at DOE National Laboratories to help industry move concepts from R&D to demonstration and deployment in an accelerated way that will transform buildings' thermal energy management.
• Conduct three to five laboratory scoping studies of the building envelope contribution to a building's virtual storage capacity, and analytics needed to intelligently shut down devices or place devices in sleep mode.	• Award industry- and academia-led FOA projects in concert with the new TES Consortium on development, validation, and demonstration of highly sustainable, scalable, and affordable TES solutions for building applications, including low-temperature phase change materials with greater lifetimes and storage capacities, heat exchanger optimization for enhanced rate capability, active control and utilization of the full storage capacity of thermal mass, and advanced HVAC and envelope system designs for ease of integration and reduced costs.	• Increased funding for new projects related to TES materials and system development, manufacturing scale-up, and market transformation.
• Competitively select projects focused on flexible building technologies including	• Competitively select projects for cold climate HP performance validation, advanced controls, and	• Increase efforts in support of the E3 Initiative.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
advanced heating, ventilation, and air conditioning systems, which can provide demand flexibility services to the grid and comprehensive electric load optimization.	electric optimization solutions to address control panel upgrades.	
• Competitively select 1-2 Connected Communities projects focused on advancing the next generation of grid interactive efficient buildings.	• Competitively select 3-4 Next Generation Connected Communities Projects to support GEB for a zero-carbon electric sector.	• Increased funding for Next Generation Connected Communities.
Lighting R&D $25,000,000	$25,000,000	$0
• Competitively select projects which improve energy efficiency, reduce costs, and improve performance, while also focusing on manufacturing R&D challenges associated with advanced lighting technologies.	• Competitively select projects from industry and fund a Minority-Serving STEM R&D Consortium focused on next generation lighting technologies.	• Continued focus on developing next generation lighting technologies while ensuring participation that brings the most meritorious, diverse approaches.
• Direct funded two National Laboratory projects that focus on connected lighting systems, lighting technology systems, and emerging lighting science.	• Direct-fund National Laboratory projects to conduct field studies with private sector partners on impact of light in health-care facilities, schools, and offices, and develop resources for installers and tradespeople.	• Activities reflect adjustment of program priorities based on new findings on linkages between light and health. • Focus on addressing barriers to installation, use, and maintenance not identified or addressed in the current R&D programs.
• Issue a competitive prize for next generation efficient and connected lighting.	• Management and execution of the next generation lighting prize.	• Continued support for the next generation lighting prize.
HVAC & Refrigeration R&D $28,320,000	$26,000,000	-$2,320,000
• Support National Laboratory funding for research in HVAC, water heating, and appliances with an increased emphasis on heat transfer and materials science. This included one to two mid-size projects as well as four to five scoping studies to inform future research directions.	• Support National Laboratory funding for research in HVAC&R, water heating, lower-GWP refrigerants, and appliances. This includes one to two mid-size projects as well as four to five scoping studies to inform future research directions.	• Increased emphasis on greenhouse gas emission reductions, market transformation, and workforce development.
• Award FOA projects on innovative heating, ventilation, air conditioning, and refrigeration (HVAC&R) technologies that push the state of the art for energy cascading (the process of	• Award FOA projects on innovative heating, ventilation, air conditioning, and refrigeration (HVAC&R) and lower-GWP refrigerant technologies that enable increased market penetration of heat	• Increased funding for lower-GWP projects including investigation of methods for refrigerant leak reduction, especially for supermarket refrigeration applications.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
using the waste heat from one process as the energy source for another).	pump systems across all climate regions. Push the state of the art for reducing refrigerant leakage in existing supermarket systems to reduce GHG emissions.	• Increased emphasis on workforce development activities in HVAC&R area to work with industry to address new skills required to service lower-GWP refrigerants and advanced heat pump designs.
• Award FOA projects to develop refrigeration technologies that reduce the energy consumption and cost of refrigeration equipment while improving demand flexibility and resilience to power interruptions, and develop heat pumping solutions, including electric and fuel-driven solutions, that focus on new technologies or major first cost reductions (>30 percent).	• Support research on Non-Vapor Compression technologies that eliminate GWP refrigerants to accelerate the timelines to achieve net-zero carbon emissions.	• Fossil fuel-driven solutions will not be included. Increased emphasis will be placed on low- to no-GWP refrigerants.
Building Envelope R&D $27,650,000	$28,000,000	$350,000
• Award FOA projects that focus on advanced envelope retrofit technologies, particularly those that can be mass produced and applied to existing facades and robotics.	• Award FOA projects focused on highly insulating and dynamic solar control window systems with the ability to provide net-positive energy contribution to buildings through passive solar compared to buildings without any windows. • Award FOA projects focused on the development and field validation of low thermal conductivity, durable, insulation materials at a comparable installed cost to conventional insulation materials, ultra-low cost retrofit approaches using advanced diagnostics and remediation tools for air sealing and adding insulation, and new approaches for redirecting, harvesting, and managing heat flux that go beyond standard insulation.	• New work on integrated dynamic highly insulating windows that combines the two core critical functions into an affordable platform to enable increased carbon reduction. • Increased funding for nearer-term thin insulation materials development, validation and scale-up, integration with advanced building construction approaches, and support for market transformation technical collaborations with manufacturing partners, NGOs, and utilities to drive innovative, high-impact envelope technologies to the market.
• Direct-funded lab Annual Operating Plan (AOP) projects (five to ten) that focus on thermal and optical characterization of materials for advanced envelope technologies, including windows, and thermal measurement science for building envelope materials.	• Direct-funded lab AOP projects to support private sector activities including advanced design integration, performance research, and market characterization and foundational research on performance metrics for electricity producing glazing systems.	• Increased support for market transformation through technical collaboration working with manufacturer partners, NGOs, utilities to drive innovative window installations creating jobs. • Support for integration of daylighting with

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
		electric lighting to address performance and occupant visual comfort metrics.
Building Energy Modeling Research $12,590,000	$12,000,000	-$590,000
• Fund National Laboratories and their subcontractors to continue development and maintenance of open-source physics-based whole building modeling engine and large-scale analysis toolkit to support evaluation of new technologies, systems, and strategies by BTO itself, utilities, states, and other organizations. Emphasize new capabilities for evaluating grid-supporting technologies like thermal energy storage.	• Fund National Laboratories and their subcontractors to continue development of open-source physics-based whole building modeling engine and large-scale analysis toolkit to support evaluation of new technologies, systems, and strategies by BTO itself, utilities, states, and others.	• Work will emphasize new capabilities for evaluating grid-supporting technologies like thermal energy storage, advanced control strategies like model-predictive control and reinforcement learning, and multi-building optimization.
	• Fund National Laboratories and subcontractors to support the development of standards that apply to the use of BEM in code compliance and above code programs.	• Additional emphasis on standards that support BEM and govern the use of BEM in code-compliance and "above code" regulatory and financial applications.
• Competitively select projects to develop new or enhanced approaches to modeling and analyzing energy use in buildings, building portfolios, and communities.	• Competitively select projects to develop new or enhanced approaches to modeling and analyzing energy use in buildings, building portfolios, and communities.	• No change

Building Technologies
Commercial Buildings Integration

Description

The U.S. commercial building sector represents 5.9 million buildings, over 200 billion square feet of real estate and $170 billion in energy expenditures each year. Commercial buildings consume roughly 18 percent of the Nation's total primary energy consumption, account for 35 percent of all U.S. electricity consumption and 16 percent of the Nation's CO_2 emissions.[1]

BTO's Commercial Buildings Integration (CBI) program plays a critical role in demonstrating and deploying replicable and scalable solutions that will enable U.S. businesses and organizations to reduce U.S. building GHG emissions to net zero by 2050. CBI advances a range activities with innovative building technologies; emphasizing solutions that do not sacrifice the productivity or comfort of building occupants or the performance of labor-saving devices, appliances, and equipment and paving the way for the voluntary integration of cost-effective technologies to produce high-performing commercial buildings.

Systems Integration and Technology Deployment: CBI works across a broad group of industry representatives to identify, demonstrate, and deploy novel and/or underutilized solutions to develop and share pathways to zero energy consumption and zero greenhouse gas emissions in new and existing commercial buildings, including harder-to-achieve solutions that provide additive efficiency benefits (compared to single equipment-based solutions) using systems-based approaches (i.e. retrofit lighting, plug control, and dynamic windows at the same time) and/or the optimization of infrastructure that touches multiple systems (i.e., air delivery systems). Through the High Impact Technology Catalyst, CBI develops strategic deployment activities, including challenges, demonstration, technical specification, bulk purchasing, adoption campaigns and direct funding, to achieve maximum energy and cost savings. CBI will expand a portfolio of work with small businesses, turnkey energy efficiency, GEB, and climate-responsive technology packages, scaled in partnership with community-level organizations and leverage workforce and jobs-development initiatives.

Technical Assistance: CBI actively supports robust technical assistance to commercial building industry stakeholders via existing multi-agency, cross-disciplinary and voluntary stakeholder networks including the Better Buildings and Efficient-Healthy Schools Initiatives. CBI's newest efforts in this area include the Better Buildings Low Carbon Challenge and deployment of technical assistance, resources, and support for healthy-efficient school upgrades. Through the Low Carbon Challenge, CBI will highlight the best practices and pathways for committed partners to identify and strategically overcome technical and structural barriers to low carbon existing building design, and operation and ongoing supply chain considerations. This effort feeds directly into rapid research and development within EERE to help solve critical technical and cost barriers. CBI also supports a broad technology demonstration portfolio which includes voluntary hosting of technology pilots with third party verification. Outcomes are deployed through innovative market transformation channels, especially via multi-agency collaboration with the Federal Energy Management Program (FEMP), the General Services Administration (GSA), the Environmental Protection Agency (EPA) and the Department of Defense (DOD) to enable Federal lead-by-example activities. CBI will continue to grow skilled jobs and training in commercial buildings, in collaboration with the DOE Advanced Manufacturing Office, through Small Commercial Assessment Centers where training programs target underserved and diverse students participating through community colleges and technical programs.

CBI will help run the WIP/BTO Climate and Clean Energy Partnerships for Local Governments activities that will empower American cities and counties to accelerate high-impact solutions tailored to their distinct clean energy goals and via their localized workforce. Within this multi-office/program Partnership, CBI will support various types of activities including technical assistance (e.g., onsite capacity, peer exchanges) to local governments to support the development and deployment of transformative clean energy programs, with an emphasis on small to medium jurisdictions and disadvantaged communities. This program will support transformative clean energy programs in local jurisdictions with a focus on one or multiple pillars:

- Achieving decarbonization: targeted toward local governments willing to take measurable steps and/or make commitments to progress in one or more major sectors of the local energy economy;

[1] https://www.eia.gov/outlooks/archive/aeo19/pdf/aeo2019.pdf

- Advancing climate and economic justice: preference for disadvantaged communities with a high energy burden;
- Leading workforce transitions toward clean energy futures: intended to support workforce development and training for local careers in a clean energy economy

Program success will be measured via number and diversity of local governments engaged, steps and commitments made by local governments, and projected savings for end users from these interventions.

Modeling and Analysis: CBI develops and maintains a user-accessible, packaged tool ecosystem to enable the affordable evaluation of commercial building energy, emissions reduction, demand flexibility, and performance investments. This work is founded on the physics-based computational simulations supported through ETs BEM activities, bringing complicated simulation activities to the level of the owner and operator. In addition, this suite of design and decision support tools and resources (Asset Score, Open Studio, UrbanOpt, etc.) can be used to evaluate efficiency investments for one building or across a portfolio of buildings at various phases of a building's life cycle–design, operation, renovation, and resale. CBI will continue support for data standardization to enable micro-level data (e.g., time-series control outputs at the sub-building level) in order to evaluate and manage macro-level grid and building efficiency opportunities (e.g., shift and shed across multiple commercial buildings based off of offsetting load and usage patterns).

Commercial Buildings Integration

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Commercial Buildings Integration $50,000,000	**$74,000,000**	**+$24,000,000**
Systems Integration & Tech Deployment $16,902,000	$30,350,000	+$13,448,000
• FOA awards to support pilot small commercial assessment centers (inspired by Industrial Assessment Centers) and turnkey upgrade solutions in small commercial buildings.	• No funding requested.	• No funding requested. Projects previously funded in FY 2021 will continue to outlay prior year obligations and shift focus to workforce and jobs development activities.
• Continue National Laboratory projects that test and document the deployment opportunity for simplified, accessible technology upgrades in small and medium commercial buildings.	• Focus on deployment of high impact, cost-effective market-ready technologies and packages for small/medium commercial buildings, using innovative market transformation approaches. Expand deployment of solutions from ABC, refrigeration leakage and for state and local governments.	• Systems Integration & Tech Deployment projects will shift scope to focus on deployment.
Technical Assistance $24,018,000	$31,700,000	+$7,682,000
• Fund technical engagement through the Better Buildings Initiative (via National Laboratories and other technical experts).	• Support focuses on the Better Buildings Zero Carbon Challenge.	• Projects will support the identification and development of pathways to zero carbon existing buildings.
• Fund technology field validation portfolio which includes voluntary hosting of technology pilots with third party verification.	• Expand technical assistance and deployment of outcomes from Connected Communities pilots.	• TA will capture solutions and scale solution sets for multi-building and DER optimization for carbon reduction to under-represented communities.
Modeling and Analysis $9,080,000	$11,950,000	+$2,870,000
• Fund National Laboratories to continue development and maintenance of data tools for accessible and affordable systems-based evaluation of commercial building energy efficiency trade-offs.	• Expanded tool functionality to support carbon reductions in buildings, with a particular focus on supporting state and local government program administrators	• Integration with carbon metrics, other tools, including those focused on equity, and usability to enhance uptake.
• Fund National Laboratories to conduct pathways analysis to support demonstrations of performance-based codes.	• No funding requested.	• No funding requested. Projects previously funded will continue to outlay prior year obligations to conduct close-out activities.

Building Technologies
Residential Buildings Integration

Description

The U.S. residential building sector, representing 95 percent of U.S. buildings, consists of approximately 125 million residences, including single family units and manufactured housing, and accounts for about 21 percent of U.S. total energy consumption, 38 percent of U.S. electricity consumption, costing consumers some $240 billion in annual energy expenditures, and resulting in about 19 percent of the Nation's CO_2 emissions. Furthermore, residential energy use in certain regions accounts for 50 percent of peak electric power demand, making it an even more important target for improving energy efficiency, demand flexibility and grid reliability. The residential sector is also expected to add nearly 4 million new housing units over the next four years. [1]

Through a combination of R&D, technical assistance, and modeling and analysis, RBI invests in technologies and approaches with the greatest promise for delivering energy, cost, carbon, and other benefits at scale. Since FY 2019, RBI's work has included the development and initial implementation of the BTO-wide Advanced Building Construction Initiative (ABC)–an effort aimed at integrating low and no-carbon solutions into modernized methods for building construction and renovation. RBI's investments focus on developing efficiency-related building technologies that require minimal onsite construction and installation time, are affordable and appealing to the market, and leverage efforts to increase the productivity of the building construction industry. In addition to funding research, development and testing of technologies, RBI partners with key building sector stakeholders to tackle related challenges, including training and expansion of the workforce, development of effective business models, aggregated demand, and co-integration of other needs such as disaster resilience. RBI puts particular focus on developing efficiency solutions that can be readily enjoyed by all homeowners and tenants, regardless of income or social status, and creating long-term employment opportunities for those seeking new jobs or career advancement across the buildings sector, from architecture and engineering to manufacturing, construction, and residential trades. These efforts are designed to overcome barriers to residential building integration that inhibit achieving a net-zero carbon emission economy by 2050, while also developing a labor force with appropriate skills, and helping make housing more affordable, resilient, better able to integrate distributed solar and other DERs, and more comfortable with improved indoor air quality.

Systems Integration R&D: Through its Building America program, RBI has funded research, development, and field validation that led to the adoption of highly efficient technologies and practices in residential construction and building energy codes. RBI's investments, which complement and extend those of ET, focus on technologies and practices that address building integration research needs and issues, including validation of technologies in non-laboratory testing environments. Since FY 2019, through the ABC Initiative, RBI has invested in research aimed at integrating and meeting zero, or close to zero, carbon goals as part of modernized methods of construction and renovation. ABC investments are focused on development of innovative technologies and practices that can more readily be applied to existing residential buildings without disruption to tenants and homeowners (e.g., pre-fabricated facades/panels) as well as integration of state-of-the-art efficiency technologies in off-site manufacturing including modular construction.

Technical Assistance: RBI works with industry, state and local governments, utilities, residential contractors (including home performance, HVAC, renovation, and other contractors), builders, building owners and operators, and training entities among other key stakeholders to both understand and address the barriers hindering widespread uptake of efficiency measures in single and multifamily homes, including manufactured homes, and to develop technologies and approaches to overcome these barriers. RBI's technical assistance includes support for workforce training (ranging from foundational energy upgrade skills through STEM and Solar Decathlon) and information tools that assist home builders, state and local governments, homeowners, utilities and others in advancing residential efficiency and decarbonization.

RBI will help run the WIP/BTO Climate and Clean Energy Partnerships for Local Governments activities that will empower American cities and counties to accelerate high-impact solutions tailored to their distinct clean energy goals and via their localized workforce. Within this multi-office/program Partnerships RBI will support various types of activities including technical assistance (e.g., onsite capacity, peer exchanges, targeted analysis/planning, subject matter expert input/review)

[1] https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf.

to local governments to support the development and deployment of transformative clean energy programs, with an emphasis on small to medium jurisdictions and disadvantaged communities. RBI will ensure that there are investments in the energy efficiency, demand flexibility, and affordability of residential buildings (multifamily, single family, manufactured homes) by supporting transformative clean energy programs in local jurisdictions with a focus on one or multiple pillars:

- Achieving decarbonization: targeted toward local governments willing to take measurable steps and/or make commitments to progress in one or more major sectors of the local energy economy;
- Advancing climate and economic justice: preference for disadvantaged communities with a high energy burden; and
- Leading workforce transitions toward clean energy futures: intended to support workforce development and training for local careers in a clean energy economy.

Program success will be measured via number and diversity of local governments engaged, steps and commitments made by local governments, and projected savings for end users from these interventions.

Modeling and Analysis: RBI funds the development of building energy models, data systems, and other tools (e.g. Building Science Advisor, Home Energy Score) to assist builders, homebuyers, utilities, state and local governments, and other decision-makers to consistently and accurately estimate energy use, savings and costs; to inform investment decisions and maximize benefits; and, to apply best building science practices. This work includes modeling and analysis to inform new technology development, assess grid-responsive building components for increased buildings/grid integration, calculate building lifecycle carbon emissions, and provide homeowners and homebuyers with reliable information concerning the energy efficiency of homes as well as how to improve them.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Residential Buildings Integration $40,000,000	**$72,000,000**	**+$32,000,000**
Systems Integration R&D $26,696,000	$ 32,000,000	+$5,304,000
• Invest in Advanced Building Construction (ABC) technologies and approaches, including state-of-the-art innovations that can dramatically scale deep energy retrofits to our Nation's 125 million residential buildings and can assist in meeting the Administration's goal for building or retrofitting 1 million sustainable and affordable housing units in four years. • Support field validation of highly efficient equipment, including heat pumps in non-moderate climates and other technologies that put the U.S. on track to achieving a 100 percent clean energy economy by 2050; support research to ensure efficient buildings maintain indoor air quality; support technical challenges and prizes to expand availability and affordability of higher efficiency products to all Americans (e.g., automated fault detection and diagnostics incorporated into standard systems, rather than only high end products).	• Expanded research, development, field validation, and demonstration of ABC solutions and other approaches with greatest promise for scalable deep energy retrofits. • On new construction, invest in research partnerships aimed at modernizing construction methods (e.g., modular builds) that achieve zero energy and low lifecycle carbon goals while maintaining cost competitiveness and speed of delivery.	• Research, development, and testing that links both ABC solutions (either in new construction or retrofit) with connected community goals of improving grid performance and energy resilience.
Technical Assistance $7,922,000	$30,000,000	+$22,078,000
• Conduct 2021 Solar Decathlon Design Challenge and complete 2020 Solar Decathlon Build Challenge to help develop our Nation's next generation of building scientists, architects, engineers, and other experts needed to attain a clean energy economy. • Provide technical assistance to utilities, state and local governments, training facilities, residential contractors, builders, and others to (a) promote best practices in new construction and retrofit of existing buildings and (b) develop	• Conduct 2022 Solar Decathlon Design Challenge and provide support for Solar Decathlon Build Challenge. • Partnerships with industry, federal, state, and local governments, architects and engineers, utilities, home efficiency contractors, and others; with a focus on wide adoption of priority technologies, aggregated demand for high efficiency solutions (e.g., ABC), workforce recruitment and training, and improved STEM	• Expand benefits of Solar Decathlon to non-competing students and institutions through access to standard building curricula, as well as current building professionals (e.g. architects and engineers) to encourage broader uptake of state-of-the-art building science principles, approaches and technologies. • Technical assistance and partnerships directed at scaling the use of targeted, high efficiency technologies (e.g., heat pumps, low e windows) and integrating high efficiency solutions with

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
a sufficiently large and skilled workforce needed to construct new low-carbon, high-performance homes and dramatically reduce the energy use of the Nation's existing homes.	capabilities across the entire buildings/construction workforce. •	non-energy related renovations (e.g., comprehensive attic upgrades at time of roof replacement; wall insulation at time of re-siding). • Technical assistance to local governments to inform prioritized investments in market transformation including both individual technologies and whole building solutions (e.g., ABC).
Modeling and Analysis $5,382,000	$10,000,000	+$4,618,000
• Invest in the development of UrbanOpt, EnergyPlus, ResStock, and other modeling and data tools that ensure accurate understanding of how individual buildings use energy as well as how communities can optimize energy use across buildings. • Apply these state-of-the art tools to analyze building typologies across the U.S. and prioritize areas of focus for the Advanced Building Construction Initiative.	• Invest in modeling capabilities, data systems, and tools to assist state and local governments, among others with targeted energy efficiency investments. • Develop tools to assess and maximize energy savings, cost savings, improved reliability and resilience, among other desired outcomes of building investments. • Work with building industry stakeholders to improve consistency in measuring lifecycle carbon in buildings, whether through development of standard specifications, guidance, or other methods.	• Develop more easily applied tools to inform investments of both public and private entities as they design and construct more resilient, low carbon new buildings and fund improvements to existing buildings. • In FY 2021, RBI funded a national building typology study to help target building segments and regions most suited for ABC solutions. In FY 2022, additional analysis using the building typology as a foundation, will similarly inform other BTO activities and strategies.

Description

The Equipment and Buildings Standards area includes two discrete programs: one covering appliance and equipment standards, the other covering building energy codes. The Appliance and Equipment Standards program (ASP) develops national appliance and equipment standards and test procedures, as required by statute. It sets minimum energy and water conservation standards for products covered by statute that are manufactured or imported into the U.S., and can amend the standards over time if technologically feasible and economically justified. ASP regulates the energy or water use (or efficiency) of labor-saving products that ultimately account for the vast majority of energy use in the building sector—nearly 90 percent of all energy used in residences and nearly 60 percent of all energy used in commercial buildings.

DOE is committed to meeting its legislatively mandated deadlines for covered appliances and equipment. The Energy Policy and Conservation Act (as amended) legislatively mandates the program's test procedure and standards rulemaking activities. The rulemaking schedule, and thus the level of program activity, is determined by existing statute.

The Building Energy Codes Program (BECP) fulfills the statutory directives to the Secretary regarding building energy codes. In response to these directives, BTO supports the advancement of aggressive building energy codes, including participating in processes to update model energy codes, making a formal determination as to whether new editions increase energy efficiency in residential and commercial buildings, and providing technical assistance to states and local governments to support code implementation.

Appliance and Equipment Standards Program (ASP)

Standards: The Appliance and Equipment Standards program is required by statute to develop and establish appliance/equipment energy efficiency standards for the purpose of saving the Nation energy. The program is legally required to meet legislative deadlines for issuing new and amended energy efficiency standards. Statute mandates that the Equipment and Buildings Standards program propose amended standards for covered products every six years.

ASP must ensure that the efficiency standards that it issues are technically feasible and economically justified, thereby ensuring that consumers incur no loss of appliance/equipment utility and realize net economic benefits. To maintain the legislative schedule mandated by Congress, the program works with contractors and National Laboratories to conduct analyses to determine the technical feasibility of new standards. Work also focuses on economic analyses to assess the economic justification of new standards. Each standards rulemaking presents its own unique challenges, which require significant data collection and primary research in order to address stakeholder issues as well as intra-governmental reviews. The analyses conducted for ASP often provide valuable information to other programs within EERE that need to assess the cost and benefits of specific research and deployment programs.

Test Procedures: The Appliance and Equipment Standards program is legally required to review test procedures for covered equipment every seven years and either publish amended test procedures or publish a determination that existing test procedures do not need to be amended. In addition, the program is also required to develop new test procedures where they do not exist for newly covered appliances and equipment for which standards will be proposed.

Test procedures are developed to provide additional rigor and accuracy during testing, to address testing requirements necessary to support DOE's certification and enforcement activities, and to better address or clarify testing of additional product designs within a given equipment type, including the need to respond to products and equipment for which testing waivers have been provided in the past. Any test procedures prescribed or amended must be reasonably designed to produce test results that measure energy efficiency, energy use, or in the case of certain products, water use, and in some cases provide a methodology to estimate the annual operating cost of a covered product during a representative average use cycle or period of use. Challenges include identifying and addressing any issues with the current testing and certification process, developing testing solutions that provide for consistent, repeatable, and precise performance measurement, documenting the issues and proposed solutions in the formal rulemaking process necessary to meet DOE's legal and policy requirements, and understanding and responding to stakeholder input as developed during the rulemaking process.

Certification and Enforcement: To ensure the implementation of current standards for covered appliances and equipment, the Equipment and Buildings Standards program has published Certification, Compliance, and Enforcement (CC&E)

regulations for these products and equipment in the Code of Federal Regulations (CFR). These regulations describe how manufacturers must establish certified ratings based on conducting DOE test procedures using a sample of units of a covered product. The regulations also describe how manufacturers must submit certification reports to DOE, and how manufacturers maintain records underlying the certification.

In addition, the regulations describe processes for DOE-initiated testing of products to support enforcing compliance with the certification provisions and the energy and water conservation standards. Efforts for this area of the program are conducted through three primary activities: Support for negotiated rulemaking efforts in the area of CC&E, DOE certification of compliance evaluations as required, and review of manufacturer certification test data as part of product/equipment enforcement cases.

Building Energy Codes Program (BECP): Work under this activity provides technical assistance supporting building energy efficiency and emissions reductions, as well as resilience and other goals, through the development and implementation of building energy codes and standards. DOE is directed by statute to review the technical and economic basis of building energy codes, and participate in processes for their review and modification, including seeking adoption of all technologically feasible and economically justified energy efficiency measures. In addition, DOE is directed to review published editions of the International Energy Conservation Code (IECC) and ANSI/ASHRAE/IES Standard 90.1, and issue a Determination as to whether the updated edition will increase energy efficiency in residential and commercial buildings, respectively, which triggers state building energy code review and update activities. DOE is also directed to provide technical assistance to states to support code implementation, including technical analysis to assess energy and environmental impacts, research to support states in evaluating how their codes are applied in practice, as well as education, training, outreach and tools to help increase compliance in the field and ensure the benefits of building energy codes are realized by American homes and businesses.

In fulfilling its statutory mission, BECP employs an array of strategies across the following activities:

Advancement of National Model Building Codes and Standards: BECP participates in industry processes to develop national model codes, fulfilling DOE's statutory directive. This directive includes seeking adoption of all technologically feasible and economically justified energy efficiency measures and identifying how building energy codes can enhance energy efficiency, resilience, and mitigate the impacts of climate change. In addition, BECP reviews published editions of the IECC and Standard 90.1, and prepares formal Secretarial Determinations as to whether the updated codes increase energy efficiency in residential and commercial buildings, respectively. BECP plans to bolster its technical analysis and support activities in this area, with an emphasis on advanced model codes, as well as stretch codes focused on zero net energy and low-carbon solutions. Furthermore, the Program will provide technical support and guidance for federal, state, and local governments who are considering the emerging, innovative, and flexible Building Performance Standards (BPS) approach to improve the energy use of existing buildings. BECP will conduct analysis and technical assistance to help decision-makers determine appropriate goals and equitable deployment approaches. These activities will yield advanced codes and standards that can be considered by national code bodies or adopted by state and local governments, as well as directly support the Administration's goals related to building energy efficiency, climate and resilience.

Technical Assistance for States and Local Implementation: BECP fulfills the DOE statutory directive to provide technical assistance to states supporting implementation of their building energy efficiency codes. Traditional activities are focused on states and include technical analysis to quantify the impacts of building codes on energy, climate, and resilience. BECP will expand these activities to more directly support local governments, where strong alignment currently exists between federal and municipal goals supporting clean energy, mitigation of climate change, and in creating more equitable policy solutions that ensure the benefits of energy efficiency are realized by all Americans. As part of this expansion, BECP will place an emphasis on support for states, and particularly local governments, pursuing stretch codes and integrated technological solutions that have the potential to increase energy efficiency and optimize cost effectiveness across the range of U.S. climates, buildings types, and construction practices. BECP will also reinstate technical assistance forums that enable the effective exchange of information and successful practices surrounding code implementation (both adoption and compliance), as well as energy code education, training, and outreach initiatives that support states, local governments and the range of critical stakeholders in adapting to evolving design and construction practices.

Equipment and Buildings Standards
Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Equipment and Buildings Standards $55,000,000	**$62,000,000**	**+$7,000,000**
Standards $22,990,000	$22,990,000	$0
• Develop appliance and equipment standards. By establishing national minimum energy efficiency standards, the program's Federal standards preempt product efficiency regulations at the state and local level, reduce regulatory burden for manufacturers and provide them with a larger national marketplace. Energy savings achieved through new or amended standards will contribute to reducing utility bills and carbon emissions as old appliances are replaced with more efficient products.	• The program plans to meet statutory obligations for energy and water conservation standards.	• DOE will maintain necessary activities regarding the development of appliance and equipment standards.
Test Procedures $18,020,000	$19,020,000	+$1,000,000
• Develop and update test procedures to ensure they remain technologically relevant and provide manufacturers with a level playing field and a platform to bring to market new product innovations. For consumers, the program's periodic review of test procedures lays the foundation for reliable and comparable operating cost information for the most common household and business appliances. Purchase and test appliances and equipment to explore the energy use in network/grid-connected mode.	• The program will meet statutory obligations for test procedures. It will continue to issue test procedure waivers.	• The program will contribute to BTO's E3 Initiative effort by testing products and developing a test procedure for cold climate heat pumps.
Certification and Enforcement $3,990,000	$3,990,000	$0
• Ensure products sold in the U.S. meet energy and water conservation standards so that all Americans save money on their energy bills when purchasing new appliances and equipment.	• The program will meet statutory obligations for energy and water conservation standards and test procedures. It will continue to issue test procedure waivers and enforce minimum standards.	• Certification database will be maintained.
Building Energy Codes $10,000,000	$16,000,000	+$6,000,000

• Limit participation in industry processes to review and modify national model energy codes to the minimum required for compliance with statute.	• Participate in industry processes to develop national model codes, fulfilling DOE's statutory directive to seek adoption of all technologically feasible and economically justified energy efficiency measures, and identifying how building energy codes can enhance energy efficiency, resilience, and mitigate the impacts of climate change. • Review published editions of the IECC and Standard 90.1 and issue formal Secretarial Determinations as to whether the updated codes increase energy efficiency in residential and commercial buildings, respectively. • Continue to fulfill all DOE statutory directives related to building energy codes development.	• Increase technical assistance supporting the advancement of national model building energy codes, including support for stretch codes targeting net-zero energy, and identifying how future building codes can better support the Administration's goals related to energy efficiency, climate, and resilience in buildings
• Technical assistance will be limited to maintaining and updating DOE's REScheck and COMcheck software and the energycodes.gov website.	• Provide technical assistance to states, with an expansion of activities to address and more directly serve local governments, to support the implementation of building energy codes. Includes technical analysis to quantify the energy and environmental impacts of updated codes, which inform state and local updated and adoption processes, as well as research, data, education, training, outreach, and tools supporting full compliance in practice. Provide technical assistance forums to enable the exchange of information and successful practices surrounding code implementation. • Continue to fulfill all DOE statutory directives related to building energy code implementation.	• Amplify technical assistance supporting states, and expand activities focused on and more directly support local governments. Includes technical analysis to quantify energy, environmental and economic benefits associated with energy codes at the national, state, and local levels, as well as support targeting the adoption of stretch codes by state and local governments. • Expand energy code education, training, and outreach programs to support states, local governments and the range of industry stakeholders in adapting to evolving design and construction practices.

Weatherization and Intergovernmental Programs

Overview

The mission of the Weatherization and Intergovernmental Programs Office (WIP) is to partner with state and local organizations to significantly accelerate the deployment of clean energy (e.g., energy efficiency and renewable energy) technologies and practices through place-based strategies involving a wide range of government, community, and business stakeholders. These activities contribute to decarbonization efforts, especially for the building sector, provide good-paying jobs with a fair and free choice to join a union and collectively bargain, and secure clean energy economy benefits for all Americans, especially marginalized and low-income communities that have long borne the brunt of pollution.

State governments wield considerable influence in the built environment through upgraded building codes and incentives; in the utility sector through energy efficiency and renewable energy targets and customer programs; and in the industrial sector with policies that encourage efficiency and/or fuel substitutions (such as energy audits and combined heat and power). States advance these energy solutions through strategic energy planning, executive orders, legislation, management of energy efficiency retrofit programs, and land use plans, and WIP extends their reach through regional networks. Local governments are an important bridge between state action and community investment. They have a unique understanding of municipal ecosystems and community needs, and a significant role in revitalization, both of which are critical to integrating innovative energy thinking into infrastructure and the built environment.

Aligning with the President's Build Back Better and American Jobs Plans, WIP addresses the demand and supply sides of energy by facilitating investments in both energy efficiency (demand), and clean energy generation (supply), as well as alternative transportation fuels and vehicles. In FY 2022 WIP's mission supports EERE's goal to accelerate the research, development, demonstration, and deployment (RDD&D) of innovative technologies that will achieve net-zero greenhouse gas emissions, economy-wide, by no later than 2050 and ensure the clean energy economy benefits all Americans, and is delivered through three subprograms: the Weatherization Assistance Program (WAP), the State Energy Program (SEP), and a newly proposed Local Government Clean Energy Workforce Program (LGCEWP).

DOE strives to amplify the transformational impacts of its state-led deployment work in WAP and SEP by expanding the scope of these programs with competitive funding, increased technical assistance to the state and local networks putting advance technologies to work in communities, and conducting impact analyses to ensure benefits are achieved broadly across the U.S. DOE also seeks to establish the Local Government Clean Energy Workforce Program (LGCEWP) within its Office of Energy Efficiency and Renewable Energy (EERE)—a new pathway for providing competitive awards, on-site capacity, peer exchanges, and technical assistance to support the development and deployment of transformative clean energy programs working with qualifying local governments, with a focus on energy communities and disadvantaged or small-to-medium jurisdictions. Within the LGCEWP, WIP proposes to create the Justice for Energy, Workforce, and the Economy across Localities (JEWEL) awards program. This program will operate in coordination with the Building Technologies Office (BTO) Climate and Clean Energy Partnerships for Local Governments program and across DOE and other Federal agencies as appropriate.

WIP and its national networks provide strategic leadership, resource leveraging, and market expertise to accelerate deployment of energy efficiency and renewable energy products and technologies that, where implemented, improve America's energy security and economic prosperity. For decades, states and local governments have demonstrated leadership through their unique authorities to develop and implement energy efficiency and renewable energy policies and programs. WIP employs an integrated approach to deploy cutting-edge clean energy technologies, comprising the following strategic mechanisms:

- Formula grants to support the core capabilities of state energy offices, and a weatherization provider network that assists low-income families through provision of home energy retrofits;
- Competitive awards to support innovative state and local high-impact and self-sustaining clean energy projects;
- Technical assistance to facilitate energy efficiency and renewable energy technology delivery through "best practice" tools, "lead-by-example" methods, peer-to-peer forums, and strategic partnerships; and
- Active management of awardees through on-site reviews and integrated web-based systems for reporting, monitoring, and communication.

Working collaboratively with state and local governments, WIP will deliver on the President's goal of economy-wide decarbonization by:

- Using state energy and weatherization networks and competitive awards to state and local governments to spur widespread adoption of cost-effective energy efficiency and renewable energy technologies delivered by a highly skilled workforce employed in durable, good-paying jobs; and
- Overcoming market, planning, implementation, and financing barriers to enable accelerated deployment of effective clean energy policies and cost-effective clean energy technologies across all communities in our economy, with a focus on improving the economic well-being of impoverished and disenfranchised communities, and/or communities that have been marginalized or overburdened.

Highlights of the FY 2022 Budget Request

The Weatherization Assistance Program (WAP) helps eligible low-income households reduce the comparatively large percentage of available income that they spend on energy. Highlights include:

- Completion of approximately 50,000 low-income residential energy retrofits;
- Establishment of a $21 million "Weatherization Readiness Fund" to address structural or health and safety repairs needed to low-income homes that are not provided for under current WAP funding allocations, but will ensure the energy efficiency benefits can be realized by those with the greatest need (. A portion of this funding will be targeted at repeat customers of Low-Income Home Energy Assistance Program support);
- Exploration and development of methodologies to estimate non-energy impact savings and evaluate the feasibility of including them in determining inclusion of energy conservation measures in WAP retrofits, as provided in section 1011(c) of the Energy Act of 2020;
- WAP Innovation and Enhancement funds of up to 6 percent (up to a maximum of $25 million) to competitively select and manage projects on improvements in indoor air quality, advanced technologies, and workforce development;
- Sustainable Energy Resources for Consumers (SERC) awards of up to 2 percent of WAP funding (approximately $8.0 million) for installation of renewable technologies in low-income dwellings;
- Continued improvements in workforce training, quality standards, and worker certification to improve the quality of the work performed;
- Equitable statewide distribution review of DOE WAP funds to understand the energy burden on a by county basis and development of best practices and tools to assist state-level staff in making allocation decisions;
- Development of targeted resources to further quality installation of energy conservation measures, develop workforce, and coordination with other funding streams through existing interagency working group; and
  Provide and expand technical assistance and training through the existing Weatherization Training Center (WTC) network and the activities described above in order to build capacity to ensure effective execution of the American Jobs Plan funding.

The State Energy Program (SEP) will continue to support the core capacity and advance innovation in state energy offices and dissemination of best practices to:

- Maintain a portfolio of diverse energy efficiency and renewable energy programs and policies through an active network of state energy offices with the capacity to develop, improve, and implement these initiatives through the provision of funding through formula grants;
- Design and launch the Build Back Better Challenge grants to support early action on clean energy deployment and incubate novel approaches to clean energy technology deployment, prioritizing investments that meet energy needs at the local level, and are inclusive in elevating impoverished and disenfranchised communities, and/or communities that have been marginalized or overburdened;
- Provide targeted technical assistance to states to advance transformative solutions for reducing energy use in government facilities; accelerating investment in public sector use of energy service performance contracts; and supporting high-impact projects focused on development and implementation of state poling barriers limiting investment in energy efficiency and renewable energy, including self-sustaining financing models; and
- Build capacity through technical assistance to state energy office staff on grant management requirements and clean energy deployment strategies to ensure efficient and effective execution of the proposed American Jobs Plan block grant funding.

EERE seeks to establish the Local Government Clean Energy Workforce Program (LGCEWP) to:

- Provide targeted competitive awards, on-site capacity, peer exchanges, and technical assistance to support the development and deployment of transformative clean energy programs of qualifying local governments, with a focus on energy communities and disadvantaged and small- (under 100,000 residents)-to-medium (under 250,000 residents)-jurisdictions;
- Operate in partnership between EERE's Weatherization and Intergovernmental Programs Office (WIP) and Building Technologies Office (BTO), and in coordination across DOE and other Federal agencies as appropriate.; and
- Empower American cities, counties, and communities with high impact, place-based low-carbon solutions tailored to their needs, and developing and using a local workforce, with a focus on local clean energy programs that target environmental justice and workforce development outcomes.

Weatherization and Intergovernmental Programs
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Weatherization and Intergovernmental Programs				
Weatherization				
Weatherization Assistance	305,000	310,000	390,000	80,000
Training and Technical Assistance	3,500	5,000	10,000	5,000
Weatherization Readiness Fund	0	0	21,000	21,000
Total, Weatherization	**308,500**	**315,000**	**421,000**	**106,000**
State Energy Program	62,500	62,500	362,500	300,000
Local Government Energy Program	0	0	25,000	25,000
Total, Weatherization and Intergovernmental Programs	**371,000**	**377,500**	**808,500**	**431,000**

Weatherization and Intergovernmental Programs
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Weatherization Assistance Program: The FY 2022 Budget Request includes an increase of $80 million for formula grants supporting weatherization retrofits to ensure a total of 50,000 low-income homes receive these services. An increase of $5 million will enhance workforce training, quality standards, and worker certification, and also fund work to explore and develop methodologies to estimate non-energy impact savings and evaluate the feasibility of including them in determining inclusion of energy conservation measures in WAP retrofits. An additional $21 million is included to establish a "Weatherization Readiness Fund" to address structural or health and safety repairs needed before some low-income homes in most need of the energy efficiency benefits are eligible for weatherization assistance. A portion of this funding will be targeted at repeat customers of Low-Income Home Energy Assistance Program support.	**106,000**
State Energy Program: The FY 2022 Budget Request includes $300 million to design and launch the Build Back Better Challenge grants program to support early action on clean energy deployment and incentivize incubation of novel clean energy technology deployment approaches. DOE will gather input from states, local governments, and community stakeholder groups, including engaging with frontline communities, on the focus and design of these grants. This funding will help build capacity to ensure efficient and effective execution of block grant funding proposed in the President's American Jobs Plan. This new place-based initiative will support a variety of competitive energy projects that will have high impact/high-visibility and replicability to other state and local entities.	**300,000**
Local Government Energy Program: A total of $25 million in funding will launch the Justice for Energy, Workforce, and the Economy across Localities (JEWEL) program. WIP will administer $20 million in competitive awards focused on assisting local entities including energy communities willing to take measurable steps and/or make commitments to progress in one or more major sectors of the local energy economy while not yet ready to set economy-wide decarbonization targets or goals. WIP will also manage $5 million in a decarbonization technical assistance fund to address broader needs.	**25,000**
Total, Weatherization and Intergovernmental Programs	**431,000**

Weatherization and Intergovernmental Programs
Weatherization Assistance Program

Description

The Weatherization Assistance Program (WAP) is a foundational building block of DOE's vision for a clean energy future for all, delivering on its national objective to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety. WAP activities reduce the cost of residential household energy bills, which are significantly disproportionately higher relative to higher income households. Up to 40 million low-income households in the U.S. are eligible for low-income housing energy assistance.[1] Since 1976, WAP has performed 7 million upgrades to low-income households, including 1 million retrofits supported through American Recovery and Reinvestment Act of 2009[2] funding. From the 38,045 supported home retrofits in FY 2019, estimated savings of $215 million will accrue to these low-income households over the 20-year life of the measures installed. A total of $421 million is requested for DOE's Weatherization Assistance Program in FY 2022, including funding for a new Weatherization Readiness Fund and a non-energy benefits impacts analysis.

Weatherization Assistance ($400,000,000): The primary focus of funding in the FY 2022 Budget Request is to provide formula grants to 50 states, the District of Columbia, 5 U.S. Territories and 1 Native American Tribe to support nationwide delivery of services - resulting in at least 50,000 homes receiving weatherization services and allowing eligible low-income families to use retrofit enabled energy cost savings to purchase other basic needs (like food, medicine, and other essentials). The formula grant allocations include funds for state-managed training and technical assistance (State T&TA) activities, at approximately 17 percent of total WAP funding.

The WAP formula grants support the largest and one of the most technically advanced networks of residential energy retrofit providers in the country, providing a foundation for related services funded by other Federal and non-Federal sources. Funds are allocated on a statutory formula basis and awarded to a single agency (referred to collectively as Grantees) within each recipient's jurisdiction that manages the deployment of services to increase the energy efficiency of homes occupied by families with household incomes of 200 percent or less of the Office of Management and Budget's Annual Poverty Guidelines. These agencies, in turn, contract with approximately 700 local service provider organizations, including Community Action Agencies and local governmental and nonprofit agencies, providing approximately 8,500 jobs and delivering weatherization services to low-income families in every geographic area of the country.

Weatherization service providers choose the best package of efficiency measures for each home based on a comprehensive energy audit. Typical energy conservation measures include installing insulation, sealing ducts, repairing or replacing heating and cooling systems, reducing air infiltration, improving hot water production and use, and reducing electric base load consumption. The consistent delivery of quality services is addressed through active Federal, regional and state training and technical assistance programs. The program leverages both Federal and non-Federal funding sources[3] to expand the array of services available for each home or to increase the number of homes weatherized.

The State T&TA funding enables Grantees to develop, train, and continually improve the skills of the local workforce performing weatherization retrofits. State T&TA funds may be used for technical and non-technical training for Grantee staff and their subgrantees, including training contractors that work within their DOE-funded weatherization program. Activities must be designed to maximize energy savings, minimize production costs, improve program management and crew/contractor "quality of work," and/or reduce the potential for waste, fraud, abuse, and mismanagement. Grantees must ensure their respective training plans include a provision to provide comprehensive training aligned to the job-task analysis (JTA) of their profession (Quality Control Inspector, Energy Auditor, Crew Leader and Retrofit Installer) on a regular basis for all field workers.

[1] U.S. Department of Energy, Weatherization Assistance Program Briefing Book (Draft Copy), December 2019.
[2] http://www.gpo.gov/fdsys/pkg/PLAW-111publ5/pdf/PLAW-111publ5.pdf .
[3] National Association of State Community Services Programs, Weatherization Assistance Program Annual Funding Report, 2019.

DOE will also implement a second year of Innovation and Enhancement competitive awards, as provided for in the recent reauthorization of WAP (P.L. 116-260). In the FY 2022 Request, DOE will allocate up to a maximum of $25 million of WAP funds to award competitive proposals that create model strategies and approaches targeted to: (1) workforce development and training; (2) addressing indoor air quality related to mold and moisture and occupant health conditions (e.g. asthma, COPD and others); and (3) braiding funds from other sources as a more flexible and sustainable means of addressing the causes of deferral. DOE intends that best practice models in the third topic area will in time obviate the need for a dedicated Weatherization Readiness Fund, as included in this budget proposal.

In FY 2022 DOE intends to use up to 2 percent of WAP funding (approximately $8 million) for Sustainable Energy Resources for Consumers (SERC) awards, as allowed per Title IV of the Energy Independence and Security Act of 2007.[1] As listed in EISA, Section 411(b), the purposes of the SERC Grants are to: (1) expand WAP for residential buildings to include materials, benefits, and renewable and domestic energy technologies not covered by the Program; and (2) work with existing partners to expand and enhance the Program. SERC grants have not been implemented in WAP since 2010. During this time major changes in available types and cost profiles for energy technologies provide real opportunities to avail low-income communities greater access to renewable energy resources.

Training and Technical Assistance: Up to a maximum of 3 percent of total WAP funding is targeted to DOE Headquarters-managed training and technical assistance (HQ T&TA). In FY 2022, DOE plans to use $10 million for HQ T&TA activities. WAP's HQ T&TA funds are used to conduct a nationally focused portfolio of research, modeling, work performance guidelines and education, and hands-on support services that sustains the entire WAP network and its workforce. These activities are designed and developed annually to improve program effectiveness, service delivery, resource accountability, and operational efficiency. Specifically, HQ T&TA funds support the development and implementation of a variety of tools needed to implement work quality, training accreditation, and workforce development across the 57 recipient agencies DOE partners with to deploy low-income weatherization services. Some examples of the WAP T&TA activities to be undertaken in FY 2022 include:

- Maintenance and upgrades to the standard work specifications (SWS) online tool (https://sws.nrel.gov/). This tool houses the SWS for home energy upgrades, which serves as the backbone of the WAP's work quality initiatives. The enhanced functionality of the tool allows grantees to develop work quality standards as well as illustrated field guides, work orders and checklists. The SWS requires regular review and updating to ensure it is current with codes, technology, and best practice for residential upgrades. The SWS online tool requires ongoing maintenance to respond to user's needs and ensure consistent functionality.
- Maintenance of the home energy professional (HEP) certifications and their underlying resources, such as the job task analyses and certification schemes. The HEP quality control inspector certification is required of all Grantees and must be maintained in order to retain their American National Standards Institute (ANSI) accreditation.
- Development of training resources to respond to continually evolving needs in the field, including an enhanced curriculum, updating of the ASHRAE 62.2 curriculum, and updating several modules related to weatherizing multi-family buildings.
- Upgrade of and enhancements to the suite of energy auditing tools for single family buildings, mobile homes, and multi-family buildings -- including user requested changes and modeling of non-energy benefit of water measures. For example, a non-energy benefit, such as sewer and water costs savings, can be readily attributed to the installation of showerheads and aerators, which are measures WAP may install.
- Evaluation of service delivery models to ensure equitable distribution of benefits. By design the Weatherization Assistance Program serves households disproportionately impacted by energy costs and inefficient homes. Based on a June 2020 report by Oak Ridge National Laboratory (ORNL), the energy burden for the WAP-eligible population was estimated at 13.9 percent compared to 3.0 percent for higher-income U.S. households. This report will be updated as new data is available and may also assist DOE in identifying regions where high energy burden correlates with other factors such as household demographics or environmental justice communities. Within the population of WAP-eligible households it is important to ensure services are provided equitably; for example, eligible housing types are served proportional to the percentages in a specific service territory or geography. Service delivery will be studied from two

[1] Energy Independence and Security Act of 2007, Section 411(b). Pub. L. 110–140, title IV, §411(b), Dec. 19, 2007, 121 Stat. 1600. https://www.govinfo.gov/content/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

perspectives, with the goal of identifying and sharing best practices and strategies among the weatherization provider network. Service providers and stakeholders will be engaged throughout this work, and the scope includes:

- A review of Grantee allocation formulas to identify strategies for fair and equitable distribution of funds. This study will also seek to identify opportunities to enhance allocation formulas with newly available national data (Residential Energy Consumption (REC), Census, etc.), and develop technical assistance resources relevant to designing and implementing allocation formulas.
- A potential study for housing types that may be historically underserved, reviewing data from all service area types (urban, rural, etc.). Input from the weatherization network will be critical in identifying existing barriers to service and the HQ T&TA resources DOE may develop to assist in overcoming identified barriers.
- Up to $1 million of FY 2022 WAP HQ T&TA funding will be used to explore and develop methodologies to estimate non-energy impact savings and evaluate the feasibility of accounting for them in determining inclusion of energy conservation measures in WAP retrofits. On average weatherization reduces annual household energy costs by $283, and results in an average first-year savings of 29.3 MMBtus per site-built home.[1] It is generally acknowledged that the Weatherization Assistance Program also positively impacts household (e.g., available income, improved comfort) and societal issues (e.g., water savings, avoided emissions, economic development), but that these non-energy impacts are more difficult to quantify. DOE will continue its work to develop savings estimates for non-energy impacts to provide a more holistic measure of the community benefits realized by the program. A longer-term goal of this work is integrating non-energy impacts in the cost-effectiveness test for weatherization services.

- Continuity of DOE coordination with partner Federal agencies to ensure client eligibility is streamlined with Health and Human Services Low Income Home Energy Assistance Program and the Housing and Urban Development Lead Hazard Control and Healthy Homes Program. The scope of work will be expanded to develop tools and technical assistance resources for WAP Grantees, including a framework for braiding multiple funding sources in low-income households and advancing environmental justice and energy equity in local communities throughout the country.

Weatherization Readiness Fund ($21,000,000): A total of $21 million in the President's Budget request is for creation of a home repair fund to address structural and health and safety issues to reduce the frequency of deferred homes that are not weatherization-ready when WAP work crews enter the home to perform retrofit services. Deferral of service occurs when the condition of the home renders delivery of weatherization services unsafe or ineffective. WAP crews are often the first or only home services professionals to enter these homes and observe these issues. Deferral means work must be postponed indefinitely until the structural deficiency or health and safety hazard can be resolved, and many low-income households are unable to afford the necessary repairs, particularly in homes of underserved and disadvantaged communities. These funds would be distributed using the existing State T&TA allocation process for each WAP Grantee. This would address the goals of environmental justice and equity and expand the number of homes that can be weatherized. A 2020 report conducted by the Federal Reserve Bank of Philadelphia and PolicyMap[2] demonstrates that households with the highest rates of repair needs nationally are people living below the federal poverty line (42.9 percent). The report also estimates an average cost of $2,920 per household with repair needs. In addition, low-income, older homeowners had the highest average repair cost across all groups ($4,187). In FY 2019, DOE reporting indicates 47 percent of WAP households were elderly. Using the cost repair figures from the study and WAP Grantee reporting:

[1] ORNL/TM-2014/338, Weatherization Works: Summary of Findings from the Retrospective Evaluation of the U.S. Department of Energy's Weatherization Assistance Program, September 2014.

[2] Federal Reserve Bank of Philadelphia and PolicyMap, The Cost to Repair America's Housing Stock—and Which Homes Need It, 2019.

Homes Weatherized per Year	Homes Needing Repair	Estimated Homes Needing Repair	2019 WAP Households Served		# of homes	Average Cost of Repairs	WAP Funds Needed
35,000	42.9%	15,015	Not Elderly Occupied	53%	7,958	$2,920	$23,237,214
			Elderly Occupied	47%	7,057	$4,187	$29,547,868
						TOTAL	**$52,785,082**

The request of $21 million to create a Weatherization Readiness Fund provides a first test of this approach as a real-time, onsite remedy for these structural repair issues. The establishment of these funds separately from the formula funds and State T&TA includes exclusion from WAP's Savings-to-Investment Ratio (SIR) of 1.0 or greater. Specifying this amount of funding as excluded from SIR will allow WAP to repair homes that otherwise would be deferred. WAP expects to increase production, up to 5 percent nationally, by no longer having the sunk costs of auditing/deferring units that never actualize into completions. The expansion of WAP to include this new budget category is the most practical means to dramatically increase the impact of Federal funds utilized in the weatherization of low-income households. A portion of this funding will be targeted at repeat customers of Low-Income Home Energy Assistance Program support.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Weatherization $315,000,000	**$421,000,000**	**$106,000,000**
Weatherization Assistance $310,000,000	$390,000,000	+$80,000,000
• Award and actively manage 57 weatherization formula grantees, which will support over 38,000 comprehensive energy audits and residential energy retrofits. • WAP Innovation and Enhancement: under P.L.116-260 WAP will competitively award and manage agreements that focus on workforce development, indoor air-quality, advanced technologies, and decrease the number of deferrals.	• Award and actively manage 57 weatherization formula grantees, which will support approximately 50,000 or more low-income residential energy retrofits. • Manage Sustainable Energy Resources for Consumers (SERC) awards process for installation of renewable technologies in low-income dwellings. • Competitively select and manage WAP Innovation and Enhancement projects for improvements in indoor air quality, advanced technologies, and workforce development.	• Number of homes weatherized annually with increased DOE funding • Demonstrates a greater number of innovative projects to: increase utilization of renewable technologies and improve indoor air quality, advanced technologies, and workforce development.
Training and Technical Assistance $5,000,000	$10,000,000	+$5,000,000
• Maintenance and improvement of the Guidelines for Home Energy Professional suite of resources including the Standard Work Specifications, Home Energy Professional Certifications, and Training Program Accreditation. • Congressionally-directed activity: implement and demonstrate programs to treat harmful substances, including vermiculite, at the State and regional level. • Congressionally-directed activity: develop a pilot that supports community and neighborhood scale weatherization. • Congressionally-directed activity: continue DOE coordination with partner Federal agencies to ensure client eligibility is streamlined with Health and Human Services Low Income Home Energy Assistance Program, the HUD Lead	• Continued improvements in workforce training, quality standards, and worker certification to improve the quality of the work performed. • Equitable statewide distribution review of DOE WAP funds to understand the energy burden on a by county basis and development of best practices and tools for Grantee use to assist state-level staff in making allocation decisions. • Develop targeted resources for WAP Grantees to further quality installation of energy conservation measures, develop workforce, and coordination with other funding streams through existing interagency working group. • Exploration and development of methodologies to estimate non-energy	• Expands quality work standards, worker training and certifications, and grantee management and capabilities. • Expands work on energy burden assessments and the development of tools and resources in order to ensure equity in service delivery, housing type, and disadvantaged communities. • Expands resources to the program to ensure Grantees understand how to braid different funding sources in order to install a broader range of energy efficiency measures. • Proactively addresses Congressional and stakeholder interest in changes to the Savings-Investment Ratio to include non-energy impacts benefits of weatherization.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Hazard Control and Healthy Homes Program, and the Department of Veterans Affairs. • Continue improvement of grantee and subgrantee performance through state plan process with expansion and enhancement of WAP Quality Management and Work Plans features. WIP will conduct a gap analysis of training needs and identify available resources to fill these needs. Tools will be developed for DOE staff and Grantees to aid in assessment of training needs and to develop curricula around management topics. WAP will also continue targeted technical assistance of the Quality Work Plan through the state plan process, which includes a review of the current certified quality control inspectors by grantee.	impact savings and evaluate the feasibility of including them in determining inclusion of energy conservation measures in WAP retrofits. • Continuity of DOE coordination with partner Federal agencies to ensure client eligibility is streamlined with Health and Human Services Low Income Home Energy Assistance Program and the Housing and Urban Development Lead Hazard Control and Healthy Homes Program.	
Weatherization Readiness Fund $0	$21,000,000	+$21,000,000
	• Establishment of a $21 million "Weatherization Readiness Fund" to address structural or health and safety repairs needed to low-income homes that are not provided for under current WAP funding allocations.	• Proactively addresses Congressional concerns on weatherization "deferrals" issue. • Increases throughput of weatherized homes by up to 5 percent.

Weatherization and Intergovernmental Programs
State Energy Program

Description

The State Energy Program (SEP) strategically engages the leadership of states in deploying clean energy technologies across the U.S. SEP funding transforms the energy economy state by state, establishing and implementing clean energy policies, plans, and programs to reduce energy costs, enhance economic competitiveness, improve emergency planning, and improve the environment. States have purview over many of the policy and program levers that can catalyze greater investment in clean energy and help the country realize the suite of economic and environmental benefits (including reduced greenhouse gas emissions) associated with clean energy. SEP provides states with capacity building resources, technical assistance, and best practice sharing networks to facilitate the adoption of plans, policies, and programs appropriate to state and regional circumstances.

A portion of the FY 2022 funding will provide foundational formula-based grants to 50 states, Washington, D.C., and 5 U.S. territories to advance their energy priorities through the design and implementation of energy efficiency and renewable energy programs. These grants support state energy offices in their development and implementation of energy programs that deploy portfolios of clean energy technologies addressing their specific goals and needs. A broad range of activities encompass the state energy offices' formula work, including: energy planning; building energy code adoption, in coordination with BTO, implementation and compliance; financing mechanisms for institutional retrofit programs; loan programs; energy savings performance contracting to retrofit government buildings and facilities; comprehensive residential energy programs for homeowners; transportation programs that accelerate the use of alternative fuels, including electric vehicles and infrastructure; and programs that remove barriers and support supply side and distributed renewable energy.

In FY 2022, SEP will continue its collaboration with states in two key initiatives that leverage states' formula-based work:

- Technology Action Groups (TAGs) are a new pilot initiative to be launched in summer 2021 to facilitate collaboration among states, leveraging SEP formula funding. DOE is providing states the opportunity to opt-in to participate in a group collaboration convened by DOE on one of three topic areas: (1) managing peak demand with energy storage, (2) onsite energy systems at critical facilities, and (3) main street revitalization. Participation in the TAGs is voluntary and will allow states to coordinate their efforts and receive topic-specific technical assistance from DOE. SEP will work with states to develop actionable plans for progress in the TAG topic areas. The collaboration will also design tools, document case studies, and create model strategies that can be used by all states interested in replicating the successful outcomes of these collaborations.
- Field Technology Validation in public sector use cases is aimed at creating a more cohesive and cross-cutting technology deployment strategy informed by state needs and expertise. Working with state energy offices and a few interested local government agencies, WIP is piloting a public sector feedback loop for DOE program offices (the Building Technologies Office [BTO], Weatherization and Intergovernmental Programs [WIP], the Federal Energy Management Program [FEMP], and the Advanced Manufacturing Office [AMO]) to inform the DOE's efforts on energy efficiency technology development, validation, and deployment. Initial activities include educating state partners about how field technology validations are conducted and providing technical assistance potential use cases and clean energy technology procurement. Next steps include supporting two to three validation projects in public buildings that help DOE test cost-effective, underutilized, deployment-ready energy-efficient technologies that reduce greenhouse gas emissions technologies and align with EERE and state clean energy and equity goals.

In FY 2022, DOE proposes to target $300 million of State Energy Program funds to initiate the Build Back Better Challenge Grants competition. These grants will leverage the SEP special project authority to incentivize state energy officials and their partners to incubate novel approaches to clean energy technology deployment, prioritizing investments that meet energy needs at the local level, and are inclusive in improving the economic well-being of impoverished and disenfranchised communities, and/or communities that have been marginalized or overburdened. Clean energy technology deployment is essential to decarbonizing the U.S. economy. To be successful, it is critical to design deployment strategies that meet the needs of the communities these clean energy technologies will serve and to foster the workforce with the skills necessary to develop, demonstrate and deliver them. Through the Build Back Better Challenge Grants Program DOE will award state, local, territorial and tribal block grants allocated on a competitive basis that are designed to encourage state- and local-

level early action, leadership and partnership with the U.S. Government in a nationwide push to meet the President's clean energy goals. States and other jurisdictions would earn bigger awards by enacting stronger policies, but criteria would be set to enable maximum participation. Grant funds could be used for a range of purposes that would accelerate clean energy deployment consistent with the President's goals but tailored to suit the needs of their states.

DOE will gather input from state energy offices, local governments, community stakeholders and others in advance of designing the program. A variety of mechanisms will be used to get feedback from a broad spectrum of parties and solicit views from the broader public on the highest priority needs and issues that could be best addressed through the competitive grants program.

The opportunity for competitive awards will also enable collaboration on sector, regional, and/or nationally focused initiatives aimed at finding solutions to overcome barriers in meeting their clean energy economy goals. These competitive projects also provide opportunities for these entities to submit innovative proposals addressing issues specific to their situations and to leverage other funding to create sustainable, high-impact solutions in energy efficiency and renewable energy development.

A portion of SEP funds will also provide technical assistance to state energy offices and related stakeholders, in support of WIP activities. SEP technical assistance tools, resources, and voluntary initiatives support state clean energy leadership, including developing plans and programs, establishing financing, implementing data management, and empowering organizations. Technical assistance is an interdependent component to the financial assistance activities—making technology deployment more efficient and effective, and enhancing the likelihood of program success. Technical support resources are integral to:

- Developing tools and solutions that address pervasive barriers;
- Creating national energy initiatives and strategic partnerships focused on deployment and sharing best practices;
- Convening peer exchanges to showcase replicable models;
- Providing technical data and information from leading experts;
- Improving web-based reporting and monitoring systems; and
- Adopting metrics that support quantitative and qualitative evaluation of state planning activities.

SEP is supporting states' workforce development efforts by conducting research, providing information, and facilitating peer exchange. SEP is working with DOE's National Renewable Energy Laboratory (NREL) to compile state-by-state forecasts for clean energy jobs in the next five to ten years. SEP's efforts are intended to help states fill existing critical clean energy jobs that will support emissions reductions and environmental justice, as well as create new jobs.

In addition to the work outlined above, SEP funding has supported technical assistance initiatives that have made significant progress. These activities produced significant results in FY 2021 and will continue in FY 2022. Examples include:

- The Sustainable Wastewater Infrastructure of the Future (SWIFt) Initiative will continue under the expanded scope launched in Phase II in 2021. SWIFt Phase II activities focus on achieving two goals: (1) engage 200 water resource recovery facilities (WRRFs) in a voluntary partnership to achieve five percent short-term and 25 percent long-term facility-wide energy savings; and (2) work with 25 WRRFs to implement at least one next-generation technology (e.g., renewable energy, resource recovery, and advanced data management). These activities leverage the Wastewater Energy Management Toolkit of SWIFt Phase I tools and resources more than 70 WRRFs used to cumulatively achieve 131 million kWh in energy savings.
- The Sustainable Corrections Infrastructure Partnership (SCIP) Accelerator is a voluntary partnership of federal, state, and local public correctional facilities working with DOE over three years to achieve portfolio-wide energy savings of 20 percent and create replicable solutions to catalyze energy resilience in the corrections sector. SCIP partners represent over 20 percent of the correctional facilities in the U.S.
- Public sector partnerships in EERE's Better Buildings Challenge working with more than 75 public sector entities who have committed to reduce energy and/or water intensity by 20 percent or more. As of 2019 data, public-sector partners have saved $790 million, 83 trillion Btus, and 1.8 billion gallons of water. The Energy Savings Performance Contracting (ESPC) Municipalities, Universities, Schools and Hospitals (MUSH) Market Working Group will support expanded ESPC best practices for the MUSH market and state and local ESPC programs.

- The State and Local Planning for Energy (SLOPE) Platform is a collaboration across EERE and with NREL to integrate and deliver data on energy efficiency, renewable energy, and sustainable transportation into an easy-to-access online platform to enable data-driven state and local energy planning.
- SEP partners with the National Association of State Energy Officials (NASEO) to enhance collaboration with states. NASEO provides direct technical assistance to all 56 State and Territory Energy Offices (SEOs) in support of state energy efficiency and renewable energy programs. NASEO is the only non-profit organization for all 56 governor-designated SEOs in the states, territories, and District of Columbia. WIP funds NASEO through a multi-year cooperative agreement that includes in-person workshops, peer exchanges, written deliverables, and state-focused outreach to support the delivery of energy efficiency and renewable energy programs in states and ensure coordination between DOE and the SEOs.

State Energy Program
Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2021 vs FY 2022
State Energy Program $62,500,000	**$362,500,000**	**+$300,000,000**
• Advance deployment of effective energy efficiency and renewable energy policies and technologies by state governments. • Award and actively manage 56 formula grants supporting in state energy projects. • Actively manage 20+ competitive awards in a variety of areas including comprehensive energy planning, public-private efforts to expand use of and development of new financing and Property Assessed Clean Energy (PACE) financing models, benchmarking and disclosure, and resilience at the local government level. • Continue with Phase II expansion of the Sustainable Wastewater Infrastructure of the Future (SWIFt) initiative. • Develop and deliver a portfolio of strategic technical assistance offerings to state energy offices.	• Advance deployment of effective energy efficiency and renewable energy policies and technologies by state governments. • Award and actively manage 56 formula grants supporting ($56,000,000) in state energy projects. • Launch the Build Back Better Challenge Grants Program ($300,000,000) to incentivize state energy officials and their partners to incubate novel approaches to clean energy technology deployment, prioritizing investments that meet energy needs at the local level, and are inclusive in improving the economic well-being of impoverished and disenfranchised communities, and/or communities that have been marginalized or overburdened. • Continue with Phase II of the Sustainable Wastewater Infrastructure of the Future (SWIFt) initiative and Sustainable Correctional Infrastructure Partnership (SCIP). • Develop and deliver a portfolio of strategic technical assistance offerings to state energy offices and in sectors that focus on areas of joint state and local interest and collaboration.	• Initiate Build Back Better Challenge Grants Program ($300,000,000) to incentivize state energy officials and their partners to incubate novel approaches to clean energy technology deployment, prioritizing investments that meet energy needs at the local level, and are inclusive in improving the economic well-being of impoverished and disenfranchised communities, and/or communities that have been marginalized or overburdened.

Weatherization and Intergovernmental Programs
Local Government Clean Energy Workforce Program

Description

EERE's Local Government Clean Energy Workforce Program is a place-based initiative that will empower American cities, counties, and communities with high impact, low-carbon solutions tailored to their needs, and developing and using a local workforce. As one key component of this program, WIP will administer the Justice for Energy, Workforce and the Economy across Localities (JEWEL) program, comprising competitive awards, on-site capacity, peer exchanges, and technical assistance to support the development and deployment of transformative clean energy programs, of qualifying local governments, that create good paying jobs. Emphasis will be placed on disadvantaged and energy communities or small-to-medium jurisdictions that are committed to but in the earlier phases of progress toward transformative energy technology and/or meeting a clean energy or decarbonization target or set of goals. Assistance will be targeted for clean energy programs and models that accelerate project delivery and deployment toward measurable outcomes and local initiatives. Assistance will include local efforts that address energy equity, diversity, and inclusion. Topics for awards, technical assistance, and other program activities will be coordinated across EERE, other DOE program offices, National Laboratories, and other Federal agencies as appropriate.

Local governments are increasingly leaders in decarbonization, climate and economic justice, and workforce transitions, creating a need to establish plans and programming that balance the needs of local public agencies, private enterprises, non-governmental organizations, community members, and utilities that serve these jurisdictions. Implementing lasting changes requires inclusive planning that incorporates a cross-sector approach. Local governments are uniquely positioned to develop programs that extend beyond isolated, short-term initiatives, and target long-range, community-based goals that connect clean energy, environmental justice, and workforce development priorities through a coordinated strategy. The JEWEL program will enable WIP to enhance its ability to support these critical local government stakeholders through a new era of clean energy program development and deployment.

Building on over 140 existing local government partnerships and its history of working with over 2,000 local governments as a part of the Energy Efficiency Conservation Block Grant (EECBG) program, WIP will administer $20 million in JEWEL competitive awards to up to 20 or more local governments that are committed, but in the earlier phases of progress toward transformative energy technology and/or meeting a clean energy/decarbonization target or set of goals and that create good paying jobs. These local entities are willing to take measurable steps to progress in one or more major sectors of the clean energy economy; however, they may not yet be ready to set economy-wide decarbonization goals.

WIP will also administer a $5 million decarbonization technical assistance fund to scale best practices across a broad base of local entities beyond competitive awardees. WIP will leverage technical assistance implementation models to establish and utilize local expertise as part of its technical assistance strategy. WIP will also explore existing technical assistance delivery models, including a voucher program, in designing this aspect of the program. Examples of technical assistance areas include community engagement with a focus on environmental justice, goal-setting, energy data management, financing, strategic planning, and in partnership across EERE, implementation of clean energy technologies.

This program will support transformative clean energy programs in local jurisdictions with a focus on one or multiple pillars:

- Achieving decarbonization: Targeted toward communities willing to take measurable steps and/or make commitments to progress in one or more major sectors of the local energy economy while not yet ready to set economy-wide decarbonization targets or goals.
- Advancing climate and economic justice: Preference for disadvantaged communities with a high energy burden.
- Leading workforce transitions toward clean energy futures: Intended to support workforce development and training for local careers in a clean energy economy.

Local Government Energy Program
Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2021 vs FY 2022
Local Government Clean Energy Workforce Program $0	**$25,000,000**	**+$25,000,000**
• No funding requested.	• Deliver replicable, place-based competitive awards and technical assistance to support localized decarbonization initiatives that creates good paying clean energy jobs in energy communities and disadvantaged communities. • Ingrain environmental justice and clean energy workforce development outcomes in local energy program planning.	• New FY 2022 program.

Program Direction

Overview

Program Direction enables EERE to maintain and support a world-class Federal workforce that supports EERE's mission to accelerate the research, development, demonstration, and deployment (RDD&D) of innovative technologies that will transition Americans to net-zero greenhouse gas emission, economy-wide, by no later than 2050 and ensure the clean energy economy benefits all Americans. The FY 2022 Program Direction Request provides resources for program and project management, oversight activities, contract administration, workforce management, IT support, and Headquarters (HQ) and field site non-laboratory facilities and infrastructure. In addition, the request builds capacity to support efficient implementation of the American Jobs Plan.

Highlights of the FY 2022 Budget Request

The FY 2022 EERE Program Direction Budget Request will:

- Support 825 FTEs at Headquarters, the Golden Field Office, and the National Energy Technology Laboratory.
- Support strengthening EERE's overall performance, organization, budget, laboratory management, operations, human capital, and project management while achieving significant cost savings; and
- Support project management and procurement across EERE's full portfolio of projects, including closing out completed financial assistance awards.
- Build capacity to ensure American Jobs Plan programs are implemented efficiently and effectively.

Salaries and Benefits: The Request assumes a 2.7 percent federal staff pay increase, annualization of the 1.0 percent increase from 2021 as well as increased funding to support up to 825 FTE. This increase in FTE reflects EERE's need for additional Federal staff in areas such as in the appliance standards development and building codes development, FEMP technical assistance to assist agencies in transitioning to carbon-free electricity and fleet electrification, and to support EERE's programmatic priorities.

Support Services: The Request includes additional funds for contract support to implement programmatic priorities. Hiring and retaining staff needed to achieve EERE's mission continues to be a priority, and the Request also provides increased funding for activities associated with attracting a diverse workforce and onboarding staff in an efficient manner.

Other Related Expenses: Improving the tracking and evaluation of EERE's investments to make sure every dollar is contributing to mission, with helpful but not onerous metrics and performance processes is a FY 2022 priority for EERE. The Request includes increased funding for information technology systems development to ensure EERE can collect and analyze data on its investments. The Request also provides an increase for information technology needs to support EERE's increased staffing planned for FY 2022 including support to ensure the EERE workforce can execute its mission remotely as needed.

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Program Direction			
Washington Headquarters			
Salaries and Benefits	86,380	76,617	103,882
Travel	3,700	1,780	4,006
Support Services	13,100	15,846	44,214
Other Related Expenses	26,376	36,570	49,025
Total, Washington Headquarters	**129,556**	**130,813**	**201,127**
Golden Field Office			
Salaries and Benefits	21,800	19,336	26,217
Travel	216	104	234
Support Services	1,100	1,331	3,713
Other Related Expenses	1,400	1,941	2,602
Total, Golden Field Office	**24,516**	**22,712**	**32,766**
National Energy Technology Laboratory			
Salaries and Benefits	6,818	6,047	8,199
Travel	240	115	260
Support Services	300	363	1,013
Other Related Expenses	3,570	4,950	6,635
Total, National Energy Technology Laboratory	**10,928**	**11,475**	**16,107**
Total Program Direction			
Salaries and Benefits	114,998	102,000	138,298
Travel	4,156	2,000	4,500
Support Services	14,500	17,539	48,939
Other Related Expenses	31,346	43,461	58,263
Total, Program Direction	**165,000**	**165,000**	**250,000**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Federal FTEs	**631**	**631**	**781**
Additional Office of Fossil Energy's FTEs at NETL	44	44	44
Total EERE-funded FTEs	**675**	**675**	**825**
Support Services			
Technical Support	9,630	11,648	32,501
Management Support	4,870	5,891	16,438
Total, Support Services	**14,500**	**17,539**	**48,939**
Other Related Expenses			
Other Services	18,746	20,714	31,516
Working Capital Fund (WCF)	12,600	22,747	26,747
Total, Other Related Expenses	**31,346**	**43,461**	**58,263**

Program Direction
($K)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $165,000	**$250,000**	**+$85,000**
Salaries and Benefits $102,000	$138,298	+$36,298
• Funding levels will support a Federal workforce of 675 FTE, provide resources for program and project management, administrative support, contract administration, and human capital management. • Funding also supports Federal employees' salary and benefits, including health insurance costs and retirement allocations in the Federal Employees Retirement System (FERS).	• The Request will support a Federal workforce of 825 FTE, provide resources for program and project management, administrative support, contract administration, and human capital management. S&B estimates take into consideration grade/step levels for the current workforce and the programmatic needs the FY 2022 workforce level. • The Request also will support costs associated with Federal employee benefits, including health insurance costs and retirement allocations in FERS.	• The increase provides additional funding for anticipated workload increases in areas such as appliance standards development and building codes development, FEMP technical assistance to assist agencies in transitioning to carbon-free electricity and fleet electrification, and to support EERE's programmatic priorities. The increase also accounts for a 2.7 percent increase in Federal salaries and the annualization of the 2021 1.0 percent pay increase.
Travel $2,000	$4,500	+$2,500
• Funding supports only the most essential travel during the COVID-19 pandemic when telepresence and virtual meetings for oversight of EERE funded projects is impossible.	• The Request will support the management of projects and close-outs where the use of virtual meeting technologies or other telepresence is not practical for oversight of EERE funded projects.	• The increase in travel funding for FY 2022 reflects EERE's anticipated travel requirements at the FY 2022 staffing and programmatic funding levels assuming a safe return to normal operations.
Support Services $17,539	$48,939	+$31,400
• Support services funding provides technical and administrative contract support, and information technology services. This funding also contributes to training, education, safety, health support, safeguards and security, computer configuration, and maintenance. This includes operation and maintenance costs associated with EERE's IT modernization project, EPIC.	• Support services funding provides technical and administrative contract support, and information technology services. This funding also contributes to training, education, safety, health support, safeguards and security, computer configuration, and maintenance. This includes operation and maintenance costs associated with EERE's IT modernization project, EPIC.	• The increase provides funding for contract support to execute EERE priorities including funding to attract and support a diverse workforce, including increased funding to expedite onboarding staff.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Other Related Expenses $43,461	$58,263	+$14,802
• Other Related Expenses provides funds for overhead at DOE Headquarters and the Golden Field Office through EERE's contribution to the WCF and through direct payments in the field. Expenses covered include building operations, telecommunications, network connectivity, supplies/equipment, printing/graphics, mail, contract closeout, purchase card surveillance, computer equipment, utilities, postage, administrative expenses, security, and publications. Also includes funding for EERE's IT modernization project (i.e., EPIC).	• The Request will provide funds for overhead at DOE Headquarters and the Golden Field Office through EERE's contribution to the WCF and through direct payments in the field. Expenses covered include building operations, telecommunications, network connectivity, supplies/equipment, printing/graphics, mail, contract closeout, purchase card surveillance, computer equipment, utilities, postage, administrative expenses, security, and publications. Also includes funding for EERE's IT modernization project (i.e., EPIC).	• Increase reflects expenses associated with EERE's FTE projection of 825 including increased WCF contributions associated with a higher number of staff on board in FY 2022. The increase also includes additional funding to ensure that all EERE staff (federal and contract support) have the necessary information technology tools to work effectively whether at a DOE facility or remote location. The increase also reflects funding for information technology systems development to ensure EERE can collect and analyze data on its investments to make sure every dollar is contributing to its mission.

Strategic Programs

Overview

Strategic Programs funds high-impact, crosscutting, integrative activities most efficiently executed by a single crosscutting organization in coordination with EERE technology programs and other DOE offices.

Strategic Programs consists of four principal subprograms:

- Technology-to-Market (T2M): supports efforts under the Energy Transitions Initiative (ETI) to address high energy costs, reliability, and inadequate infrastructure challenges faced by islands and remote communities. Further, ETI engages a cross-sector set of organizations pursuing similar efforts to address energy challenges, build capacity, and accelerate the sharing of best practices and innovations to leverage specialized expertise into commercial opportunity and support long-term recovery efforts.
- Strategic Priorities and Impact Analysis: provides a portfolio-based analytical foundation to perform impact assessments of EERE's portfolio. Informs R&D strategic planning and decision-making, enabling continuous improvement of EERE's approach. Analyzes crosscutting issues that affect EERE technologies, such as integration of EERE technologies into the energy system, changing demand for energy, and competitiveness implications of clean energy technologies to enable the transition to a net-zero carbon emission economy.
- Communications and Outreach: provides key stakeholders and the public with the latest and most accurate information regarding advances, impacts, and issues on clean energy technology development and deployment, in addition to resources available through EERE programs, communicated objectively and transparently across a range of traditional and online media. Supports and coordinates workshops, roundtables, and other manners of data exchange to inform crosscutting initiatives and executive priorities.
- Deployment Program Planning: This new subprogram for FY 2022 will provide support for capacity building for cross-technology investments – including implementing an Energy Efficiency and Clean Energy Standard – in the American Jobs Plan that EERE will manage upon enactment.

Highlights of the FY 2022 Budget Request

EERE's approach to integrated technology management will require corporate analysis to develop a framework for investments. Strategic Priorities and Impact Analysis (SPIA) will significantly expand analysis and impact evaluation efforts and stand up new technical assistance functions in support of key EERE strategic priorities. This includes support to expand existing capabilities and conduct analysis to assess and track the distributional impacts of EERE activities, technologies, and policies, especially on disadvantaged communities in alignment with EERE's emphasis on Energy Justice and the Administration's Justice40 Initiative.

EERE will leverage its communication and outreach functions to engage state and local policymakers, business leaders, community advocates, academics, utilities, transit agencies, and other partners to leverage their regions' unique strengths to tackle our climate emergency and to create healthy, safe, and thriving communities, including energy communities, with clean energy jobs that cater to different education and experience levels. This function will support EERE's programs in communicating their work and why it matters to these stakeholders and will help technology offices develop and execute effective communications campaigns that inform about EERE opportunities and resources and highlight EERE's accomplishments and successes. In addition, the Request includes increased support for collaboration and outreach to disadvantaged and energy communities in line with the objectives of the Justice40 Initiative. EERE will take a strategic approach to partnering with a broader array of system stakeholders across the RDD&D portfolio while expanding American clean energy innovation leadership,

The Request also initiates support for a new subprogram to allow EERE to support cross-technology initiatives in the American Jobs Plan – including implementing an Energy Efficiency and Clean Energy Standard. Such capacity building funding will allow EERE to initiate these programs after enactment by the Congress at a rapid pace to ensure the greatest immediate impact.

Strategic Programs
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Strategic Programs				
Technology-to-Market	3,000	4,500	3,000	-1,500
Strategic Priorities and Impact Analysis	7,000	7,000	12,085	+5,085
Communications and Outreach	4,500	3,000	4,500	+1,500
Deployment Program Planning	0	0	24,000	+24,000
Total, Strategic Programs	**14,500**	**14,500**	**43,585**	**+29,085**

Strategic Programs
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Strategic Programs	
Technology-to-Market: In FY 2022, the T2M subprogram will continue coordinating and building upon Energy Transition Initiative efforts. The decrease reflects an adjustment after a one time increase in FY 2021. Overall, this subprogram will continue to be responsible for coordinating activities defined across the EERE structure.	**-1,500**
Strategic Priorities and Impact Analysis: In FY 2022, SPIA will significantly expand analysis and impact evaluation efforts and stand up new technical assistance functions in support of key EERE programmatic priorities and key emphasis areas including equity and environmental justice.	**+5,085**
Communications and Outreach: Funding increases reinstate communications and outreach activities to the FY 2020 and prior levels. Communications and Stakeholder Engagement activities will increase significantly in support of EERE's programmatic priorities.	**+1,500**
Deployment Program Planning: In FY 2022, EERE will support cross-technology office capacity building for investments in the American Jobs Plan.	**+24,000**
Total, Strategic Programs	**+29,085**

Strategic Programs
Technology-to-Market

Description

The Technology-to Market subprogram supported efforts under the Energy Transitions Initiative (ETI) to address high energy costs, reliability, and inadequate infrastructure challenges faced by islands and remote communities. These activities target both resiliency and first-market adopters of modular emerging technologies across the EERE portfolio. Further, ETI engages a cross-sector set of organizations pursuing similar efforts to address energy challenges, build capacity, and accelerate the sharing of best practices and innovations to leverage specialized expertise into commercial opportunity and support long-term recovery efforts in jurisdictions impacted by natural disasters. Activities supported through ETI are in line with EERE's commitment to environmental justice in the Request, as these efforts will ensure that the clean energy economy benefits all Americans in a fair and equitable manner.

In support of the Administration's goals of achieving a carbon-free electricity system by 2035 and net-zero emissions, economy-wide, by no later than 2050, the ETI team is working in close coordination with the Renewable Power offices and the Office of Electricity, to broaden the scope of existing ETI models and tools. In FY 2022, the Technology-to Market subprogram will continue administration of the ETI activities and increase coordination of related activities across EERE Technology Offices. These efforts will focus on considering the unique challenges associated with remote communities, targeting additional remote communities (such as alternative Alaskan areas) and deepening engagement with Puerto Rico and similar island communities in the Caribbean and the Pacific. ETI will maintain its key relationships with partners like Hawaii (and others) to provide decision support tools and lessons learned for other locations in the U.S. looking to pursue resiliency and ambitious sustainable energy goals. ETI will broaden the tools and technical assistance provided to relevant stakeholders for clean and renewable energy technologies

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Technology-to-Market $4,500,000	**$3,000,000**	**-$1,500,000**
• Continued investment in Energy Transitions Initiatives ecology of models and activities. Expand upon the initial Energy Transitions Initiatives Partnership Program to include additional communities.	• Coordinate with new investments across EERE on new initiatives that leverage the existing successful Energy Transitions Initiative or the Energy Transition Initiative Partnership Program. Continue Energy Transitions Initiative activities to expand the base suite of models to account for a broader set of circumstances identified by the expanded communities brought into the portfolio.	• Decrease reflects the one-time effort in FY 2021 for an expansion of the ETIPP activity to support additional community groups; base activities continue at same level of effort.

Strategic Programs
Strategic Priorities and Impact Analysis

Description

The Strategic Priorities and Impact Analysis (SPIA) subprogram supports EERE's cutting-edge, transformational research, development, and deployment activities to ensure favorable short- and long-term returns on investment by Americans by providing evidence-based, portfolio-wide analysis for energy decision-makers in EERE and beyond. SPIA funds high-impact, crosscutting, integrative activities most efficiently executed by a single crosscutting organization in coordination with EERE technology programs and other DOE offices. This is accomplished by performing gap-filling and corporate analyses associated with EERE technologies; developing tools and methods that enable consistent evaluation and analysis across EERE; and providing analytical thought leadership across DOE, other government agencies, and external stakeholders.

In FY 2022, SPIA will support several key EERE and DOE priorities to place the Nation on an accelerated timeline to achieve net-zero carbon emissions as quickly as possible.

In support of the Administration's goals of achieving a carbon free electricity system by 2035 and net-zero emissions, economy-wide, by no later than 2050, SPIA, working in close coordination with the Renewable Power offices and the DOE Office of Electricity, will lead activities to provide extensive data, tools, and technical assistance to relevant stakeholders as the Nation embarks on an unprecedented build-out of clean energy generation and a significant expansion of inter- and intra-regional transmission. SPIA will coordinate a comprehensive nationwide analysis of pathways to 100 percent clean electricity to inform R&D prioritization.

SPIA, in partnership with the Renewable Power offices and the Office of Electricity, will significantly expand upon current technical assistance efforts in order to support stakeholders, including state and local governments, regulators, system operators, utilities, and local communities, faced with making data-driven decisions and investments such as evaluating technologies, designing clean energy deployment programs, developing market and policy solutions, and planning transmission and distribution upgrades to facilitate the transition to a carbon free electricity system. Efforts will be coordinated with outreach and analysis conducted as part of the Grid Modernization Initiative and the Energy Storage Grand Challenge.

Additionally, in FY 2022, SPIA will lead efforts to ensure that EERE is maximizing the impact of its research dollars, tracking the impacts of EERE investments, and striving to ensure that the clean energy economy benefits all Americans. Efforts will be coordinated with the Department's larger efforts to meet the goals of the Justice40 Initiative, address workforce needs, and examine the potential for good paying jobs.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Strategic Priorities and Impact Analysis $7,000,000	**$12,085,000**	**+$5,085,000**
• Conduct preliminary analysis of potential pathways to achieve a carbon pollution-free electricity sector by 2035, examining threats and solutions to ensure cost effective grid reliability and resilience.	• Conduct comprehensive nationwide analysis of pathways to carbon free electricity to inform examining the following topics: reliability and grid stability, transmission expansion, land use conflicts and tradeoffs, distribution system evolution, jobs, environmental impacts, and overall costs.	• Analysis of pathways to achieve carbon free electricity will be substantially increased.
• No funding requested in FY 2021.	• Launch new technical assistance efforts for renewable integration and grid modernization to support stakeholders making data-driven decisions around clean energy pathways, transmission buildouts, and market as well as policy solutions.	• Provisioning of technical assistance is a new activity in FY 2022 and will build upon activities currently lead by other DOE offices.
• Support decarbonization of the transportation sector, examining the potential for managed electric vehicle (EV) charging to provide services to the grid.	• Work will be completed in FY 2021.	• No funding is requested in FY 2022.
• Conduct analysis of renewable technology pathways for industrial processes, process heating, and fuels production that can help Americans transition to a 100 percent clean energy economy no later than 2050.	• Continue analysis of renewable technology pathways for industrial processes, process heating. and fuels production. Enhance modeling and workforce analysis tools to project clean energy job shifts and opportunities for equitable transitions within energy communities.	• Efforts will be completed with FY 2021 funding and will inform clean energy pathways work in FY 2022. Efforts continue and include new work to enhance modeling and workforce analysis tools.
• Provide analytical support for the Energy Storage Grand Challenge and identify opportunities to integrate EERE technologies with storage and enhance grid integration to meet clean energy goals.	• Continue to provide analytical support for the Energy Storage Grand Challenge in coordination with nationwide analysis of pathways to a carbon free electricity sector and new technical assistance efforts for renewable integration and grid modernization.	• Efforts will continue and will include new technical assistance efforts.
• No funding requested in FY 2021.	• Support Justice40 Initiative by developing tools to measure and inform EERE efforts to foster equity and environmental justice.	• Efforts to support Justice40 initiative are new in FY 2022.

Strategic Programs
Communications and Outreach

Description

The Communications and Outreach subprogram provides strategic communications leadership, coordination, and operation support for EERE and for the Department by organizing, editing, and disseminating information and associated impacts to media and the public on EERE programs, activities, and technologies. In addition, this subprogram supports investments to raise awareness and understanding of EERE technologies and inform key stakeholders and audiences of EERE resources and opportunities.

The Communications and Outreach subprogram activities in FY 2022 will focus on:

- Informing key EERE audiences and stakeholders about the work that EERE is doing to transition the Nation to a clean energy economy and fight the global climate crisis. This includes increased support for collaboration with disadvantaged and energy communities in line with the objectives of the Justice40 Initiative. In addition, EERE will increase outreach efforts to raise awareness of clean energy research and career opportunities at minority-serving institutions and minority professional organizations and ensure that organizations receiving EERE funding are thinking through diversity and equity in their own work.
- Supporting EERE's programs in communicating their work and why it matters and helping them develop and execute effective communications campaigns that inform about EERE opportunities and resources and highlight EERE's accomplishments and successes.
- Supporting EERE's senior leaders by developing and presenting information for frequent engagements with internal and external stakeholders as well as the public.
- Developing targeted stakeholder engagement and outreach campaigns that leverage a wide range of virtual and live event platforms and communications tactics to engage with a wide range of EERE audiences and stakeholders.
- Executing a wide range of events, conferences, workshops, roundtables, and other means of data exchange (both in-person and virtual) to inform crosscutting initiatives and organizational and executive priorities.
- Improving the functionality and effectiveness of EERE's digital, web-based, social media products with the end-user, the American people, in mind. These efforts will prioritize:
  - Improving the functionality of EERE's web site and digital communications products to make them more user friendly and accessible;
  - Increasing engagement and effectiveness of EERE social media content and campaigns;
  - Improving the analysis and reporting of metrics to measure the effectiveness and engagement of communications products and campaigns; and
  - Utilizing videography, photography, animation, commercial art, and graphic design to tell EERE's story and more effectively engage with online audiences on social media and digital/web-based platforms.

Communications and Outreach

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Communications and Outreach $3,000,000	**$4,500,000**	**+$1,500,000**
• Support and coordinate workshops, roundtables, and other manners of data exchange to inform crosscutting initiatives and executive priorities. Conduct analysis and reporting of metrics to measure and improve the effectiveness and engagement of communications products and campaigns. Support the development and implementation of a wide range of digital, web-based, social media products to inform and engage target audiences of EERE's efforts and impact in advancing the transition to a clean energy economy and tackling the global climate challenge.	• Conduct increased analysis and reporting of metrics to measure and improve the effectiveness and engagement of communications products and campaigns. Efforts will continue to develop and implement a wide range of digital, web-based, social media products to inform and engage target audiences of EERE's efforts and impact in advancing the transition to a clean energy economy and tackling the global climate challenge. Support the development of virtual events and roundtables, strategic communications campaigns, and stakeholder engagement initiatives that highlight progress made towards EERE's strategic goals and tell the story of EERE's successes in an engaging, impactful, and meaningful way; provide information and resources on how to engage with EERE and the work the organization is doing; and convey why EERE's work matters.	• Additional funding will support efforts to develop an integrated EERE strategic communications and stakeholder engagement plan that aligns with EERE's strategic objectives and priorities, including efforts targeting disadvantaged and energy transition communities. Additional resources will also support and enhance tactics including the analysis of the effectiveness and impact of current communications and outreach activities and improvements to resource allocation and efficiencies; identification and prioritization of key audiences and stakeholders, including those in disadvantaged and energy transition communities; creation of key EERE messaging and narratives; and the development of advanced web and digital engagement activities, content marketing activities, and event planning and execution. Additional funding will also increase outreach efforts to raise awareness of clean energy research and career opportunities at minority-serving institutions and minority professional organizations and ensure that organizations receiving EERE funding are thinking through diversity and equity in their own work.

Strategic Programs
Deployment Program Planning

Description:

The Deployment Program Planning subprogram provides initial funding in FY 2022 for technical assistance, laboratory support, and other contract needs associated with EERE's development, implementation, and execution of several activities proposed in the American Jobs Plan – including implementing an Energy Efficiency and Clean Energy Standard. Based on past experience implementing significant surges of funding appropriated under the American Recovery and Reinvestment Act of 2009, EERE recognizes the importance of building capacity to ensure effective and efficient implementation. These funds allow EERE to work with stakeholders to build a foundation for expeditiously administering several new investments such as increases for Weatherization, block grants, and other deployment focused programs that will rely on new and existing relationships with stakeholder networks and communities.

Deployment Program Planning

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Deployment Program Planning $0	**$24,000,000**	**+$24,000,000**
• No FY 2021 funding for this activity.	• The Request will allow EERE to plan and implement several new American Jobs Plan investments	• The increase provides initial funding in FY 2022 for technical assistance, laboratory support, and other contract needs associated with EERE's development, implementation, and execution of several activities in an expedited fashion upon enactment by the Congress.

Facilities and Infrastructure

Overview

The National Renewable Energy Laboratory (NREL) is the Office of Energy Efficiency and Renewable Energy's (EERE) Federally Funded Research and Development Center. EERE is NREL's steward and primary sponsor. NREL serves as the Nation's preeminent institution for delivering impactful scientific knowledge and technology innovations that transform renewable energy technologies, systems, and markets. NREL's research advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies, and provides the scientific knowledge to integrate and optimize energy systems. To succeed in this mission, EERE's Facilities and Infrastructure Program (F&I) FY 2022 Budget Request ensures NREL's existing research and support infrastructure are maintained and upgraded in key areas to attract world-class research scientists and to develop cutting-edge, innovative solutions to the most challenging technology issues while ensuring the laboratory facilities and real property is resilient to foreseeable climate risks that may impact mission readiness.

The objectives of the F&I Program are to:

- Provide the laboratory with a safe, secure work environment for the protection of personnel, partners, and the public.
- Provide NREL with secure information networks with strong cybersecurity protocols.
- Maintain NREL's science and support infrastructure through regular reinvestments determined by age, condition, risk, and DOE and industry standards, ensuring the availability of a world-class Research and Development (R&D) environment for ongoing EERE mission activities and emerging areas of R&D of interest throughout all of government and industry;
- Acquire new mission-critical science and technology capabilities, when warranted.
- Provide direct funding for operational activities of major facilities and infrastructure and site-wide investments; and
- Develop and steward grid modernization and broader energy systems integration capabilities at the Energy Systems Integration Facility (ESIF), a DOE-designated user facility designed to inform early-stage research, utilizing high performance computing capabilities.

Highlights of the FY 2022 Budget Request

To posture NREL's capabilities to support emerging technologies and future requirements, the FY 2022 F&I Budget Request focuses on sustaining NREL's world-class R&D environment by maintaining and upgrading its capabilities, equipment, and facilities. Demand for NREL facilities from government and industry partners is increasing. This Request supports the first year of a four-year refresh/upgrade of the High-Performance Computer (HPC) at the ESIF. High-performance computing enables unprecedented large-scale numerical models for studying and simulating material properties, processes, and fully integrated energy systems that would otherwise be too expensive, too dangerous, or even impossible to study by direct experimentation. With state-of-the-art computational modeling and predictive simulation capabilities, high-performance computing reduces the risks and uncertainty that are often barriers to industry adopting new and innovative technologies, thereby accelerating the transformation or our Nation's energy system.

The Request reflects EERE's commitment to put in place the capabilities to advance the Administration priorities to achieve a carbon pollution-free electricity sector by 2035 and net-zero emissions, economy-wide, by no later than 2050. To that end, the Request prioritizes investment in the Advanced Research in Integrated Energy Systems (ARIES) initiative to address the challenges of designing and constructing future energy systems using the basic principles of operating large-scale hybrid energy systems that interconnect multiple generation, storage, and end-use technologies and solving the complex problem of controlling the interactions between millions of distributed assets. ARIES research focus areas include energy storage, power electronics, hybrid systems, future energy infrastructure, and cybersecurity. Further, EERE plans to convert the remaining four NREL Flatirons Campus facilities from natural gas to electric heating. This will achieve a significant milestone: operating the NREL Flatirons Campus at net zero emissions no later than 2023. EERE also reduces climate risks to property and infrastructure on the NREL campuses, as a "living laboratory", through integration of battery storage, investigation of alternative fuels for diversified renewable generation, and exploration of microgrid feasibility for autonomous operation (islanding) of building operations.

The Request provides funding for preliminary design of the Energy Materials and Processing at Scale (EMAPS) line-item construction project. EMAPS is envisioned to address the full lifecycle of our products, materials, and energy economy to

enable partnerships with U.S. industry to incentivize waste reduction, reuse, and reduced persistence in the environment, as well as accelerate innovations to market viability. Such a capability will enable research activities critical for a more rapid transition to a circular economy for energy-relevant and energy-intensive materials and processes. The EMAPS project achieved Critical Decision 0 (CD-0), *Mission Need Statement,* on December 20, 2019. EMAPS is expected to achieve Critical Decision 1 (CD-1), *Alternate Selection and Cost Range,* in late FY 2022.

Facilities and Infrastructure
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)
Facilities and Infrastructure				
Operations and Maintenance	87,500	86,321	118,400	+32,079
Facility Management	42,500	43,679	48,600	+4,921
Construction				
21-EE-001, Energy Materials Processing at Scale (EMAPS)	0	0	8,000	+8,000
Total, Facilities and Infrastructure	**130,000**	**130,000**	**175,000**	**+45,000**

Explanation of Major Changes ($K)

	FY 2022 Enacted vs FY 2021 Request
Facilities and Infrastructure	
Operations and Maintenance: FY 2021 Enacted funds infrastructure upgrades and refurbishments at the NREL South Table Mountain (STM) Campus, design for the NREL Flatirons Campus 34.5kV electrical upgrade project, and Other Project Costs and preliminary engineering and design for the Energy Materials and Processing at Scale (EMAPS). FY 2022 Request prioritizes Advanced Research in Integrated Energy Systems infrastructure and equipment investments, increases cybersecurity and sitewide facility support, and provides a Waste Handling Facility on the NREL STM Campus.	+32,079
Facility Management: FY 2021 Enacted funds an electrical and cooling upgrade to the ESIF High Performance Computer (HPC) Data Center and the last year of the four-year refresh/upgrade cycle of the ESIF HPC. The FY 2022 Request prioritizes ESIF Advanced Research in Integrated Energy Systems infrastructure and equipment investments and funds the first year of a four-year refresh/upgrade of the ESIF HPC.	+4,921
Construction: The Request provides funding for the Energy Materials and Processing at Scale (EMAPS) project for preliminary design activities.	+8,000
Total, Facilities and Infrastructure	**+45,000**

Facilities and Infrastructure
Operations and Maintenance

Description

The Operations and Maintenance subprogram provides the program planning and implementation required by DOE Order 430.1C, Real Property and Asset Management, to maintain real property assets at NREL. The subprogram includes Minor Construction Projects (i.e., General Plant Projects (GPP)), General Plant Equipment (GPE), Maintenance and Repair (M&R), Safeguards and Security (S&S), Site-Wide (SW) as well as overhead-funded investments in institutional GPP (IGPP).

Minor Construction investments maintain and enhance the real property portfolio, renovate general science capabilities and buildings, and upgrade laboratories for technical advancements. Examples of Minor Construction Projects are laboratory refurbishments, laboratory reconfigurations, utility enhancements, facility additions, and small (<$20 million) projects to accommodate new research capabilities.

Major Minor Construction Project activities:

- 34.5kV Flatirons Campus upgrade project construction for an expansion to the substation and installation of 34.5kV transformers, switchgear, and underground cables to support the next generation wind turbines and the second Controllable Grid Interface connectivity bus. Design funding was provided in FY 2021. Supports the Advanced Research in Integrated Energy Systems research platform.
- Waste Handling Facility to store, stage, and streamline hazardous waste processing in support of R&D and operational activities as the current processes are inefficient and require pause in waste acceptance while stored items are packaged and processed for offsite shipment.

EERE and NREL aim to 1) leverage NREL research capabilities, 2) build upon the previous success of designing and constructing the net-zero energy Research Support Facility, 3) use over 10 years of data gathered by operating the NREL campus as a 'living laboratory' for energy solutions, and 4) lead by example to develop a roadmap to achieve near-term decarbonization of the NREL Flatirons and South Table Mountain Campuses no later than 2025. The roadmap includes, but is not limited to, fleet electrification, fully electrify new facilities, reduce embodied carbon in new construction, and maximize onsite renewables. NREL will also partner with other DOE National Laboratories to develop an integrated roadmap across the DOE complex and to serve as a roadmap template, beyond, as applicable.

EERE and NREL also identify solutions to mitigate climate change impacts on mission-essential research at NREL facilities. For example, NREL is pursuing a microgrid on the South Table Mountain Campus for autonomous operation (islanding) of building operations. A recent equipment failure at the Flatirons Campus, that resulted in a full-campus power outage, provided an opportunity to demonstrate the successful deployment of on-site research renewable energy assets, including solar arrays, battery energy storage, and wind turbines, minimizing the need for diesel generators and reducing the duration and impact of the outage. EERE successfully repowered the campus from black start using EERE's NREL ARIES assets. This experience highlighted the value of renewable assets for future consideration in campus planning and capital infrastructure activities to start campus power. NREL is mitigating wildfire risk with the Flatirons Campus Water Project to connect the campus to a local water supply and reduce NREL's reliance on trucked-in water to meet ongoing site potable and increase firewater needs. Existing and future GPP investments are key to advancing climate and resilience goals and objectives.

GPE investments acquire and maintain shared science and support equipment to meet research mission needs, replace outdated technology, and provide for emergent research opportunities.

The Request supports the Advanced Research in Integrated Energy Systems research platform GPE investments.

M&R funding sustains real property equipment, systems, and facilities in a condition suitable to ensure their availability for research activities and their effectiveness in supporting the safety and security of the personnel and DOE-owned assets on the campus. The FY 2022 Request ensures NREL will continue to remain within the DOE control standard of two to four percent of Replacement Plant Value (RPV).

S&S funding provides for physical security and cyber protection of NREL personnel, information, and property from threats and hazards, including the capability to respond to emergencies as well as protecting networks and information resources. The Request increases funding for cybersecurity.

SW funding provides for site management of both campuses which includes fire and emergency services, environment, safety and health compliance, hazardous waste management, health programs, medical services, safety programs including electrical safety, energy intelligent campus, shipping/receiving, facility and space planning, facility condition assessment inspections, and database management of DOE's Facilities Information Management System. The Request increases SW.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Operations and Maintenance $86,321,000	**$118,400,000**	**+$32,079,000**
• Minor Construction and GPE reduces deferred maintenance and refurbishes laboratories at the NREL South Table Mountain Campus and provides ARIES infrastructure investments at the NREL Flatirons Campus that include design for a 34.5kV Grid Infrastructure upgrade project. Provides Other Project Costs for EMAPS.	• The Request prioritizes Minor Construction and GPE ARIES investments in the five research areas of the initiative: Cybersecurity, Future Energy Infrastructure, Energy Storage, Hybrid Energy Systems, and Power Electronics. Includes construction for the 34.5kV Grid Infrastructure upgrade project and a new Waste Handling Facility on the South Table Mountain Campus.	• Increased support for ARIES Minor Construction and GPE investments. Construction segment for the 34.5kV Grid Infrastructure upgrade project. New Waste Handling Facility on the South Table Mountain Campus.
• Maintains operational readiness for M&R activities and keeps funding within the DOE control standard of two to four percent of RPV.	• M&R funding enables continuation of the DOE control standard of two to four percent of RPV.	• No significant change.
• Maintains operational readiness for S&S activities.	• Maintains operational readiness for S&S activities, with increased investments in cybersecurity.	• Increased investments in cybersecurity.
• Maintains operational readiness for SW activities.	• Maintains operational readiness for SW activities, with increased investments for additional facility management, maintenance, chemical management, industrial hygiene, electricians, fire systems technicians, and health and safety initiatives as NREL's two-campuses build-out to ensure the level of services necessary to keep the Laboratory running safely, securely, and effectively .	• Increased investments in SW activities.

Facilities and Infrastructure
Facility Management

Description

The Facility Management subprogram provides funding for core operations at the Energy Systems Integration Facility (ESIF), keeping the facility and research assets of this world-class DOE user facility as state-of-the-art and available to support research across EERE's portfolio and with EERE's partners in other DOE offices, at other Federal agencies, at universities, and in the private sector. The FY 2022 Request continues the research-readiness efficiency-charge for users of the ESIF.

ESIF is a unique national asset that provides the public and private sectors with the ability to conduct critical R&D on multiple technologies and energy sources in integrated energy systems. ESIF provides state-of-the-art laboratories and support infrastructure to advance innovation that enables energy systems design and performance optimization. A priority focus is to enable a resilient, secure, modern grid that can accommodate a variety of domestic energy resources.

ESIF investments continue relevance of ESIF laboratory facilities and capabilities and advance multi-program focused cross-cutting integration research in Energy Storage, Cybersecurity, Hydrogen and Renewable Fuel Systems, Thermal Systems, Future Energy Infrastructure, Hybrid Energy Systems, Power Electronics, Transportation, Autonomous Energy Systems, and Buildings.

ESIF's High Performance Computer (HPC) supports research across nine EERE programs as well as the Advanced Research in Integrated Energy Systems research platform and produces computational experiments that advance critical NREL research efforts at temporal and spatial scales that evade direct observation. In addition, the HPC establishes a foundational scientific and engineering capability that attracts leading talent, collaborators, and partners, and demonstrates the world's most efficient HPC data center technologies. The FY 2022 Request provides the first year of a four-year refresh/upgrade of the ESIF HPC.

The FY 2022 Request emphasizes investments in ARIES equipment and infrastructure within ESIF. The Request supports the addition of an Integrated Networking Communications and Control Computing Platform, the modernization of the Research Electrical Distribution Bus (REDB) control and dispatch control systems to incorporate an industrial plant control interface, and the addition of Medium Voltage Assets and Capabilities.

ESIF investments also fund a user program (e.g., user outreach, engagement, and education; development of calls for proposals; conduct of technical peer reviews of proposals; scheduling of R&D projects, and reporting on ESIF status and progress); the maintenance and safety envelope of the ESIF; and technical support to research activities. Funding also implements Integrated Safety Management, Environmental Management, and Hazard Management requirements within the ESIF; maintains, repairs, and modifies connection for SCADA, laboratory safety, research chiller/boiler; research project equipment receiving, placement, setup, fabrication, and decommissioning; gas distribution, fuel distribution, and gas detection; and general logistics support (consumables procurement, equipment storage, material handling, and general maintenance activities).

ESIF-dedicated technical staff support users in designing, setting-up, and conducting experiments in the ESIF. In the user-facility model, peer reviewed, and selected projects receive facility-funded support for equipment and experimental configuration design, set-up, problem solving, and operation.

ESIF investments also fund HPC refresh/upgrade and expansion; HPC operations, HPC cybersecurity, HPC user operations, data center operations, and HPC project management/scheduling.

Facility Management

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Facility Management $43,679,000	**$48,600,000**	**+$4,921,000**
• Supports the last year of a four-year refresh/upgrade of the ESIF Eagle High Performance Computer, upgrades the ESIF High Performance Computer infrastructure in preparation for the next refresh/upgrade cycle, and provides HPC equipment and continues HPC operations.	• Provides for the first year of the next four-year refresh/upgrade cycle of the Kestrel High Performance Computer and parallel operations of Eagle and Kestrel. Eagle decommissioning planned in FY 2023. Increases ARIES equipment and infrastructure investments at ESIF.	• The increase provides additional funding to start a new HPC refresh/upgrade cycle and new ESIF equipment and infrastructure investments associated with the ARIES initiative at NREL.
• Provides Advanced Research in Integrated Energy Systems (ARIES) equipment and infrastructure investments.	• ARIES equipment and infrastructure investments.	• No significant change.
• Continues research-readiness efficiency-charge for users of the ESIF.	• Continues research-readiness efficiency- charge for users of the ESIF.	• No significant change.
• Provides for energy system security and resilience to ensure that activities at ESIF meet all cybersecurity requirements and needs of users.	• Provides for energy system security and resilience to ensure that activities at ESIF meet all cybersecurity requirements and needs of users.	• No significant change.
• Decreases support for site operating costs and utilities as these costs are transferred to indirect NREL funding.	• Continues charging prorated share of site operating costs and utilities to indirect funding.	• No significant change.
• Continues funding for systems engineers, area supervisors, health and safety personnel, and management for ESIF research activities.	• Provides for systems engineers, area supervisors, health and safety personnel, and management for ESIF research activities.	• No significant change.

Facilities and Infrastructure
Construction

Description

Supports line-item construction projects associated with EERE's mission. The Request includes design funding for one project, the Energy Materials and Processing at Scale (EMAPS). EMAPS is envisioned to address the full lifecycle of our products, materials, and energy economy to enable partnerships with U.S. industry to incentivize waste reduction, reuse, and reduced persistence in the environment, as well as accelerate innovations to market viability. Such a capability will enable research activities critical for a more rapid transition to a circular economy for energy-relevant and energy-intensive materials and processes.

The most recent DOE Order 413.3B Critical Decision (CD) is CD-0, Approve Mission Need, approved on December 20, 2019. The preliminary estimate for CD-1, Approve Alternative Selection and Cost Range, is anticipated in the third quarter of FY 2022. This project is pre-CD 2; therefore, schedule estimates are preliminary and subject to change. The current preliminary Total Estimated Cost (TEC) range for this project is $90,000,000 to $159,000,000 and the preliminary Total Project Cost (TPC) range of $96,000,000 to $165,000,000. These cost ranges encompass the most feasible preliminary alternatives currently.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Construction $0	**$8,000,000**	**+$8,000,000**
• No direct funding for EMAPS; all investments were Other Project Costs as EMAPS is pre-CD-1.	• Provides preliminary design funding for EMAPS line item construction project.	• The Request provides preliminary design funding for the EMAPS construction line item project.

Facilities and Infrastructure
Capital Summary ($K)

	Total	Prior Years	FY 2020 Enacted	FY 2020 Actuals	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Capital Summary (including Major Items of Equipment (MIE))							
Capital Equipment > $5M (including MIE)	-	-	10,080	10,080	20,887	29,970	+9,083
Minor Construction	-	-	40,010	40,010	38,811	38,630	-181
Major Construction	-	-	-	-	-	8,000	+8,000
Total, Capital Summary	**-**	**-**	**50,090**	**50,090**	**59,698**	**76,600**	**+16,902**
Capital Equipment > $5M (including MIE)							
Total Non-MIE Capital Equipment (< $5M)	-	-	2,380	2,380	20,887	28,070	+7,183
Beyond Megawatt-Scale Fast Charging Station	7,700	-	7,700	7,700	-	-	-
Scalable Wireless Communications Platform (DF)	5,000	-	-	-	-	1,900	+1,900
Total, Capital Equipment (including MIE)	**-**	**-**	**10,080**	**10,080**	**20,887**	**29,970**	**+9,083**
Minor Construction Projects							
Total Direct Funded Minor Construction Projects (TEC <$5M)	-	-	8,800	8,800	20,011	22,880	+2,869
Enhanced Grid/Energy Systems Control Center (DF)	10,500	-	10,500	10,500	-	-	-
Research and Innovation Laboratory (DF)	19,510	-	19,510	19,510	-	-	-
Flatirons Campus Water Line Project (IF)	12,400	-	1,200	1,200	11,200	-	-11,200
ARIES 34.5kV Infrastructure Upgrade (DF)	8,000	-	-	-	1,600	6,400	+4,800
ESIF HPC Data Center 7.5MW Upgrade (DF)	6,000	-	-	-	6,000	-	-6,000
Waste Handling Facility (DF)	9,350	-	-	-	-	9,350	+9,350
Total, Minor Construction Projects	**-**	**-**	**40,010**	**40,010**	**38,811**	**38,630**	**-181**
Construction Project Summary							
21-EE-001, Energy Materials and Processing at Scale, TBD[1],[2]							
TEC	160,000	-	-	-	-	8,000	+8,000
Total, Construction	**160,000**	**-**	**-**	**-**	**-**	**8,000**	**+8,000**
Total, Capital Summary	**160,000**	**-**	**50,090**	**50,090**	**59,698**	**76,600**	**+16,902**

[1] This project has not received CD-2 approval; therefore, preliminary estimates are shown for TEC.

[2] Indicates a project where the cost of the Conceptual Design Report is estimated to exceed $3 million.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Flatirons Campus Water Line Project
Project Site/Location:	NREL Flatirons Campus
Type:	Minor Construction (Indirect-funded)
Total Estimated Cost:	$12,400
Construction Design:	$ 1,200
Project Start:	FY 2020
Design Complete:	FY 2021
Construction Complete:	FY 2023
Project Description:	This project provides an onsite water system enabling a safe, reliable, and secure connection to a municipal water supply and upgrades existing sanitary sewer facilities. Currently, water supply on the campus is truck-delivered multiple times each week and stored onsite for potable and fire suppression purposes. The infrastructure investments include a water pipeline to supply raw water to the campus; a water treatment system producing potable water, storage tanks for fire suppression and domestic water demands; an onsite wastewater treatment system; and associated appurtenances including, electrical, controls, pumps, fire hydrants, and valves. The water system project ensures long-term beneficial impacts to public safety and asset protection by mitigating fire risk and ensuring compliance with National Fire Protection Association (NFPA) requirements as the Flatirons campus continues to expand. • Design (FY 2021): $1,200 • Water Rights and Easements (FY 2022): $1,000 • Construction (FY 2021 – 2023): $10,200
Prior Year Accomplishments:	• Integrated Project Teams (IPT) for NREL and DOE have been formed. • The Project Management Plan has been reviewed and approved by the NREL IPT. • The Project Charter has been reviewed and approved by the DOE IPT. • The NEPA for design has been reviewed. • The DOE has contracted with WAPA to provide real estate services for the project on behalf of DOE. WAPA has started researching existing land rights on Section 16 of the wildlife refuge. • Right-of-Way extension discussions have started with the Fish and Wildlife Service. • Procurement of the design and environmental engineering services is underway.
Planned Activities:	• Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project). • Procure water rights and/or easements for the project. • Construction (Construction of the project up to final payment as defined in the construction subcontract; construction administration by the design team). • Project Management, Laboratory Services (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction).
Significant Changes from original plan:	Design completion changed from FY 2020 to FY 2021 and Project completion changed from FY 2022 to FY 2023 due to a delay in the start of design.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Enhanced Grid/Energy Systems Control Center
Project Location/Site:	NREL Flatirons Campus
Type:	Minor Construction (Direct-funded)
Total Estimated Cost:	$10,500
Construction Design:	$800
Project Start:	FY 2020
Design Complete:	FY 2021
Construction Complete:	FY 2022
Project Description:	A central control center at the Flatirons campus serves a dual function for enabling remote data collection and analysis involving diverse research portfolios while also conducting grid integration research. The center would accommodate space to allow for multiple parallel project field campaigns; a visualization room capable of providing state of the art, high-resolution visual imagery that will illustrate research findings to stakeholders; a conference room and offices. This control center will serve as the hub for all grid/energy research at the site and coordinate multiple level energy integration and cybersecurity experiments with both local and remote facilities. The visualization room will be connected to the Energy Systems Integration Facility and other National Laboratories through a high-speed data connection.
Prior Year Accomplishments:	• The Integrated Project Team (IPT) for NREL has been formed. • The PMP has been reviewed and approved by the IPT. • The project scope and building concept plan prepared by the IPT is nearing completion. • The NEPA for design has been reviewed.
Planned Activities:	• Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project) • Construction (Construction of the project up to final payment as defined in the construction subcontract, construction administration by the design team) • Project Management, Laboratory Services, and Government Furnished Equipment (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction; IT and other laboratory provided services; procurement and installation of Government Furnished Equipment
Significant Changes from original plan:	N/A.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Research and Innovation Laboratory (RAIL)
Project Location/Site:	NREL South Table Mountain Campus:
Type:	Minor Construction (Direct-funded)
Total Estimated Cost:	$19,510
Construction Design:	$ 1,350
Project Start:	FY 2020
Design Complete:	FY 2022
Construction Complete:	FY 2023
Project Description:	This project provides flexible laboratory space for highly integrated, interdisciplinary research open to support active collaboration across disciplines with enhanced types of ventilation required to keep researchers safe and to enable conducting diverse experiments compatibly and safely in proximity with each other. Design of the laboratories will enable adapting quickly to new research opportunities with state-of-the-art capabilities to attract and collaborate with industry to move knowledge and knowhow from proof-of-principal experiments to co-development and initial experimentation at a scale that catalyzes commercial investment. The project will employ a design-build contract estimated to take nearly 30 months to complete from design through beneficial occupancy. Estimated facility size is approximately 15,000 square feet. Useful segments: Design FY 2021 $1,350; Construction FY 2022 – FY 2023 $18,160.
Prior Year Accomplishments:	• Integrated Project Team (IPT) and Source Evaluation Team (SET) established • Completion of Request for Qualifications (RFQ) to establish proposer pool • Completion of Request for Proposal (RFP) documents; received DOE board approval and issued RFP July 31, 2020 • NEPA for design phase has been submitted • Proposals by the three short-listed design-builders received September 30, 2020
Planned Activities:	• Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project) • Construction (Construction of the project up to final payment as defined in the construction subcontract; construction oversight by NREL) • Project Management, Laboratory Services, and Government Furnished Equipment (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction; IT and other laboratory provided services; procurement and installation of Government Furnished Equipment)
Significant Changes from original plan:	N/A.

Minor Construction Projects ($K)

Facilities & Infrastructure **Facilities Management**	
Project Name: Location/Site:	ESIF HPC Datacenter - 7.5-Megawatt Upgrade NREL STM Campus
Type: Total Estimated Cost: Construction Design:	Minor Construction (Direct-funded) $6,000 $430

Project Description:	• The upgrade to the ESIF Datacenter will include:
	  ○ Populating the existing transformer pads, main distribution panels and sub distribution panels to increase the datacenter electrical capacity from 5KVA (4 MW usable) to 7.5KVA (6 MW usable)
	  ○ Add ERW (datacenter cooling water) distribution piping in the ESIF HPC Datacenter mechanical room (B215). Add pumps, heat exchangers, cooling towers, and building control system to increase the datacenter cooling capacity to match the new electrical capacity.
	• Completing electrical and mechanical designs to increase HPC datacenter capacity.

Prior Year Accomplishments:	• Cost Estimates
Planned Activities:	• RFP • Award Contract
Significant Changes from original plan:	N/A

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	34.5kV Grid Infrastructure
Location/Site:	NREL Flatirons Campus
Type:	Minor Construction (Direct-funded)
Total Estimated Cost:	$8,000
Construction Design:	$1,600
Project Description:	This project includes an expansion to the substation, 34.5kV transformers, switchgear, and underground cable Installation. The 34.5kV is required to support next generation wind turbines and the second Controllable Grid Interface (CGI) connectivity bus expected to be completed in FY 2021. Funding of Useful segments: Design: FY 2021 -- $1,600; Construction: FY 2022 –$6,400.
Prior Year Accomplishments:	• N/A
Planned Activities:	• Project scope definition, IPT determination and PMP preparation and approval. • Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project) • Construction (Construction of the project up to final payment as defined in the construction subcontract, construction administration by the design team) • Project Management, Laboratory Services (project management, independent testing/inspection, commissioning, and other third-party services, technical oversight during design and construction)
Significant Changes from original plan:	N/A.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Waste Handling Facility
Location/Site:	NREL Flatirons Campus
Type:	Minor Construction (Direct-funded)
Total Estimated Cost:	$9,350
Construction Design:	$1,000
Project Description:	This project constructs an 8,000 sq. ft. facility to store, stage, and process hazardous wastes to support R&D and operational activities. Additional space and facility attributes are required to effectively and efficiently manage hazardous wastes and support NREL's mission. The facility would (1) allocate space for materials, supplies, and equipment, (2) allow for forklift access, (3) incorporate a transport truck dock, (4) provide separate processing and storage areas to allow for continued acceptance of wastes while others are being processed for offsite shipment, (5) co-locate a portion of NREL's hazardous materials preparedness and response activities (such as spill control materials, chemical response team equipment, SCBA bottle refilling), (6) provide a small office area for waste management administrative activities, (7) provide locker room and shower facilities for worker health and safety, (8) centralize industrial hygiene equipment calibration and respiratory fit testing. The current 1,000 sq. ft. Waste Handling Facility is not adequately sized to meet NREL's current or reasonably foreseeable level of activities.
Prior Year Accomplishments:	• N/A
Planned Activities:	• Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project) • Construction (Construction of the project up to final payment as defined in the construction subcontract, construction administration by the design team) • Project Management, Laboratory Services (project management, independent testing/inspection, commissioning, and other third-party services, technical oversight during design and construction)
Significant Changes from original plan:	N/A.

21-EE-001, Energy Materials and Processing at Scale, **TBD**
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary: The $8,000,000 FY 2022 Request funds preliminary design for the Energy Materials and Processing at Scale project. The current, preliminary Total Estimated Cost (TEC) range is $90,000,000 to $159,000,000 and the preliminary Total Project Cost (TPC) range is $96,000,000 to $165,000,000. The DOE 413.3B Critical Decision 0 (CD-0) approval was obtained the first quarter of FY 2020. The preliminary estimate for CD-1, Approve Alternative Selection and Cost Range, is anticipated in the third quarter of FY 2022. This project is pre-CD-2; therefore, schedule estimates are preliminary and subject to change.

Significant Changes:
N/A

Critical Milestone History

Fiscal Quarter or Date

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	D&D Complete	CD-4
FY 2021	1Q FY2020	2Q FY2022	3Q FY2022	3Q FY2023	4Q FY2023	3Q FY2023	NA	2QFY2025
FY 2022	12/20/2019	2Q FY2022	3Q FY2022	3Q FY2023	4Q FY2023	3Q FY2023	NA	2Q FY2025

Note: preconceptual timeline to provide a rough order of magnitude for milestones

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range
Conceptual Design Complete – Actual date the conceptual design was completed (if applicable)
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
Final Design Complete – Estimated/Actual date the project design will be/was complete (d)
CD-3 – Approve Start of Construction
D&D Complete – Completion of D&D work
CD-4 – Approve Start of Operations or Project Closeout

Project Cost History

(Dollars in Thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, D&D	OPC, Total	TPC
FY 2021	12,000	148,000	160,000	5,000	0	5,000	165,000
FY 2022	12,000	147,000	159,000	6,000	0	6,000	165,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 75,000-95,000 square feet.

2. Project Scope and Justification

Scope

As advanced energy generation technologies including photovoltaics, wind, and batteries approach terawatt scale, end-of-life and supply chain management become increasingly important. The challenge requires much more than end-of-life recycling for complex components, devices, and systems deployed at large scales. What is also required is the design for maximum economic useful life, reuse, refurbishment, repair, remanufacturing, and then recycling, all of which require

multi-disciplinary research and scalable research facilities. These technologies may also utilize new recyclable polymers and composites as we establish their scalability and durability. To advance this critical need to address end-of-life considerations for energy-related technologies, a multi-disciplinary research capability in process integration that draws on bench scale innovations from multiple institutions and transforms them into integrated and scalable "hybrid technology processes" is needed to ready Department of Energy innovations for commercial development. The Financial Schedule provides an initial rough order of magnitude, assuming the high end of the rough order magnitude cost estimate with a 75,000-95,000 square foot research facility.

Justification

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*. The TEC and TPC estimates used in this document are the high end of the Rough Order of Magnitude (ROM) cost range developed. The estimate was based on a new facility which conservatively bounds the potential alternatives. An Analysis of Alternatives (AoA) to include a justification of the alternative to be selected will be conducted prior to CD-1 approval.

For polymers, as well as many energy technologies, it is becoming clear that the United States needs to increase efficiencies for energy-relevant and energy-intensive materials and processes incorporating other more traditional attributes such as high performance, affordability and reliability into new energy technologies at the start rather than dealing with future legacies. There are now major opportunities at the interfaces of biology, chemistry and materials science and engineering to develop hybrid processes to couple abiotic (e.g., chemical, catalytic, electrochemical) and biological (e.g., enzymatic or organism-based) processes for chemical synthesis, polymer deconstruction, and carbon dioxide reduction to useful products and materials.

Addressing the full lifecycle of our materials, products, and energy economy is of paramount importance for the U.S. to maintain global economic competitiveness. This project allows DOE to lead innovation at the interfaces of biology, physics, chemistry, and materials science and engineering to develop hybrid processes to couple abiotic and biological processes for synthesis, polymer deconstruction, and carbon dioxide reduction to useful products and materials.

Key Performance Parameters (KPPs)

The Key Performance Parameters (KPPs) are preliminary and derived from a pre-CD-1 draft Analysis of Alternatives (AoA) report that is not yet finalized and not yet approved. KPPs may change as the project continues through CD-1 and CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve, are high-level screening criteria that must be met to satisfy the mission need and determine viability or non-viability. The Objective KPPs represent the desired project performance. Since we are at the draft AoA stage, Threshold and Objective KPP descriptions are the same. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
1 – Polymer upcycling	Development of robust processes that upcycles existing waste polymers and creates new polymers and composites that are recyclable-by-design enabling a more circular and sustainable economy. Key elements include polymer deconstruction, synthesis and characterization and multi-scale, hybrid processing (e.g. integrated chem/bio approaches) from g to kg.	Development of robust processes that upcycles existing waste polymers and creates new polymers and composites that are recyclable-by-design enabling a more circular and sustainable economy. Key elements include polymer deconstruction, synthesis and characterization and multi-scale, hybrid processing (e.g. integrated chem/bio approaches) from g to kg.
2 – Electrons to Molecules	Multi-disciplinary capabilities that integrate electricity-driven	Multi-disciplinary capabilities that integrate electricity-driven

3 – Green Process Integration	processes with both biotic and abiotic processes that enable net zero fuels and deep decarbonization of transportation and industrial sectors. Key elements include novel electrochemistry, H2 production, CO2 conversion, rapid membrane electrode assembly, multi-scale hybrid processing (e.g. electrochemical/bio) from g to kg scale.	processes with both biotic and abiotic processes that enable net zero fuels and deep decarbonization of transportation and industrial sectors. Key elements include novel electrochemistry, H2 production, CO2 conversion, rapid membrane electrode assembly, multi-scale hybrid processing (e.g. electrochemical/bio) from g to kg scale.
4 – Advanced Electrification	Multi-disciplinary research capabilities for process innovation and integration to create scalable processes including hybrid concepts that accelerate sustainable manufacturing. Key elements included: synthesis and scalable processing of complex and hybrid (e.g. organic/inorganic perovskites) materials, components, and multifunctional structures for photovoltaics, electrochemical systems (membrane electrode assemblies, battery electrodes, separation membranes, catalysts), photonics, and buildings.	Multi-disciplinary research capabilities for process innovation and integration to create scalable processes including hybrid concepts that accelerate sustainable manufacturing. Key elements included: synthesis and scalable processing of complex and hybrid (e.g. organic/inorganic perovskites) materials, components, and multifunctional structures for photovoltaics, electrochemical systems (membrane electrode assemblies, battery electrodes, separation membranes, catalysts), photonics, and buildings.
5 – Pilot-Scale Process Integration and Scale-up	Next-generation batteries and power electronics that leapfrog state-of-the-art to achieve low-cost, safety, long-life goals while being inherently scalable, manufacturable and free of critical materials to enable integration of electrified mobility (e.g. fast EV charging), buildings, grid, and renewable energy generation. Key elements include advanced materials and devices, thermal management, beyond Li-ion battery chemistries, prototype development, characterization, and manufacturing	Next-generation batteries and power electronics that leapfrog state-of-the-art to achieve low-cost, safety, long-life goals while being inherently scalable, manufacturable and free of critical materials to enable integration of electrified mobility (e.g. fast EV charging), buildings, grid, and renewable energy generation. Key elements include advanced materials and devices, thermal management, beyond Li-ion battery chemistries, prototype development, characterization, and manufacturing.
	Integrated, modular, pilot-scale capabilities that provide interchangeable configurations for g-kg per day production equipment	Integrated, modular, pilot-scale capabilities that provide interchangeable configurations for g-kg per day production equipment

	for intermediate chemicals, polymers, and composites as well as energy device fabrication and electricity-driven process scale-up capabilities.	for intermediate chemicals, polymers, and composites as well as energy device fabrication and electricity-driven process scale-up capabilities.

3. Financial Schedule

(Dollars in Thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2021	0	0	0
FY 2022	8,000	8,000	5,500
Outyears	4,000	4,000	6,500
Total Design	12,000	12,000	12,000
Construction			
FY 2021	0	0	0
FY 2022	0	0	0
Outyears	147,000	147,000	38,000
Total Construction	147,000	147,000	147,000
Total Estimated Costs (TEC)			
FY 2021	0	0	0
FY 2022	8,000	8,000	5,500
Outyears	151,000	151,000	153,500
Total TEC	**159,000**	**159,000**	**159,000**
Other Project Costs (OPC)			
FY 2021	6,000	6,000	1,500
FY 2022	0	0	2,500
Outyears	0	0	2,000
Total OPC	**6,000**	**6,000**	**6,000**
Total Project Costs (TPC)			
FY 2021	6,000	6,000	1,500
FY 2022	8,000	8,000	8,000
Outyears	151,000	151,000	155,500
Grand Total	**165,000**	**165,000**	**165,000**

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 75,000-95,000 square feet.

4. Details of Project Cost Estimate

(Budget Authority in Thousands of Dollars)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)	0	N/A	N/A
Design			
Design	10,000	N/A	N/A
Contingency	2,000	N/A	N/A
Total, Design	12,000	N/A	N/A
Construction			
Site Work	1,250	N/A	N/A
Equipment	15,300	N/A	N/A
Construction	96,450	N/A	N/A
Other, as needed	4,700	N/A	N/A
Contingency	29,300	N/A	N/A
Total, Construction	147,000	N/A	N/A
Other TEC (if any)			
Cold Startup	0	N/A	N/A
Contingency	0	N/A	N/A
Total, Other TEC	0	N/A	N/A
Total Estimated Cost	**159,000**	N/A	N/A
Contingency, TEC	*31,300*	N/A	N/A
Other Project Cost (OPC)			
OPC except D&D			
R&D	0	N/A	N/A
Conceptual Planning	1,000	N/A	N/A
Conceptual Design	2,500	N/A	N/A
Other OPC Costs	2,500	N/A	N/A
Contingency	0	N/A	N/A
Total, OPC	**6,000**	N/A	N/A
Contingency, OPC	*0*	N/A	N/A
Total Project Cost	**165,000**	N/A	N/A
Total Contingency (TEC+OPC)	**31,300**	N/A	N/A

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 75,000-95,000 square feet.

5. Schedule of Appropriations Requests

(Dollars in Thousands)

Request Year	Type	FY 2021	FY 2022	Outyears	Total
FY 2022	TEC	0	8,000	151,000	159,000
	OPC	6,000	0	0	6,000
	TPC	6,000	8,000	151,000	165,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 75,000-95,000 square feet. FY 2022 is the first-year funding is requested. In FY 2021, Congress appropriated $6,000 for OPC.

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	2QFY2025
Expected Useful Life (number of years)	30
Expected Future Start of D&D of this capital asset (fiscal quarter)	2QFY2055

Related Funding Requirements

(Budget Authority in Millions of Dollars)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations and Maintenance		5.4		270

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 75,000-95,000 square feet.

7. D&D Information

If the preferred alternative is a new Federal facility, then this new facility will not replace existing facilities.

8. Acquisition Approach

An Acquisition Approach/Plan will be developed post CD-1 approval in accordance with DOE O 413.3B.

Energy Efficiency and Renewable Energy
Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget and displayed below are intended to halt asset condition degradation and increase the NREL facilities and infrastructure resilience to climate risks. This excludes maintenance of excess facilities (including high-risk excess facilities) necessary to minimize the risk posed by those facilities prior to disposition.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2020 Planned Cost	FY 2020 Actual Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
National Renewable Energy Laboratory	11,283	14,647	16,605	17,296
Total, Direct-Funded Maintenance and Repair	**11,283**	**14,647**	**16,605**	**17,296**

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2020 Actual Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
National Renewable Energy Laboratory	0	0	0
Total, Indirect-Funded Maintenance and Repair	**0**	0	**0**

Report on FY 2020 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2020 to the amount planned for FY 2020, including Congressionally-directed changes.

Energy Efficiency and Renewable Energy
Total Costs for Maintenance and Repair ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost
National Renewable Energy Laboratory	14,647	11,283
Total, Maintenance and Repair	**14,647**	**11,283**

The Planned Cost is an estimate developed early in the budgeting process and is a minimum target amount. The driver of the actual to planned cost variance is the availability of additional resources to execute additional priority maintenance and repair projects in FY 2020.

Energy Efficiency and Renewable Energy
Safeguards and Security ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Protective Forces	3,100	3,215	3,470	+255
Physical Security Systems	750	815	875	+60
Information Security	500	515	550	+35
Cybersecurity	5,200	7,200	9,200	+2,000
Personnel Security	200	215	230	+15
Material Control and Accountability	0	0	0	0
Program Management	800	820	690	-130
Security Investigations	170	170	185	+15
Transportation Security	0	0	0	0
Construction	0	0	0	0
Total, Safeguards and Security	**10,720**	**12,950**	**15,200**	**+2,250**

Energy Efficiency and Renewable Energy
Research and Development ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Basic	0	0	0	0
Applied	1,162,325	1,293,975	1,322,147	+28,172
Development	794,507	710,254	1,576,067	+865,813[1]
Subtotal, R&D	1,956,832	2,004,229	2,898,214	+893,985
Equipment	10,517	8,574	35,734	+27,160
Construction	41,744	30,675	46,048	+15,373
Total, R&D	**2,009,093**	**2,043,478**	**2,979,996**	**936,518**

[1] DOE has proposed a significant increase in its Development investment (which includes demonstration) to advance Administration mission objectives to enable the transition to a net-zero carbon emission economy.

Energy Efficiency and Renewable Energy Research and Development
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Vehicles Technologies				
SBIR	10,380	10,768	17,454	6,686
STTR	1,756	1,514	2,454	940
Bioenergy Technologies				
SBIR	8,079	7,128	10,842	3,714
STTR	1,367	1,002	1,525	523
Hydrogen and Fuel Cell Technologies				
SBIR	3,887	3,810	6,288	2,478
STTR	658	536	884	348
Solar Energy				
SBIR	11,285	8,025	10,199	2,174
STTR	1,458	1,128	1,434	306
Wind Energy				
SBIR	2,484	2,524	5,283	2,759
STTR	763	355	743	388
Water Power				
SBIR	7,062	4,402	6,063	1,661
STTR	1,323	619	853	234
Geothermal Technologies				
SBIR	3,426	3,344	4,860	1,516
STTR	580	470	683	213
Advanced Manufacturing				
SBIR	10,926	11,232	15,622	4,390
STTR	1,849	1,580	2,197	617
Building Technologies				
SBIR	9,229	6,440	7,679	1,239
STTR	1,814	906	1,080	174
Total, SBIR	66,758	57,673	84,290	26,617
Total, STTR	11,568	8,110	11,853	3,743

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Ames Laboratory			
Vehicle Technologies	300	300	300
Hydrogen and Fuel Cells Technologies	830	9,100	1,093
Sustainable Transportation	1,130	9,400	1,393
Advanced Manufacturing	25,000	25,397	25,000
Energy Efficiency	25,000	25,397	25,000
Total Ames Laboratory	**26,130**	**34,797**	**26,393**
Argonne National Laboratory			
Vehicle Technologies	39,700	45,640	47,500
Bioenergy Technologies	10,218	6,000	7,250
Hydrogen and Fuel Cells Technologies	6,539	7,412	11,802
Sustainable Transportation	56,457	59,052	66,552
Geothermal Technologies	25	0	0
Solar Energy Technologies	874	652	900
Water Power Technologies	727	1,000	0
Wind Energy Technologies	1,646	2,318	2,159
Renewable Energy	3,272	3,970	3,059
Building Technologies	2,327	2,282	1,897
Advanced Manufacturing	2,206	6,206	2,000
Energy Efficiency	4,533	8,488	3,897
Strategic Programs	1,650	800	1,500
Corporate Support	1,650	800	1,500
Total Argonne National Laboratory	**65,912**	**72,310**	**75,008**
Brookhaven National Laboratory			
Vehicle Technologies	2,500	2,900	4,000
Bioenergy Technologies	0	0	250
Hydrogen and Fuel Cells Technologies	1,206	1,000	2,369
Sustainable Transportation	3,706	3,900	6,619
Geothermal Technologies	0	50	0
Renewable Energy	0	50	0
Building Technologies	950	700	213
Energy Efficiency	950	700	213
Total Brookhaven National Laboratory	**4,656**	**4,650**	**6,832**
Golden Field Office			
Bioenergy Technologies	95,000	110,000	180,000
Hydrogen and Fuel Cells Technologies	68,859	60,691	73,922
Sustainable Transportation	163,859	170,691	253,922
Geothermal Technologies	47,800	64,240	130,710
Solar Energy Technologies	75,865	134,623	185,455
Water Power Technologies	65,550	53,050	59,150
Wind Energy Technologies	35,000	34,472	97,623
Renewable Energy	224,215	286,385	472,938
Building Technologies	37,000	19,223	52,600
Advanced Manufacturing	272,699	80,275	409,513
Weatherization Assistance Program	1,115	0	44,000
Training and Technical Assistance	450	2,075	3,950
Weatherization Readiness Fund	0	0	2,900
Weatherization	1,565	2,075	50,850
State Energy Program Grants	1,600	2,150	3,000
Local Government Clean Energy Workforce Program	0	0	2,800
Weatherization and Intergovernmental Programs	3,165	4,225	56,650

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Federal Energy Management Program	11,623	13,000	400,000
Energy Efficiency	324,487	116,723	918,763
Program Direction - Energy Efficiency and Renewable Energy	24,516	24,516	37,145
Corporate Support	24,516	24,516	37,145
Total Golden Field Office	**737,077**	**598,315**	**1,682,768**
Idaho National Laboratory			
Vehicle Technologies	9,800	9,825	11,000
Bioenergy Technologies	16,371	16,000	11,250
Hydrogen and Fuel Cells Technologies	6,591	4,350	9,154
Sustainable Transportation	32,762	30,175	31,404
Geothermal Technologies	25	100	0
Solar Energy Technologies	0	1,151	1,589
Water Power Technologies	834	1,570	3,000
Wind Energy Technologies	1,166	1,534	1,520
Renewable Energy	2,025	4,355	6,109
Advanced Manufacturing	0	3,939	0
Federal Energy Management Program	181	442	600
Energy Efficiency	181	4,381	600
Total Idaho National Laboratory	**34,968**	**38,911**	**38,113**
Lawrence Berkeley National Laboratory			
Vehicle Technologies	13,500	16,970	20,000
Bioenergy Technologies	9,049	6,500	7,000
Hydrogen and Fuel Cells Technologies	6,636	6,844	11,299
Sustainable Transportation	29,185	30,314	38,299
Geothermal Technologies	4,130	1,950	0
Solar Energy Technologies	1,349	2,025	2,796
Wind Energy Technologies	1,674	1,515	4,239
Renewable Energy	7,153	5,490	7,035
Building Technologies	44,784	37,041	36,284
Advanced Manufacturing	9,868	7,656	3,600
Weatherization Assistance Program	0	24,800	0
Training and Technical Assistance	200	75	200
Weatherization Readiness Fund	0	0	100
Weatherization	200	24,875	300
State Energy Program Grants	875	475	1,000
Local Government Clean Energy Workforce Program	0	0	100
Weatherization and Intergovernmental Programs	1,075	25,350	1,400
Federal Energy Management Program	4,020	4,000	6,000
Energy Efficiency	59,747	74,047	47,284
Strategic Programs	2,050	1,300	3,500
Corporate Support	2,050	1,300	3,500
Total Lawrence Berkeley National Laboratory	**98,135**	**111,151**	**96,118**
Lawrence Livermore National Laboratory			
Vehicle Technologies	3,800	4,416	4,416
Bioenergy Technologies	700	750	750
Hydrogen and Fuel Cells Technologies	3,431	1,091	6,094
Sustainable Transportation	7,931	6,257	11,260
Geothermal Technologies	25	350	0
Solar Energy Technologies	1,049	1,267	1,749
Wind Energy Technologies	1,327	1,040	961
Renewable Energy	2,401	2,657	2,710
Building Technologies	0	128	178

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Advanced Manufacturing	5,200	7,716	6,000
Energy Efficiency	5,200	7,844	6,178
Total Lawrence Livermore National Laboratory	**15,532**	**16,758**	**20,148**
Los Alamos National Laboratory			
Vehicle Technologies	600	0	0
Bioenergy Technologies	7,422	5,000	5,000
Hydrogen and Fuel Cells Technologies	6,954	4,940	12,063
Sustainable Transportation	14,976	9,940	17,063
Geothermal Technologies	25	250	0
Wind Energy Technologies	353	365	365
Renewable Energy	378	615	365
Total Los Alamos National Laboratory	**15,354**	**10,555**	**17,428**
National Energy Technology Lab			
Vehicle Technologies	185,100	170,560	347,784
Bioenergy Technologies	505	230	400
Hydrogen and Fuel Cells Technologies	24	4,000	187
Sustainable Transportation	185,629	174,790	348,371
Geothermal Technologies	30,000	30,553	20,000
Renewable Energy	30,000	30,553	20,000
Building Technologies	53,500	14,295	4,790
Energy Efficiency	53,500	14,295	4,790
Program Direction - Energy Efficiency and Renewable Energy	10,928	10,928	16,558
Strategic Programs	0	1,500	0
Corporate Support	10,928	12,428	16,558
Total National Energy Technology Lab	**280,057**	**232,066**	**389,719**
National Renewable Energy Laboratory			
Vehicle Technologies	20,200	34,550	36,500
Bioenergy Technologies	50,577	40,000	42,500
Hydrogen and Fuel Cells Technologies	17,555	15,236	25,318
Sustainable Transportation	88,332	89,786	104,318
Geothermal Technologies	1,800	1,416	2,250
Solar Energy Technologies	122,416	80,534	111,187
Water Power Technologies	15,838	18,606	26,570
Wind Energy Technologies	30,000	36,164	46,032
Renewable Energy	170,054	136,720	186,039
Building Technologies	31,437	33,120	25,475
Advanced Manufacturing	4,000	10,707	11,000
Weatherization Assistance Program	0	1,000	0
Training and Technical Assistance	850	1,800	1,900
Weatherization Readiness Fund	0	0	500
Weatherization	850	2,800	2,400
State Energy Program Grants	1,475	475	1,000
Local Government Clean Energy Workforce Program	0	0	100
Weatherization and Intergovernmental Programs	2,325	3,275	3,500
Federal Energy Management Program	6,739	9,000	13,330
Energy Efficiency	44,501	56,102	53,305
Strategic Programs	6,150	5,500	6,785
Facilities and Infrastructure - NREL	130,000	130,000	167,000
Total Facilities and Infrastructure	130,000	130,000	167,000
Corporate Support	136,150	135,500	173,785
Total National Renewable Energy Laboratory	**439,037**	**418,108**	**517,447**

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Oak Ridge Institute for Science & Education			
Vehicle Technologies	0	350	600
Bioenergy Technologies	351	600	850
Hydrogen and Fuel Cells Technologies	873	1,000	1,136
Sustainable Transportation	1,224	1,950	2,586
Geothermal Technologies	600	630	0
Renewable Energy	600	630	0
Building Technologies	650	2,300	1,100
Advanced Manufacturing	5,495	6,375	2,250
Training and Technical Assistance	450	100	700
Weatherization	450	100	700
State Energy Program Grants	450	965	900
Weatherization and Intergovernmental Programs	900	1,065	1,600
Federal Energy Management Program	325	599	665
Energy Efficiency	7,370	10,339	5,615
Total Oak Ridge Institute for Science & Education	**9,194**	**12,919**	**8,201**
Oak Ridge National Laboratory			
Vehicle Technologies	29,500	33,970	34,000
Bioenergy Technologies	13,381	9,500	9,250
Hydrogen and Fuel Cells Technologies	3,160	3,584	8,423
Sustainable Transportation	46,041	47,054	51,673
Geothermal Technologies	1,025	0	0
Solar Energy Technologies	0	867	1,197
Water Power Technologies	6,985	8,258	6,165
Wind Energy Technologies	1,306	1,954	1,718
Renewable Energy	9,316	11,079	9,080
Building Technologies	27,568	18,848	18,853
Advanced Manufacturing	36,028	40,329	44,000
Weatherization Assistance Program	0	825	2,000
Training and Technical Assistance	1,550	400	1,350
Weatherization Readiness Fund	0	0	500
Weatherization	1,550	1,225	3,850
State Energy Program Grants	0	49	100
Weatherization and Intergovernmental Programs	1,550	1,274	3,950
Federal Energy Management Program	6,052	4,000	6,060
Energy Efficiency	71,198	64,451	72,863
Total Oak Ridge National Laboratory	**126,555**	**122,584**	**133,616**
Pacific Northwest National Laboratory			
Vehicle Technologies	13,300	16,314	20,000
Bioenergy Technologies	17,350	12,000	12,800
Hydrogen and Fuel Cells Technologies	5,940	6,855	8,603
Sustainable Transportation	36,590	35,169	41,403
Geothermal Technologies	725	700	0
Solar Energy Technologies	316	0	0
Water Power Technologies	12,411	14,186	15,450
Wind Energy Technologies	6,430	6,107	8,447
Renewable Energy	19,882	20,993	23,897
Building Technologies	30,172	23,406	35,247
Advanced Manufacturing	300	1,779	300
State Energy Program Grants	0	0	50
Weatherization and Intergovernmental Programs	0	0	50
Federal Energy Management Program	4,839	4,157	6,270

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Energy Efficiency	35,311	29,342	41,867
Strategic Programs	50	350	2,500
Corporate Support	50	350	2,500
Total Pacific Northwest National Laboratory	**91,833**	**85,854**	**109,667**
Sandia National Laboratories			
Vehicle Technologies	13,000	10,556	9,000
Bioenergy Technologies	7,113	5,500	6,500
Hydrogen and Fuel Cells Technologies	9,135	10,986	10,298
Sustainable Transportation	29,248	27,042	25,798
Geothermal Technologies	2,981	650	0
Solar Energy Technologies	6,179	5,347	7,382
Water Power Technologies	7,779	8,796	8,269
Wind Energy Technologies	8,769	10,097	11,498
Renewable Energy	25,708	24,890	27,149
Building Technologies	1,100	618	168
Advanced Manufacturing	0	2,075	0
Energy Efficiency	1,100	2,693	168
Strategic Programs	300	250	0
Corporate Support	300	250	0
Total Sandia National Laboratories	**56,356**	**54,875**	**53,115**
Savannah River National Laboratory			
Vehicle Technologies	0	390	400
Hydrogen and Fuel Cells Technologies	1,628	1,065	2,791
Sustainable Transportation	1,628	1,455	3,191
Total Savannah River National Laboratory	**1,628**	**1,455**	**3,191**
SLAC National Accelerator Laboratory			
Vehicle Technologies	5,200	4,050	6,000
Bioenergy Technologies	0	125	200
Hydrogen and Fuel Cells Technologies	61	0	144
Sustainable Transportation	5,261	4,175	6,344
Solar Energy Technologies	1,998	0	0
Renewable Energy	1,998	0	0
Building Technologies	567	640	0
Energy Efficiency	567	640	0
Total SLAC National Accelerator Laboratory	**7,826**	**4,815**	**6,344**
Washington Headquarters			
Vehicle Technologies	59,500	49,209	53,500
Bioenergy Technologies	31,463	42,795	56,000
Hydrogen and Fuel Cells Technologies	10,578	11,846	12,804
Sustainable Transportation	101,541	103,850	122,304
Geothermal Technologies	20,839	5,111	10,800
Solar Energy Technologies	69,954	53,534	74,320
Water Power Technologies	37,876	44,534	77,956
Wind Energy Technologies	16,329	14,434	30,308
Renewable Energy	144,998	117,613	193,384
Building Technologies	54,945	137,399	205,195
Advanced Manufacturing	34,204	203,546	46,837
Weatherization Assistance Program	6,765	0	22,000
Training and Technical Assistance	0	550	1,900
Weatherization Readiness Fund	0	0	17,000
Weatherization	6,765	550	40,900

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
State Energy Program Grants	2,100	2,386	300,450
Local Government Clean Energy Workforce Program	0	0	22,000
Weatherization and Intergovernmental Programs	8,865	2,936	363,350
Federal Energy Management Program	6,221	4,802	5,225
Energy Efficiency	104,235	348,683	620,607
Program Direction - Energy Efficiency and Renewable Energy	129,556	129,556	196,297
Strategic Programs	4,300	4,800	29,300
Corporate Support	133,856	134,356	225,597
Total Washington Headquarters	**484,630**	**704,502**	**1,161,892**
Grants			
Weatherization Assistance Program	297,120	283,375	322,000
Weatherization	297,120	283,375	322,000
State Energy Program Grants	56,000	56,000	56,000
Weatherization and Intergovernmental Programs	353,120	339,375	378,000
Energy Efficiency	353,120	339,375	378,000
Total Grants	**353,120**	**339,375**	**378,000**
Undesignated LPI			
21-EE-001, Energy Materials Processing at Scale (EMAPS)	0	0	8,000
Total Facilities and Infrastructure	0	0	8,000
Corporate Support	0	0	8,000
Total Undesignated LPI	**0**	**0**	**8,000**
Total Funding by Site for TAS_0321 - Energy Efficiency and Renewable Energy	**2,848,000**	**2,864,000**	**4,732,000**

Power Marketing Administrations

Power Marketing Administrations

Power Marketing Administrations

Table of Contents

Southeastern Power Administration

Southeastern Power Administration

Southeastern Power Administration
Proposed Appropriation Language

For expenses necessary for operation and maintenance of power transmission facilities and for marketing electric power and energy, including transmission wheeling and ancillary services, pursuant to section 5 of the Flood Control Act of 1944 (16 U.S.C. 825s), as applied to the southeastern power area, [$7,246,000] *$7,184,000*, including official reception and representation expenses in an amount not to exceed $1,500, to remain available until expended: *Provided,* That notwithstanding 31 U.S.C. 3302 and section 5 of the Flood Control Act of 1944, up to [$7,246,000] *$7,184,000*, collected by the Southeastern Power Administration from the sale of power and related services shall be credited to this account as discretionary offsetting collections, to remain available until expended for the sole purpose of funding the annual expenses of the Southeastern Power Administration: *Provided further,* That the sum herein appropriated for annual expenses shall be reduced as collections are received during the fiscal year so as to result in a final fiscal year [2021] *2022* appropriation estimated at not more than $0: *Provided further,* That, notwithstanding 31 U.S.C. 3302, up to [$52,000,000] *$74,986,000* collected by the Southeastern Power Administration pursuant to the Flood Control Act of 1944 to recover purchase power and wheeling expenses shall be credited to this account as offsetting collections, to remain available until expended for the sole purpose of making purchase power and wheeling expenditures: *Provided further,* That for purposes of this appropriation, annual expenses means expenditures that are generally recovered in the same year that they are incurred (excluding purchase power and wheeling expenses). (Energy and Water Development and Related Agencies Appropriations Act, 2021.)

Explanation of Changes

No changes.

Public Law Authorizations:
Public Law 78-534, Flood Control Act of 1944
Public Law 95-91, DOE Organization Act of 1977, Section 302
Public Law 101-1-1, Title III, Continuing Fund (amended 1989)
Public Law 102-486, Energy Policy Act of 1992

Southeastern Power Administration

Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Gross	77,301	77,409	95,623
Offsets	-77,301	-77,409	-95,623
Net BA	0	0	0

Overview

Southeastern Power Administration (Southeastern or SEPA) exists to carry out the functions assigned by the Flood Control Act of 1944: to market the electric power and energy generated by the Federal reservoir projects to public bodies and cooperatives in the southeastern United States in a professional, innovative, customer-oriented manner, while continuing to meet the challenges of an ever-changing electric utility environment through continuous improvement. Southeastern provides 473 public power customers with 3,392 megawatts of hydroelectric capacity from 22 Federal multipurpose projects, operated by the U.S. Army Corps of Engineers (Corps) at cost-based rates.

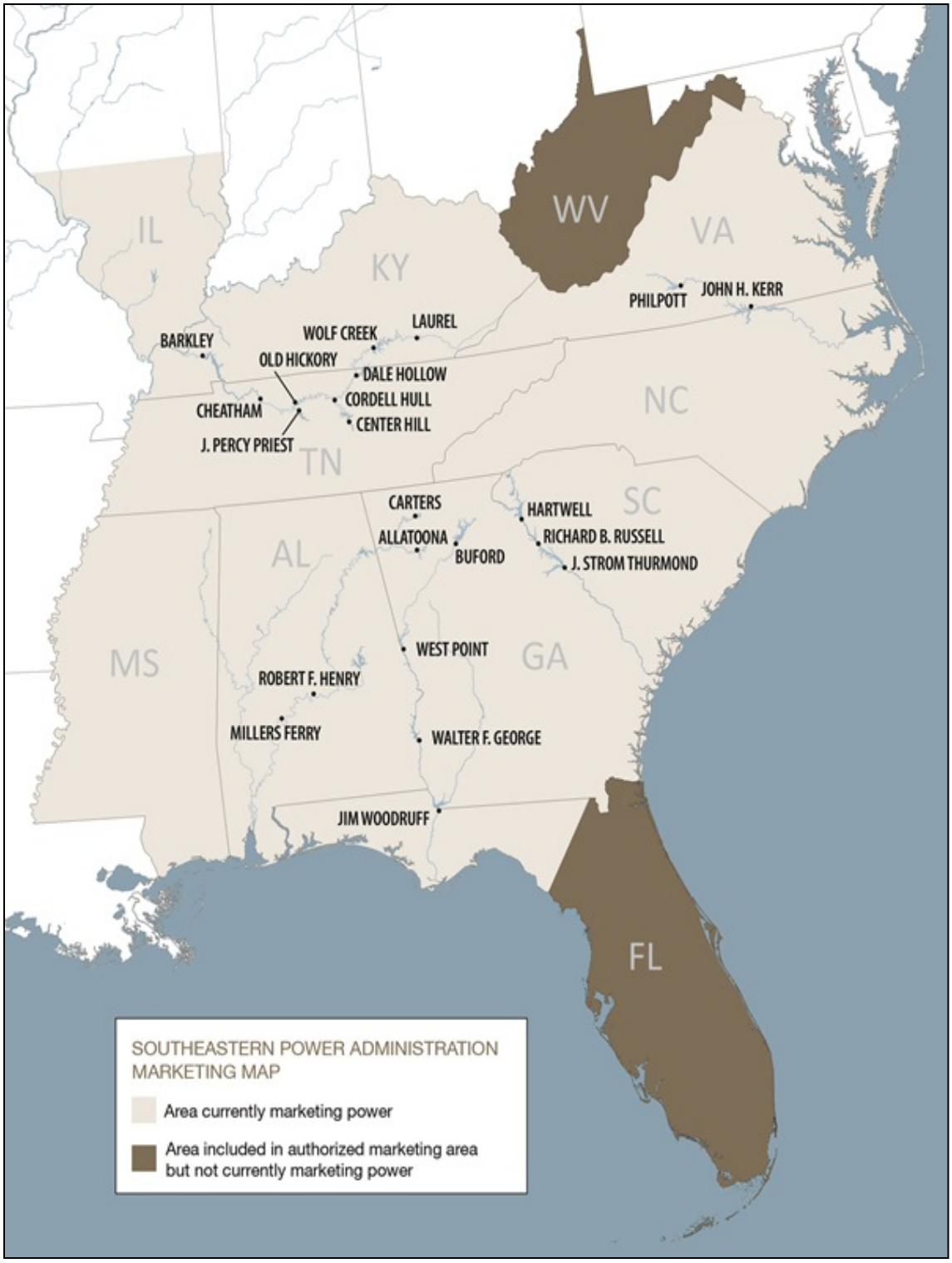
Annually, Southeastern produces an average of 7,613 gigawatt-hours of clean renewable hydroelectric energy. Southeastern maintains and upgrades its energy infrastructure to ensure reliable and efficient delivery of Federal power. Southeastern promotes energy efficiency, renewable energy, and sound management of the dispatch and distribution of Federal hydroelectric power resources in the southeastern United States while also meeting national utility performance standards and balancing the diverse interests of other water resource stakeholders. This budget submission enables Southeastern to promote the effective management of hydroelectric resources.

Program Direction supports day-to-day agency operation and Purchase Power and Wheeling supports acquisition of replacement and pumping power along with contractually required transmission services. Consistent with the authority provided in the FY 2010 Energy and Water Appropriations, the FY 2022 budget provides funding for annual expenses (Program Direction) through discretionary offsetting collections derived from power receipts collected to recover those expenses.

Highlights and Major Changes in the FY 2022 Budget Request

Southeastern's request for FY 2022 increases Purchase Power and Wheeling (+$22.176 million), reflecting changes in transmission rates and rainfall estimates, and decreases Program Direction (-$3.962 million) based on more accurate cost estimates.

Service Area Map



Southeastern Power Administration
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Southeastern Power Administration					
Purchase Power and Wheeling (PPW)	70,704	66,163	88,339	22,176	34%
Program Direction (PD)	6,597	11,246	7,284	-3,962	-35%
Subtotal, Southeastern Power Administration	77,301	77,409	95,623	18,214	24%
Offsetting Collections, PPW	-56,000	-52,000	-74,986	-22,986	44%
Alternative Financing, PPW	-14,704	-14,163	-13,353	810	-6%
Offsetting Collections, Annual Expenses, PD	-6,597	-7,246	-7,184	62	-1%
Alternative Financing, PD	0	-4,000	-100	3,900	-98%
Total, Southeastern Power Administration	0	0	0	0	0%
Federal FTEs	44	44	44	0	0%

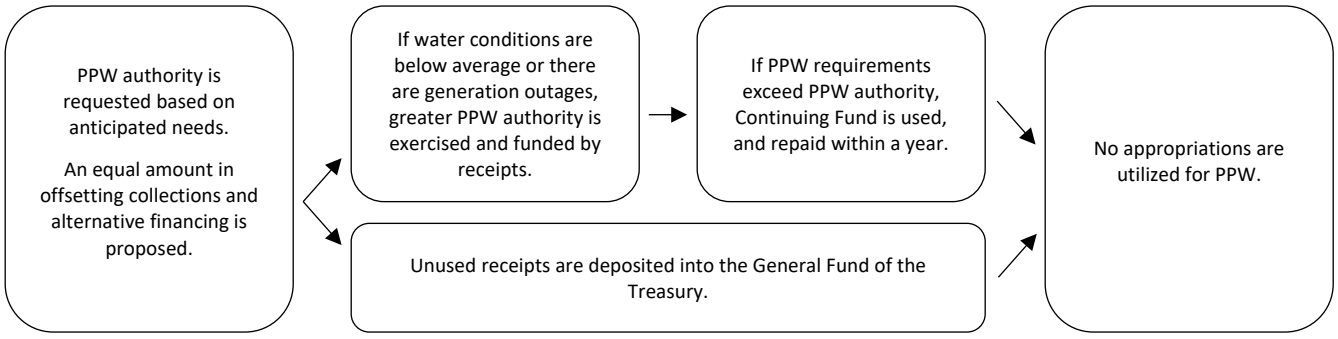
Purchase Power and Wheeling

Overview

The mission of Purchase Power and Wheeling (PPW) is to provide funding for acquisition of transmission services, ancillary services for the system, pumping energy for the Richard B. Russell and Carters Pumped Storage units, and support of the Jim Woodruff Project. Southeastern must purchase power on the open market when its Federal generating assets cannot provide enough power to fulfill its contracts with its customers.

Additionally, because Southeastern does not own or operate any transmission infrastructure, transmission expenses are based on contracts with area transmission providers to deliver specified amounts of Federal power from the hydropower projects to Federal power customers. Southeastern has access to a continuing fund for emergency expenses necessary to ensure continuity of service. Southeastern has implemented a plan to repay any Purchase Power and Wheeling expenditures made through the Continuing Fund within one year.

The FY 2022 request uses customer receipts and net billing to pay for purchase power and wheeling expenses at no cost to the Federal Treasury. Some customers, acting independently or in partnerships, acquire replacement power and transmission services directly from suppliers. Southeastern will continue to assist its customers by arranging funding for these activities through alternative financing instruments, as needed.



Highlights of the FY 2022 Budget Request

The PPW subprogram supports Southeastern's mission to market and deliver reliable, cost-based hydroelectric power and related services. PPW enables Southeastern to wheel Federal power to preference customers, purchase replacement power, and acquire pumping energy to maximize the efficiency and benefits of Southeastern's hydropower resources. Power and services are marketed at rates designed to provide recovery of expenses and Federal investment, as established by law.

Purchase Power & Wheeling
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Purchase Power					
Replacement Power	3,797	3,797	11,761	7,964	210%
Russell Project pumping power	10,250	6,770	12,601	5,831	86%
Carters Project pumping power	8,964	5,500	14,088	8,588	156%
Jim Woodruff Project support	2,600	2,600	2,600	0	0%
Total, Purchase Power	25,611	18,667	41,050	22,383	120%
Wheeling					
Wheeling service charges	40,353	42,756	42,579	-177	0%
Ancillary Services	4,740	4,740	4,710	-30	-1%
Total, Wheeling	45,093	47,496	47,289	-207	0%
Total, Purchase Power and Wheeling	70,704	66,163	88,339	22,176	34%
Alternative Financing					
Net Billing	-14,704	-14,163	-13,353	810	-6%
Subtotal, Purchase Power and Wheeling	56,000	52,000	74,986	22,986	44%
Offsetting Collections Realized	-56,000	-52,000	-74,986	-22,986	44%
Total, Purchase Power and Wheeling Budget Authority	0	0	0	0	0

Southeastern Power Administration
Purchase Power and Wheeling
($K)

Activities, Milestones, and Explanation of Changes ($K)

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Purchase Power and Wheeling $66,163	**$88,339**	**+$22,176**
Purchase Power $18,667	**$41,050**	**+$22,383**
• On-Peak Replacement Power purchased to meet contract minimum service in drought conditions. • Off-Peak Pumping Power purchased to supplement stream flow energy demand. • Jim Woodruff System Generating Support required for high river flows at low head plant.	• Continuing activities from prior year.	• The increase reflects anticipated needs based on projected market prices.
Wheeling $47,496	**$47,289**	**-$207**
• Transmission expenses based on contracts with area transmission providers to deliver specified amounts of Federal power from the hydropower projects to Federal power customers.	• Continued funding supports ongoing activities.	• The decrease is due to variations in transmission rates.

Program Direction

Overview

Program Direction provides the Federal staffing resources and associated costs required to provide overall direction and execution of the Southeastern Power Administration. Provision is made for negotiation and administration of transmission and power contracts, collections of revenues, accounting and budget activities, development of wholesale power rates, amortization of the Federal power investment, energy efficiency and competitiveness programs, investigation and planning of proposed water resources projects, scheduling and dispatch of power generation, scheduling storage and release of water, administration of contractual operation requirements, and determination of methods of operating generating plants individually and in coordination with others to obtain maximum allowable utilization of resources.

Highlights of the FY 2022 Budget Request

The FY 2022 Budget Request provides for the continuation of Southeastern's activities related to Program Direction at the level necessary to meet mission requirements.

Program Direction Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Program Direction Summary					
Southeastern Power Administration					
Salaries and Benefits	4,800	5,500	5,600	100	2%
Travel	100	50	50	0	0%
Support Services	3	0	0	0	0%
Other Related Expenses	1,694	5,696	1,634	-4,062	-71%
Subtotal, Southeastern Power Administration	6,597	11,246	7,284	-3,962	-35%
Offsetting Collections (annual expenses)	-6,597	-7,246	-7,184	62	-1%
Alternative Financing, PD	0	-4,000	-100	3,900	-98%
Total, Program Direction	0	0	0	0	0%
Federal FTEs	44	44	44	0	0%
Support Services and Other Related Expenses					
Support Services					
Management and Professional Support Services	3	0	0	0	0%
Total, Support Services		0	0	0	0%
Other Related Expenses					
Training	20	21	21	0	0%
Communications, Utilities, Misc.	202	209	214	5	2%
Equipment	68	129	132	3	2%
Maintenance Agreements	171	430	339	-91	-21%
Land and Structures	0	4,000	0	-4,000	-100%
Rent to GSA	352	0	0	0	0%
Tuition	47	48	50	2	4%
Contract Services	456	472	482	10	2%
Audit of Financial Statements	251	257	263	6	2%
Supplies and Materials	71	73	74	1	1%
Working Capital Fund	48	49	50	1	2%
Printing and Reproduction	8	8	9	1	13%
Total, Other Related Expenses	1,694	5,696	1,634	-4,062	-71%

Program Direction
($K)

Activities, Milestones, and Explanation of Changes ($K)

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $11,246	**$7,284**	**-$3,962**
Salaries and Benefits $5,500	**$5,600**	**+$100**
The funding supports Federal salaries and benefits for 44 FTEs who market Federal hydropower, promote energy efficiency and renewable energy, administrative support, and workloads in cyber-security and operational reliability. These estimates are derived from the current year budgeted salaries, plus cost-of-living adjustments, promotions, within-grade increases, overtime, DOE-cascading performance awards, and retirement payouts for unused leave.	Continue funding support for Federal salaries and benefits for 44 FTEs.	Continue funding support for Federal salaries and benefits including the recruiting and retaining of FTEs.
Travel $50	**$50**	**$0**
Funding supports transportation and per diem expenses incurred for preference customer meetings, relocation expenses for new FTEs, contract negotiations, rate forums, Congressional hearings, site visits, and operations meetings with industry organizations.	Continued funding supports ongoing activities.	Continued use of conference calls, webinar sessions, internet training, and video conferencing.
Support Services $0	**$0**	**$0**
Funding supports preference customers' efforts in support of the Energy Policy Act of 2005.	No funding is requested for FY 2022.	Reduced customer participation in program funding.
Other Related Expenses $5,696	**$1,634**	**-$4,062**
Funding provides administrative support for office, emergency control center, communications, maintenance, contract services, supplies, materials, equipment and support for cyber and physical security, training expenses for power operator certification, support for installation of electronic hardware and software for the operations center and provides maintenance to integrate real-time data from the control area and provides the data to other transmission operators and NERC. Southeastern sought to purchase current or construct a new headquarters facility to reduce future costs and overhead expenses.	Continue funding support for Southeastern Power Administration's headquarters office and emergency control center, along with services of the Power Marketing Liaison Office, and the Human Resources Shared Service Center (HRSSC).	Reflects required hardware and software service agreements and updates along with training, tuition, and communications costs. Costs are based on the historical usage and actual cost of similar items as well as inflationary increases. FY 2021 request included $4 million to purchase headquarters facility,

Additional Tables

Revenue and Receipts ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Gross Revenues	302,899	309,226	318,122	319,772	321,512	323,339	325,259
Net Billing (Credited as an Offsetting Receipt)	-13,257	-14,163	-13,353	-13,532	-13,719	-13,916	-14,123
Total Cash Receipts	289,642	295,063	304,769	306,240	307,793	309,423	311,136
Use of Offsetting Collections to fund PPW	-46,000	-52,000	-74,986	-76,464	-78,017	-79,647	-81,360
Use of Offsetting Collections to fund Annual Expenses	-6,597	-7,246	-7,184	-7,522	-7,648	-7,887	-7,914
Total Receipts, net use of Offsetting Collections	237,045	235,817	222,599	222,254	222,128	221,889	221,862
Cumberland Rehabilitation	-61,389	-25,000	-25,000	-25,000	-25,000	-25,000	-25,000
GA-AL-SC Rehabilitation	-28,703	-10,000	-15,000	-15,000	-15,000	-1,500	-1,500
Kerr-Philpott Rehabilitation	-5,574	-3,000	-5,000	-5,000	-5,000	-5,000	-5,000
Jim Woodruff	-1,047	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000
Accts Rec Yearly Difference	1,367	0	0	0	0	0	0
Total Proprietary Receipts	141,698	196,817	176,599	176,254	176,128	189,389	189,362
Percent of Sales to Preference Customers	99%	99%	99%	99%	99%	99%	99%
Energy Sales and Power Marketed (megawatt-hours)	8,908,447	5,587,740	5,587,740	5,587,740	5,587,740	5,587,740	5,587,740

Alternative Financing

2020	Transmission	Purchase Power	Offsetting Collections	Net Billing	Appropriated Funds
Jim Woodruff System	334	1,806	-1,721	-419	0
Kerr-Philpott System	12,729	0	-12,729	0	0
GA-AL-SC System	29,038	6,150	-31,480	-3,708	0
Cumberland System	9,200	0	-70	-9,130	0
	51,301	7,956	-46,000	-13,257	0

2021	Transmission	Purchase Power	Offsetting Collections	Net Billing	Appropriated Funds
Jim Woodruff System	336	2,600	-2,236	-700	0
Kerr-Philpott System	9,994	0	-9,994	0	0
GA-AL-SC System	31,215	12,270	-39,695	-3,790	0
Cumberland System	9,748	0	-75	-9,673	0
	51,293	14,870	-52,000	-14,163	0

2022	Transmission	Purchase Power	Offsetting Collections	Net Billing	Appropriated Funds
Jim Woodruff System	359	2,600	-2,259	-700	0
Kerr-Philpott System	10,171	0	-10,171	0	0
GA-AL-SC System	27,605	38,450	-62,482	-3,573	0
Cumberland System	9,154	0	-74	-9,080	0
	47,289	41,050	-74,986	-13,353	0

Power Marketed, Wheeled, or Exchanged by Project

Project	State	Plants	Installed Capacity (KW)	FY 2020 Estimated Power (GWH)	FY 2021 Estimated Power (GWH)	FY 2022 Estimated Power (GWH)
Kerr-Philpott System				293	293	293
John H. Kerr	VA-NC	1	291,000			
Philpott	VA	1	15,000			
Georgia-Alabama-South Carolina System				2,508	2,508	2,508
Allatoona	GA	1	82,000			
Buford	GA	1	127,000			
Carters	GA	1	600,000			
J. Strom Thurmond	GA-SC	1	364,000			
Walter F. George	GA-AL	1	160,000			
Hartwell	GA-SC	1	424,000			
R. F. Henry	AL	1	82,000			
Millers Ferry	AL	1	90,000			
West Point	GA-AL	1	87,000			
Richard B. Russell	GA-SC	1	656,000			
Jim Woodruff Project	FL-GA	1	43,500	148	148	148
Cumberland System				2,481	2,481	2,481
Barkley	KY	1	130,000			
Center Hill	TN	1	135,000			
Cheatham	TN	1	36,000			
Cordell Hull	TN	1	99,900			
Dale Hollow	TN	1	54,000			
Old Hickory	TN	1	103,752			
J. Percy Priest	TN	1	28,000			
Wolf Creek	TN	1	270,000			
Laurel	TN	1	61,000			
Total Power Marketed		22	3,939,152	5,430	5,430	5,430

System Statistics

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
Generating Capacity:			
Nameplate Capacity (KW)	3,939,152	3,939,152	3,939,152
Peak Capacity (KW) [a]	4,330,000	4,330,000	4,330,000
Generating Stations			
Generating Projects (Number)	22	22	22
Available Energy			
Energy from Stream-flow (MWH)	8,427,085	4,685,000	4,685,000
Energy generated from Pumping (MWH)	481,362	745,100	745,100
Energy Purchased for Replacement (MWH)	0	157,640	157,640
Total, Energy available for marketing [b] (MWH)	8,908,447	5,587,740	5,587,740

[a] Southeastern markets capacity based on nameplate plus an overload factor. NERC requires that Southeastern keep a portion of the capacity in reserve for emergency purposes and to cover losses.

[b] Gross amount. Transmission losses are deducted from this amount to estimate the amount of energy marketed.

DEPARTMENT OF ENERGY

Funding by Site

TAS_0302 - Southeastern Power Administration (SEPA) BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Southeastern Power Administration Office			
Purchase Power and Wheeling - SEPA	70,704	85,401	88,339
Program Direction - SEPA	6,597	11,246	7,284
Total Southeastern Power Administration Office	**77,301**	**96,647**	**95,623**
Total Funding by Site for TAS_0302 - Southeastern Power Administration (SEPA)	**77,301**	**96,647**	**95,623**

Southwestern Power Administration

Southwestern Power Administration

Southwestern Power Administration
Proposed Appropriation Language

For expenses necessary for operation and maintenance of power transmission facilities and for marketing electric power and energy, for construction and acquisition of transmission lines, substations and appurtenant facilities, and for administrative expenses, including official reception and representation expenses in an amount not to exceed $1,500 in carrying out section 5 of the Flood Control Act of 1944 (16 U.S.C. 825s), as applied to the Southwestern Power Administration, [$47,540,000] *$48,324,000* to remain available until expended: Provided, That notwithstanding 31 U.S.C. 3302 and section 5 of the Flood Control Act of 1944 (16 U.S.C. 825s), up to [$37,140,000] *$37,924,000* collected by the Southwestern Power Administration from the sale of power and related services shall be credited to this account as discretionary offsetting collections, to remain available until expended, for the sole purpose of funding the annual expenses of the Southwestern Power Administration: Provided further, That the sum herein appropriated for annual expenses shall be reduced as collections are received during the fiscal year so as to result in a final fiscal year [2021] *2022* appropriation estimated at not more than $10,400,000: Provided further, That, notwithstanding 31 U.S.C. 3302, up to [$34,000,000]*$70,000,000* collected by the Southwestern Power Administration pursuant to the Flood Control Act of 1944 to recover purchase power and wheeling expenses shall be credited to this account as offsetting collections, to remain available until expended for the sole purpose of making purchase power and wheeling expenditures: Provided further, That for purposes of this appropriation, annual expenses means expenditures that are generally recovered in the same year that they are incurred (excluding purchase power and wheeling expenses). (Energy and Water Development and Related Agencies Appropriations Act, 2021.)

Explanation of Changes

No changes.

Public Law Authorizations

Southwestern Power Administration:

- P.L. 78-534, Section 5, Flood Control Act of 1944
- P.L. 95–91, Section 302, DOE Organization Act of 1977
- P.L. 100-71, Supplemental Appropriations Act, 1987
- P.L. 101–101, Title III, Continuing Fund (amended 1989)
- P.L. 102-486, Section 721, Energy Policy Act of 1992
- P.L. 108-447, Appropriations Act, FY 2005
- P.L. 111-85, Appropriations Act, FY 2010

Southwestern Power Administration
Overview

($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Gross	131,863	116,194	156,816
Offsets	-121,463	-105794	-146,416
Net BA	10,400	10,400	10,400

Overview

Southwestern Power Administration's (Southwestern) mission is to market and reliably deliver Federal hydroelectric power, with preference to public bodies and cooperatives. This is accomplished by maximizing the use of Federal assets to repay the Federal investment, participating with other water resource users in an effort to balance diverse interests with power needs within broad parameters set by the U.S. Army Corps of Engineers (Corps), and implementing public policy.

Southwestern markets and delivers power at wholesale rates to 78 municipal utilities, 21 rural electric cooperatives, and 3 military installations in the six states of Arkansas, Kansas, Louisiana, Missouri, Oklahoma, and Texas. In turn, these customers distribute that power to approximately 10 million end users in the six-state area. To integrate the operation of the Federal hydroelectric generating plants and to transmit power from 24 multi-purpose Corps dams to customers, Southwestern operates and maintains 1,380 miles of high-voltage transmission lines, 26 substations/switchyards, and 51 microwave and very high frequency (VHF) radio sites. Southwestern is headquartered in Tulsa, Oklahoma, and has maintenance facilities in Gore, Oklahoma; Jonesboro, Arkansas; and Springfield, Missouri. In addition, around-the-clock power scheduling and dispatching are conducted by staff in Southwestern's Operations Center located in southwest Missouri.

Southwestern participates in the Southwest Power Pool (SPP) Regional Transmission Organization (RTO) and the Midcontinent Independent System Operator (MISO) RTO, which reinforces Southwestern's role as part of the Nation's interconnected generation and transmission system. In participation with the RTOs, Southwestern works on regional and interregional transmission policy initiatives in response to the evolution of the electric utility industry. Furthermore, Southwestern coordinates its varied utility activities in conjunction with a broader group of stakeholders. As the demand for the transmission of power increases across regional and interregional footprints, maintaining and improving the Nation's energy infrastructure through improvements, replacements, interconnections, and coordination with the RTOs in Southwestern's marketing area has become more critical than ever. Southwestern assures the efficient and reliable delivery of Federal hydropower, thus fulfilling clean energy security for the present as well as for future generations.

Southwestern's marketing services and delivery capability provide for recovery of all annual operating costs, including the Corps' hydropower related costs, and for repayment of taxpayer investment in all assets and facilities that support the Federal hydropower program. Hydropower is not only an important part of the Nation's clean energy portfolio due to clean generation capabilities, but it also provides support for other renewable resources. Federal hydropower supports the Nation's grid and complements other generation to create stability as the industry faces energy production changes, organized market evolution and increased threats to the grid. Hydroelectric power is a domestic energy source that helps America achieve clean energy security and create good paying American jobs. Southwestern markets an average of 5,570 gigawatt-hours of clean renewable hydroelectric energy annually.

Southwestern will use the following strategies to fulfill its mission:

- Market and deliver, at the lowest possible cost, all available Federal hydropower generated at the Corps multipurpose projects and work with the Corps, States, cooperatives, and municipalities to meet its statutory requirements while balancing the interests of other water users.

- Maintain infrastructure and modernize systems to increase the resilience, reliability, efficiency, and use of Federal assets. This will be accomplished using appropriations; Federal power receipts; and alternative financing arrangements, which include net billing and/or reimbursable authority (customer advances).[1]
- Conduct annual power repayment studies to ensure power rates are sufficient to repay all annual operating costs and the Federal investment with interest.
- Meet Southwestern's 1200-hour peaking power contractual obligations with necessary purchase power and wheeling using Federal power receipts; alternative financing arrangements, which include net billing and/or reimbursable authority (customer advances); and the Continuing Fund as necessary in periods of below-average hydropower generation.
- Operate the transmission system efficiently to support the Nation's integrated power grid and engage in transmission policy initiatives within the RTOs in Southwestern's marketing area to respond effectively to the evolution of the electric utility industry.
- Meet requirements for Southwestern's compliance with the latest North American Electric Reliability Corporation (NERC) standards.
- Bolster Southwestern's grid resilience and cyber and physical security postures using best-available technologies and in cooperation with DOE and industry partners to protect the Federal transmission system and the Nation's power grid. Ongoing assessments, realigning vacant positions, investments in the cyber and physical security programs, and infrastructure protection improvements enable Southwestern to continue to provide a safe and reliable product. Southwestern will continue to emphasize security, both cyber and physical, as an agency priority.

External factors that present potential impacts to the overall achievement of the programs' strategic goals include weather, natural disasters, NERC reliability standards, industry market developments, physical and cybersecurity, changing electric industry organizational structure, interconnections, open access, the uncertainty of sustainable funding resources, competing uses' demand for the limited water resource, and other unforeseen requirements. More specifically:

- The bulk of Southwestern's transmission infrastructure is approximately 60 years old and requires ongoing maintenance and replacement while concurrently balancing changing and increasing demands for availability.
- Industry efforts to improve the reliability of the Nation's power grid are placing more requirements on Southwestern's workforce to implement mandatory reliability standards.
- The potential for malicious physical and cyber-attacks on Southwestern's assets remains a primary concern. These attacks, cyber and physical, on a utility's operation would threaten electric system reliability and potentially result in large scale power outages.
- As more of Southwestern's employees retire or leave Federal service, Southwestern must compete with the rest of the electric utility industry to attract and retain the quality workforce needed to provide a reliable power supply and transmission service.
- Southwestern is increasingly challenged by more complex transmission policy developments including intricate energy and capacity markets, transmission planning processes, and technical rate structures; the deployment of new technologies such as renewables and distributed generation; and heightening emissions and environmental restrictions.
- The Corps water resources projects from which Southwestern markets the hydropower are all multi-purpose. As the demand for water for other purposes increases, energy generation and operating capacity of the hydropower units can be impacted by loss of water storage and availability as well as required operational changes.

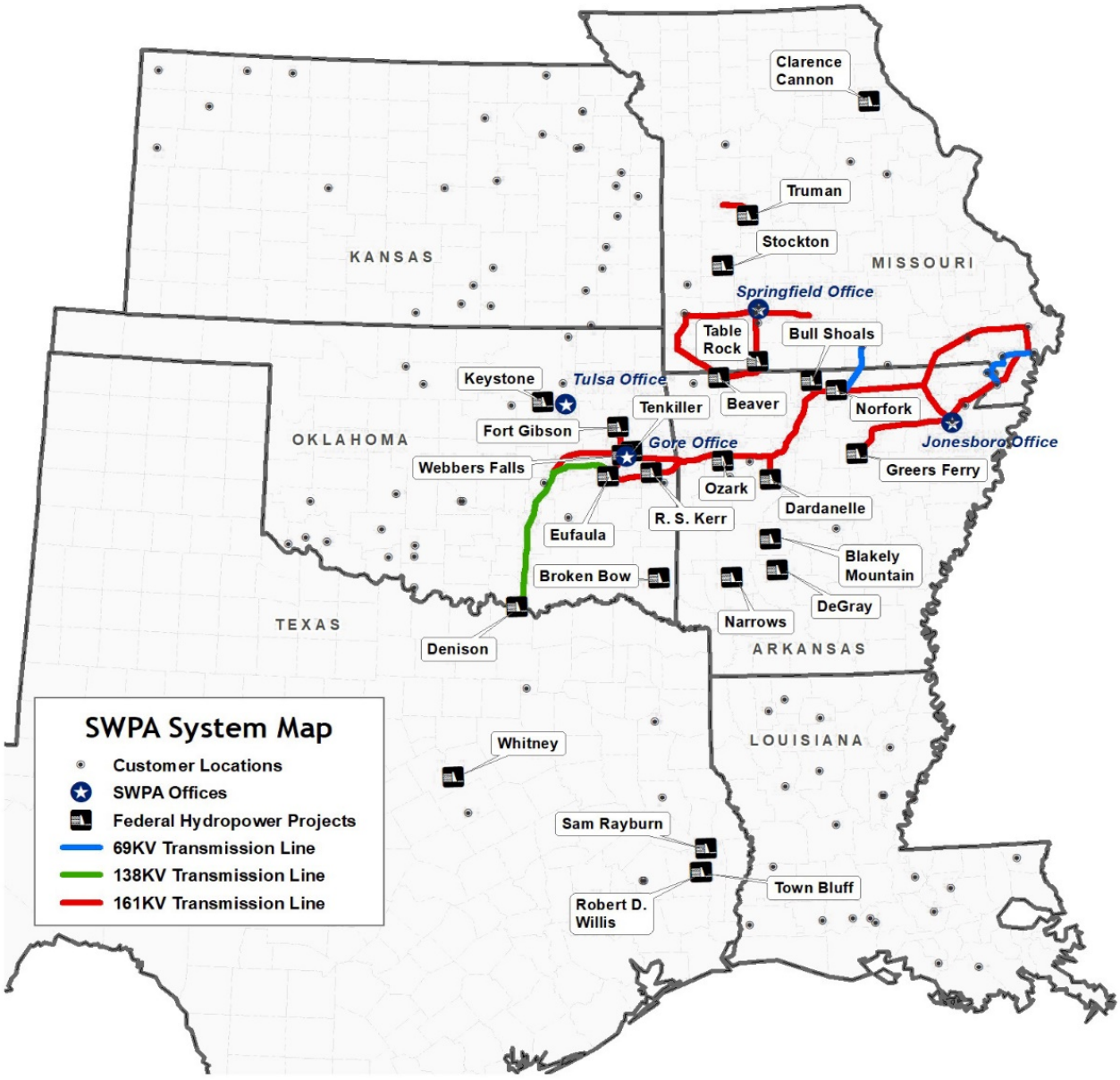
[1] Southwestern's authority to use net billing is inherent in the authority provided by the Flood Control Act of 1944 and has been affirmed by the Comptroller General to the Honorable Secretary of the Interior B-125127 (February 14, 1956). This allows Southwestern to accept goods and services in lieu of payment.

Highlights of the FY 2022 Budget Request

Southwestern requests a net appropriation of $10.4 million for FY 2022. Southwestern's appropriation consists of four subprograms: Operations and Maintenance, Construction, Purchase Power and Wheeling, and Program Direction. Southwestern utilizes a variety of financing methods including appropriations, Federal power receipts, and alternative financing arrangements, which include net billing and/or reimbursable authority (customer advances).

Priority is placed on maintenance, upgrades, physical and cybersecurity, compliance, and cost containment.

Southwestern Service Area Map



Southwestern Power Administration
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Operation and Maintenance					
Operations and Maintenance (O&M)	13,639	13,292	11,082	-2,210	-19.9%
Construction (CN)	15,067	13,267	15,901	+2,634	+16.6%
Purchase Power and Wheeling (PPW)	68,000	54,000	93,000	+39,000	+41.9%
Program Direction (PD)	35,157	35,635	36,833	+1,198	+3.3%
Subtotal, Operation and Maintenance	131,863	116,194	156,816	+40,622	+25.9%
Offsetting Collections, O&M	-5,908	-5,657	-4,395	+1,262	-28.7%
Offsetting Collections, PD	-31,467	-31,483	-33,529	-2,046	+6.1%
Offsetting Collections, PPW	-43,000	-34,000	-70,000	+36,000	+51.4%
Alternative Financing, O&M	-6,018	-5,635	-4,591	+1,044	-22.7%
Alternative Financing, CN	-10,070	-8,167	-10,901	-2,734	+25%
Alternative Financing, PD	0	-852	0	+852	-100%
Alternative Financing, PPW	-25,000	-20,000	-23,000	+3,000	-13.0%
Net Budget Authority, Operation and Maintenance	10,400	10,400	10,400	0	0%
Federal FTEs	194	194	194	0	0%

Operation and Maintenance
Explanation of Major Changes ($K)

	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Operations and Maintenance: The decrease in the operations and maintenance subprogram reflects completion of the upgrades to the operations building and servers and the completion of the cultural resources archeological survey of Southwestern's transmission lines.	**-2,210**
Construction: The increase in the construction subprogram reflects the purchase and installation of a new auto-transformer at the Carthage Substation.	**+2,634**
Purchase Power and Wheeling: The increase in system support reflects the anticipated needs based on projected market prices and severe drought hydrologic conditions. It is important for Southwestern to maintain Purchase Power and Wheeling (PPW) funding authority at a level that allows for timely response to severe drought conditions that can develop rapidly (in a matter of months) in Southwestern's region. Access to funding via spending authority from offsetting collections and utilizing alternative financing provides Southwestern PPW funding options to best plan for and respond to varied hydrologic conditions, such as periods of drought or low water conditions, as well as operational impacts, such as hydropower unit outages for major rehabilitation. This increase reflects anticipated needs for periods of drought or low water conditions.	**+39,000**
Program Direction: The increase in the program direction subprogram reflects aggressive recruiting to fill several technical hard to fill positions, back-filling retirees, cost of living increases for craft workers and power system dispatchers, and filling succession planning positions for knowledge transfer. Also, increase in support services for projected contractual cost of living adjustments.	**+1,198**
Total, Southwestern, Operation and Maintenance	**+40,622**

Operations and Maintenance
Funding ($K)

	FY2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)
Operations and Maintenance (O&M)				
Power Marketing	200	200	200	0
Operations	8,217	8,178	5,570	-2,608
Maintenance	3,834	3,550	3,784	+234
Capitalized Moveable Equipment	1,388	1,364	1,528	+164
Subtotal, Operations and Maintenance	**13,639**	**13,292**	**11,082**	**-2,210**
Offsetting Collections (annual expenses)	-5,908	-5,657	-4,395	+1,262
Alternative Financing	-6,018	-5,635	-4,591	+1,044
Total, Operations and Maintenance	**1,713**	**2,000**	**2,096**	**+96**

Southwestern Power Administration
Operations and Maintenance

Description

The activities of the Operations and Maintenance (O&M) subprogram are critical components in maintaining the reliability of the Federal power system, which is part of the Nation's interconnected generation and transmission system. By marketing and delivering hydroelectric energy, Southwestern makes a meaningful contribution of clean, safe, reliable, affordable, and secure renewable hydroelectric energy to our Nation. The Energy Policy Act (EPACT) and the Department of Energy (DOE) and Administration's policies emphasize its significant contribution to the Nation's past, current, and future energy supply; and identify Southwestern's important role in meeting electricity demand by supplying hydroelectric energy to its customers. These laws and policies emphasize the need to repair, maintain, and improve transmission and generation facilities to ensure safety, security, and reliability of the Nation's energy infrastructure.

Southwestern's planned O&M projects are subject to change due to unanticipated equipment failure, customer needs, and weather conditions. The realities of maintaining a complex interconnected electric power system periodically require unforeseen reprioritizations of planned projects. All projects share the commonality of maintaining, repairing, and improving the aging infrastructure to ensure the reliability of the Federal power system. Southwestern will continue to maintain infrastructure and modernize systems to increase the resilience, reliability, efficiency, and use of Federal assets. This will be accomplished using appropriations; offsetting collections; and alternative financing arrangements, which include net billing, and/or reimbursable authority (customer advances).[2]

Southwestern will continue to strengthen cyber and physical security postures using strong and proven technologies that are part of the Continuous Diagnostics and Mitigation (CDM) program. The CDM program provides capabilities and tools to identify cybersecurity risks on an ongoing basis, prioritize these risks based on potential impacts, and enable cybersecurity personnel to mitigate the most significant problems first. In addition to CDM, Southwestern continues to look for other technologies that can be leveraged to ensure compliance with the Federal Information Security Management Act (FISMA) and North American Energy Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) Standards to protect the Federal transmission system and the Nation's power grid.

[2] Southwestern's authority to use net billing is inherent in the authority provided by the Flood Control Act of 1944 and has been affirmed by the Comptroller General to the Honorable Secretary of the Interior B-125127 (February 14, 1956).

Power Marketing

The Power Marketing activity funds technical and economic studies to support Southwestern's transmission planning, water resources management, and communication functions. Technical and economic studies provide data to analyze and evaluate the impacts of proposed operational changes and decision-making based on cost-benefit analysis. Funding is also required for Southwestern's coordination with the RTOs and to provide regional power restoration assistance to other non-hydropower generation sources during electric power grid emergencies. The National Electric Transmission Congestion Study identified constraints in the Nation's interconnected electrical grid which could impede power flows. Studies to identify any constraints on Southwestern's system will continue to be conducted. These studies show how the marketing and delivery of power is operationally impacted. The funding level for this activity is derived from Southwestern's engineering plan, negotiated architect/engineering contracts, and the number of studies required per year.

Operations

The Operations activity funds communication functions associated with the dispatch and delivery of power; environmental, safety, and health activities; and other transmission activity costs such as physical security, cybersecurity, and day-to-day power dispatch functions. The Operations activity includes three subactivities:

Communications

This subactivity funds telemetering improvements, technical support to protect cyber infrastructure, an e-tagging system that electronically schedules power for customers, load forecasting, digital test equipment, the radio frequency spectrum fee, and supplies and materials. The telemetering improvements include replacement of obsolete power and energy accounting equipment and modification of existing remote terminal units that improve the reliability of the power system, specifically in the areas of monitoring and control. Funding is required for upgrades that enable Southwestern to meet the goals of the EPACT and NERC by replacing aging infrastructure while assuring reliability and continuing to coordinate with the RTOs in its marketing area. The funding level for communications maintenance is derived from maintenance history, the age of equipment, expected life span, annual diagnostic maintenance testing, and historical pricing information.

Environmental, Safety, and Health

This subactivity funds environmental activities including waste disposal and clean-up of transformers, grounding and drainage, cultural resource reviews, and environmental assessments for threatened and endangered species such as the American Burying Beetle, various endangered bats, the Leopard Darter, and Interior Least Tern. Additionally, Southwestern may have environmental activities it performs as a Consulting Agency or participating agency resulting from a Biological Opinion or Biological Assessment, or as a participant on an interagency committee or working group. This subactivity also funds property transfers, wetland assessments, environmental library access, Toxic Substance Control Act and Resource Conservation Recovery Act compliance, contractor services, and requirements of the Environmental Protection Program as identified in DOE Order 450.1. The Safety and Health Program activities require funding for aviation safety, industrial hygiene, medical examinations, medical officer, wellness program, safety equipment, and first aid equipment and supplies.

Other Transmission

This subactivity funds physical security, field utility costs, and day-to-day power expenses of the dispatch center and the Alternate Control Center.

Maintenance

The Maintenance activity funds routine repair, maintenance, and improvement of Southwestern's substations/switchyards and high-voltage transmission lines and ensures delivery of reliable, efficient, and clean power to its customers. Southwestern's initial facilities, which were built approximately 60 years ago, are constantly evaluated. The funding level is based on analysis derived from age of equipment, risk of failure, life-cycle of equipment, and field crew evaluation. Internal and external factors include obsolescence of technology and unavailability of replacement parts. This budget request reflects Southwestern's assessment of the funding required to ensure continued reliability of the Federal power system and to fulfill the NERC operational criteria. By replacing aging equipment and removing constraints that impede power flows, Southwestern ensures the provision of a reliable Federal transmission system. The maintenance activity includes two subactivities:

Substation Maintenance

This subactivity funds power circuit breakers, disconnect switches, instrument transformers, protective relays and related equipment, computer aided drafting and design, revenue meters, vehicle maintenance, fuel, and other equipment to reliably perform general maintenance projects. Southwestern maintains the Federal power system in compliance with the regional electric reliability council and NERC requirements. The funding level for this subactivity is derived from an internal maintenance information system, which includes age and condition of the existing equipment.

Transmission Line Maintenance

This subactivity funds the purchase and maintenance of wood and steel structures, crossarms and braces, right-of-way (ROW) clearing, herbicide application, aerial patrol of the transmission system to identify maintenance needs, routine vehicle repair and maintenance, tractors, equipment, and fuel. The number of steel or wood poles and crossarms and high-voltage insulators replaced is derived from internal maintenance information system criteria. Emphasis has been placed on ROW clearing since NERC identified improper/insufficient ROW clearing as a major factor in potential blackouts. The funding level is appropriate for the number of structures and components to be replaced and the miles of ROW to be cleared as set forth by Southwestern's maintenance plan for meeting the goals of the EPACT and NERC to maintain a reliable transmission system.

Capitalized Moveable Equipment

This activity funds the replacement of vehicles, tractor-trailers, and heavy equipment used for the maintenance and repair of the transmission system and facilities. These vehicles and equipment have exceeded their useful lives and require high levels of maintenance. The vehicle cost estimates are derived from General Services Administration (GSA) pricing schedules.

Operations and Maintenance

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Operations and Maintenance $13,292,000	**$11,082,000**	**-$2,210,000**
Power Marketing $200,000	**$200,000**	**$0**
• The Power Marketing activity funds the technical and economic studies to support transmission planning.	• The Power Marketing activity funds the technical and economic studies to support transmission planning.	• No change.
Operations $8,178,000	**$5,570,000**	**-$2,608,000**
Communications ($5,408,000) • This subactivity funds telemetering improvements, technical support to protect cyber infrastructure, SCADA/EMS system maintenance, load forecasting, and digital testing equipment.	*Communications ($3,924,000)* • This subactivity funds telemetering improvements, technical support to protect cyber infrastructure, SCADA/EMS system maintenance, load forecasting, and digital testing equipment.	*Communications (-$1,484,000)* • The decrease reflects completion of the Springfield Operations building improvements and server upgrade in support of a more robust cyber security network.
Environmental, Safety, and Health ($2,050,000) • The subactivity funds environmental, safety, and health services.	*Environmental, Safety, and Health ($866,000)* • The subactivity funds environmental, safety, and health services.	*Environmental, Safety, and Health (-$1,184,000)* • The decrease reflects the completion of the cultural resources archeological survey on Southwestern's transmission lines.
Other Transmission ($720,000) • The subactivity funds physical security, field utility costs, and day to day expenses of the dispatch center.	*Other Transmission ($780,000)* • The subactivity funds physical security, field utility costs, and day to day expenses of the dispatch center.	*Other Transmission (+$60,000)* • The increase reflects an increase in planned service agreements for security.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Maintenance $3,550,000	**$3,784,000**	**+234,000**
Substation ($2,001,000) • This subactivity funds all equipment, parts, and materials for the operation of high voltage substations.	*Substation ($2,397,000)* • This subactivity funds all equipment, parts, and materials for the operation of high voltage substations.	*Substation (+396,000)* • The increase reflects improvements to existing substation grounding and drainage improvements.
Transmission Line Maintenance ($1,549,000) • This subactivity funds all equipment, parts, and materials for the operation of the high voltage transmission system. Also, vegetation management contracts.	*Transmission Line Maintenance ($1,387,000)* This subactivity funds all equipment, parts, and materials for the operation of the high voltage transmission system. Also, vegetation management contracts.	*Transmission Line Maintenance (-$162,000)* • The decrease reflects the change in the number of miles planned to be cleared by vegetation management contract.
Capitalized Moveable Equipment $1,364,000	**$1,528,000**	**+$164,000**
This activity funds the replacement of vehicles, tractor-trailers, and heavy equipment used for the maintenance and repair of the transmission system and facilities.	• This activity funds the replacement of vehicles, tractor-trailers, and heavy equipment used for the maintenance and repair of the transmission system and facilities.	• The increase reflects the estimated replacement cost of the heavy equipment and utility trucks being purchased.

Construction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)
Construction				
Transmission System				
Substation Upgrades	1,933	0	2,400	+2,400
Communication Upgrades	4,412	2,980	3,405	425
Transmission Upgrades	8,722	10,287	10,096	-191
Subtotal, Construction	**15,067**	**13,267**	**15,901**	**+2,634**
Alternative Financing	-10,070	-8,167	-10,901	-2,734
Total, Construction	**4,997**	**5,100**	**5,000**	**-100**

Southwestern Power Administration
Construction

Description

The activities of the Construction subprogram enable Southwestern to market and deliver Federal hydropower in the most reliable, safe, efficient, and cost-effective manner to meet the operational criteria required by the North American Electric Reliability Corporation while avoiding transmission infrastructure deterioration. Southwestern's planned construction projects are subject to change based on unanticipated equipment failure, customer needs, and weather conditions. The realities of maintaining a complex interconnected power system include unforeseen priority projects which arise periodically, causing a reprioritization of planned projects. All projects share the commonality of replacing aging infrastructure necessary to maintain the reliability of the Federal power system.

Southwestern will continue to maintain infrastructure and modernize systems to increase the resilience, reliability, efficiency, and use of Federal assets. This will be accomplished using appropriations and alternative financing arrangements, which include net billing and/or reimbursable authority (customer advances).[3]

Transmission System

This activity funds current construction projects that require expansion of, or additions to, existing facilities. Southwestern ensures system reliability by replacing aging equipment and removing constraints that limit power flows. The projects outlined below address Southwestern's efforts to reduce the risk of extended service outages, avoid more costly replacements in the future, and support the increased transmission system usage. The funding level for this activity is derived from internal and external management decisions and field crew observations. System age, risk of equipment failure, life-cycles, obsolescence of technology and unavailability of spare parts, cost, and demand for more capacity are also considered in these budgeting decisions. These variables are assessed and incorporated into Southwestern's ten-year construction plan. The transmission activity includes three subactivities:

Substation Upgrades

This subactivity funds the construction and upgrade of the substations and the components necessary to provide improved system reliability and reduce future maintenance and equipment costs. Southwestern owns and operates 26 substation/switching stations. Many of these facilities were designed and constructed over 60 years ago. The equipment which will be replaced or upgraded includes power transformers, circuit breakers, and control equipment, as well as the structural components necessary to sustain reliable power delivery and support a stable, flexible interconnected power grid.

Communication Upgrades

This subactivity funds all communication equipment planned to provide improved system reliability and reduce future maintenance and equipment costs. This subactivity also provides funding for microwave radios and microwave tower additions, replacements, and modifications that will increase the reliability of communications with generating plants and substations. The communication system provides for the transfer of voice and data traffic to allow monitoring and control of power system generation and transmission assets.

[3] Southwestern's authority to use net billing is inherent in the authority provided by the Flood Control Act of 1944 and has been affirmed by the Comptroller General to the Honorable Secretary of the Interior B-125127 (February 14, 1956).

Transmission Upgrades

This subactivity funds transmission system upgrades. Much of the conductor, optical ground wire (OPGW), and static wire on Southwestern's transmission lines has reached the end of its original assumed service life. With this assumed service life, approximately 20 to 30 miles of transmission line, including the conductor, OPGW, static wire, and structures, will need to be replaced each year. As Southwestern replaces the conductor, Southwestern will use the opportunity to increase line capacity where practical to accommodate increased loads in the region.

Spectrum Relocation

The Commercial Spectrum Enhancement Act of 2004 (CSEA, Title II of P.L. 108-494) created the Spectrum Relocation Fund (SRF) to streamline the relocation of Federal systems from existing spectrum bands and accommodate commercial use by facilitating reimbursement of relocation costs to affected agencies. Southwestern has received $42.8 million in spectrum relocation funds, as approved by the Office of Management and Budget, and as reported to the Congress. Southwestern has completed 100 percent of the tower installation project and anticipates completing antenna and radio installation and obtaining comparable capability by June 30, 2023. These mandatory funds will remain available until expended, and Southwestern will return any amounts received in excess of actual relocation costs to the SRF. Spectrum relocation activities were funded from spectrum auction proceeds; thus, no funding is requested in this subactivity.

Construction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Construction $13,267,000	**$15,901,000**	**+2,634,000**
Transmission System $13,267,000	**$15,901,000**	**+2,634,000**
Substation Upgrades ($0) • No planned transformer replacements in FY 2021.	*Substation Upgrades ($2,400,000)* • Carthage Substation Autotransformer #3 Addition.	*Substation Upgrades (+2,400,000)* • The increase is due to an autotransformer addition at Carthage Substation.
Communication Upgrades ($2,980,000) This subactivity funds all communication equipment additions and upgrades. Projects include microwave equipment, fiber terminal equipment upgrades, and microwave tower at Tulsa Headquarters.	*Communication Upgrades (3,405,000)* • This subactivity funds all communication equipment additions and upgrades. Projects include microwave equipment, fiber terminal equipment upgrades, and microwave tower replacement at White Oak. Design funding for the replacement of Table Rock and Bull Shoals tower replacements.	*Communication Upgrades (+425,000)* The increase reflects cost of replacing White Oak tower and design work for replacing two additional towers.
Transmission Upgrades ($10,287,000) • Rebuild structures from Clarksville to Structure 87TC, 15.15 miles and Reconductor Dardanelle Dam to structure 39, Line 3001C, phase one (west side), 8.66 miles.	*Transmission Upgrades ($10,096,000)* • Reconductor Dardanelle Dam-steel structure (line 3001C, west side, phase 2, 14.95 miles	*Transmission Upgrades (-$191,000)* • The decrease in the transmission upgrades reflects the use of a composite conductor on the steel structures for Line 3001C phase two. This product is lighter and will prevent the need to replace the steel towers.

Purchase Power and Wheeling
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Purchase Power and Wheeling				
System Support	64,500	50,500	89,500	+39,000
Other Contractual Services	3,500	3,500	3,500	0
Subtotal, Purchase Power and Wheeling	**68,000**	**54,000**	**93,000**	**+39,000**
Offsetting Collections (PPW)	-43,000	-34,000	-70,000	+36,000
Alternative Financing	-25,000	-20,000	-23,000	+3,000
Total, Purchase Power and Wheeling	**0**	**0**	**0**	**0**

Southwestern Power Administration
Purchase Power and Wheeling

Description

The Purchase Power and Wheeling (PPW) subprogram provides for the purchase of energy to meet peaking power contractual obligations and the delivery of Federal power. Except for contractual arrangements pertaining to a few electrically-isolated hydropower projects, Southwestern's power sales contracts provide for 1200-hours of peaking power per year delivered from its interconnected system of hydropower projects. At times, due to below average water conditions or hydropower unit outages, Southwestern must purchase power when the hydropower projects cannot produce enough to fulfill its 1200-hour contract obligations. Blending purchased power with the Federal hydropower provides a reliable product while ensuring contract fulfillment occurs.

Southwestern assesses its purchase power needs based on hydrologic conditions and anticipated hydropower unit outages. Hydrologic conditions can vary widely and change rapidly, such that purchase power needs are assessed at least seasonally and can change daily. Unit outages for major rehab and replacement work are known years in advance so that purchase power needs can be planned; however, forced outages or delays in units returning to service can cause sudden changes to anticipated purchase power needs. Power purchases are typically made through contractual arrangements but may also be made on the spot market when conditions are more severe than anticipated or otherwise unexpected. Delivery of purchase power to Southwestern's system is made via the SPP RTO or Southwestern's own transmission system.

Southwestern's budget request for the PPW subprogram reflects the maximum anticipated need to ensure adequate funding to fulfill its 1,200-hour peaking power contractual obligations considering volatile market prices, unknown forced generation outages, and all but the most severe hydrological conditions. Southwestern will continue to use offsetting collections and alternative financing arrangements, which include net billing and/or reimbursable authority (customer advances), to fund this subprogram. When hydropower generation falls significantly below normal due to severe drought conditions or major outages, Southwestern will utilize the Continuing Fund for emergency PPW expenses.

Southwestern employs a risk mitigation strategy to ensure continuous operations during periods of significant drought. The strategy involves maintaining an unobligated reserve balance of funds from receipts credited as offsetting collection for PPW, in order to respond to rapid-developing severe drought conditions. Any receipts retained are available until expended and are available only for PPW expenses. As of the end of FY 2020, Southwestern's PPW reserve balance was $88 million. Customers will provide other power resources and/or purchases for the remainder of their firm loads.

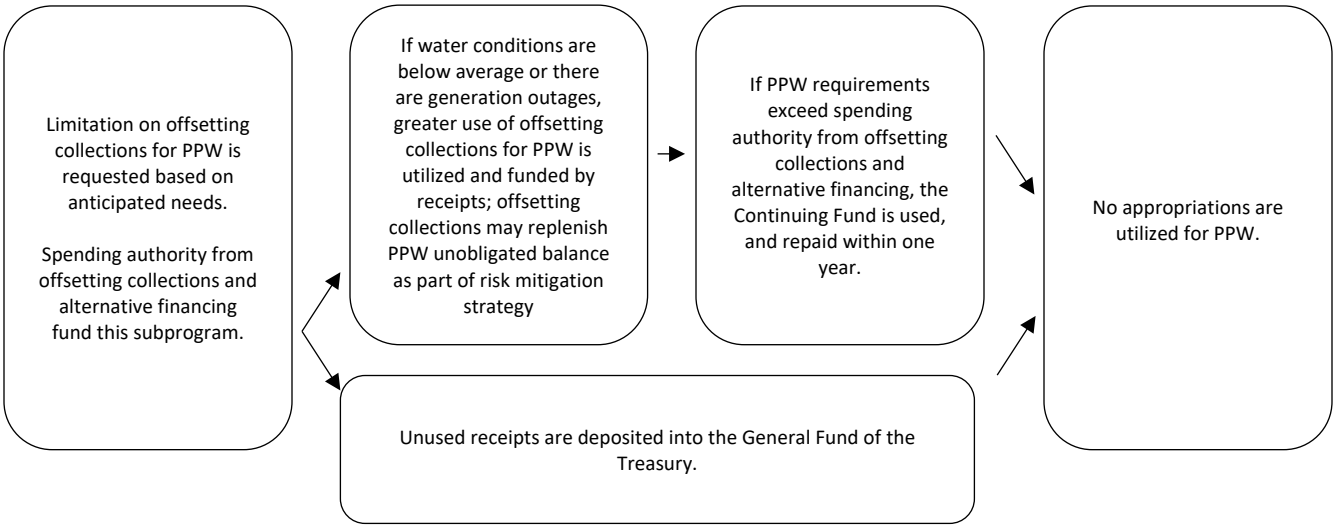
The activities of the PPW subprogram provide for the purchase of power that helps fulfill limited peaking power contractual obligations, thereby ensuring the marketability of the Federal hydropower resource and repayment of the Federal investment. This subprogram also provides for wheeling services that deliver Federal power to optimize the operation of the hydropower facilities marketed by Southwestern. This subprogram enhances the reliability of the electrical transmission grid. PPW includes two activities:

System Support

This activity funds Southwestern's purchase power requirements needed to fulfill all 1200-hour contractual peaking power obligations with customers. System support requirements depend on the conditions of the interconnected system of hydropower projects which is affected by weather, unit operational condition, power market prices (which can be volatile), and limited availability of energy banks. In prior years, inadequate funding for PPW and hydrological fluctuations required multiple requests to access the Continuing Fund to ensure sufficient funding was available to fulfill Southwestern's 1200-hour peaking power contractual obligations. In FY 2001, Southwestern requested, and Congress enacted, authority to use Federal power receipts that recover purchase power and wheeling expenses (offsetting collections) to fund its PPW program (up to a specified limit). The use of this authority will be largely dependent upon the hydrological conditions realized during the fiscal year. Under average conditions, less than half of the limit requested will be collected and used. Since the rates Southwestern charges its customers are based on full cost recovery, Southwestern has a built-in incentive to minimize expenditures for purchase power. The spending authority from offsetting collections supports proactive strategies and ensures greater flexibility when Southwestern experiences low water conditions, hydropower unit outages, and/or volatile power market prices, and will decrease dependence on the Continuing Fund under all but the most severe hydrological conditions.

Other Contractual Services

This activity funds other contractual services that provide for wheeling associated with the purchase of transmission service to meet limited peaking power obligations and for the integration of projects for the delivery of Federal power. The funding level is derived from contractual wheeling requirements. The FY 2022 funding request reflects the projected cost for wheeling services based on contractual pricing and delivery terms.



Purchase Power and Wheeling

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Purchase Power and Wheeling $54,000,000	**$93,000,000**	**+39,000,000**
System Support $50,500,000	*$89,500,000*	*+$39,000,000*
• This activity funds purchase power requirement needed to fulfill all 1200-hour contractual peaking power obligations with customers, through moderate drought conditions. Droughts in Southwestern's region can develop in a matter of months, such that adequate PPW funding must be available for proactive planning and rapid response.	• This activity funds purchase power requirement needed to fulfill all 1200-hour contractual peaking power obligations with customers, through moderate drought conditions. Droughts in Southwestern's region can develop in a matter of months, such that adequate PPW funding must be available for proactive planning and rapid response.	• The overall increase in system support reflects maximum anticipated needs based on projected market prices and severe drought hydrologic conditions. Droughts in Southwestern's region can develop in a matter of months, such that adequate PPW funding must be available for proactive planning and rapid response.
Other Contractual Services $3,500,000	*$3,500,000*	*+$0*
• Contractual services for wheeling associated with the purchase of transmission service.	• Contractual services for wheeling associated with the purchase of transmission service.	• Funding request remains the same.

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)
Southwestern Power Administration				
Salaries and Benefits	25,157	25,238	26,467	+1,229
Travel	1,561	1,710	1,697	-13
Support Services	3,983	4,037	5,254	+1,217
Other Related Expenses	4,456	4,650	3,415	-1,235
Subtotal, Southwestern Power Administration	**35,157**	**35,635**	**36,833**	**+1,198**
Offsetting Collections (annual expenses)	-31,467	-31,483	-33,529	-2,046
Alternative Financing	0	-852	0	+852
Total, Program Direction	**3,690**	**3,300**	**3,304**	**+4**
Federal FTEs	194	194	194	0
Support Services				
Management Support				
Engineering and Technical Services	0	2,624	0	-2,624
Technical Support				
Management and Professional Support Services	3,983	1,413	5,254	+3,841
Total Support Services	3,983	4,037	5,254	+1,217
Total, Support Services	**3,983**	**4,037**	**5,254**	**+1,217**
Other Related Expenses				
Rent to Others	889	852	0	-852
Communication, Utilities, Misc.	966	937	893	-44
EITS	34	36	36	0
Printing and Reproduction	76	76	76	0
Other Services	719	719	500	-219
Training	185	190	190	0
Power Marketing Liaison	140	140	140	0
Financial Audit	400	430	430	0
Supplies and Materials	150	170	150	-20

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)
Equipment	450	450	350	-100
Working Capital Fund	447	650	650	0
Total, Other Related Expenses	**4,456**	**4,650**	**3,415**	**-1,235**

Program Direction

Overview

Southwestern's Program Direction subprogram ensures continued reliability of the Federal power system by utilizing Federal staffing resources and associated funds required to provide overall direction and execution of Southwestern's Operation and Maintenance Program.

The Program Direction subprogram supports DOE's and Southwestern's missions by providing compensation and all related expenses for its workforce, including those employees that operate and maintain Southwestern's high-voltage interconnected transmission system and associated facilities; those that plan, design, and supervise the construction of replacements, upgrades, and additions (capital investments) to the transmission facilities; those that market the power and energy produced to repay annual expenses and capital investment; those that perform cyber and physical security roles; and those that administratively support these functions.

Southwestern will use available programs and develop new strategies to hire and train the next generation of engineers, cyber and physical security specialists, power system dispatchers, high voltage electricians, and linemen. These initiatives will address the shortage of these valuable resources because of retirement trends, and the ever-expanding demands on the electric utility industry, such as compliance with NERC and FISMA standards.

Southwestern trains all employees on a continuing basis in occupational safety and health regulations, policies, and procedures to keep the safety culture strong. Accidents are always reviewed to ensure lessons are learned and proper work protocol is in place.

Program Direction is mainly funded from offsetting collections. Other funding utilized for Program Direction is appropriations and if necessary alternative financing arrangements.

Highlights of the FY 2022 Budget Request

The FY 2022 Budget Request's funding level for salaries is derived from the current year budgeted salaries, projected cost-of-living adjustments, promotions, and within-grade increases. The funding level for benefits is derived from a percentage of budgeted salaries.

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $35,635,000	**$36,833,000**	**+$1,198,000**
Salaries and Benefits $25,238,000	*$26,467,000*	*+1,229,000*
• The FY 2021 level supports 194 Federal employees: 54 percent of the employees are GS; salaries of the remaining 46 percent (craft workers and power system dispatchers) are determined through union negotiations and wage surveys. This activity also includes overtime, awards, relocation, workers' compensation, recruitment bonuses, retention pay, and advanced in-hire rates. By the end of FY 2021, approximately 27 percent of Southwestern's staff will be eligible for optional retirement. Southwestern will continue to invest in its employees, emphasizing strong development programs, completing skills gap analyses, and pursuing aggressive recruitment and retention efforts.	• The FY 2022 level supports 194 Federal employees: 54 percent of the employees are GS; salaries of the remaining 46 percent (craft workers and power system dispatchers) are determined through union negotiations and wage surveys. This activity also includes overtime, awards, relocation, workers' compensation, recruitment bonuses, retention pay, and advanced in-hire rates. By the end of FY 2022, approximately 27 percent of Southwestern's staff will be eligible for optional retirement. Southwestern will continue to invest in its employees, emphasizing strong development programs, completing skills gap analyses, and pursuing aggressive recruitment and retention efforts.	• The increase in Salaries and Benefits reflects aggressive recruiting to fill several technical hard to fill positions, back-filling retirees, and filling succession planning positions for knowledge transfer.
Travel $1,710,000	*$1,697,000*	*-$13,000*
• This activity funds all related travel and per diem expenses for mission-related travel to maintain the integrity and reliability of Southwestern's geographically dispersed power system. The funding level for this activity is primarily derived from the daily requirement of the field maintenance personnel to maintain 1,380 miles of transmission lines, 26 substations/switchyards, 51 microwave/radio sites, communication equipment, and the Supervisory Control and Data Acquisition network. Travel for the performance of general and administrative functions is also included.	• This activity funds all related travel and per diem expenses for mission-related travel to maintain the integrity and reliability of Southwestern's geographically dispersed power system. The funding level for this activity is primarily derived from the daily requirement of the field maintenance personnel to maintain 1,380 miles of transmission lines, 26 substations/switchyards, 51 microwave/radio sites, communication equipment, and the Supervisory Control and Data Acquisition network. Travel for the performance of general and administrative functions is also included.	• The decrease in travel reflects lower estimated transmission policy related efforts, water resource activities, and field maintenance crew travel.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Support Services $4,037,000	*$5,254,000*	*+$1,217,000*
• This activity funds contracted management support services including information technology, E-government, and administrative/records management support. The funding level for this activity is derived from the most recent negotiated contract for support services essential to achieve Southwestern's mission.	• This activity funds contracted management support services including information technology, E-Government, and administrative/records management support. The funding level for this activity is derived from the most recent negotiated contract for support services essential to achieve Southwestern's mission.	• Increase reflects new contract costs for headquarters support services, increases for IT and administrative contractor support, and projected contractual cost-of-living increase.
Other Related Expenses $4,650,000	*$3,415,000*	*-$1,235,000*
• This activity funds rental space, facility security, the financial audit, services of the Power Marketing Liaison Office, the Human Resources Shared Service Center (HRSSC), the working capital fund, technology refresh in the areas of personal computers, hardware and software, printing and reproduction, and training and tuition fees in support of workforce planning and required training to meet the NERC emergency operations requirement. Rental space costs assume the GSA inflation factor. Other costs are based on the historical usage and actual cost of similar items.	• This activity funds rental space, facility security, the financial audit, services of the Power Marketing Liaison Office, the Human Resources Shared Service Center (HRSSC), the working capital fund, technology refresh in the areas of personal computers, hardware and software, printing and reproduction, and training and tuition fees in support of workforce planning and required training to meet the NERC emergency operations requirement. Other costs are based on the historical usage and actual cost of similar items.	• Decrease reflects the reduction in rent at the Tulsa Headquarters Facility and related costs. Although the move to Southwestern's new HQ facility has been delayed, costs associated with continued rent will be covered through available prior year alternative financing.

Southwestern Power Administration
Revenues and Receipts

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Gross Revenues							
Sale and Transmission of Electric Energy	227,668	198,610	198,610	198,610	198,610	198,610	198,610
Alternative Financing Credited as an Offsetting Receipt (O&M, CN, PD, PPW), Net Billing	-53,508	-34,654	-38,492	-35,856	-39,555	-37,126	-38,913
Alternative Financing Credited as an Offsetting Receipt (Section 212), Net Billing[4]	-104,913	-86,269	-45,611	-47,567	-43,068	-44,797	-43,010
Offsetting Collections, Annual Expenses (Net Zero)	-37,375	-37,140	-37,924	-38,680	-39,440	-40,098	-40,098
Offsetting Collections, Purchase Power and Wheeling ('up to' ceiling)[5]	-26,000	-34,000	-70,000	-70,000	-70,000	-70,000	-70,000
Total Proprietary Receipts	5,872	6,547	6,583	6,507	6,547	6,589	6,589
Percent of Sales to Preference Customers	100%	100%	100%	100%	100%	100%	100%
Energy Sales from Power Marketed (billions of kilowatt hours)	7.7	5.1	5.2	5.2	5.2	5.4	5.4

[4] Actual Alternative Financing in estimated years may be more than estimated to provide funding to the WRDA 2000 Section 212 Customer Funding Program, as authorized, dependent upon available receipts based on actual revenues from the sale and transmission of electric energy and utilization of PPW offsetting collections and/or Alternative Financing for PPW in each FY.

[5] FY 2020 amount enacted for the limit on PPW offsetting collections was $43 million; Southwestern actually collected $26 million. For FY 2021 through FY 2026, the estimated amount of offsetting collections for PPW is equivalent to the "up to" amount enacted or requested in the budget (FY 2022) and anticipated to be requested in the budget (FY 2023-2026). The PPW offsetting collections limit requested (when matched with PPW receipts), along with alternative financing used for PPW, could potentially fund a drought for one year or replenish unobligated balances after a drought has occurred. This will also allow funding to be collected in case the drought persists for more than a year.

Southwestern Power Administration
Estimate of Offsetting Collections for Reimbursable Work and Work for Others[6]

	(Dollars in Thousands)		
	FY 2020	FY 2021	FY 2022
Offsetting Collections for Reimbursable Work [7]			
Alternative Financing			
Operations and Maintenance	6,018	5,635	4,591
Construction	10,070	8,167	10,901
Purchase Power and Wheeling (PPW)	25,000	20,000	23,000
Program Direction	0	852	0
Subtotal, Alternative Financing	41,088	34,654	38,492
Offsetting Collections not anticipated for obligation in budget year	0	0	0
Subtotal, Offsetting Collections for Reimbursable Work	**41,088**	**34,654**	**38,492**
Offsetting Collections for Reimbursable Work-for-Others [8]	**9,912**	**11,346**	**18,508**
Total, Offsetting Collections for Reimbursable	**51,000**	**46,000**	**57,000**

[6]Southwestern received permanent non-Federal reimbursable authority pursuant to 16 USC 825s-4. Table is shown for transparency purposes.

[7]Southwestern relies significantly on alternative financing arrangements with customers to finance much of its direct mission work on a reimbursable basis.

[8] Southwestern utilizes various forms of Federal and non-Federal reimbursable agreements. Work-for-Others agreements include interconnection requests, system upgrades for reliability, relocation of structures for State and Federal highways and work for other Federal agencies.

Southwestern Power Administration
System Statistics

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Generating Capacity (kilowatts)							
Installed Capacity	2,192,500	2,192,500	2,192,500	2,221,500	2,221,500	2,221,500	2,221,500
Marketed Capacity	2,058,300	2,058,500	2,058,500	2,058,500	2,058,500	2,058,500	2,058,500
Generating Stations							
Generating Projects (Number)	24	24	24	24	24	24	24
Substations/Switchyards (Number)	26	26	26	26	26	26	26
Substations/Switchyards (kVA Capacity)	1,026,900	1,026,900	1,026,900	1,026,900	1,026,900	1,026,900	1,026,900
Available Energy[9] (Megawatt-hours)							
Energy Generated	7,436,520	4,786,500	4,929,300	4,941,500	4,969,500	5,185,800	5,185,800
Energy Received	255,022	307,500	289,000	283,700	278,900	227,400	227,400
Total, Energy Available for Marketing	7,691,522	5,094,000	5,218,300	5,225,200	5,248,400	5,413,200	5,413,200
Transmission Lines (Circuit-Miles)							
161-KV	1,117	1,117	1,117	1,117	1,117	1,117	1,117
138-KV	164	164	164	164	164	164	164
69-KV	99	99	99	99	99	99	99
Total, Transmission Lines	1,380	1,380	1,380	1,380	1,380	1,380	1,380

[9] Available Energy: actual available energy data is net of losses and other non-marketed energy; estimated data comes from Southwestern's 2021 power repayment studies.

Power Marketed, Wheeled, or Exchanged by Project

	State	Number of Plants	Installed Capacity (kW)	Marketed Capacity (kW)	FY 2020 Actual Energy (GWh)	FY 2021 Estimated Energy (GWh)	FY 2022 Estimated Energy (GWh)	FY 2023 Estimated Energy (GWh	FY 2024 Estimated Energy (GWh)	FY 2025 Estimated Energy (GWh)	FY 2026 Estimated Energy (GWh)
Power Marketed											
Integrated											
System	Missouri	4	470,000	696,748	2,637	1,722	1,765	1,768	1,776	1,834	1,834
	Arkansas	9	1,037,050	385,488	1,459	953	977	978	983	1,014	1,014
	Oklahoma	7	514,100	416,490	1,576	1,030	1,056	1,057	1,062	1,096	1,096
	Texas	2	112,000	208,837	790	516	529	530	532	550	550
	Louisiana	0	0	136,172	515	337	345	346	347	358	358
	Kansas	0	0	155,294	588	384	394	394	396	409	409
Subtotals		22	2,133,150	1,998,988	7,565	4,942	5,066	5,073	5,096	5,261	5,261
Isolated:											
Robert D. Willis Project											
Sam Rayburn Project											
50% to Texas		2	59,350	29,675	127	76	76	76	76	76	76
50% to Louisiana		0	0	29,675	0	76	76	76	76	76	76
Subtotals		2	59,350	59,350	127	152	152	152	152	152	152
Total, Power Marketed[10]		24	2,192,500	2,058,338	7,692	5,094	5,218	5,225	5,248	5,413	5,413
Power Wheeled (MW)					526	536	523	519	522	526	526

[10] Total, Power Marketed: actual energy data is the energy delivered and therefore net of losses and other non-marketed energy; estimated data comes from Southwestern's 2021 power repayment studies.

DEPARTMENT OF ENERGY

Funding by Site

TAS_0303 - Southwestern Power Administration (SWPA) BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Southwestern Power Administration Office			
Operation And Maintenance - SWPA	13,639	13,292	0
Construction - SWPA	15,067	13,267	0
Purchase Power And Wheeling - SWPA	68,000	95,000	0
Program Direction - SWPA	35,157	35,635	36,833
Subtotal, SWPA	131,863	157,194	36,833
Total Southwestern Power Administration Office	**131,863**	**157,194**	**36,833**
Total Funding by Site for TAS_0303 - Southwestern Power Administration (SWPA)	**131,863**	**157,194**	**36,833**

Western Area Power Administration

Western Area Power Administration

Construction, Rehabilitation, Operation and Maintenance
Western Area Power Administration
Proposed Appropriation Language

For carrying out the functions authorized by title III, section 302(a)(1)(E) of the Act of August 4, 1977 (42 U.S.C. 7152), and other related activities including conservation and renewable resources programs as authorized, [$259,126,000] *$285,237,000*, including official reception and representation expenses in an amount not to exceed $1,500, to remain available until expended, of which [$259,126,000] *$285,237,000* shall be derived from the Department of the Interior Reclamation Fund: Provided, That notwithstanding 31 U.S.C. 3302, section 5 of the Flood Control Act of 1944 (16 U.S.C. 825s), and section 1 of the Interior Department Appropriation Act, 1939 (43 U.S.C. 392a), up to [$169,754,000] *$194,465,000* collected by the Western Area Power Administration from the sale of power and related services shall be credited to this account as discretionary offsetting collections, to remain available until expended, for the sole purpose of funding the annual expenses of the Western Area Power Administration: Provided further, That the sum herein appropriated for annual expenses shall be reduced as collections are received during the fiscal year so as to result in a final fiscal year [2021] *2022* appropriation estimated at not more than [$89,372,000] *$90,772,000* of which [$89,372,000] *$90,772,000* is derived from the Reclamation Fund: Provided further, That notwithstanding 31 U.S.C. 3302, up to [$192,000,000] *$316,000,000* collected by the Western Area Power Administration pursuant to the Flood Control Act of 1944 and the Reclamation Project Act of 1939 to recover purchase power and wheeling expenses shall be credited to this account as offsetting collections, to remain available until expended for the sole purpose of making purchase power and wheeling expenditures: Provided further, That for purposes of this appropriation, annual expenses means expenditures that are generally recovered in the same year that they are incurred (excluding purchase power and wheeling expenses). (Energy and Water Development and Related Agencies Appropriations Act, 2021.)

Explanation of Changes

There is no change in the appropriation language.

Public Law Authorizations
P.L. 57-161, "The Reclamation Act of 1902"
P.L. 78-534, "Flood Control Act of 1944"
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 102-486, "Energy Policy Act of 1992"
P.L. 66-389, "Sundry Civil Appropriations Act" (1922)
P.L. 76-260, "Reclamation Project Act of 1939"
P.L. 80-790, "Emergency Fund Act of 1948"
P.L. 102-575, "Reclamation Projects Authorization and Adjustment Act of 1992"
"Economy Act" of 1932, as amended (41 stat. 613)
"Interior Department Appropriation Act of 1928" (44 Stat. 957)
P.L. 70-642, "Boulder Canyon Project Act" (1928)
P.L. 75-756, "Boulder Canyon Project Adjustment Act" (1940)
P.L. 98-381, "Hoover Power Plant Act of 1984"
P.L. 75-529, "The Fort Peck Project Act of 1938"
P.L. 84-484, "The Colorado River Storage Project Act of 1956"
P.L. 90-537, "The Colorado River Basin Project Act of 1968"
The Act of June 18, 1954 (68 Stat. 255)
P.L. No 111-5, "American Recovery and Reinvestment Act of 2009"

Falcon and Amistad Operating and Maintenance Fund
Proposed Appropriation Language

For operation, maintenance, and emergency costs for the hydroelectric facilities at the Falcon and Amistad Dams, [$5,776,000] *$5,808,000*, to remain available until expended, and to be derived from the Falcon and Amistad Operating and Maintenance Fund of the Western Area Power Administration, as provided in section 2 of the Act of June 18, 1954 (68 Stat. 255): Provided, That notwithstanding the provisions of that Act and of 31 U.S.C. 3302, up to [$5,548,000] *$5,580,000* collected by the Western Area Power Administration from the sale of power and related services from the Falcon and Amistad Dams shall be credited to this account as discretionary offsetting collections, to remain available until expended for the sole purpose of funding the annual expenses of the hydroelectric facilities of these Dams and associated Western Area Power Administration activities: Provided further, That the sum herein appropriated for annual expenses shall be reduced as collections are received during the fiscal year so as to result in a final fiscal year [2021] *2022* appropriation estimated at not more than $228,000: Provided further, That for purposes of this appropriation, annual expenses means expenditures that are generally recovered in the same year that they are incurred: Provided further, That for fiscal year [2021] *2022*, the Administrator of the Western Area Power Administration may accept up to [$1,526,000] *$1,737,000* in funds contributed by United States power customers of the Falcon and Amistad Dams for deposit into the Falcon and Amistad Operating and Maintenance Fund, and such funds shall be available for the purpose for which contributed in like manner as if said sums had been specifically appropriated for such purpose: Provided further, That any such funds shall be available without further appropriation and without fiscal year limitation for use by the Commissioner of the United States Section of the International Boundary and Water Commission for the sole purpose of operating, maintaining, repairing, rehabilitating, replacing, or upgrading the hydroelectric facilities at these Dams in accordance with agreements reached between the Administrator, Commissioner, and the power customers. (Energy and Water Development and Related Agencies Appropriations Act, 2021.)

Explanation of Changes

There is no change in the appropriation language.

Public Law Authorizations
P.L. 103-236, "Foreign Relations Authorization Act, Fiscal Years 1994 and 1995"
The Act of June 18, 1954 (68 Stat. 255)

Western Area Power Administration
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Gross	1,157,256	1,108,393	1,250,326
Offsets	-1,089,232	-1,040,193	-1,180,726
Net BA	**68,024**	**68,200**	**69,600**

Overview

Western Area Power Administration (WAPA) continues to support the Department of Energy (DOE) priorities for a resilient, reliable and secure North American electricity system.

WAPA's mission is to market and reliably deliver cost-based Federal hydroelectric power. WAPA markets power in 15 central and western states from Federally owned power plants operated primarily by the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation and the Department of State's International Boundary and Water Commission. WAPA operates and maintains a high-voltage, integrated transmission system, including approximately 17,000 circuit-miles of high-voltage transmission lines, more than 300 substations/switchyards and associated power system controls, and communication and electrical facilities.

WAPA serves a diverse group of nearly 700 wholesale customers, including more than two dozen military installations, DOE National labs, municipalities, cooperatives, public utility and irrigation districts, Federal and state agencies and Native American tribes. In turn, WAPA's customers provide service to millions of retail consumers.

WAPA's base program is funded through three appropriation accounts: 1) the Construction, Rehabilitation, Operation and Maintenance Account (CROM); 2) Falcon and Amistad Operating and Maintenance Fund; and 3) Colorado River Basins Power Marketing Fund (CRBPMF). Within these three accounts, there are seven subprograms; four in the CROM Account, one in the Falcon and Amistad Operating and Maintenance Fund and two in CRBPMF.

In FY 2022, WAPA's request has been formulated to meet its power marketing and contractual power delivery obligations with continued high marks for reliability. The request prioritizes grid modernization through data-driven investment decisions designed to improve resiliency and reliability of WAPA's transmission system.

Western Area Power Administration
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Construction, Rehabilitation, Operation and Maintenance (CROM)					
Operation and Maintenance	72,176	77,874	81,983	+4,109	+5%
Construction and Rehabilitation	45,887	26,251	35,185	+8,934	+34%
Purchase Power and Wheeling	515,769	485,890	589,677	+103,787	+21%
Program Direction	250,091	253,575	267,246	+13,671	+5%
Subtotal, CROM Program	883,923	843,950	974,091	+130,501	+15%
Alternative Financing					
Operation and Maintenance	-6,600	-6,297	-7,122	-825	+13%
Construction and Rehabilitation	-39,922	-20,353	-31,090	-10,737	+53%
Purchase Power and Wheeling	-288,769	-293,890	-273,677	+20,213	-7%
Program Direction	-44,719	-48,546	-51,849	-3,303	+7%
Subtotal, Alternative Financing	-380,010	-369,086	-363,738	+5,348	-1%
Offsetting Collections from Colorado River Dam Fund					
Operation and Maintenance	-1,415	-1,868	-1,491	+377	-20%
Program Direction	-7,539	-6,510	-7,625	-1,115	+17%
Subtotal, Offsetting Collections from Colorado River Dam Fund	-8,594	-8,378	-9,116	-738	+9%
Offsetting Collections, annual Operation and Maintenance and Program Direction					
Operation and Maintenance	-24,445	-24,744	-27,530	-2,786	+11%
Program Direction	-149,142	-145,010	-166,935	-21,925	+15%
Subtotal, Offsetting Collections, annual Operation and Maintenance and Program Direction	-173,587	-169,754	-194,465	-24,711	+15%
Offsetting Collections, Purchase Power and Wheeling	-227,000	-192,000	-316,000	-124,000	+65%
Use of Prior Year Balances					
Annual Operation and Maintenance	-1,000	-2,200	0	+2,200	-100%
Annual Program Direction	-4,000	-12,800	0	+12,800	-100%
Subtotal, Use of Prior Year Balances	-5,000	-15,000	0	+15,000	-100%
Subtotal, CROM	**89,372**	**89,372**	**90,772**	**+1,400**	**+2%**
Rescission of Prior Year Balances	-176	0	0	0	0%
Total, CROM	**89,196**	**89,372**	**90,772**	**+1,400**	**+2%**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Federal FTEs	**1,210**	**1,216**	**1,202**	**-14**	**-1%**
Falcon and Amistad Operating and Maintenance Fund	5,647	7,302	7,545	+243	+3%
Offsetting Collections, annual Operation and Maintenance	-2,932	-5,548	-5,580	-32	+1%
Use of Prior Year Balances	-1,300	0	0	0	0%
Alternative Financing	-1187	-1,526	-1,737	-211	+14%
Total, Falcon and Amistad	**228**	**228**	**228**	**0**	**0%**
Federal FTEs	**0**	**0**	**0**	**0**	**0%**
Colorado River Basins Power Marketing Fund (CRBPMF)	220,244	245,047	237,290	-7,757	-3%
Offsetting Collections	-241,644	-266,447	-258,690	+7,757	-3%
Total, CRBPMF	**-21,400**	**-21,400**	**-21,400**	**0**	**0%**
Federal FTEs	**296**	**294**	**308**	**+14**	**+5%**
Transmission Infrastructure Program Fund (TIP)	47,442	12,454	31,400	+18,946	+152%
Advance Funding	-4,300	-2,025	-1,750	+275	-14%
Offsetting Collections	-43,142	-10,429	-29,650	-19,221	+184%
Total TIP	**0**	**0**	**0**	**0**	**0%**
Federal FTEs	**15**	**11**	**11**	**0**	**0%**
Total, Western Area Power Administration	**68,024**	**68,200**	**69,600**	**+1,400**	**+2%**
Federal FTEs	**1,521**	**1,521**	**1,521**	**0**	**0%**

Construction, Rehabilitation, Operation and Maintenance
Western Area Power Administration
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Gross	883,923	843,590	974,091
Offsets	-794,551	-754,218	-883,319
Subtotal	**89,372**	**89,372**	**90,772**
Rescission of prior year balances	-176	0	0
Net BA	**89,372**	**89,372**	**90,772**

Overview

WAPA markets and delivers reliable, cost-based Federal hydroelectric power and related services. WAPA's marketing efforts and delivery capability provide for recovery of annual operational costs, including the generating agencies' hydropower related costs, and repayment of taxpayer investment in the Federal hydropower program. WAPA repays the Federal investment for which it is responsible within the timeframes established by law and regulations.

WAPA's Construction, Rehabilitation, Operation and Maintenance Account (CROM) is comprised of four subprograms:

- Operation and Maintenance
- Construction and Rehabilitation
- Purchase Power and Wheeling
- Program Direction

WAPA's subprograms are funded using a variety of financing methods including appropriations, alternative financing (primarily customer advances), and use of receipt authorities.

In FY 2022, WAPA's request has been formulated to meet its power marketing and contractual power delivery obligations with continued high marks for reliability. The request prioritizes grid modernization through data-driven investment decisions designed to improve resiliency and reliability of WAPA's transmission system.

Operation and Maintenance
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Operation and Maintenance					
Regular Operation and Maintenance	33,923	35,586	36,322	+736	+2%
Replacements and Additions	38,253	42,288	45,661	+3,373	+8%
Total, Operation and Maintenance	**72,176**	**77,874**	**81,983**	**+4,109**	**+5%**
Alternative Financing	-6,600	-6,297	-7,122	-825	+13%
Use of Receipts from Colorado River Dam Fund	-1,415	-1,868	-1,491	+377	-20%
Offsetting Collections	-24,445	-24,744	-27,530	-2,786	+11%
Use of Prior Year Balances	-1,000	-2,200	0	+2,200	-100%
Total, Operation and Maintenance (Budget Authority)	**38,716**	**42,765**	**45,840**	**+3,075**	**+7%**

Description
The Operation and Maintenance (O&M) subprogram provides the supplies, materials and equipment necessary for WAPA to continue to deliver on its mission of providing reliable, resilient domestic energy to 40 million Americans across its 15-state footprint.

Regular Operation and Maintenance
Supplies and materials necessary to respond to routine and emergency situations across WAPA's 17,000 miles of high-voltage interconnected transmission system will be purchased. This includes miscellaneous equipment and software used for power billing, transmission planning, e-tagging, and energy scheduling, as well as supplies and materials such as wood poles (individual pole replacement only; excludes whole line replacements), instrument transformers, meters, relays, etc. Additionally, cyber and physical security audits and monitoring as well as grid operations and monitoring are provided through this activity, which is funded primarily through offsetting collections and alternative customer financing.

Replacements and Additions
WAPA's planned replacements and additions activity is based on cyber and physical security audits, assessments of condition and criticality of equipment, maintenance and frequency of problems on individual items of equipment, availability of replacement parts, safety of the public and WAPA's personnel, environmental concerns and an orderly work plan. Cost estimates are based on an analysis of system operation and maintenance requirements and concerns, customer-coordinated work plans, actual costs of recent similar projects, and bottom-up budgeting techniques. Planned activity is detailed by category below.

Cyber and Physical Security
Investments in the hardening of the transmission grid against increasing foreign and domestic threats include firewalls, cybersecurity upgrades, encryptors for operations offices, security equipment such as perimeter intrusion detection devices, card readers and associated software, security cameras and recording devices at various sites throughout WAPA's service area. These investments in cyber, physical security, and grid technology improvements rely primarily on appropriated funds.

Electrical Equipment
Electrical equipment, such as circuit breakers, transformers, relays, batteries and chargers, reactors, meters, buses, surge arresters, capacitor banks and disconnect switches, will replace obsolete equipment at facilities throughout WAPA's 15-state area. Test equipment used by maintenance crews, such as metering and relaying test sets, pentameters, Ohm testers, oil dielectric testers, battery load testers, and specialized communication and environmental control test equipment is also included. Also included in this request is funding for WAPA's wood pole replacement program. This is a continuing program to replace aging wood transmission line structures, line hardware, and repair damaged conductors and static wires. Many of WAPA's wood transmission line structures were built in the 1950's and 1960's, with the facilities reaching ages in excess of recommended lifespan. Due to age, woodpecker damage, vibratory fatigue, and general deterioration, the system requires constant maintenance upgrades and repairs in order to eliminate the weak links and improve the reliability to our customers.

Communications Equipment
Key to system reliability, replacement of aged or obsolete remote terminal units (RTU), telephone systems, microwave and mobile radio systems with new generation digital radio and fiber optic systems continues. Manufacturers are discontinuing support of obsolete time domain multiplexing (TDM) digital technology equipment in favor of newer packet/internet protocol (IP) based technology as the industry transitions to packet-based networks. WAPA continues with its migration plans to incorporate packet technologies as the current TDM based equipment reaches its end-of-life. Manufacturers have discontinued support of the digital mobile radio equipment WAPA is operating due to obsolescence; this equipment is being replaced with new digital mobile radio technology equipment now and will continue for the next several years.

WAPA's communication systems are currently comprised of approximately 20 percent fiber optics, 70 percent fixed radio, and 10 percent mobile radio. WAPA currently has 1,193 radio frequency authorizations in the fixed radio bands, all of which are digital. This funding will not be used to replace equipment impacted by the Spectrum Relocation initiative.

In addition, WAPA will continue to upgrade its existing supervisory control and data acquisition (SCADA) systems which control WAPA's electric power system. These hardware and software upgrades improve grid reliability by allowing the main SCADA computer to communicate with RTUs in over 300 substations across WAPA's territory, thus allowing the power system dispatcher to operate a device in any of these substations to rapidly make changes in response to electric power industry requirements or system emergencies.

Spectrum Relocation Equipment

The Commercial Spectrum Enhancement Act (CSEA, Title II of P.L. 108-494) of 2004, created the Spectrum Relocation Fund (SRF) to streamline the relocation of Federal systems from specific radio spectrum bands. These spectrum bands will accommodate commercial users and the SRF will facilitate reimbursement to affected agencies for relocation costs. The Federal Communications Commission has allocated this spectrum for Advanced Wireless Services. Funds have been made available to agencies from the crediting of auction receipts to the SRF during FY 2007 and system relocation efforts commenced. WAPA received $108.2 million for this effort. This amount included WAPA's estimated relocation costs, as approved by the Office of Management and Budget, and as reported to the Congress by the Department of Commerce in December 2005. Since receipt of these funds, WAPA has completed all design work including radio path analysis, tower load analysis, communication building upgrades and replacements, acquiring radio frequency authorizations, and all communication equipment purchases. Final communication equipment installation has been completed. Due to complications during system transition, system clean-up activities and acceptance testing will now be completed by FY 2023. WAPA anticipates returning approximately $16 million received in excess of actual relocation costs to the SRF. No appropriations are being requested for this activity.

Capitalized Movable Equipment

The majority of these funds will be used to purchase and lease the fleet of standard and specialized vehicles required for WAPA's O&M activities. Although WAPA prefers to lease its vehicles from GSA, GSA cannot always provide the necessary specialized vehicles, especially in the Upper Great Plains Region and the Desert Southwest Region, where they must be equipped for extreme weather and terrain conditions. In these instances, WAPA is forced to purchase its specialized vehicles. All sedans, vans, SUVs, and light trucks are leased from GSA. WAPA replaces government-owned vehicles according to the Federal Management Regulations guidelines, the same guidelines used by GSA. Other capitalized movable equipment in this estimate includes substation test equipment, brush chipper, map board replacement, information technology equipment such as server and router replacements, LAN upgrades, network equipment replacements, storage upgrades, upgrades to WAPA's power system simulator equipment for training purposes, auto-CAD workstation replacements, and helicopter equipment replacements that add value to the helicopter or extend the service life, such as engine, rotor blades, avionics, airframe, and other major components.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Operation and Maintenance		
$77,874,000	**$81,983,000**	**+$4,109,000**
Regular O&M ($35,586,000) The continuing maintenance of WAPA's transmission system at or above industry standards supports DOE and WAPA missions by minimizing sudden failure, unplanned outages, and possible regional power system disruptions. The request is based on projected work plans for activities funded from this account. Estimates are based on historical data of actual supplies needed to operate and maintain the transmission system and recent procurement of similar items. This request also includes approximately $137,000 for appropriated O&M annual expenses that are required to fund WAPA's Salinity and Levee non-reimbursable power systems. The request includes approximately $1,868,000 for activities in the Boulder Canyon Project, funded through receipts from the Colorado River Dam Fund.	*Regular O&M ($36,322,000)* The continuing maintenance of WAPA's transmission system at or above industry standards supports DOE and WAPA missions by minimizing sudden failure, unplanned outages, and possible regional power system disruptions. The request is based on projected work plans for activities funded from this account. Estimates are based on historical data of actual supplies needed to operate and maintain the transmission system and recent procurement of similar items. This request also includes approximately $179,000 for appropriated O&M annual expenses that are required to fund WAPA's Salinity and Levee non-reimbursable power systems. The request includes approximately $1,491,000 for activities in the Boulder Canyon Project, funded through receipts from the Colorado River Dam Fund.	*Regular O&M (+$736,000)* Regular O&M increases are consistent with inflation.
Replacements and Additions ($42,288,000) Replacement needs are based on age, reliability, and safety of equipment, customer-coordinated review, cost analysis of rebuild versus replacement, availability of replacement parts, and obsolescence of diagnostic maintenance tools. Estimates are determined using actual costs of similar items.	*Replacements and Additions ($45,661,000)* Replacement needs are based on age, reliability, and safety of equipment, customer-coordinated review, cost analysis of rebuild versus replacement, availability of replacement parts, and obsolescence of diagnostic maintenance tools. Estimates are determined using actual costs of similar items.	*Replacements and Additions (+$3,373,000)* Replacements and Additions increases reflect year to year fluctuations in the equipment replacement cycle and are largely driven by substation and movable equipment replacements.

Construction and Rehabilitation
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Construction and Rehabilitation					
Transmission Lines and Terminal Facilities	27,599	13,722	28,400	+14,678	+107%
Substations	14,825	2,727	888	-1,839	-67%
Other	3,463	9,802	5,897	-3,905	-40%
Subtotal, Construction and Rehabilitation	**45,887**	**26,251**	**35,185**	**+8,934**	**+34%**
Alternative Financing	-39,922	-20,353	-31,090	-10,737	+53%
Total, Construction and Rehabilitation	**5,965**	**5,898**	**4,095**	**-1,803**	**-31%**

Construction, Rehabilitation, Operation and Maintenance
Construction and Rehabilitation

Description

The Construction and Rehabilitation (C&R) subprogram supports WAPA's mission to deliver reliable, clean Federal hydroelectric power by emphasizing the replacement, upgrade, and modernization of the electrical system infrastructure to bring continued reliability, improved connectivity, and increased resilience, flexibility and capability to the power grid.

Financing of the FY 2022 C&R budget, planned at $35.2 million, will continue to rely heavily on voluntary stakeholder participation in alternative methods for capital financing. Approximately 88 percent of the program funding, or $31.1 million, will be required from stakeholders, requiring significant partnering efforts.

WAPA has initiated a formalized asset management program to capture data uniformly and systematically on condition, consequences of failure data, and other relevant asset information. The improvements to WAPA's current asset management practices include stronger, more objective data driven evidence, risk-informed priority and decision making, and greater transparency to stakeholders in the allocation of limited resources.

The request incorporates the most current information to identify and schedule necessary C&R projects. WAPA assigns priority to those situations that pose the highest risk to compliance, system reliability, and economic impact to WAPA and its customers, while meeting the mandates for open access to our transmission system. When conditions change, WAPA shifts funding as necessary to ensure the highest program priorities continue to be met to maintain the reliability and integrity of WAPA's power transmission system.

All replacement and rehabilitation plans are coordinated with stakeholders to help establish the timing and scope of work at specific substations. When upgrades or additional capacity are required, WAPA actively pursues partnering with neighboring utilities to jointly finance activities, resulting in cost savings and increased efficiencies for participants.

Unless otherwise provided by law, all C&R costs are recovered from ratepayers with interest over the useful life of the asset providing a revenue stream to the U.S. Treasury. In rare cases, where a C&R project is abandoned, costs are still recovered, but may be expensed.

Transmission Lines and Terminal Facilities

WAPA's 17,000 circuit-mile transmission infrastructure was primarily constructed in the 1940s through 1960s. Thousands of miles of transmission line already exceed their design life. For FY 2022, there is continued focus on replacement and upgrade of deteriorating and inadequate infrastructure across WAPA's service area using alternative financing, with continued emphasis on deteriorating transmission lines with high risk of failure and high consequence of failure as determined through data-driven asset management assessments. This activity funds the construction, replacement, or upgrade of transmission line infrastructure and related components necessary to sustain reliable power delivery and support a stable, flexible interconnected power grid.

Substations

WAPA owns and operates more than 320 substations across its 15-state service territory. Many of these facilities were designed and constructed more than 50 years ago. As substation equipment (such as power transformers, circuit breakers, and control equipment) ages, maintenance costs increase, replacement parts become unavailable, risk of outages increase, and system reliability declines. The normal service life for power transformers and circuit breakers is 40 years and 35 years, respectively. This activity funds the construction, replacement, or upgrade of the substations and its components necessary to sustain reliable power delivery and support a stable, flexible interconnected power grid.

Other

The Other category includes C&R activities not otherwise included in the Substations or Transmission Lines and Terminal Facilities categories. These include communication system equipment and other miscellaneous projects covering items like

construction or major rehabilitation of maintenance facilities, access roads, and facility decommissioning and removal costs.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Construction and Rehabilitation **$26,251,000**	**$35,185,000**	**+$8,934,000**
Transmission and Terminal Facilities ($13,722,000) • Continue rehabilitation and construction required on WAPA's transmission lines and terminal facilities to cost-effectively market and deliver clean Federal hydropower and promote a strong record of reliability and safety. • Address additional system reliability risk and operational problems. • Appropriations ($5,898,000) are requested for the following projects in FY 2021: o Parker-Bouse (AZ) construct 15-mile segment of 230-kV double circuit transmission line and upgrade equipment at Bouse substation to improve reliability of service, improve safety, and reduce ongoing maintenance costs • Alternative financing ($7,824,000) sought for the following projects in FY 2021: o Parker-Bouse (AZ) construct 15-mile segment of 230-kV double circuit transmission line and upgrade equipment at Bouse substation to improve reliability of service, improve safety, and reduce ongoing maintenance costs	*Transmission and Terminal Facilities ($28,400,000)* • Continue rehabilitation and construction required on WAPA's transmission lines and terminal facilities to cost-effectively market and deliver clean Federal hydropower and promote a strong record of reliability and safety. • Address additional system reliability risk and operational problems. • Appropriations ($2,585,000) are requested for the following projects in FY 2022: o Parker-Bouse (AZ) construct 15-mile segment of 230-kV double circuit transmission line and upgrade equipment at Bouse substation to improve reliability of service, improve safety, and reduce ongoing maintenance costs • Alternative financing ($25,815,000) sought for the following projects in FY 2022: o Blythe-Knob (CA) replacement of failed and deteriorating wood transmission line structures to increase reliability and reduce maintenance costs o Bouse-Kofa (AZ) rebuild of a 75.6 miles of 161-kV transmission line to comply with NERC standards, increase reliability and reduce maintenance costs o DJ Tap Sidney (NE/WY) replacement of failing conductor along 210 miles of 115-kV transmission line to increase reliability and mitigate significant safety risk to the public	*Transmission and Terminal Facilities (+$14,678,000)* • The increase in transmission line work reflects the year to year fluctuation in the timing of capital investments while maintaining a continued focus on upgrading and replacing aging and inadequate infrastructure to improve reliability and safety and reduce maintenance costs.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	○ Groton-Bristol (SD) rebuild of 21-miles of 115-kV transmission line and deteriorating structures to increase reliability and reduce maintenance costs ○ Lovell-Yellowtail (MT) rebuild of 15-miles of two 115-kV transmission lines and deteriorating structures to increase reliability and reduce maintenance costs	
Substations ($2,727,000) • Continue construction, modification, and rehabilitation of WAPA's substations to ensure power system reliability and stability. • Address additional system reliability risk and operational problems. • Appropriations ($0) are not requested for projects in FY 2021 • Alternative financing ($2,727,000) sought for the following projects in FY 2021: ○ Fort Thompson Substation (SD) transformer replacement due to age (50+ years) and high consequence of failure which could result in catastrophic failure, reliability, and customer outages ○ Maurine Substation (SD) aging (manufactured in 1962 and in service for 50+ years) transformer replacement to ensure reliability and mitigate risk of catastrophic failure ○ Sand Creek Tap (CO) installation of 3 breaker ring bus (power circuit breakers and line relays) to sectionalize the Erie-Hoyt-Willowby 115-kV transmission line and	*Substations ($888,000)* • Continue construction, modification, and rehabilitation of WAPA's substations to ensure power system reliability and stability. • Address additional system reliability risk and operational problems. • Appropriations ($888,000) are requested for the following projects in FY 2022: ○ Fort Thompson Substation (SD) transformer replacement due to age (50+ years) and high consequence of failure which could result in catastrophic failure, reliability, and customer outages ○ Maurine Substation (SD) aging (manufactured in 1962 and in service for 50+ years) transformer replacement to ensure reliability and mitigate risk of catastrophic failure • Alternative financing ($0) is not being sought for projects in FY 2022	*Substations (-1,839,000)* • The decrease in substation work reflects the year to year fluctuation in the timing of capital investments while maintaining a continued focus on replacing aging and deteriorating equipment and facilities to provide for system reliability. Projects are individually prioritized within available resource levels which also contributes to year to year fluctuations in program levels.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
to increase reliability and reduce maintenance costs ○ Sioux City 2 Substation (IA) transformer replacement is needed due to deteriorating conditions creating an environmental hazard and will provide for increased reliability		
Other ($9,802,000) • Appropriations ($0) are not requested for projects in FY 2021 • Alternative financing ($9,802,000) sought for the following projects in FY 2021: ○ Devils Lake Substation (ND) cold storage building will house critical equipment and materials to enable WAPA to better manage supply levels and be more efficient in maintenance and response to emergencies ○ Gila Substation (AZ) maintenance building replacement will provide climate-controlled crew meeting and workstation/workshop space, and vehicle/equipment storage to increase efficiency and reduce maintenance costs ○ Rapid City Substation (SD) maintenance building replacement (40+ years old) will accommodate crew quarters, shop areas, house vehicles, and provide equipment storage and enable WAPA to be more efficient in maintenance and response to emergencies ○ Substation service upgrades at Tracy substation (CA) to mitigate safety hazards and increase reliability	*Other ($5,897,000)* • Appropriations ($622,000) are requested for the following projects in FY 2022: ○ Substation service upgrades at Keswick substation (CA) and Shasta substation (CA) to mitigate safety hazards and increase reliability • Alternative financing ($5,275,000) sought for the following projects in FY 2022: ○ Bismarck maintenance facility (ND) addition of a 60’ x 100’ cold storage building to house critical vehicles and equipment required for maintenance activities ○ Rapid City Substation (SD) maintenance building replacement (40+ years old) will accommodate crew quarters, shop areas, house vehicles, and provide equipment storage and enable WAPA to be more efficient in maintenance and response to emergencies	*Other (-$3,905,000)* • The decrease in other investments reflects the year to year fluctuation in the timing of capital investments while maintaining a continued focus on replacing aging and deteriorating equipment and facilities to provide for system reliability.

Purchase Power and Wheeling
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Purchase Power and Wheeling					
Central Valley	293,804	318,235	312,699	-5,536	-2%
Pick-Sloan Missouri Basin and other Programs	221,965	167,655	276,978	+109,323	+65%
Subtotal, Purchase Power and Wheeling	**515,769**	**485,890**	**589,677**	**+103,787**	**+21%**
Alternative Financing Needed	-288,769	-293,890	-273,677	+20,213	-7%
Offsetting Collections	-227,000	-192,000	-316,000	-124,000	+65%
Total, Purchase Power and Wheeling (New Budget Authority)	**0**	**0**	**0**	**0**	**0%**

Construction, Rehabilitation, Operation & Mainenance
Purchase Power and Wheeling

Description
The Purchase Power and Wheeling subprogram continues to support WAPA's marketing efforts and delivery capability which spans a 1.3 million square mile area serving a diverse group of several hundred wholesale customers, including municipalities, cooperatives, public utility and irrigation districts, Federal and state agencies and Native American tribes. No appropriated budget authority is necessary.

For a historical perspective, WAPAs Purchase Power and Wheeling subprogram is highly variable; it is affected by reservoir storage levels, annual and long-term drought conditions, downstream flow concerns due to icing, flooding, environmental, health and safety, recreation, irrigation and navigation requirements. To illustrate the extent of the variability, WAPA Purchase Power and Wheeling costs during FY 2008, an adverse water year, were nearly $600 million; whereas in FY 2019, a much-improved water year, costs were $147 million. Year-to-year changes can be extensive, and during long-term drought scenarios the increased purchase power requirements can last several years. The FY 2022 budget request reflects anticipated requirements utilizing current information on hydro conditions, generation, contractual commitments, and power pricing.

WAPA has implemented a Purchase Power and Wheeling risk mitigation strategy to ensure continuous operations during periods of significant drought. The strategy was developed consistent with existing authorities, and with the participation and support of WAPA power customers. Under this approach, WAPA retains receipts from the recovery of purchase power and wheeling expenses within the 'up to' amount specified by Congress. The receipts retained are available until expended and are available only for purchase power and wheeling expenses. At the end of FY 2020, WAPA's PPW reserve balance was at the strategy level of $393 million. The FY 2022 request for PPW includes $93 million to replenish the reserve balance due to significant PPW costs incurred due to extreme weather events in February 2021. Since inception, the full cost of the PPW program has been included in the rate setting process. Through this process, and utilizing interim rate adjusting capabilities, all PPW costs are fully recovered through WAPA's rates.

Central Valley Project
WAPA continues to deliver on its contractual power commitments to customers under the Central Valley Project's Post 2004 Marketing Plan. The budget request assumes current full load service customers will continue to choose service from WAPA through "Custom Product" contractual agreements. WAPA also purchases power to support variable resource customers on a pass-thru basis. If project net generation is not sufficient, WAPA may also purchase to support project use load, First Preference Customer load, and sub-control area reserve requirements. As part of the Order 741, FERC promulgated guidance requiring RTO/ISOs to take physical title/ownership to the energy bought/sold in their respective markets, making it necessary for WAPA to acknowledge that customers receive the financial, and not the physical benefit of their Federal power allocations. In order to provide service in the state, WAPA is voluntarily participating in the California greenhouse gas cap-and-trade program which became effective January 1, 2013.

Pick-Sloan Missouri Basin and Other Programs
The budget request continues to support long-term firm power commitments to customers of the eastern and western divisions of the Pick-Sloan Missouri Basin Program, the Fryingpan-Arkansas Project, and the Parker-Davis Project commensurate with the levels of average firm hydroelectric energy marketed by WAPA. The request also provides transmission support for the Pacific Northwest-Southwest Intertie Project. The total program estimates shown are based primarily on market pricing of short-term firm energy, negotiated transmission rates, and WAPA and generating agency's forecasts.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Central Valley Project		
Program Requirements ($318,235,000) The Purchase Power and Wheeling subprogram continues to support WAPA's power marketing effort by providing for power purchases to firm the variable hydropower resource and securing transmission services as necessary to meet its contractual power delivery.	*Program Requirements ($312,699,000)* The Purchase Power and Wheeling subprogram continues to support WAPA's power marketing effort by providing for power purchases to firm the variable hydropower resource and securing transmission services as necessary to meet its contractual power delivery.	*Program Requirements (-$5,536,000)* Decrease is attributed to anticipated purchase needs based on hydro generation estimates to meet contractual needs. Amounts are for offsetting collections and alternative financing; no direct appropriations are requested for this activity.
Alternative Financing (-$196,235,000) Contractual arrangements made with customers provide opportunities for alternative financing of the purchase power requirements. Alternative financing methods include net billing, bill crediting, energy exchanges, and direct customer funding.	*Alternative Financing (-$171,699,000)* Contractual arrangements made with customers provide opportunities for alternative financing of the purchase power requirements. Alternative financing methods include net billing, bill crediting, energy exchanges, and direct customer funding.	*Alternative Financing (+$24,536,000)* Decrease in the offset is due to potentially lower anticipated alternative financing in FY 2022.
Pick-Sloan Missouri Basin		
Program Requirements ($167,655,000) The Purchase Power and Wheeling subprogram continues to support WAPA's power marketing effort by providing for power purchases to firm the variable hydropower resource and securing transmission services as necessary to meet its contractual power delivery.	*Program Requirements ($276,978,000)* The Purchase Power and Wheeling subprogram continues to support WAPA's power marketing effort by providing for power purchases to firm the variable hydropower resource and securing transmission services as necessary to meet its contractual power delivery.	*Program Requirements (+$109,323,000)* The increase is attributed to anticipated purchase needs based on hydro generation estimates to meet contractual needs and the restoration of funds for the risk mitigation reserve. During February of 2021, unprecedented PPW costs were experienced due to extreme weather conditions and a spike in market prices for wholesale power, resulting in a $93M drawdown in the reserve. Amounts are for offsetting collections and alternative financing; no direct appropriations are requested for this activity.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Alternative Financing (-$97,655,000) Alternative financing methods negotiated with customers provide an offset to the total program receipt financing requirement. Alternative financing methods include net billing, bill crediting, energy exchanges, and direct customer funding.	*Alternative Financing (-$101,978,000)* Contractual arrangements made with customers provide opportunities for alternative financing of the purchase power requirements. Alternative financing methods include net billing, bill crediting, energy exchanges, and direct customer funding.	*Alternative Financing (-$4,323,000)* Increase in the offset is attributed to an increase in estimated transmission costs expected to be funded through alternative financing coming from WAPA's participation in markets (Southwest Power Pool). Amounts are for alternative financing. No direct appropriations are requested for this activity.

Construction, Rehabilitation, Operation & Maintenance
Program Direction

Overview

WAPA's Program Direction subprogram provides compensation and all related expenses for its workforce, including those employees that operate and maintain WAPA's high-voltage interconnected transmission system and associated facilities; those that plan, design, and supervise the construction of replacements, upgrades and additions (capital investments) to the transmission facilities; those that market the power and energy produced to repay annual expenses and capital investment; and those that administratively support these functions.

The Program Direction subprogram supports DOE's and WAPA's mission of operating and maintaining a resilient and secure energy grid by attaining and developing a critical highly skilled workforce of engineers, dispatchers, linemen, power system operators, and high voltage electricians. The Program Direction subprogram also includes the administrative staff, including those positions that monitor, detect and deter physical and cyber-attacks on WAPA's infrastructure.

WAPA trains its employees on a continuing basis in occupational safety and health regulations, policies and procedures, and conducts safety meetings at employee, supervisory and management levels to keep the safety culture strong. Accidents are reviewed to ensure lessons are learned and proper work protocol is in place.

In consultation with its customers, WAPA reviews required replacements and upgrades to its existing infrastructure to sustain reliable power delivery to its customers and to contain annual maintenance expenses. The timing and scope of these replacements and upgrades are critical to assure that WAPA's facilities do not become the "weak link" in the interconnected system. WAPA pursues opportunities to join with neighboring utilities to jointly finance activities, which avoid redundant facilities and result in realized cost savings and/or increased efficiencies for all participants.

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Program Direction					
Salaries and Benefits	169,663	172,151	183,875	+11,724	+7%
Travel	11,540	10,658	10,497	-161	-2%
Support Services	33,417	31,811	36,732	+4,921	+15%
Other Related Expenses	35,471	38,955	36,142	-2,813	-7%
Total, Program Direction	**250,091**	**253,575**	**267,246**	**+13,671**	**+5%**
Use of Alternative Financing	-44,719	-48,546	-51,849	-3,303	+7%
Use of Receipts from Colorado River Dam Fund	-7,539	-6,510	-7,625	-1,115	+17%
Offsetting Collections, Other Expenses	-149,142	-145,010	-166,935	-21,925	+15%
Use of Prior Year Balances	-4,000	-12,800	0	+12,800	-100%
Total, Program Direction	**44,691**	**40,709**	**40,837**	**+128**	**0%**
Federal FTEs	**1,210**	**1,216**	**1,202**	**-14**	**-1%**
Support Services					
Technical Support Economic and Environmental Analysis	9,687	9,631	13,583	+3,952	+41%
Total, Technical Support	**9,687**	**9,631**	**13,583**	**+3,952**	**+41%**
Management Support Automated Data Processing	13,508	13,024	13,445	+421	+3%
Training and Education	3,338	3,416	3,537	+121	+4%
Reports and Analysis, Management and General Administrative Support	6,884	5,740	6,167	+427	+7%

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Total Management Support	**23,730**	**22,180**	**23,149**	**+969**	**+4%**
Total, Support Services	**33,417**	**31,811**	**36,732**	**+4,921**	**+15%**
Other Related Expenses					
Rent to GSA	2,571	2,431	2,398	-33	-1%
Communication, Utilities, Misc.	5,576	6,832	7,930	+1,098	+16%
Printing and Reproduction	117	111	105	-6	-5%
Other Services	12,755	15,015	11,019	-3,996	-27%
Training	12	12	12	0	0%
Purchases from Gov. Accounts	1,285	1,544	1,341	-203	-13%
Operation and Maintenance of Equipment	5,926	4,785	6,201	+1,416	+30%
Supplies and Materials	2,260	2,077	2,293	+216	+10%
Equipment	2,335	3,681	2,304	-1,377	-37%
Working Capital Fund	2,634	2,467	2,539	+72	+3%
Total, Other Related Expenses	**35,471**	**38,955**	**36,142**	**-2,813**	**-7%**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $253,575,000	**$267,246,000**	**+$13,671,000**
Salaries and Benefits $172,151,000	**$183,875,000**	**+$11,724,000**
Salary and benefits provide for Federal employees who construct and replace, operate and maintain and secure, on a continuing basis, WAPA's high-voltage interconnected transmission system. Salary and benefits fund those FTEs assigned to this account, including those salaries determined through negotiations.	Salary and benefits funding is for Federal employees who construct and replace, operate and maintain and secure, on a continuing basis, WAPA's high-voltage interconnected transmission system.	The salary and benefits reflect inflationary factors and higher negotiated baseline salaries for journeymen.
Travel $10,658,000	**$10,497,000**	**-$161,000**
This activity funds all travel, and related expenses associated with WAPA's mission-related operation and maintenance activities, and those functions that support them.	Request funds all travel, and related expenses associated with WAPA's mission-related operation and maintenance activities, and those functions that support them.	Request reflects variabilities in scope and location associated with mission related operation and maintenance travel, and travel for cross-functional collaboration among various internal and external programs.
Support Services $31,811,000	**$36,732,000**	**+$4,921,000**
Support Services funded in this category include information technology, job related training and education, engineering, miscellaneous advisory and reporting services, and general administrative support.	Request funds information technology, job related training and education, engineering, miscellaneous advisory and reporting services, and general administrative support services.	Increase reflects technical support needed for operations security; financial system enhancements, upgrades and $2M budget realignment from other related expenses category.

Other Related Expenses $38,955,000	$36,142,000	-$2,813,000
Other related expenses include rental space, utilities, supplies and materials, telecommunications, information technology modernization (data/network), printing and reproduction, training tuition, and DOE's Working Capital Fund distribution. Rental space costs assume the General Services Administration's (GSA) inflation factor. Other costs are based on historical usage and actual cost of similar items.	Request funds rental space, utilities, supplies and materials, telecommunications, information technology modernization (data/network), printing and reproduction, training tuition, and DOE's Working Capital Fund distribution. Rental space costs assume the General Services Administration's (GSA) inflation factor. Other costs are based on historical usage and actual cost of similar items.	The decrease is primarily attributable to budget realignment to support services category and other services for general facility maintenance/janitorial; vegetation management; asset management; and equipment purchases.

Falcon and Amistad Operating and Maintenance Fund
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Gross	5,647	7,302	7,545
Offsets	-5,419	-7,074	-7,317
Net BA	**228**	**228**	**228**

Overview

The Falcon and Amistad Operating and Maintenance fund (Maintenance Fund) was established in the Treasury of the United States as directed by the Foreign Relations Authorization Act, FYs 1994 and 1995. The Maintenance Fund is administered by WAPA's Administrator for use by the Commissioner of the U. S. Section of the International Boundary and Water Commission (IBWC) to defray administrative, O&M, replacement, and emergency costs for the hydroelectric facilities at the Falcon and Amistad Dams. IBWC owns and operates the U.S. portion of the projects, and Federal staff funded under this program continues to be allocated to the U.S. Section of IBWC by the Department of State. The Falcon and Amistad project supports WAPA's program goals by providing power to rural electric cooperatives through WAPA. With the exception of monies received from the Government of Mexico, all revenues collected from the sale of electric power generated at the Falcon and Amistad Dams are credited to the Maintenance Fund. Monies received from the Government of Mexico are credited to the General Fund of the U.S. Treasury. Revenues collected in excess of operating expenses are used to repay, with interest, the cost of replacements and original investments. Full funding will support 24-hour/day operation and maintenance of the two power plants to ensure response to ever-changing water conditions, customer demand, and continual coordination with operating personnel of the Government of Mexico.

Highlights of the FY 2022 Budget Request

In FY 2022, WAPA's request has been formulated to meet its power marketing and contractual power delivery obligations with continued high marks for reliability. Revenues collected from customers to recover the costs of the Federal Power Program will be sufficient to provide for FY 2022 planned expenses for the facilities operated by the IBWC. Also included in FY 2022 is the continuation of WAPA's request to allow for U.S. customer(s) of the Falcon and Amistad Dams to contribute funds for use by the IBWC in fulfilling their duties in accordance with agreements between WAPA, IBWC, and the power customers. This will allow work to be accomplished using customer advances/alternative financing, a funding mechanism used throughout WAPA under the Contributed Funds Act, 43 USC 395. The customer contributed funds are planned to predominantly assist in capitalized replacement projects.

Falcon and Amistad Operating and Maintenance Fund
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Western Area Power Administration					
Falcon and Amistad Operating and Maintenance Fund	5,647	7,302	7,545	+243	+3%
Subtotal, Falcon and Amistad Operating and Maintenance Fund	**5,647**	**7,302**	**7,545**	**+243**	**+3%**
Offsetting Collections	-2,932	-5,548	-5,580	-32	+1%
Use of Prior Year Balances	-1,300	0	0	0	0%
Alternative Financing	-1,187	-1,526	-1,737	-211	+14%
Total, Falcon and Amistad Operating and Maintenance Fund	**228**	**228**	**228**	**0**	**0%**

Falcon and Amistad Operating and Maintenance Fund

Description

The Falcon and Amistad Project consists of two international dams located on the Rio Grande River between Texas and Mexico. The United States and Mexico operate separate hydroelectric power plants on each side of the Rio Grande River. The power plants are independent and legislatively severable from the international reservoir storage dams. The Operating and Maintenance Fund was established in the Treasury of the United States and is administered by WAPA's Administrator for use by the Commissioner of the U.S. Section of the IBWC to defray administrative, O&M, replacement, and emergency costs for the hydroelectric facilities at the Falcon and Amistad Dams.

IBWC

O&M

Activities include salaries and benefits for the approximately 40 positions of the U.S. Section of the IBWC who operate and maintain the two power plants on a 24-hour/day basis, planned maintenance activities, required safety services, and emergency response to flood operations and/or equipment failure. O&M includes inspection and service of the HVAC and air compressor system, fire suppression systems, elevators, self-contained breathing apparatus, recharge and hydro-testing of fire extinguishers, calibration of test equipment, rebuild of electric motors, and repair of obsolete equipment when replacement parts are no longer available. Travel, training, communications, utilities, printing, and office supplies and materials for the IBWC employees and technical advisors is also funded by the O&M activity. The request includes essential training for employees to comply with standards of the Interagency Commission on Dam Safety, Occupational and Health Administration, and the National Dam Safety Act.

Capital Investment

WAPA, the IBWC, and the customer have collaboratively developed a rehabilitation work plan to address immediate and future infrastructure needs for the hydroelectric facilities. Future infrastructure needs will be appropriately planned and categorized by all parties through regularly scheduled progress reviews.

WAPA

Marketing, Contract, Repayment Studies

This activity funds power marketing, administration of power contracts, and preparation of rate and repayment studies. Based on accurate studies, staff ensures power revenues are set at an appropriate level to recover annual expenses and meet repayment schedules.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Falcon and Amistad Operating and Maintenance Fund $7,302,000	**$7,545,000**	**+$243,000**
IBWC O&M ($5,470,000) This activity funds the salaries and benefits for those employees assigned to the U.S. Section of the IBWC who operate and maintain the two power plants, equipment inspections and maintenance services, and travel, training, communications, utilities, printing, and office supplies/materials for the IBWC employees and technical advisors.	*IBWC O&M ($5,498,000)* This activity funds the salaries and benefits for those employees assigned to the U.S. Section of the IBWC who operate and maintain the two power plants, equipment inspections and maintenance services, and travel, training, communications, utilities, printing, and office supplies/materials for the IBWC employees and technical advisors.	*IBWC O&M (+$28,000)* The slight increase is attributed to projects in the 10-year O&M work plan that was developed to address recommendations in the U.S. Army Corps of Engineers inspection report completed in 2018. Projects planned for FY 2022 include inspection and repair of penstock unit 3 intake gate system at Falcon, and sandblasting and painting of unit 2 wicket gates and runner cone for corrosion control at Amistad. Amounts are for offsetting collections; no direct appropriations are requested for this activity.
IBWC Capital Investment ($1,754,000) This activity funds capital investment activities at the Falcon and Amistad hydroelectric facilities.	*IBWC Capital Investment ($1,965,000)* This activity funds capital investment activities at the Falcon and Amistad hydroelectric facilities.	*IBWC Capital Investment (+$211,000)* The increase is attributed to projects in the 10-year capital work plan that was developed to address recommendations in the U.S. Army Corps of Engineers inspection report completed in 2018. Projects planned for FY 2022 include replacement of the excitation system on all three generators and installation of a plant SCADA system at Falcon, and replacement of the 13.8kV switchgear breaker at Amistad.
WAPA Marketing, Contracts, Repayment ($78,000) This activity funds power marketing, administration of power contracts, and preparation of rate and repayment studies.	*WAPA Marketing, Contracts, Repayment ($82,000)* This activity funds power marketing, administration of power contracts, and preparation of rate and repayment studies.	*WAPA Marketing, Contracts, Repayment (+$4,000)* The increase is attributed to inflationary factors. Amounts are for offsetting collections; no direct appropriations are requested for this activity.

Colorado River Basins Power Marketing Fund
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Gross	220,244	245,047	237,290
Offsets	-241,644	-266,447	-258,690
Net BA	**-21,400**	**-21,400**	**-21,400**

Overview

WAPA operates and maintains the transmission system for the projects funded in this account to ensure an adequate supply of reliable electric power in a clean and environmentally safe, cost-effective manner. The Colorado River Basins Power Marketing Fund Program (CRBPMF) is comprised of the Colorado River Storage Project, including the Dolores and Seedskadee and Olmsted Projects, and the Fort Peck Project. WAPA is responsible for construction, maintenance, and operation of facilities for transmitting and marketing the electrical energy generated in these power systems.

Highlights of the FY 2022 Budget Request

In FY 2022, WAPA's request has been formulated to meet its power marketing and contractual power delivery obligations with continued high marks for reliability. Revenues collected from customers to recover the costs of the Federal Power Program will be sufficient to provide for WAPA's FY 2022 planned expenses for the power systems in the CRBPMF.

Colorado River Basins Power Marketing Fund
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Colorado River Basins Power Marketing Fund					
Equipment, Contracts and Related Expenses					
Supplies, Materials and Services	12,047	13,330	12,237	-1,093	-8%
Purchase Power Costs	98,172	116,673	104,946	-11,727	-10%
Capitalized Equipment	19,104	15,449	16,616	+1,167	+8%
Interest/Transfers	5,500	3,368	2,509	-859	-26%
Generating Agency Activities	18,309	25,911	26,401	+490	+2%
Total, Equipment, Contracts and Related Expenses	**153,132**	**174,731**	**162,709**	**-12,022**	**-7%**
Program Direction	**67,112**	**70,316**	**74,581**	**+4,265**	**+6%**
Total, Operating Expenses from new authority	**220,244**	**245,047**	**237,290**	**-7,757**	**-3%**
Offsetting Collections Realized	-241,644	-266,447	-258,690	+7,757	+3%
Total, Obligational Authority	**-21,400**	**-21,400**	**-21,400**	**0**	**0%**

Colorado River Basins Power Marketing Fund
Equipment, Contracts and Related Expenses

Description

WAPA's equipment, contracts and related expenses are necessary to operate and maintain this activity. Revenues from the sale of electric energy, capacity and transmission services replenish the fund and are available for expenditure for operation, maintenance, power billing and collection, purchase power and wheeling, interest, emergencies, and other power marketing expenses.

Supplies, Materials and Services

This activity funds the procurement of supplies, materials, and services necessary to respond to routine and emergency situations in the transmission system. Estimates are based on recent actual costs for supplies needed to maintain transmission system reliability. Reimbursements to the U.S. Army Corps of Engineers has been moved to a new Generating Agency Activities category.

Purchase Power Costs

This activity funds the procurement of electrical power, transmission capacity and wheeling services on the open market. The request anticipates the results of continued low-steady-flow tests conducted at Glen Canyon Dam, as required by the Glen Canyon Dam Environmental Impact Statement Record of Decision. Additionally, the request includes obligation authority to accommodate replacement power purchases for customers served by the Colorado River Storage Project. The replacement power purchases, a provision of the Salt Lake City Area Integrated Projects electric power contracts, are made at the request of power customers at times when WAPA lacks sufficient generation to meet its full contract commitment. The funds for the replacement power purchases are advanced by the requesting customers prior to the purchase.

Capitalized Equipment

This activity funds the procurement of capitalized equipment including circuit breakers, transformers, relays, switches, transmission line equipment, microwave, SCADA, and other communication and control equipment to assure reliable service to WAPA's customers. Replacement and upgrade of aged power system components are crucial to system reliability and transmission services.

Transmission line estimates include the purchase of poles, crossarms, conductors, fusion splicers, line switches, overhead ground wire and hardware for the continued transmission line rebuilds. This estimate includes line rebuilds with the anticipated completion of 10 miles a year.

Planned substation estimates include upgrades, replacement of breakers and circuit switches, and replacement of transformers, test equipment, as well as other aged equipment at various substations. WAPA cyclically replaces older electro-mechanical relays with microprocessor relays. The microprocessor relays assist in finding faults faster in order to restore service more efficiently to customers. Other miscellaneous items required for substation replacements include surge arrestors, batteries and chargers, and monitoring equipment.

Planned movable capitalized property estimates include replacements of special purpose trucks, replacement of generators to maintain the reliability and backup power to the communications system, and replacement of outdated test and recording equipment. Other estimates include the replacement of test equipment used to troubleshoot the new digital microwave radio system. Ongoing replacement is also planned for aging information technology support systems and routers. Other requests include funding for other minor enhancements that provide for the ease of maintenance, protection of equipment and materials, and environmental compliance.

Interest/Transfers

This activity funds interest payments to the U.S. Treasury. Estimates are based on Power Repayment Studies for the Projects funded in this account.

Generating Agency Activities

This activity funds the continuation of reimbursements to the U.S. Army Corps of Engineers for operation and maintenance of the Fort Peck Power Plant. Estimates are based on recent actual costs for supplies needed to maintain generating system reliability. In prior year budgets, this activity was included in the Supplies, Materials and Services category.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Equipment and Related Expenses $174,731,000	**$162,709,000**	**-$12,022,000**
Supplies, Materials & Services ($13,330,000) This activity funds the procurement of supplies, materials, and services necessary to respond to routine and emergency situations in the transmission system. In prior budgets, Supplies, Materials and Services also captured Generating Agency activity. It is now separated out and reported in Generating Agency Activities for transparency.	*Supplies, Materials & Services ($12,237,000)* This activity funds the procurement of supplies, materials, and services necessary to respond to routine and emergency situations in the transmission system.	*Supplies, Materials & Services (-$1,093,000)* This is primarily attributed to decreases in miscellaneous services from Non-Federal Sources.
Purchase Power Costs ($116,673,000) This activity funds the procurement of electrical power, transmission capacity and wheeling services on the open market. Purchase power cost estimates are based on 24-month study factors including water cycle, snowpack, and market rates.	*Purchase Power Costs ($104,946,000)* This activity funds the procurement of electrical power, transmission capacity and wheeling services on the open market. Purchase power cost estimates are based on 24-month study factors including water cycle, snowpack, and market rates.	*Purchase Power Costs (-$11,727,000)* The decrease is primarily attributed to purchase power requirements and costs. Power wheeling expenses remain static.
Capitalized Equipment ($15,449,000) This activity funds the procurement of capitalized equipment including circuit breakers, transformers, relays, switches, transmission line equipment, microwave, SCADA, and other communication and control equipment to assure reliable service to WAPA's customers. In prior budgets, Capitalized Equipment also captured Generating Agency activity. It is now separated out and reported in Generating Agency Activities for transparency.	*Capitalized Equipment ($16,616,000)* This activity funds the procurement of capitalized equipment including circuit breakers, transformers, relays, switches, transmission line equipment, SCADA, and other communication and control equipment to assure reliable service to WAPA's customers.	*Capitalized Equipment (+$1,167,000)* Request reflects increase in replacement of fixed equipment with an offset in capitalized equipment.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Interest/Transfers ($3,368,000) This activity funds interest payments to the U.S. Treasury. Estimates are based on Power Repayment Studies for the Projects funded in this account.	*Interest/Transfers ($2,509,000)* This activity funds interest payments to the U.S. Treasury. Estimates are based on Power Repayment Studies for the Projects funded in this account.	*Interest/Transfers (-$859,000)* The decrease in interest/transfers is due to reduction in unpaid interest-bearing portion of capital investments.
Generating Agency Activities ($25,911,000) In prior budgets, this activity was reported in Supplies, Materials & Services and Capitalized Equipment. It is now being reported in Generating Agency Activities for transparency. It funds the continuation of reimbursements to the U.S. Army Corps of Engineers operation and maintenance of the Fort Peck Power Plant.	*Generating Agency Activities ($26,401,000)* This activity funds the continuation of reimbursements to the U.S. Army Corps of Engineers for operation and maintenance of the Fort Peck Power Plant.	Generating Agency Activities (+$490,000) The slight increase is due to scheduled replacements for capitalized communication, substation equipment and maintenance of the Fort Peck Power Plant.

Colorado River Basins Power Marketing Fund
Program Direction

Overview

Program Direction provides the Federal staffing resources and associated costs required to provide overall direction and execution of the Colorado River Basins Power Marketing Fund. WAPA trains its employees on a continuing basis in occupational safety and health regulations, policies, and procedures, and conducts safety meetings at employee, supervisory and management levels to keep the safety culture strong. Accidents are reviewed to ensure lessons are learned and proper work protocol is in place.

Highlights of the FY 2022 Budget Request

The FY 2022 request provides for the continuation of WAPA's revolving fund activities related to Program Direction at the level necessary to meet mission requirements. The requested level of 308 FTE is critical to WAPA's mission activities.

Colorado River Basins Power Marketing Fund
Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Requestt vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Program Direction					
Salaries and Benefits	46,963	49,157	52,246	+3,089	+6%
Travel	3,268	3,396	3,466	+70	+2%
Support Services	7,678	7,091	8,176	+1,085	+15%
Other Related Expenses	9,203	10,672	10,693	+21	+0%
Total, Program Direction	**67,112**	**70,316**	**74,581**	**+4,265**	**+6%**
Federal FTEs	**296**	**294**	**308**	**+14**	**+5%**
Support Services					
Technical Support					
Engineering and Technical Services	1,448	1,573	2,214	+641	+41%
Total, Technical Support	1,448	1,573	2,214	+641	+41%
Management Support					
Automated Data Processing	3,304	2,749	2,921	+172	+6%
Training and Education	970	1,011	1,052	+41	+4%
Reports and Analyses, Management and General Administrative Support	1,956	1,758	1,989	+231	+13%
Total, Management Support	**6,230**	**5,518**	**5,962**	**+444**	**+8%**
Total, Support Services	**7,678**	**7,091**	**8,176**	**+1,085**	**+15%**
Other Related Expenses					
Rent to GSA	723	694	685	-9	-1%
Communication, Utilities, Misc.	1,468	1,854	2,227	+373	+20%
Printing and Reproduction	24	24	22	-2	-8%
Other Services	3,067	4,046	3,579	-467	-12%
Training	13	15	15	0	0%
Purchases from Gov. Accounts	237	319	343	+24	+8%

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Requestt vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Operation and Maintenance of Equipment	1,653	1,374	1,782	+408	+30%
Supplies and Materials	631	596	659	+63	+11%
Equipment	652	1,057	662	-395	-37%
Working Capital Fund	735	693	719	+26	+4%
Total, Other Related Expenses	**9,203**	**10,672**	**10,693**	**+21**	**0%**

Colorado River Basins Power Marketing Fund
Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $70,316,000	**$74,581,000**	**+$4,265,000**
Salaries and Benefits $49,157,000	**$52,246,000**	**+$3,089,000**
Salary and benefits support a FY 2021 request level of 294 FTE. This includes General Schedule employees, as well as those salaries determined through negotiations. This activity provides for Federal employees who operate and maintain the Program's high-voltage integrated transmission system and associated facilities; plan, design, and supervise the replacement (capital investments) to the transmission facilities; and market the power and energy produced to repay annual expenses and capital investment.	Salary and benefits support a FY 2022 request level of 308 FTE. This includes General Schedule employees, as well as those salaries determined through negotiations. This activity provides for Federal employees who operate and maintain the Program's high-voltage integrated transmission system and associated facilities; plan, design, and supervise the replacement (capital investments) to the transmission facilities; and market the power and energy produced to repay annual expenses and capital investment.	The increase in salaries and benefits supports the 308 FTE charged to this account for planned capital investments. The salary and benefits reflect inflationary factors; OPM pay increase for engineers and journeymen negotiated salaries.
Travel $3,396,000	**$3,466,000**	**+$70,000**
This activity funds personnel travel and per diem expenses for essential mission-related activities, including the maintenance of transmission facilities. The request includes estimates for the rent/lease of GSA vehicles and other transportation.	This activity funds personnel travel and per diem expenses for essential mission-related activities, including the maintenance of transmission facilities. The request includes estimates for the rent/lease of GSA vehicles and other transportation.	The increase supports mission related operation and maintenance travel as well as capturing inflationary factors.
Support Services $7,091,000	**$8,176,000**	**+$1,085,000**
Support services funded in this category include information technology support, warehousing, computer-aided drafting/engineering, job related training and education, and general administrative support.	Support services funded in this category include information technology support, warehousing, computer-aided drafting/engineering, job related training and education, and general administrative support.	The increase is primarily due to Engineering and Technical support services.
Other Related Expenses $10,672,000	**$10,693,000**	**+$21,000**
Other related expenses include, but are not limited to, DOE's working capital fund	Other related expenses include, but are not limited to, DOE's working capital fund distribution, space,	The increase to this activity is driven by communication & utilities and operation and

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
distribution, space, utilities and miscellaneous charges, printing and reproduction, training tuition, maintenance of office equipment, supplies and materials, telecommunications, and office equipment to include computers.	utilities and miscellaneous charges, printing and reproduction, training tuition, maintenance of office equipment, supplies and materials, telecommunications, and office equipment to include computers.	maintenance of equipment with offsets in equipment and other services.

Transmission Infrastructure Program
Funding ($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
0	0	0

Overview

WAPA established the Transmission Infrastructure Program (TIP) and Office to implement Title III, Section 301 of the Hoover Power Plant Act of 1984 as amended by the American Recovery and Reinvestment Act of 2009 (Recovery Act), which provided WAPA borrowing authority of up to $3.25 billion for the purposes of: (1) constructing, financing, facilitating, planning, operating, maintaining, or studying construction of new or upgraded electric power transmission lines and related facilities with at least one terminus within the area served by WAPA; and (2) delivering or facilitating the delivery of power generated by renewable energy resources constructed or reasonably expected to be constructed after the Recovery Act's date of enactment.

TIP is expected to be an administratively self-sustaining program that relies on funding arrangements with project developers. When developers seek technical assistance, WAPA collects funds from the project developers to support development of eligible projects and to cover the overhead and administrative costs of the program. Reimbursable or Advance Funding Agreements with project developers are required prior to initiating efforts to evaluate the technical and financial merits of a potential project to ensure the full cost of services delivered are paid by project beneficiaries. For projects that are approved for use of WAPA's borrowing authority, the authority to cover the full amount of the loan is apportioned at the outset and cash is borrowed periodically from the Department of the Treasury (Treasury) as needed. The debt is repaid according to the financial agreement terms and conditions of each project.

As mandated, the TIP program is completely separate and distinct from WAPA's power marketing program.
TIP has one project currently using the borrowing authority for a total of $91 million in loan authority obligated.
All administrative costs for TIP are offset by advanced financing and collections. WAPA is not requesting any new annual appropriated funds for TIP.

Highlights of the FY 2022 Budget Request

Construction and project debt estimates are based on preliminary information provided by the Project Sponsors/Proponents.

Note: Values for TIP are based on early stages of project development, forecasts of current projects, estimates of future project development, and departmental collaboration, which are subject to change. While based on knowledge and experience to date, these estimates are to be regarded as non-binding representations that are determined by Project Sponsors/Proponents.

Transmission Infrastructure Program
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Mandatory, Direct Budget Authority					
New Borrowing Authority	550,000	100,000	1,200,000	+1,100,000	+1,100%
Use of Collections from Projects	4,800	5,000	5,000	0	0%
Collections from Projects	-4,800	-5,000	-5,000	0	0%
Total Mandatory	**550,000**	**100,000**	**1,200,000**	**1,100,000+**	**+1,100%**
Repayment of Borrowing Authority	-25,000	0	0	0	0%
Federal FTEs (Mandatory)	**0**	**0**	**0**	**0**	
Discretionary, Reimbursable Budget Authority					
Program Direction	47,442	12,454	31,400	+18,946	+152%
Advance Funding	-4,300	-2,025	-1,750	+275	-14%
Offsetting Collections	-43,142	-10,429	-29,650	-19,221	+184%
Total Discretionary	**0**	**0**	**0**	**0**	**0%**
Federal FTEs (Discretionary)	**15**	**11**	**11**	**0**	**0%**
Total, Transmission Infrastructure Program					
Total, Federal FTEs	**15**	**11**	**11**	**0**	**0%**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Direct Budget Authority $100,000,000	**$1,200,000,000**	**+$1,100,000,000**
New Borrowing Authority $100,000,000	**$1,200,000,000**	**+$1,100,000,000**
Estimated new projects approved for use of WAPA's borrowing authority.	Estimated new projects approved for use of WAPA's borrowing authority.	The increase is due to higher estimates provided by potential Project Sponsors/Proponents.
Collections from Projects $5,000,000	**$5,000,000**	**$0**
Collections in this category are from excess capacity offtake from borrowing authority funded projects.	Collections in this category are from excess capacity offtake from borrowing authority funded projects. TIP estimates collecting $5 million in excess capacity from the ED5 energized line in FY 2022. These collections will be used for costs associated with operating and maintaining those lines generating the capacity, and interest and principal payments.	No change in collections is anticipated for FY 2022.
Repayment of Borrowing Authority $0	**$0**	**$0**
This activity represents repayments to Treasury from projects for principal.	This activity represents repayments to Treasury from projects for principal.	No repayments are anticipated for FY 2022.

Transmission Infrastructure Program
Program Direction

Overview

WAPA's TIP Program Direction subprogram provides compensation and all related expenses for its workforce, including those employees that are directly assigned to the program as project management, technical experts, finance and administration; those that provide expertise in land acquisition, engineering and environmental compliance; those that provide legal counsel; and those that administratively support these functions.

All TIP program direction costs are expected to be offset by customers over time, either through advanced funding agreements or offsetting collections. Advanced funding is provided to TIP from project applicants who use TIP's expertise in the development of their project. The advanced funding agreements fund federal and/or contract staff working on the development of a specific project. Other sources of funds include the overhead rate applied to each active project; service charges; interest rate differentials; and the advance collection of Project Proposal and Business Plan Proposal evaluation expenses. These collections offset the costs of administering the TIP program and provide a risk mitigation reserve.

The Program Direction subprogram supports DOE and WAPA missions, specifically in facilitating delivery of renewable energy resources to market.

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Transmission Infrastructure					
Salaries and Benefits	2,065	1,225	1,678	+453	+37%
Travel	106	60	94	+34	+57%
Support Services	2,166	756	1,485	+729	+96%
Other Related Expenses	43,105	10,413	28,143	+17,730	+170%
Subtotal, Program Direction	**47,442**	**12,454**	**31,400**	**+18,946**	**+152%**
Use of Offsetting Collections	-47,442	-12,454	-31,400	-18,946	+152%
Total, Program Direction	**0**	**0**	**0**	**0**	**0%**
Federal FTEs (Mandatory Direct)	**0**	**0**	**0**	**0**	**0%**
Federal FTEs (Discretionary Reimbursable)	**15**	**11**	**11**	**0**	**0%**
Federal FTEs (Total TIP)	**15**	**11**	**11**	**0**	**0%**
Support Services					
Technical Support					
Engineering and Technical Services	1,982	358	1,302	+944	+264%
Total, Technical Support	1,982	358	1,302	+944	+264%
Management Support					
Automated Data Processing	127	285	127	-158	-55%
Training and Education	12	13	12	-1	-8%
Reports and Analyses, Management and General Administrative Support	45	100	44	-56	-56%
Total Management Support	184	398	183	-215	-54%
Total, Support Services	**2,166**	**756**	**1,485**	**+729**	**+96%**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Other Related Expenses					
Communications; utilities; miscellaneous charges	223	20	27	+7	+35%
Services from Non- Federal and Federal Sources	2,250	5,389	6,112	+723	+13%
Supplies and materials	5	4	4	0	0%
Interest Payments	40,627	5,000	22,000	+17,000	+340%
Total, Other Related Expenses	**43,105**	**10,413**	**28,143**	**+17,730**	**+170%**

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $12,454,000	**$31,400,000**	**+$18,946,000**
Salaries and Benefits $1,225,000	**$1,678,000**	**+$453,000**
Salary and benefits provide for Federal employees that are directly assigned to the TIP program as project management, technical experts, finance and administration; those that provide expertise in land acquisition, engineering and environmental compliance; those that provide legal counsel; and those that administratively support these functions. FTE assigned to this account charge TIP's mandatory as well as discretionary funding accounts.	Salary and benefits provide for Federal employees that are directly assigned to the TIP program as project management, technical experts, finance and administration; those that provide expertise in land acquisition, engineering and environmental compliance; those that provide legal counsel; and those that administratively support these functions. FTE assigned to this account charge TIP's mandatory as well as discretionary funding accounts.	The increase of salaries and benefits reflects direct and indirect support provided to this account to include the proportionate FTE. This also captures inflationary factors.
Travel $60,000	**$94,000**	**+$34,000**
Planned essential travel supports TIP's mission related activities. TIP supports efficient spending initiatives and is cognizant of travel costs associated with general program operations. TIP focuses on using alternative means to conduct meetings and training sessions where appropriate.	Planned essential travel supports TIP's mission related activities. TIP supports efficient spending initiatives and is cognizant of travel costs associated with general program operations. TIP focuses on using alternative means to conduct meetings and training sessions where appropriate.	The increase supports TIP's effort towards its mission related travel in collaboration with potential project sponsors. It also captures inflationary factors.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Support Services $756,000	**$1,485,000**	**+$729,000**
Support services funded in this category include technical support costs directly associated with TIP projects; to include Environmental, Lands, Engineering, and Project Management activities. Also, within this category are costs to cover legal and financial support activities to include financial modeling, outside legal counsel for contract review, policy issues and legislative concerns.	Support services funded in this category include technical support costs directly associated with TIP projects; to include Environmental, Lands, Engineering, and Project Management activities. Also, within this category are costs to cover legal and financial support activities to include financial modeling, outside legal counsel for contract review, policy issues and legislative concerns.	The increase in support services is due to the growth for technical support associated with project management and stage of development of projects given revised work scope demands. This is offset by decrease in management support.
Other Related Expenses $10,413,000	**$28,143,000**	**+$17,730,000**
Other related expenses include communications, utilities, training, depreciation, WAPA overhead rates, supplies and materials, services from Federal and Non-Federal sources and interest loan payments.	Other related expenses include communications, utilities, training, depreciation, WAPA overhead rates, supplies and materials, services from Federal and Non-Federal sources and interest loan payments.	The increase primarily reflects anticipated loan interest payments and interest rate adjustment along with increase in services from Federal and Non-Federal sources.

Estimate of Gross Revenues [1]

(Dollars in Thousands)

	FY 2020[2]	FY 2021	FY 2022
Boulder Canyon Project	67,858	84,269	91,693
Central Valley Project	241,401	409,540	417,026
Falcon-Amistad Project	5,927	7,261	7,289
Fryingpan-Arkansas Project	18,586	18,052	17,742
Pacific Northwest-Southwest Intertie Project	43,543	42,014	43,293
Parker-Davis Project	80,943	80,071	85,525
Pick-Sloan Missouri Basin Program	579,384	543,099	539,870
Provo River Project	463	508	529
Washoe Project	536	439	439
Salt Lake City Area Integrated Projects	222,417	186,487	186,504
Other	75,337	0	0
Total, Gross Revenues	**1,336,395**	**1,371,740**	**1,389,910**

[1] Amounts for FY 2021 and FY 2022 are based on the FY 2019 Final Power Repayment Studies (PRS).

[2] FY 2020 amounts are actuals from the preliminary annual financial reports. For Central Valley Project, FY 2020 amounts reported exclude contractual pass-through purchase power arrangements which are included in the PRS estimates. The 'Other' FY 2020 amounts shown represent WAPA activities reported in the financials that are not reimbursable through the power and transmission rate-setting process and are not forecasted through the PRS.

Estimate of Proprietary Receipts

(Dollars in Thousands)

	FY 2020 Actual	FY 2021	FY 2022
Mandatory Receipts			
Falcon Amistad Maintenance Fund	1,579	2,000	2,000
Sale and Transmission of Electric Power, Falcon and Amistad Dams	900	1,000	1,000
Sale of Power and Other Utilities Not Otherwise Classified	0	30,000	30,000
Sale of Power–WAPA–Reclamation Fund	253,679	232,936	139,481
Total, Mandatory Receipts	**256,158**	**265,936**	**172,481**
Discretionary Receipts			
Offsetting Collections from the Recovery of Power Related Expenses – WAPA CROM	227,000	192,000	316,000
Less Purchase Power and Wheeling Expenses	-227,000	-192,000	-316,000
Subtotal, WAPA CROM Recovery of Power Related Expenses	0	0	0
Offsetting Collections from the Recovery of Annual Expenses – WAPA CROM	173,587	169,754	194,465
Less Operating and Maintenance expenses	-24,445	-24,744	-27,530
Less Program Direction Expenses	-149,142	-145,010	-166,935
Subtotal, WAPA CROM Recovery of Annual Expenses	0	0	0
Offsetting Collections from the recovery of power related expenses – Falcon and Amistad	1,340	5,548	5,580
Less Operating and Maintenance expenses	-1,340	-5,548	-5,580
Subtotal, Falcon and Amistad Recovery of Power Related Expenses	0	0	0
Total, Discretionary Receipts	**0**	**0**	**0**
Total, Proprietary Receipts	**256,158**	**265,936**	**172,481**

Western Area Power Administration
Estimate of Offsetting Collections for Reimbursable Work and Work-for-Others

	(Dollars in Thousands)		
	FY 2020	FY2021	FY2022
Construction, Rehabilitation, Operation and Maintenance (CROM)			
Offsetting Collections for Reimbursable Work [1]			
Alternative Financing			
Operations and Maintenance	6,600	6,297	7,122
Construction and Rehabilitation	39,922	20,353	31,090
Purchase Power and Wheeling (PPW)	288,769	293,890	273,677
Program Direction	44,719	48,546	51,849
Subtotal, Alternative Financing	380,010	369,086	363,738
Offsetting Collections not anticipated for obligation in budget year	122,357	2,936	188,792
Less PPW net billing, bill crediting, energy exchange	-256,321	-233,400	-242,646
Offsetting collections from Colorado River Dam Fund	8,954	8,378	9,116
Subtotal, Offsetting Collections for Reimbursable Work	**255,000**	**147,000**	**319,000**
Offsetting Collections for Reimbursable Work-for-Others [2]	**490,000**	**601,000**	**337,000**
Total, Offsetting Collections for Reimbursable	**745,000**	**748,000**	**656,000**

[1] WAPA relies significantly on alternative financing arrangements with customers to finance much of its direct mission work on a reimbursable basis.

[2] WAPA has partnering arrangements with many power customers and Federal agencies to perform electrical systems operations, maintenance, construction, purchase power, and transmission services on a reimbursable basis.

DEPARTMENT OF ENERGY

Funding by Site

TAS_5068 - Western Area Power Administration BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Western Area Power Administration Office			
System Operation And Maintenance - CROM	72,176	77,874	81,983
Construction And Rehabilitation - CROM	45,887	26,251	35,185
Purchase Power And Wheeling - CROM	515,769	485,890	589,677
Program Direction - CROM	250,091	253,575	267,246
Construction, Rehabilitation, Operation, and Maintenance (CROM) - WP	883,923	843,590	974,091
Total Western Area Power Administration Office	**883,923**	**843,590**	**974,091**
Total Funding by Site for TAS_5068 - Western Area Power Administration	**883,923**	**843,590**	**974,091**

DEPARTMENT OF ENERGY

Funding by Site

TAS_4452 - Colorado River Basins Power Marketing Fund BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Western Area Power Administration Office			
Program Direction - Colorado River Basins Fund	67,112	70,316	74,581
Equipment, Contracts and Related Expenses - Colorado River Basins Fund	153,132	174,731	162,709
Colorado River Basins Fund	220,244	245,047	237,290
Total Western Area Power Administration Office	**220,244**	**245,047**	**237,290**
Total Funding by Site for TAS_4452 - Colorado River Basins Power Marketing Fund	**220,244**	**245,047**	**237,290**

DEPARTMENT OF ENERGY

Funding by Site

TAS_5178 - Falcon and Amistad Operating and Maintenance Fund BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Western Area Power Administration Office			
Falcon And Amistad Operation And Maintenance	5,647	7,302	7,545
Total Western Area Power Administration Office	**5,647**	**7,302**	**7,545**
Total Funding by Site for TAS_5178 - Falcon and Amistad Operating and Maintenance Fund	**5,647**	**7,302**	**7,545**

Bonneville Power Administration

Bonneville Power Administration

Bonneville Power Administration (Bonneville, BPA)

Proposed Appropriations Language

Expenditures from the Bonneville Power Administration Fund, established pursuant to Public Law 93–454, are approved *for the Umatilla Hatchery Facility project and, in addition,* for official reception and representation expenses in an amount not to exceed $5,000: Provided, That during fiscal year [2021] *2022*, no new direct loan obligations may be made. (Energy and Water Development and Related Agencies Appropriations Act, 2021.)

Explanation of Changes

Language is included to allow expenditures from the Bonneville Power Administration Fund for the Umatilla Hatchery Facility Project.

The proposed appropriations language restricts new direct loans in FY 2022 as in FY 2021**.** This bill language is drafted consistent with the Credit Reform Act of 1990.

Please Note - The FY 2022 Bonneville Power Administration Congressional Budget submission includes FY 2021 budget estimates.

Bonneville operates under a business-type budget under the Government Corporation Control Act, 31 U.S.C 9101-10 and on the basis of the self-financing authority provided by the Federal Columbia River Transmission System Act of 1974 (Transmission Act) (Public Law 93-454). Bonneville has authority to borrow from the U.S. Treasury under the Transmission Act, and the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) (Public Law 96-501) for acquisition of energy conservation, renewable and other power resources, investment in fish facilities, and other purposes, the American Recovery and Reinvestment Act of 2009 (Public Law 111-5), and other legislation. Authority to borrow from the U.S. Treasury is available to Bonneville on a permanent, revolving basis. The principal amount of U.S. Treasury borrowing outstanding at any time may not exceed $7.70 billion[1]. Bonneville finances its approximate $4.4 billion annual cost of operations and investments by primarily using its power and transmission revenues, and proceeds of borrowing from the U.S. Treasury.

This budget has been prepared in accordance with the Statutory Pay-As-You-Go Act (PAYGO) of 2010. Under PAYGO, all Bonneville budget estimates are treated as mandatory and are not subject to the discretionary caps included in the Budget Control Act of 2011. These estimates support activities that are separate from discretionary activities and accounts. Thus, any changes to Bonneville estimates cannot be used to affect any other budget categories, which have their own dollar caps. Because Bonneville's obligations are and will be incurred under pre-existing legislative authority, Bonneville is not subject to a "pay-as-you-go" test regarding its revision of current-law funding estimates.

[1] The outstanding principal amount of bonds issued by Bonneville to the U.S. Treasury can be found in tables BP-4A – 4D in the Additional Tables section.

Bonneville Power Administration

Funding Profile by Subprogram [1/]

(Accrued Expenditures in Thousands of Dollars)

	Fiscal Year			
	2020 Actual	2021 Original [2/]	2021 Revised [2/]	2022 Proposed
Capital Investment Obligations				
Associated Project Costs [3/]	178,264	256,000	272,493	264,120
Fish & Wildlife	40,185	47,266	47,266	43,000
Subtotal, Power Services	218,449	303,266	319,759	307,120
Transmission Services	280,263	474,305	484,469	497,086
Capital Equipment & Bond Premium	21,144	22,131	21,744	22,002
Total, Capital Obligations [3/]	519,856	799,703	825,972	826,208
Expensed and Other Obligations				
Expensed	3,075,657	2,978,229	2,785,321	2,733,825
Projects Funded in Advance [5/]	89,450	66,179	70,107	55,775
Total, Obligations	3,684,963	3,844,110	3,681,400	3,615,807
Capital Transfers (cash)	471,310	401,721	724,000	696,000
Bonneville Total (Oligations & Capital Transfers)	4,156,273	4,245,831	4,405,400	4,311,807
Bonneville Net Outlays	44,000	(110,068)	(159,707)	(322,967)
Full-time Equivalents (FTEs) [4/]	2,743	3,000	3,000	3,000

Public Law Authorizations include:

Bonneville Project Act of 1937, Public Law No. 75-329

Federal Columbia River Transmission System Act of 1974, Public Law No. 93-454

Regional Preference Act of 1964, Public Law No. 88-552

Flood Control Act of 1944, Public Law No. 78-543

Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act), Public Law No. 96-501

Outyear Funding Profile by Subprogram [1/]

(Accrued Expenditures in Thousands of Dollars)

	Fiscal Year			
	2023	2024	2025	2026
Capital Investment Obligations				
Associated Project Costs [3/]	281,260	300,000	306,850	313,647
Fish & Wildlife	43,000	30,000	25,000	15,000
Subtotal, Power Services	324,260	330,000	331,850	328,647
Transmission Services	529,506	585,979	666,327	649,747
Capital Equipment & Bond Premium	21,052	19,721	19,056	17,386
Total, Capital Obligations [3/]	874,818	935,700	1,017,233	995,780
Expensed and Other Obligations				
Expensed	2,794,650	2,863,211	2,933,961	3,012,460
Projects Funded in Advance [5/]	61,384	47,682	35,221	35,474
Total, Obligations	3,730,852	3,846,593	3,986,415	4,043,715
Capital Transfers (cash)	726,000	678,000	689,000	701,000
Bonneville Total (Oligations & Capital Transfers)	4,456,852	4,524,593	4,675,415	4,744,715
Bonneville Net Outlays	(258,532)	(143,089)	(14,806)	19,240
Full-time Equivalents (FTEs) [4/]	3,000	3,000	3,000	3,000

These notes are an integral part of this table.

1/ This budget has been prepared in accordance with PAYGO. Under PAYGO all Bonneville budget estimates are treated as mandatory and are not subject to the discretionary caps included in the Budget Control Act of 2011. These estimates support activities that are separate from discretionary activities and accounts. Thus, any changes to Bonneville estimates cannot be used to affect any other budget categories which have their own dollar caps. Because Bonneville's obligations are and will be incurred under pre-existing legislative authority, Bonneville is not subject to a "pay-as-you-go" test regarding its revision of current-law funding estimates.

2/ Original estimates reflect Bonneville's FY 2021 Congressional Budget Submission. Revised estimates, consistent with Bonneville's annual near-term funding review process, provide notification to the Administration and Congress of updated capital and expense funding levels for FY 2021. The BPA estimates in this budget are consistent with the 2020 initial IPR. Please see https://www.bpa.gov/Finance/RateCases/BP-22-Rate-Case/Pages/Meetings-and-Workshops.aspx for further information.

3/ Includes infrastructure investments to address the long-term electric power related needs of the Northwest and significant changes affecting Bonneville's power and transmission markets.

4/ As of 10/21/2020, DOE HR staff has reported FY 2020 BPA's FTE usage at 2,743.

5/ In this instance, Projects Funded in Advance represents prepayment of Power customers' bills reimbursed by future credits and third party non-federal financing for Conservation initiatives. Also this category includes those facilities and/or equipment where Bonneville retains control or ownership but which are funded or financed by a third party, revenue, or with reserves, either in total or in part.

Additional Notes

Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

Cumulative advance amortization payments as of the end of FY 2020 are $5,819 million.

Refer to 16 USC Chapters 12B, 12G, 12H, and Bonneville's other organic laws, including P.L. 100-371, Title III, Sec. 300, 102 Stat. 869, July 19, 1988, regarding Bonneville's ability to obligate funds.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

Net Outlay estimates are based on current cost savings to date and anticipated cash management goals. They are expected to follow anticipated management decisions throughout the rate period that, along with actual market conditions, will impact revenues and expenses. Actual Net Outlays are volatile and are reported in Report on Budget Execution and Budgetary Resources (SF-133). Actual Net Outlays could differ from estimates due to changing market conditions, streamflow variability, continued restructuring of the electric industry, and other reasons.

Revenues, included in the Net Outlay formulation, are calculated consistent with cash management goals and assume a combination of adjustments. Assumed adjustments include the use of a combination of tools, including upcoming rate adjustment mechanisms, a net revenue risk adjustment, debt service refinancing strategies and/or short-term financial tools to manage net revenues and cash. Some of these potential tools will reduce costs rather than generate revenue, causing the same Net Outlay result. Adjustments for depreciation and 4(h)(10)(C) credits of the Northwest Power Act are also assumed.

FY 2020 Net Outlays are calculated using Bonneville's audited actual revenue. FYs 2021 to 2026 Net Outlays are based on FY 2020 initial IPR assumptions and an escalation factor from using the FY 2018 White Book Loads and Resources Report.

FTE outyear data are estimates and may change. Bonneville is facing a dynamic and changing energy marketplace and operations while, at the same time, many of its employees are eligible to retire in the near future. It is important that Bonneville continue to attract and retain skilled individuals to meet the growing demands of a competitive and rapidly changing industry. Accordingly, FTE estimates may need to be adjusted in the future.

Amounts in tables and schedules may not add to totals due to rounding.

Major Outyear Considerations

Bonneville's outyear estimates reflect ongoing efforts to achieve its long-term mission and strategic direction. The outyear estimates are developed with consideration and support of Bonneville's multi-year performance targets that lay out the course for achieving Bonneville's long-term objectives. Outyear capital investment levels support Bonneville's infrastructure program, hydro efficiency program, and its fish and wildlife mitigation projects.

Bonneville continues to incorporate the various aspects of the Energy Policy Act of 2005 related to its business, in particular the energy supply, conservation, and new energy technologies for the future that are highlighted in the legislation.

Bonneville provides electric power services, transmission services, and acquires energy efficiency throughout the Pacific Northwest. Bonneville serves a 300,000 square mile area including Oregon, Washington, Idaho, western Montana, and small parts of eastern Montana, California, Nevada, Utah, and Wyoming with a population of about 14 million people. Bonneville markets the electric power produced from 31 federal hydro projects in the Pacific Northwest owned by the U.S. Army Corps of Engineers (Corps) and the U.S. Department of Interior, Bureau of Reclamation (Reclamation). In addition, Bonneville also acquires power from non-federal generating resources, including the power from a nuclear power plant, the Columbia Generating Station (CGS). Bonneville uses the power from its non-federal purchases and the federal projects, collectively the Federal Columbia River Power System (FCRPS), primarily to meet the Administrator's long term firm power sales contract obligations. Bonneville currently maintains and operates 15,197 circuit miles of transmission lines, 262 substations, and associated power system control and communications facilities over which this electric power is delivered. Bonneville has capital and similar leases for certain transmission facilities. Bonneville also supports the protection and enhancement of fish and wildlife, and encourages the development of conservation and energy efficiency, as part of meeting its obligations to supply power and balance the economic and environmental benefits of the FCRPS.

The organization of Bonneville's FY 2022 Budget reflects Bonneville's business services basis for utility enterprise activities. Bonneville's two major areas of activity on a consolidated budget and accounting basis are Power Services and Transmission Services and include their related administrative costs. Power Service's costs include line items for Fish and Wildlife, Energy Efficiency, Residential Exchange Program, Federal Projects Operations & Maintenance (O&M) Costs, and the Northwest Power and Conservation Council (Planning Council or Council). Transmission Service's costs include line items for engineering, operations, and maintenance for Bonneville's electric transmission system.

Bonneville's mission as a public service organization is to create and deliver federal power and transmission services at cost as it acts to assure its customers in the Pacific Northwest have the following: (1) an adequate, efficient, economical, and reliable power supply; (2) an open access transmission system that is adequate for integrating and transmitting power from federal and non-federal generating units, providing service to Bonneville's customers, providing interregional interconnections, and maintaining electrical reliability and stability; and (3) mitigation of the impacts on fish and wildlife from the federally owned hydroelectric projects from which BPA markets power.

Bonneville's vision is to be an engine of the Northwest's economic prosperity and environmental sustainability by advancing a Northwest power and transmission system that is a national leader in providing high reliability, low rates consistent with sound business principles, responsible environmental stewardship, and accountability to the region, all through a commercially successful business. Bonneville pursues this vision consistent with its four core values of safety, trustworthy stewardship, collaborative relationships, and operational excellence.

Legislative History

The Bonneville Project Act of 1937 provides the statutory basis for Bonneville's power marketing responsibilities and authorities. In 1974, passage of the Federal Columbia River Transmission System Act (Transmission Act) applied provisions of the Government Corporation Control Act (31 U.S.C. §§ 9101-9110) to Bonneville. The Transmission Act provides Bonneville with "self-financing" authority, establishes the Bonneville Fund (a permanent, indefinite appropriation) allowing Bonneville to use its revenues from electric power and transmission ratepayers to fund all programs without further appropriation, and authorizes Bonneville to sell bonds to the U.S. Treasury. As of the end of FY 2020, Bonneville has revolving U.S. Treasury borrowing authority of $7.7 billion of which approximately $2.1 billion remains available to be drawn.

The 1980 enactment of the Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act) expanded Bonneville's authorities, obligations, and responsibilities. The purposes of the act include encouraging development of electric energy conservation to meet regional electric power loads placed on Bonneville; the development of renewable energy resources within the Pacific Northwest; to assure the Northwest an adequate, efficient, economical, and reliable power supply; to promote regional participation and planning; and to protect, mitigate, and enhance the fish and wildlife of the Columbia River and its tributaries. The Northwest Power Act also established a revised statutory framework for Bonneville's administrative rate-setting process and established judicial review of Bonneville's final actions in the U.S. Court of Appeals for the Ninth Circuit.

Strategic Direction

In early 2018, Bonneville released its 2018-2023 Strategic Plan which describes how it will operate in a commercially successful manner while meeting its statutory obligations. Bonneville developed this strategic plan after listening to customers and constituents express their interests in Bonneville's commercial viability and ability to meet those obligations. The strategic plan was developed at the point when Bonneville was midway through 20-year firm power sales contracts with its preference power customers. Those customers continue to evaluate how Bonneville will be positioned to meet their needs beyond the terms of their current contracts. The strategic plan is framed by these goals:

- Strengthen financial health
- Modernize assets and system operations
- Provide competitive power products and services
- Meet transmission customer needs efficiently and responsively

In 2020, Bonneville reassessed and reconfirmed its strategic goals and objectives. In its Strategic Plan Update, Bonneville added a fifth goal, "Value people and deliver results," which captures the agency's commitment to its workforce and the people it serves.

Financial Plan

In 2018, Bonneville also completed its Financial Plan. The Financial Plan responds to the objective in the strategic plan to strengthen Bonneville's financial health. The 2018 Financial Plan establishes a guiding framework for decision-making by defining the financial constraints within which Bonneville operates, and outlines objectives to establish Bonneville's financial health. The plan contains Bonneville's statutory obligations and authorities, financial policies and established practices, and financial health objectives.

Pursuant to the Financial Plan, Bonneville adopted two specific policies. The Financial Reserves Policy (FRP) defines the level of financial reserves Bonneville and each business line should hold; how to build financial reserves when they fall below a prescribed level; and a process to consider repurposing financial reserves when they exceed a prescribed level. The policy provides a framework to help ensure Bonneville maintains a minimum of 60 days cash on hand for each business line and 90 days for the Agency.

The Leverage Policy creates a strategy to reduce Bonneville's total debt compared to its assets in an effort to strengthen financial health and flexibility. Reducing debt will help Bonneville lower its interest costs, support its strong credit rating, maintain access to borrowing from the U.S. Treasury, and improve financial strength and flexibility.

Fiscal Year 2020 and 2021 Rates

BPA adopted its power and transmission rates for Fiscal Years 2020 and 2021 in July 2019. FERC granted final approval to the rates on April 17, 2020. The average base power rate was the same as for the previous rate period before a rate surcharge of up to 1.5 percent that was triggered in November 2019, based on the provision of Bonneville's FRP. For transmission rates, the weighted average increase is 3.6 percent for the two-year rate period, consistent with the settlement agreed upon during the rate proceeding. The transmission and power rates will be in effect through September 30, 2021.

In June, 2020, Bonneville responded to power customers who anticipated uncertain financial conditions resulting from the COVID-19 pandemic. Bonneville completed an expedited rate proceeding to suspend the FRP surcharge for the remainder of FY 2020 and for FY 2021.

Financial Mechanisms

Bonneville's program is treated as mandatory and nondiscretionary. Bonneville is "self-financed" from its own revenues and does not rely on annual appropriations from Congress. Under the Transmission Act, Bonneville funds the expense portion of its budget and repays the federal investment with revenues from electric power and transmission sales. Bonneville's revenues fluctuate for a variety of reasons, including in response to variations in market prices for fuels and stream flow in the Columbia River System caused by variations in weather conditions and fish mitigation needs.

In the FY 2022 Budget, the term Bonneville "bonds" refers to the debt instruments under which Bonneville receives advances of funds from the U.S. Treasury. This reference is consistent with section 13(a) of the Transmission Act, which defines "bonds" as all bonds, notes, and other evidences of indebtedness issued and sold by Bonneville to the U.S. Treasury.

As of June 2020, debt instruments issued by non-federal entities but secured by payment and other financial commitments provided by Bonneville received the following credit ratings: Moody's at Aa2 with a stable outlook, Standard & Poor's at AA- with a stable outlook, and Fitch at AA with a stable outlook.

Bonneville and the U.S. Treasury have a comprehensive banking arrangement that covers Bonneville's short- and long-term federal borrowings. This provides Bonneville with the ability to borrow from the U.S. Treasury to finance capital investments and, on a short-term basis, to cover Northwest Power Act-related operating expenses. This latter ability provides Bonneville with much needed liquidity to help manage within-year cash flow needs and mitigate risk. Access to this use of U.S. Treasury borrowing authority has been incorporated into and relied upon in Bonneville's rate-setting process.

U.S. Treasury Payments and Budget Overview

Bonneville's FY 2020 payment to the U.S. Treasury was approximately $736 million. This was the 37th consecutive year that Bonneville made its scheduled payments to the U.S. Treasury on time and in full. The payment included $471.3 million in principal, which included $20 million in early retirement of higher interest rate U.S. Treasury debt, $208 million for interest, $24.1 million in irrigation assistance payments, and $29.5 million in pension and post-retirement benefits. Total credits associated with fish mitigation and recovery that are applied toward Bonneville's U.S. Treasury payment were about $95.5 million for FY 2020. These credits are established and applied under section 4(h)(10)(C) of the Northwest Power Act. The FYs 2021 and 2022 U.S. Treasury payments are currently estimated at $1,007 million and $963 million, respectively. The FY 2021 and 2022 4(h)(10)(C) credits are estimated to be $80.3 million and $92.8 million, respectively.

Estimates of interest and amortization levels for outyear U.S. Treasury payments are included in the FY 2020-2021 final transmission and power rates. Bond and Appropriations Interest will continue to be revised based on upcoming capital investments and debt management actions. These estimates may change due to revised capital investment plans and actual U.S. Treasury borrowing. In recent years, Bonneville has made amortization payments in excess of those scheduled in its FERC-approved rate filings resulting in a balance of advance repayment. The cumulative balance of advance amortization payments as of the end of FY 2020 was in excess of $5.8 Billion.

Bonneville has direct funding arrangements to fund the power-related portion of O&M and capital investments at the Corps and Reclamation facilities as well as the O&M costs of the U.S. Fish and Wildlife Service Lower Snake River Compensation Plan facilities. Direct funded FCRPS capital costs, which had been funded exclusively through appropriations to the Corps and Reclamation prior to the initiation of direct funding, are now funded primarily from the proceeds of bonds issued by Bonneville to the U.S. Treasury. Certain power prepayments have also been a source of funds for direct funding. Bonneville's aggregate direct funding provided for capital and O&M was $595.8 million in FY 2020.

Starting in FY 2014, Bonneville and Energy Northwest, the Washington state joint operating agency that owns and operates the Columbia Generating Station nuclear plant, have been working together to implement a new phase of integrated debt management for their combined total debt portfolios. The debt service of these portfolios is borne by Bonneville and

recovered from Bonneville ratepayers through Bonneville's rates. Energy Northwest-related debt, as refinanced under this effort, is called Regional Cooperation Debt.

Bonneville manages its overall debt portfolio, which includes both debt that is issued by non-federal entities and secured by Bonneville's financial commitments ("Non-Federal Debt"), and Bonneville's repayment obligations to the United States Treasury, to meet the objectives of: (i) minimizing the cost to Bonneville's ratepayers, (ii) maximizing Bonneville's access to its lowest cost capital sources to meet future capital needs, and (iii) maintaining sufficient financial flexibility to meet Bonneville's financial requirements.

The most recent efforts have included the issuance of Net Billed Bonds to refund outstanding Net Billed Bonds in Fiscal Year 2014 through Fiscal Year 2020. These refinancings were known as the initial phase of "Regional Cooperation Debt" which have enabled Bonneville to repay, earlier than would otherwise occur, Federal Appropriations Repayment Obligations. The initial phase of Regional Cooperation Debt refinancings achieved significant interest rate savings that has and will result in total debt service savings of approximately $2.8 billion.

Similar to the initial phase, the second phase of Regional Cooperation Debt refinancings would have the effect of freeing up amounts in the Bonneville Fund which otherwise would have been used to fund the repayment of the principal of the refunded Net Billed Bonds, which will instead be used to make payments to reduce the outstanding principal amount of bonds issued by Bonneville to the United States Treasury. Bonneville estimates that the aggregate potential principal amount of refinancing Net Billed Bonds that could be issued in Fiscal Year 2021 through Fiscal Year 2030 could approach $3.5 billion.

Power Prepayment Program

Bonneville undertook a Power Prepayment Program in FY 2013 under which all Bonneville preference customers had an opportunity to submit formal offers to provide lump-sum payments to Bonneville as prepayments of a portion of their power purchases through September 30, 2028, the termination date of their current Long-Term Regional Dialogue Power Sales Contracts. Bonneville accepted power prepayments from four preference customers, as described below.

Upon Bonneville's receipt of the agreed-to, lump-sum prepayments, the selected preference customers became entitled to future portions of their electricity from Bonneville without further payment. The power prepayments are and will be recognized in the customers' future power bills from Bonneville as fixed, equal monthly prepayment credits. In effect, the amount of electricity that is prepaid may vary by month, depending on Bonneville's power rates and rate schedules that apply to electricity purchases by the prepaying customers in the related month. Because this is structured as a variable amount of prepayment and not as a fixed-price/fixed-amount type of prepayment, Bonneville maintains flexibility to establish rates for the electric power that is prepaid.

As a result of the FY 2013 Prepayment solicitation, Bonneville received $340 million in prepayments, which Bonneville is using to fund needed FCRPS investments. The aggregate prepayment credits are set at $2.55 million per month through FY 2028.

Depending on a variety of factors it is possible that Bonneville may seek to implement later phases of the Power Prepayment Program in connection with future FCRPS hydroelectric investment needs.

Asset Management

The foundation of Bonneville's value is the base of the generating resources from which it markets electricity, and Federal transmission assets it owns and operates. Bonneville utilizes an Asset Management Program based on The Institute of Asset Management (IAM's) conceptual model that aligns with the International Organization of Standardization (ISO) 55000 Series and Publically Available Specification (PAS) 55 standards. Investments are created, selected, and executed based on a strategy to apply best-practice industry standards to manage the lifecycle costs of Federal assets. This is central to maintaining the long-term value and reliability of the power and transmission systems. Achieving these objectives for power requires collaborative, long-term planning with Bonneville's Federal partners, the Corps and Reclamation. Through the Asset Investment Excellence Initiative, the three agencies are establishing a long term asset investment plan, applying

prioritization tools to inform investment decisions to ensure the long term affordability and reliability of the hydropower assets.

Bonneville Power Administration operates within a complex environment that requires asset management tradeoffs. Bonneville's business decisions consider five dimensions of risk: financial, reliability, compliance, safety and environmental. Reliability and safety remain Transmission priorities. Transmission's asset management capability is continually maturing to maximize the value of its assets and help BPA maintain competitive advantage in the marketplace, enable industry change and deliver on public responsibilities; as well as strengthen financial health through the management of lifecycle cost.

Infrastructure Investments

The FCRPS is one of the nation's largest nearly carbon-free power systems, and preserving and enhancing the value of the FCRPS for the future continues to be a major Bonneville focus. Bonneville's ongoing prioritization and execution of capital investment in transmission and FCRPS generation assets is the foundation for delivering clean, low cost power to support the communities and economies of the region well into the future.

Bonneville continues to assess needed infrastructure investments in the Pacific Northwest to meet transmission capacity and reliability needs and continues to support a competitive wholesale market in the Western Interconnection, which encompasses 14 western states, two Canadian provinces, and one Mexican state.

Bonneville signed two agreements to participate with two investor-owned utilities in the environmental work and permitting for a transmission project, the proposed Boardman-to-Hemingway 500kV line; the initial agreements were executed in FY 2012 and subsequently amended in FY 2018. Participation in this preliminary review keeps Bonneville's options open for serving its six southeast Idaho preference customers following the termination of legacy transmission service agreements. Bonneville has not made a decision to co-develop or purchase capacity in this project. On January 17, 2014, Public Law 113-76 was enacted, which provided Bonneville with expenditure authority approval to construct or participate in the construction of a transmission line to southeast Idaho, should Bonneville decide to continue pursuing that service arrangement.

Bonneville continues to evaluate additional transmission investments and alternative non-wires solutions across the Pacific Northwest to improve reliability and support both load and renewable generation needs. Bonneville makes use of certain alternative capital financing mechanisms, in addition to or in lieu of the use of its U.S. Treasury borrowing authority, to sustain funding for its infrastructure investment requirements. These approaches include revenue and financial reserves financing some amount of either or both power and transmission investments, or seeking, when feasible, third party financing sources. See the BP-5 Potential Third Party Financing Transparency table in the budget schedules section of this document.

In 2019, Bonneville and a partner customer utility completed another innovative addition to system transmission capabilities that reflected Bonneville's strategic objective to meet transmission customer needs more efficiently and responsively. The customer utility, Lower Valley Energy, approached Bonneville with a proposal to finance and complete the Hooper Springs Transmission Project, planned for construction by Bonneville to continue service to the utility. Bonneville had completed project design and siting processes. With Lower Valley's assumption for the costs and final construction of the project, Bonneville was able to preserve Treasury borrowing authority and lease operating rights for service over the project.

Bonneville plays a key role in advancing energy efficiency across the region consistent with its statutes, including developing and promoting related technologies, and exploring demand-side management opportunities.

Bonneville is making disciplined technology innovation investments and looking to apply new operational and market mechanisms that enhance the reliability, efficiency, and flexibility of system operations.

Revised Transmission Tariff

In 2018, Bonneville engaged in settlement discussions with transmission customers to reach consensus on terms and conditions for a new Bonneville transmission tariff as well as gain agreement from those customers to convert their current

contracts to the new tariff when it becomes effective. Bonneville presented its need for a modernized tariff that can be modified over time so that the region can take advantage of opportunities in the rapidly changing industry as well as further its objectives for improving the agency's commercial performance. This resulted in a settlement package that includes a TC-20 Settlement Agreement on the tariff terms and conditions and a BP-20 Partial Transmission Rates Settlement Agreement that settles transmission and ancillary and control area services rates. Bonneville's Fiscal Year 2020 and 2021 rate decision included the transmission, and ancillary and control area services rates agreed upon in the settlement.

Grid Modernization

Bonneville continues a cross-agency grid modernization initiative. Bonneville's reliance on legacy systems and non-standard commercial practices are costly to maintain and have led to being conservative in its power and transmission operations, planning, and marketing. Bonneville's strategic objective is to modernize federal power and transmission systems and their supporting technology. BPA's Grid Modernization initiative includes 35 projects designed to increase automation, improve accuracy and enhance visibility into how the federal power and transmission systems are functioning in real time, to ultimately enhance the optimization and reliability of the grid. The program includes upgrades to metering technology, outage management systems and other operational tools that improve visibility and accuracy in BPA's operations and contribute to build the resilience of the grid.

Grid modernization involves improving transmission and generation system visibility and controls, and increasing the electricity market skills of Bonneville employees. The grid modernization initiative focuses on five areas of effort:

- Operational modernization
- Commercial modernization
- Energy Imbalance Market implementation
- Mission critical information technology improvements
- Improvements to core business practices

Part of the grid modernization scope is Bonneville's evaluation of joining the Western Energy Imbalance Market (EIM) and enabling Federal and non-federal resources in its service area to access that market. Bonneville expects that joining the EIM will optimize the day-to-day operation of the power system and leverage hydropower in a market increasingly driven by intermittent renewable resources. As part of its evaluation, Bonneville conducted monthly public meetings to include its customers and regional constituents in assessing the EIM and its impacts on Bonneville's operational and commercial processes as well as its statutory obligations. In September 2019, Bonneville signed a Western EIM Implementation Agreement with the California Independent System Operator to begin work on projects that need to be completed to allow BPA to start EIM operations.

Bonneville continues to engage its customers and constituents in the implementation of its plan to join the EIM in 2022 through regular public workshops. The workshops consider the rate, tariff and operational issues of participating in the EIM and preparation for BPA's FY 2022-2023 rates processes. The rate and tariff issues are included in the TC-22 and BP-22 rate case that is currently underway. BPA is currently holding stakeholder workshops on EIM implementation in preparation for a potential go-live of March 2, 2022. BPA will kick off the final phase of its EIM decision process in August 2021, with a final decision on whether or not to join the EIM determined by September 30, 2021.

Integrating Regional Transmission Planning

Bonneville now participates in the newly formed NorthernGrid regional planning organization. Bonneville's 2018-2023 Strategic Direction included the objective of pursuing a single entity to consolidate regional planning efforts and reduce duplication. In support of that objective, Bonneville worked together with other entities to scope and develop a new, single regional planning organization. The result of that effort is NorthernGrid. NorthernGrid's formation will facilitate Bonneville's efforts to meet transmission customer needs efficiently and responsibly across a broad spectrum of participants and a larger footprint. It includes participation by both FERC-jurisdictional and non-jurisdictional entities.

Regional Resource Adequacy

Recent regional forecasts have shown that the Pacific Northwest as a whole is nearing periods of times of the year when regional power supplies may not be adequate to meet demand. Bonneville is joining other regional utilities through the

Northwest Power Pool on an initiative to develop a voluntary, but enforceable, program to ensure that the region maintain a balance of supplies and demand in a very high percentage of likely conditions. Development of a regional resource adequacy program has continued into 2021. Bonneville will continue to consult its customers and regional leaders about the business case and principles for its participation.

The Columbia River System Operations

In 2020, the U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration completed the public process to prepare an updated environmental impact statement (EIS) on the Columbia River System operations (CRSO) and configurations for 14 federal projects in the interior Columbia Basin. The last comprehensive system EIS was completed in 1997. In the updated CRSO EIS, the three agencies prepared a reasonable range of alternatives for long-term system operations and evaluated the potential environmental and socioeconomic impacts on a number of resources, including flood risk management, irrigation, power generation, navigation, fish and wildlife, cultural resources and recreation.

The on-going action that requires evaluation under NEPA is the long-term coordinated management of the System projects. An underlying need to which the co-lead agencies are responding is reviewing and updating the management of the System, including evaluating measures to avoid, offset, or minimize impacts to resources affected by the management of the System in the context of new information and changed conditions in the Columbia River basin. In addition, the co-lead agencies are responding to the Opinion and Order issued by the U.S. District Court for the District of Oregon such that this EIS will evaluate how to insure that the prospective management of the System is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of designated critical habitat, including evaluating mitigation measures to address impacts to listed species.

The co-lead agencies released a draft EIS in February 2020, beginning a 45-day public comment period. Due to state and Federal measures to prevent the spread of the COVID-19 virus, public workshops that had been scheduled for comment were conducted by conference calls in March and April. The public comment period closed on April 13 and the co-lead agencies began analysis and response to over 58,000 comments received in that period. The co-lead agencies released a final record of decision in September 2020.

Fish and Wildlife Program Overview

Bonneville remains committed to funding its share of the region's efforts to protect and mitigate Columbia River Basin fish and wildlife affected by the construction and operations of the FCRPS. To the extent possible, Bonneville integrates actions to protect species listed for protection under the Endangered Species Act (ESA) in response to relevant FCRPS Biological Opinions with the Fish and Wildlife Program of the Northwest Power and Conservation Council. Implementation of these efforts involve significant collaboration with Pacific Northwest states, Indian tribes, local communities and other Federal agencies.

Included with the budget schedules section of this document is the current tabulation of Bonneville's fish and wildlife costs from FY 2011 through FY 2020.

The Columbia River Treaty

The U.S. Government reached consensus on a high level position for negotiations of the post-2024 future of the Columbia River Treaty in June 2015, and received authorization to negotiate with Canada on the Columbia River Treaty in October 2016. Government Affairs Canada notified the United States State Department in December 2017 of Canada's mandate to negotiate the Columbia River Treaty with the United States. Negotiations began in spring 2018 and continue to date. Both the U.S. Department of State and Canadian negotiators have discussed shared objectives and exchanged information on flood risk management, hydropower and ecosystem considerations.

Radio Spectrum Communications

Bonneville's wireless communication system is used to operate and control critical national transmission grid infrastructure in a reliable, secure, and safe manner. Bonneville's communication systems are designed to meet strict reliability/availability objectives required by the North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) standards. Concerning proper spectrum stewardship, Bonneville designs highly

efficient radio systems that use minimal radio frequency (RF) channel bandwidths to meet critical mission needs. However, in certain circumstances, efficiently designed spectrum radio systems will require broad RF channels and/or lower state RF modulation schemes to meet existing and future requirements in order to meet operational and reliability/availability objectives.

In order to meet Bonneville's mission/operational requirements, RF communication equipment approved for system use goes through a rigorous evaluation and testing process. RF spectrum efficiency factors are considered during the evaluation/testing period. RF terminal equipment approved for use is normally purchased directly from vendors and is not typically supplied through a Request for Proposal process.

Bonneville's operational telecommunications and other capital equipment and systems are acquired using Bonneville's self-financing and procurement authorities. The Bonneville budget includes a system-wide electric reliability performance indicator, consistent with NERC rules, to track and evaluate performance.

Bonneville may share temporarily-available spare capacity on its RF communication system with other government agencies (both Federal and State), and with other electric utilities in the region whose power systems interconnect with Bonneville. Non-critical administrative traffic is typically supported by commercial carrier enterprises. However, to meet the NERC and WECC electrical bulk transmission requirements, Bonneville exclusively operates highly critical transmission control traffic over its private telecommunication system as Bonneville has no control over the reliability/availability of the commercial enterprise or on how quickly critical operational control circuits are restored to active service during an interruption.

For high capacity communication system applications, Bonneville considers and operates non-spectrum dependent alternatives such as fiber optic cable infrastructure systems.

During FY 2014, Bonneville began upgrading the Very High Frequency (VHF) land mobile system and installing a number of digital Synchronous Optical Network (SONET) rings typically consisting of fiber segments in combination with point-to-point microwave hops operating in the 4 GHz and 7/8 GHz bands. These various telecommunication systems operate within Bonneville's approximate 300,000 square mile regional utility service territory (Oregon, Washington, Idaho, western Montana) with the majority of the RF infrastructure located in low population-rural areas.

The FCRPS hydroelectric projects, owned by the Corps and Reclamation, also utilize federal radio spectrum to preserve very high operational telecommunications and power system reliability.

In FY 2014, Bonneville completed work costing approximately $40 million, funded through the Spectrum Relocation Fund, to relocate its operational telecommunication systems from the 1710-55 MHz radio spectrum bands to alternative federal radio spectrum bands, part of the AWS-1 Federal Spectrum Relocation. In accordance with Federal law, Bonneville plans to return the approximately $8.2 million of excess funds to the U.S. Treasury, via the Spectrum Relocation Fund, as soon as the National Telecommunications and Information Administration (NTIA) officially notifies the Federal Communications Commission (FCC) that the DOE relocation effort is complete.

Bonneville began participating in a new spectrum relocation effort in FY 2015 to relocate its operational telecommunication systems from the 1755-80 MHz radio spectrum bands. The NTIA has approved and, in July 2014, web-posted federal agency relocation plans, including the Bonneville relocation plan. The FCC held an auction of this spectrum on November 13, 2014. Bonneville received an additional $5.2 million from the Spectrum Relocation Fund on July 29, 2015 to fully pay for this new relocation effort, including, as in the prior relocation, the purchase and installation of new digital radio equipment. Bonneville received obligational authority to proceed with this relocation effort by apportionment on July 24, 2015.

Bonneville has worked to complete its move off of 1755-80 MHz in two stages. First, Bonneville moved off of the old federal frequencies and "retuned" to new alternate federal frequencies in the band segment of 1780-1850 MHz which is above the highest frequency that is involved in the auction. Three hops federal frequency moves/retuning were completed as of June 7, 2017. The last remaining path, Happy Camp to Hilltop in northern California near the Oregon California Border, was moved/retuned, and as of July 31, 2018, Bonneville was off of the AWS-3 radio frequencies, meeting the

commitment date promised to the NTIA. Bonneville still has additional work remaining to finish the construction related to the AWS-3 relocations. Bonneville will use the SRF relocation funds until the AWS-3 relocation work is completed and closed out. Second, Bonneville will complete its move of these four microwave hops to 7GHz-8GHz. This will take additional time because two of four hops require building construction to complete the work. AWS-3 funds will need to be retained by Bonneville at least through FY 2023 to complete construction of two communications buildings. This will accommodate the adjusted construction schedule with contingency for minor access issues due to weather or fire. Construction at the Glass Butte site may not occur until FY 2021. The construction of the new control house at Richland Substation is on a similar timeline as the Glass Butte project. The building construction will likely occur in FY 2021 with cutovers to the new radio equipment and retirement of old radio equipment likely concluding in FY 2022. Bonneville will assure that "comparable capability" has been achieved for these four AWS-3 relocated Bonneville operational telecommunication hops.

Educational Activities

Bonneville is a supporter of science, technology, engineering, and math (collectively known as "STEM") education programs. These programs provide support and encouragement to middle and high school students to study the sciences in school and to pursue careers in these fields. As a regional leader in STEM education, Bonneville proudly supports and organizes an award-winning Science Bowl. Bonneville also sponsors Science Fair competitions for students in Washington State, as well as a First Robotics tournament championship. Bonneville employees also serve as volunteer ambassadors, providing presentations, curricula, and activities to K-12 schools that enhance the learning experience for students and teachers, and extend awareness of the role of the region's hydroelectric system.

Budget Estimates and Planning

This FY 2022 Budget proposes estimated accrued expenditures of $2,734 million for operating expenses, $56 million for Projects Funded in Advance (PFIA), $826 million for capital investments, and $696 million for capital transfers in FY 2022.

The estimated spending levels in this budget are still subject to change to accommodate competitive dynamics in the region's energy markets, debt management strategies, continuing changes in the electric industry, and other factors.

This FY 2022 Budget includes capital and expense estimates based on initial approved spending proposals from Bonneville's BP-22 Integrated Program Review (IPR). Capital investment levels reflect Bonneville's capital asset management process and external factors such as changes affecting the West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region and national energy security goals.

Bonneville utilizes a structured capital project selection process requiring submission of a standardized business case for review. Each business case consists of a description of the project, a clear statement of objectives, description and mitigation of risks, and a rigorous analysis of project costs and benefits including a status quo assumption and preferred alternatives. In addition, both annual and end-of-project targets are set for each project covering cost, scope, and schedule. Progress reports on these targets are provided to Bonneville's senior executives at least quarterly.

The FYs 2021-2026 revenue estimates in this budget, included in the Net Outlay formulation, are calculated consistent with cash management goals. The revenue estimates reflect assumed adjustments, which include the use of a combination of tools, including upcoming rate adjustment mechanisms, reduced cost estimates, a net revenue risk adjustment, debt management strategies, and/or short-term financial tools to manage net revenues and cash. The revenue estimates also include depreciation and U.S. Treasury repayment credit assumptions. These U.S. Treasury repayment credits offset, among other things, Bonneville's fish and wildlife program costs allocable to the non-power project purposes of the FCRPS, as provided under section 4(h)(10)(C) of the Northwest Power Act.

Overview of Detailed Justifications

In Bonneville's Detailed Justification Summaries, accrued expenditure is the basis of presenting Bonneville's program funding levels in the power and transmission rate making processes and the basis upon which Bonneville managers control their resources to provide products and services. Accrued expenditures relate period costs to period performance. Traditional budget obligation requirements for Bonneville's budget are assumed on the Program and Financing Summary Schedule prepared in accordance with Office of Management & Budget Circular A-11.

The organization of Bonneville's FY 2022 Budget and these performance summaries reflect Bonneville's business services basis for its utility enterprise activities. Bonneville's major areas of activity on a consolidated budget and accounting basis include power and transmission, with administrative costs included. Power Services includes line items for Fish and Wildlife, Energy Efficiency, Residential Exchange Program, Associated Projects (The Corps and Reclamation hydro projects that comprise part of the FCRPS are known as Associated Projects) O&M Costs, and the Northwest Power Council. Environmental activities are shown in the relevant Power Services and Transmission Services sections, as are reimbursable costs. Bonneville's interest expense, pension and post-retirement benefits, and capital transfers to the U.S. Treasury are shown by program.

The first section of performance summaries, Capital Investments, includes accrued expenditures for investments in electric utility and general plant associated with the FCRPS generation and transmission services, fish and wildlife, and capital equipment. These capital investments are estimated to require budget obligations and expected use of $826 million in bonds to be issued and sold to the U.S. Treasury in FY 2022.

The near-term forecast of capital funding levels has undergone an extensive internal review as a result of Bonneville's development of asset management plans. These plans encompass project cost management initiatives, capital investment assessments, and categorization of capital projects to be funded based on risk and other factors. Consistent with Bonneville's near-term asset planning process and Bonneville's standard operating budget process, this FY 2022 Budget includes updated capital investment levels for FY 2021. Utilizing this review process helps Bonneville in its efforts as a participant in wholesale energy markets. Bonneville will continue to work with the Corps and Reclamation to optimize the mix of projects.

The second section of Bonneville's performance summaries, entitled Annual Operating Expenses, includes accrued expenditures for services and program activities financed by power sales revenues, transmission sales revenues, and projects funded in advance. For FY 2022, budget expense obligations are estimated at $3,616 million. The total program requirements of all Bonneville programs include estimated budget obligations of $4,312 million in FY 2022.

Evidence and Analysis in the Budget

Bonneville has undertaken several initiatives and processes to determine appropriate budget expenditures.

Bonneville's Integrated Program Review (IPR) process allows the public to see all relevant FCRPS expense and capital spending level estimates in the same forum. In addition, Bonneville's IPR process allows the public to review and comment on Bonneville's 10-year capital forecasts. The IPR occurs every two years, prior to each Bonneville rate case, and provides the public an opportunity to review and comment on Bonneville's program level cost estimates prior to being set for inclusion in rate cases. BPA conducted the BP-22 IPR, which reviewed spending plans for the FY 2022 and FY 2023 rate period during the summer of 2020. Bonneville initiated the BP-22 IPR with the objective to be consistent with the 2018 Strategic Direction, which included holding costs at or below the level of inflation through 2028. Bonneville issued the closeout report for the BP-22 IPR in September 2020.

The final spending levels in the BP-22 IPR reflect shifts in how BPA views and plans its work, using program plans to show how all of the organizations in BPA support the critical commercial, operations and asset management functions and performance objectives.

As it began the BP-22 IPR, Bonneville stated its recognition that the COVID-19 pandemic has created uncertainty for its customers. Bonneville presented its initial proposal as a baseline of costs for the BP-22 rates, recognizing the need to remain flexible and adaptable to changing conditions. Those conditions may warrant revisiting some proposed spending levels in an IPR-2 in the early part of 2021. Even if the outlook improves, an IPR-2 may still be warranted to factor in any impacts that may arise related to the Columbia River System Operations review or other changing conditions.

Bonneville is focused on institutionalizing operational excellence – continuous improvement that produces more efficient and effective ways to deliver on Bonneville's mission and vision. Bonneville's Business Transformation Office (BTO) ensures

that Bonneville's transformational initiatives, including its Key Strategic Initiatives (KSIs), are executed in the most efficient manner from a time, cost and resource perspective. Bonneville currently focuses on Grid Modernization as its single KSI. Grid Modernization will advance the way BPA markets and operates the federal power and transmission systems, so that Bonneville can benefit from new technology and emerging market opportunities. This work is critical to ensuring BPA's long-term commercial success and competitiveness.

Judicial and Regulatory Activity

The Energy Policy Act of 2005 authorized the Federal Energy Regulatory Commission (FERC) to approve and enforce mandatory electric reliability standards with which users, owners, and operators of the bulk electric power system, including Bonneville, are required to comply. These standards became enforceable on June 18, 2007, and compliance is monitored by the North American Electric Regulatory Corporation (NERC) and the regional reliability organizations.

COVID-19 Impacts

Beginning in March, 2020, Bonneville responded to the expanding COVID-19 pandemic by instructing all non-mission critical operating personnel to telework for an indefinite period of time. Bonneville implemented the suspension of transmission construction projects and limited field operations to critical work.

Through the spring of 2021, most Bonneville employees have remained in telework status. As local health conditions permitted, Bonneville resumed work on prioritized construction projects and system maintenance activities. Bonneville continued the functions of its Incident Management Team to monitor the pandemic situation across Bonneville's service territory and advise Bonneville's leadership on conditions affecting employees and operations.

Even with the majority of Bonneville employees teleworking, business lines and work teams moved forward on major organizational initiatives. As discussed earlier, Bonneville announced in June 2020 a significant action to provide rate relief to customer utilities potentially impacted by economic conditions related to the pandemic. Bonneville completed an expedited rate proceeding to suspend its Financial Reserve Policy power rate surcharge. Suspending the surcharge provided power customers rate relief of $9 million in FY 2020 and avoided any possibility of a surcharge triggering for FY 2021.

FCRPS Cost Allocations

The FY 2020 Energy and Water Development Appropriations Act included House subcommittee report language addressing the allocation of costs for multi-purpose projects of the Federal Columbia River Power System. Noting that the allocations of cost sharing among the authorized project purposes can be decades old, the subcommittee report requested that Bonneville, the Corps of Engineers, and Reclamation return an outline of how cost allocations may be updated. The three agencies provided the subcommittee with an outline of cost allocation methods and authorities in June 2020.

Power Services - Capital
Funding Schedule by Activity

Funding ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2022 vs FY 2021 $	FY 2022 vs FY 2021 %
Power Services – Capital					
Associated Project Costs	178,264	272,493	264,120	-8,373	-3.1%
Fish & Wildlife	40,185	47,266	43,000	-4,266	-9.0%
Total, Power Services – Capital	**218,449**	**319,759**	**307,120**	**-12,639**	**-4.0%**

Outyears ($K)

	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Power Services – Capital					
Associated Project Costs	264,120	281,260	300,000	306,850	313,647
Fish & Wildlife	43,000	43,000	30,000	25,000	15,000
Total, Power Services - Capital	**307,120**	**324,260**	**330,000**	**331,850**	**328,647**

Program Overview

Associated Project Costs provide for direct funding of additions, improvements, and replacements of existing Reclamation and Corps hydroelectric projects in the Pacific Northwest. The FCRPS hydro projects produce a large portion of the electric power that is marketed by Bonneville.

Maintaining the availability and increasing the efficiency of the FCRPS is critical to ensuring that the region has an adequate, efficient, economic, and reliable power supply. The FCRPS represents about 80 percent of Bonneville's firm power supply and includes 31 operating federal hydroelectric projects with over 200 generating units. These projects have an average age of about 50 years, with some that exceed 60 years of age. Through direct funding and the cooperation of the Corps and Reclamation, Bonneville uses its U.S. Treasury borrowing authority and other sources to make investments needed to restore generation availability and improve efficiency, reducing demand on Corps and Reclamation appropriations for power-related investments.

Since the beginning of Direct Funding in 1997, BPA has invested over $2 Billion in Direct Capital in the Federal Columbia River Power System with the goal of maximizing system value for the region and its stakeholders. Ongoing analysis with its operating partners, the Army Corps of Engineers and the Bureau of Reclamation, has identified ongoing investment needs for the foreseeable future in order to maintain the health of the hydro system.

These planned investments, included in the FY 2022 Budget estimates, will maintain the generation performance of the FCRPS. Moving forward with the cost-effective opportunities to expand the generation and to preserve and enhance the capability of the FCRPS is a smart, economic, and environmentally beneficial decision when compared to purchasing power from the wholesale power market to serve growing Pacific Northwest electricity needs of BPA customers.

Fish and wildlife capital costs incurred by Bonneville are directed at activities that mitigate Columbia River Basin fish and wildlife resources. Bonneville uses capital to fund projects designed to increase juvenile and adult fish passage through the federal hydrosystem, to increase fish production and survival through construction of hatchery, acclimation and fish monitoring facilities, and to increase wildlife and resident fish populations through land acquisitions and associated habitat maintenance. These capital projects support both Northwest Power Act and ESA priorities and are integrated with the Pacific Northwest Electric Power Planning Council's (Council) Columbia Basin Fish and Wildlife Program (Council's Program)in order to efficiently meet Bonneville's responsibilities under the Northwest Power Act and other statutes to mitigate federal hydrosystem impacts to Columbia River Basin fish and wildlife.

Bonneville implements such projects consistent with the Council's Program and the purposes of the Northwest Power Act. Under the Northwest Power Act, the Council must develop a program that protects, mitigates, and enhances Columbia River Basin fish and wildlife affected by the federal and non-federal hydroelectric projects in the basin while assuring the Pacific Northwest an adequate, efficient, economical, and reliable power supply. The Program, the Columbia River System BiOps, other BiOps, and Bonneville's long-term agreements include prioritized strategies for mitigation actions and projects to meet Bonneville's responsibilities under the Northwest Power Act, the ESA, the Federal Clean Water Act, and other laws. When issues arise that potentially trigger the *in lieu* provision of the Northwest Power Act, which prohibits Bonneville from funding mitigation that other entities are authorized or required to undertake, Bonneville works with the Council and the regional fish and wildlife managers, customers, and tribes, as appropriate, to ensure ratepayers fund only appropriate mitigation.

Most projects recommended by the Council also undergo independent scientific review as directed by the 1996 Energy and Water Appropriations Act, which added section 4(h)(10)(D) to the Northwest Power Act. As a result, the Council appoints an Independent Scientific Review Panel (ISRP) "to review a sufficient number of projects" proposed to be funded through Bonneville's annual fish and wildlife budget "to adequately ensure that the list of prioritized projects recommended is consistent with the Program." The Northwest Power Act further states that "in making its recommendations to Bonneville, the Planning Council shall consider the impact of ocean conditions on fish and wildlife populations; and shall determine whether the projects employ cost effective measures to achieve program objectives." Today, most mitigation projects funded by Bonneville receive ISRP review as part of the Council recommendation process. The Council uses a multi-year project review cycle during which the ISRP reviews categories of projects grouped together.

To comply with the ESA, Bonneville funds capital investment actions to avoid jeopardizing listed species. Guidance for those actions is found in the current BiOps issued by NOAA and the USFWS.

Under these collective BiOps, the Action Agencies have committed to implement hydro, habitat, hatchery, and other actions throughout the Columbia River Basin to address impacts stemming from the operation of the federal hydro-electric dams on ESA-listed fish, and to ensure that operations of the federal dams do not jeopardize the continued existence of the ESA listed species or adversely modify their designated critical habitat.

The Action Agencies also signed the 2008 Columbia Basin Fish Accords (Fish Accords or Accords) with five Northwest Tribes and the states of Idaho and Montana. In 2009, an agreement was signed with the state of Washington and federal agencies (the state of Washington Estuary agreement). And in 2012, the Action Agencies signed an agreement with the Kalispel Tribe of Indians covering Albeni Falls Dam and FCRPS operations. Wildlife settlement agreements have been signed with the states of Oregon and Idaho to help complete mitigation for the flooding and inundation caused by the construction of FCRPS dams operating in those states. These Fish Accords and settlements complement the BiOps and provide firm commitments to prioritize mitigation actions and secure funding over the life of the agreements.

In October 2018, Bonneville and its federal partners Corps and Reclamation signed extension agreements with current Accords partners, namely certain states and tribes, to extend the Columbia Basin Fish Accords (2018 Fish Accord extensions). The 2018 Fish Accord extensions expire with the issuance of the agencies' record of decision on the CRSO EIS in September 2020. The agencies and Accord partners are in discussions to amend the 2018 Fish Accord extensions through 2022. The extension agreements commit nearly $450 million for fish and wildlife protection and mitigation, which is likely to result in future expenses or regulatory assets.

As noted above, BiOps, 2018 Fish Accord extensions, and wildlife settlement commitments are integrated along with other projects and implemented through the Council Program under the Northwest Power Act. They provide the basis for Bonneville's planned capital investment for fish and wildlife.

Accomplishments

- The BP-20 - Rate Case final record of decision was released July 25, 2019. FERC granted final approval to the rates on April 17, 2020.
- Completed the McNary 4160V/480V Station Service Upgrade
- Completed Attic Safety Improvements at Bonneville Dam
- Completed emergency gantry crane replacement and 500kV disconnect replacement John Day Dam
- Completed arc flash hazard reduction, fish unit breaker replacements and SCC breaker replacement at The Dalles Dam
- Completed GDACS installation across the Willamette Valley, digital governors at Lookout Point and Big Cliff intake gantry crane replacement at Williamette Plants
- Completed Spillway Gate Lifecycle Maintenance at Chief Joseph Dam
- Completed exciter replacements at Dworshak Dam
- Completed Main Unit Cooling Water Replacement, Spare Main Unit Bearing purchase, and 4160-480V station service rehabilitation at McNary Dam
- Completed station service transformer replacements at Ice Harbor Dam
- Completed drainage system oil water separator installation at Little Goose Dam
- Completed purchase of spare main unit bearing at Lower Granite Dam
- Completed microwave system backbone modernization at Palisades Dam
- Completed arc flash mitigation and governor system replacement at Minidoka Dam

Explanation of Changes

Bonneville's budget includes $307.1 million in FY 2022 for Power Services capital, which is a 4.0 percent decrease from the FY 2021 forecasted level. The FY 2022 level reflects additional cost management efforts while continuing to align with BPA's strategic asset management plans which focus on the need for investment in the hydroelectric system assets and

investments necessary to implement the BiOps, 2018 Fish Accord extensions, and other Columbia Basin Fish and Wildlife activities.

The FY 2022 budget decreases the levels for Associated Projects (-$8.4 million) and the funding level for Fish & Wildlife (-$4.3 million), relative to FY 2021.

Strategic Management

Bonneville markets available electric power to meet requested load while supporting the achievement of its vital responsibilities for fish and wildlife, energy efficiency, renewable resources, and low-cost power in the Pacific Northwest region. Bonneville will continue to implement the following strategies to serve the region:

1. Bonneville coordinates its power operational activities with the Corps, Reclamation, NERC, regional electric reliability councils, its customers, and other stakeholders to provide the most efficient use of federal assets.
2. Ongoing work with the Corps and Reclamation is focused on improving the reliability of the FCRPS, increasing its generation efficiency, and optimizing hydro facility operation.
3. Bonneville is committed to funding efforts to protect listed fish and wildlife species in the Columbia Basin under the ESA and working closely with the Council, regional fisheries managers, and other federal agencies to prioritize and manage projects to mitigate fish and wildlife affected by the FCRPS.
4. Bonneville's utility customers have been, and continue to be, a critical part of Bonneville's collaborative efforts to promote and foster the efficient use of energy.
5. Bonneville has assisted with a DOE Wind Power crosscutting initiative to strengthen energy security.

The following external factors present the most significant risk and impact to overall achievement of the strategies listed above:

1. Continually changing regional economic and institutional conditions;
2. Competitive dynamics; and
3. Ongoing changes in the electric industry.

Associated Projects

Overview

Bonneville will work with both the Corps and Reclamation to reach mutual agreement on budgeting and scheduling capital improvement projects that are cost-effective and provide system or site-specific enhancements, increase system reliability, or provide generation efficiencies.

The work is focused on improving the reliability of the FCRPS and on increasing its generation efficiency or capacity through turbine runner replacements, optimizing hydro facility operation, and new unit construction. Also, limited investments may be made in joint-use facilities that are beneficial to both the FCRPS operations and to other Corps and Reclamation project purposes.

Corps of Engineers Projects

($K)		
FY 2020 Actual	**FY 2021 Estimate**	**FY 2022 Estimate**
144,716	128,271	216,296

Bonneville Dam:

- FY 2020. Completed Attic Safety Improvements. Continued GSU transformer instrumentation, main unit breaker and station service reconfiguration, control room fire protection upgrades, oil water separator improvements, tailrace gantry crane rehabilitation, and generator fire protection projects. Began oil storage room fire protection and SU and CQ Feeder Boards replacement.
- FY 2021. Complete control room fire protection upgrades, GSU transformer instrumentation and oil water separator improvements. Continue main unit breaker and station service reconfiguration, tailrace gantry crane rehabilitation, oil storage room fire protection, and generator fire protection projects. Continue SU and CQ Feeder Board replacement. Begin headgate repair pit rehabilitation, trashracks replacement and preferred AC/DC improvement.
- FY 2022. Begin digital governor replacement, Bradford Island Service Building PRQ Switchgear replacement and spillway cranes replacement. Continue main unit breaker and station service reconfiguration.

John Day Dam:

- FY 2020. Completed emergency gantry crane replacement and 500kV disconnect replacement. Continued heating, ventilating, air conditioning (HVAC) system upgrade, SQ board replacement, powerhouse roof replacement, BLH Turbine Hub Upgrades and fixed blade conversions and trash rack crane replacement.
- FY 2021. Complete trash rack crane replacement and powerhouse roof replacement. Continue HVAC system upgrade, BLH Turbine Hub Upgrades and fixed blade conversions, and SQ board replacement.
- FY 2022. Continue HVAC system upgrade, BLH Turbine Hub Upgrades and fixed blade conversions, and SQ board replacement.

The Dalles Dam:

- FY 2020. Completed arc flash hazard reduction, fish unit breaker replacements and SCC breaker replacement. Continued transformer replacements and gate repair pit upgrades. Began emergency gantry crane rehabilitation and intake and crane rails replacement.
- FY 2021. Complete transformer replacements. Continue emergency gantry crane rehabilitation, intake and crane rails replacement and gate repair pit upgrades.
- FY 2022. Continue emergency gantry crane rehabilitation, intake and crane rails replacement and gate repair pit upgrades.

Willamette Plants:

- FY 2020. Completed GDACS installation across the Willamette Valley, digital governors at Lookout Point and Big Cliff intake gantry crane replacement. Continued electrical reliability upgrades at Foster, and fire detection, HVAC and life

safety improvements at Dexter and oil water separators at Hills Creek. Began intake gantry crane at Dexter, transformer replacements and spillway gate replacements at Detroit, and spillway gate rehabilitation at Hills Creek.

- FY 2021. Continue electrical reliability upgrades at Foster, intake gantry crane at Dexter, spillway gate replacements at Detroit, and fire detection, HVAC and life safety improvements at Dexter. Continue transformer replacements at Detroit and oil water separators at Hills Creek. Begin turbine and generator rehabilitation at Foster, powerhouse and transformer oil water separators at Foster and main unit breakers and electric reliability upgrades at Green Peter and Hills Creek.
- FY 2022. Continue electrical reliability upgrades at Foster, intake gantry crane at Dexter, and fire detection, HVAC and life safety improvements at Dexter. Continue transformer replacements and spillway gate replacements at Detroit, turbine and generator rehabilitation at Foster, powerhouse and transformer oil water separators at Foster and Hills Creek, and main unit breakers and electric reliability upgrades at Green Peter and Hills Creek.

Albeni Falls Dam:

- FY 2020. Continued spillway gate modifications and installation of main unit transformers. Began fire suppression upgrades.
- FY 2021. Complete spillway gate modifications. Continue installation of main unit transformers and fire suppression upgrades.
- FY 2022. Continue installation of main unit transformers and fire suppression upgrades.

Libby Dam:

- FY 2020. Continued system control console replacement. Began powerhouse gantry crane rehabilitation, DC boards and breakers system replacement, and security system upgrades.
- FY 2021. Complete security system upgrades and powerhouse gantry crane rehabilitation. Continue system control console replacement, and DC boards and breakers system replacement. Begin left abutment rock slide stabilization.
- FY 2022. Continue system control console replacement, left abutment rock slide stabilization and DC boards and breakers system replacement.

Chief Joseph Dam:

- FY 2020. Completed Spillway Gate Lifecycle Maintenance at Chief Joseph. Continued CO2 system replacement, upgrades for station service units and intake gantry crane rehabilitation. Began powerbus replacement, exciter replacements, fire suppression upgrades, and intake gantry crane rehabilitation.
- FY 2021. Complete intake gantry crane rehabilitation and CO2 system replacement. Continue upgrades for station service units, powerbus replacement, exciter replacements, and fire suppression upgrades. Begin generator rewinds and cooling.
- FY 2022. Continue upgrades for station service units, powerbus replacement, exciter replacements and fire suppression upgrades. Begin spillway sump pump and controls replacement.

Dworshak Dam

- FY 2020. Completed exciter replacements. Continued tailrace crane rehabilitation. Began RO valve upgrade.
- FY 2021. Complete RO valve upgrade and tailrace crane rehabilitation.
- FY 2022. No planned capital projects.

McNary Dam

- FY 2020. Completed Main Unit Cooling Water Replacement, Spare Main Unit Bearing purchase, and 4160-480V station service rehabilitation. Continued exciters upgrade, governor systems upgrade, levee drainage pump station upgrades, turbine design and replacement, spillway gate rehabilitation, powerhouse control system upgrade, and station service units rehabilitation. Began intake gantry crane replacement and rehabilitation of spillway gates.
- FY 2021. Complete intake gantry crane replacement. Continue exciters upgrade, governor systems upgrade, levee drainage pump station upgrades, turbine design and replacement, spillway gate rehabilitation, powerhouse control system upgrade, and station service units rehabilitation. Begin headgate system rehabilitation.

- FY 2022. Continue exciters upgrade, governor systems upgrade, levee drainage pump station upgrades, turbine design and replacement, spillway gate rehabilitation, powerhouse control system upgrade, station service units rehabilitation, and headgate system rehabilitation.

Ice Harbor Dam

- FY 2020. Completed station service transformer replacements. Continued drainage system oil water separator installation, units 1-3 turbine runner replacements and stator winding replacements. Began intake gantry crane controls upgrade.
- FY 2021. Continue units 1-3 turbine runner replacements, stator winding replacements and intake gantry crane controls upgrade. Begin intake gate hydraulic system upgrades and HVAC system upgrade.
- FY 2022. Continue units 1-3 turbine runner replacements, stator winding replacements, intake gantry crane controls upgrade, intake gate hydraulic system upgrades and HVAC system upgrade.

Little Goose Dam

- FY 2020. Completed drainage system oil water separator installation. Continued isophase bus replacement, headgate repair pit upgrade and drainage and unwatering pump replacement. Began DC system and LV switchgear upgrade and powerhouse roof replacement.
- FY 2021. Complete headgate repair pit upgrade and powerhouse roof replacement. Continue isophase bus replacement, DC system and LV switchgear upgrade. Begin intake gate rehabilitation.
- FY 2022. Complete isophase bus replacement. Continued DC system and LV switchgear upgrade and intake gate rehabilitation.

Lower Granite Dam

- FY 2020. Completed purchase of spare main unit bearing. Continued DC system and LV switchgear upgrade, isophase bus and housing upgrade, and intake gate rehabilitation.
- FY 2021. Complete isophase bus and housing upgrade. Continue DC system and LV switchgear upgrade. Begin trashrake crane and rake replacement.
- FY 2022. Continue DC system and LV switchgear upgrade, trashrake crane and rake replacement. Begin restoration of Lindsay Creek and 380 drainage lines.

Lower Monumental Dam

- FY 2020. Continued DC and LV switchgear upgrades and intake gate rehabilitation. Began headgate repair pit upgrades and isophase bus upgrades.
- FY 2021. Continue DC system and LV switchgear upgrades, intake gate rehabilitation and headgate repair pit upgrades.
- FY 2022. Complete isophase bus upgrades. Continue DC system and LV switchgear upgrades, intake gate rehabilitation and headgate repair pit upgrades. Begin Bridge Crane Wheel and Drive System Upgrade.

Bureau of Reclamation Projects
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
33,548	144,222	47,824

Grand Coulee Dam

- FY 2020. Continued SCADA replacement, Block 31 elevator replacement, Third Powerplant roof replacement, G22-G24 wear ring replacements, firehouse construction and G1-G18 penstock stoplogs, left and right powerhouse bridge crane replacements, and crane control upgrades. Began fire alarm system upgrades.
- FY 2021. Complete crane control upgrades, SCADA replacement and new firehouse construction. Continue Block 31 elevator replacement, left and right powerhouse bridge crane replacements, and fire alarm system upgrades. Begin 230kV switchyard modernization and 230kv Switchyard current limiting reactor, radio system modernization and G11-G18 transformer replacements.
- FY 2022. Continue Block 31 elevator replacement, left and right powerhouse bridge crane replacements, fire alarm system upgrades, 230kV switchyard modernization and 230kV Switchyard current limiting reactor, radio system modernization and G11-G18 transformers replacement. Begin inclined elevator rehabilitation.

Keys Pump Generating Plant

- FY 2020. Continued P5 and P6 impeller and core replacement and rewinds. Continued P1-P6 exciters, relays and unit controls, PG7-12 governors, exciters, relays and unit controls and phase reversal switch replacement.
- FY 2021. Complete P5 and P6 impeller and core replacement and rewinds. Continue P1-P6 exciters, relays and unit controls, PG7-12 governors, exciters, relays and unit controls and phase reversal switch replacement.
- FY 2022. Continue P1-P6 exciters, relays and unit controls, PG7-12 governors, exciters, relays and unit controls and phase reversal switch replacement.

Hungry Horse Dam

- FY 2020. Continued SCADA replacement and control room panel revisions. Continue powerplant crane controls, and main unit transformer fire protection system replacement.
- FY 2021. Complete SCADA replacement. Continue powerplant crane controls and main unit transformer fire protection system replacement. Begin radio system modernization.
- FY 2022. Continue powerplant crane controls, radio system modernization and main unit transformer fire protection system replacement. Begin static exciters replacement.

Chandler Dam

- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Palisades Dam

- FY 2020. Completed microwave system backbone modernization. Began switchyard modernization.
- FY 2021. Continue switchyard modernization.
- FY 2022. Continue switchyard modernization.

Green Springs Dam

- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Black Canyon Dam

- FY 2020. Continued station service arc flash mitigation and Units 1 & 2 Life Safety modernization.
- FY 2021. Continue station service arc flash mitigation and units 1 & 2 life safety modernization.
- FY 2022. Continue station service arc flash mitigation and units 1 & 2 life safety modernization.

Anderson Ranch Dam

- FY 2020. No capital projects.
- FY 2021. Begin turbine runner replacement.
- FY 2022. Continue turbine runner replacement.

Roza Dam

- FY 2020. Continued switchyard rehabilitation and breaker upgrade.
- FY 2021. Continue switchyard rehabilitation and breaker upgrade.
- FY 2022. Complete switchyard rehabilitation and breaker upgrade.

Minidoka Dam

- FY 2020. Completed arc flash mitigation and governor system replacement. Continued microwave system backbone modernization and switchyard modernization.
- FY 2021. Complete microwave system backbone modernization and switchyard modernization.
- FY 2022. No planned capital projects.

Fish & Wildlife
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
40,185	47,266	43,000

Overview

Bonneville continues to develop budgets for the suite of fish and wildlife mitigation projects originally adopted in FY 2007 based on recommendations from the Council. Bonneville reaffirmed and expanded many project-specific commitments in subsequent agreements and processes, including BiOps and 2018 Fish Accord extensions, and since then, virtually all these projects received independent science review through the Council and its project review processes. Bonneville's funding decisions embrace many of the management objectives and priorities in the Program and continue to integrate ESA compliance as described in the NOAA Fisheries' and USFWS's FCRPS BiOps. Coordination continues among Bonneville, Council, federal resource management agencies, states, tribes, and others to support the projects that satisfy Bonneville's mitigation responsibilities.

Bonneville intends to continue implementing the kinds of capital projects listed below. These projects are based upon the best available science and are regionally important in that they provide high priority mitigation and protection actions for fish and wildlife populations affected by the construction and operation of the FCRPS dams. Projects and facilities listed below deliver direct on-the-ground benefits to both ESA listed and non-listed fish and wildlife throughout the Columbia River Basin and have been evaluated and coordinated with the Council, state, federal and tribal fish and wildlife resource managers, local governments, watershed and environmental groups, and other interested parties. Specifically, as capital construction projects, hatchery facilities typically go through the Council's three-step process, which includes development of a Master Plan, environmental compliance, ESA consultation, value engineering analysis, and review by the Independent Science Review Panel.

The three types of fish and wildlife projects that Bonneville capitalizes are as follows:

1) Fish passage structures – Structures funded with capital that enhance fish access to habitat in the Columbia River Basin include but not limited to wells, ladders, screens, pumping, culverts, diversion (irrigation) consolidation, piping to reduce water loss, irrigation efficiencies (drip irrigation), lining of ditches (seepage reduction), removal of objects impeding fish passage or pushup dams, and construction-related habitat restoration.
2) Hatchery facility construction – Projects and activities relating to the construction, improvement, and replacement of fish hatcheries, including related satellite facilities (acclimation ponds and collection weirs). This may also include construction-related habitat restoration.
3) Land acquisition and stewardship – Land acquisition projects protect, enhance, and maintain fish and wildlife habitat and provide credit to Bonneville, such as acres for wildlife or instream miles for resident fish, to fulfill the legal obligation of Bonneville to mitigate the impacts from construction and operation of the FCRPS.

Requesting Expenditure Authority for the following project:

- Umatilla Hatchery Facility: The Northwest Power and Conservation Council in 1990 recommended that Bonneville construct the Umatilla Hatchery, just east of the town of Irrigon, Oregon, to mitigate for the loss of salmon and steelhead habitat and migration blockage resulting from the Columbia River System dams. Umatilla River anadromous fish had been largely extirpated in the early 1900s by irrigation dams, prior to construction of the Columbia River System dams. Current hatchery production includes 800,000 spring Chinook, 600,000 fall Chinook, and 150,000 summer steelhead. Construction of the Umatilla Hatchery cost $14 million and was complete in 1991. Bonneville funds the Oregon Department of Fish and Wildlife to operate the hatchery and the Confederated Tribes of the Umatilla Indian Reservation to operate acclimation facilities supporting the hatchery. The available water supply at the hatchery never met expected production levels, and water supply has continued to deteriorate over time. To preserve and improve fish production at the Umatilla Hatchery, Bonneville is exploring options to address the water supply issue and is in the early evaluation phase. It appears costs will exceed the statutory threshold of $2,500,000 and have an estimated life of 15 years or more, thus triggering the need to obtain expenditure authority from Congress, prior to commencing construction, as required by 16 U.S.C. 839b(h)(10)(B),

which was amended by section 307 of the 2012 Consolidated Appropriations, P.L. 112–74 125 STAT. 877. (Dec. 23, 2011). Congress originally authorized construction of the Umatilla Hatchery under P.L. 98-360, 98 STAT. 403, 415 (July 16, 1984).).

New construction-related habitat restoration projects that may require capital funds in FY 2022 include the following:

- Svensen Island : The Svensen Island Restoration Project will reconnect the 320 acre island, east of Astoria, Oregon, directly to the mainstream Columbia River to increase ecological function and provide refuge and rearing capacity for out-migrating juvenile salmon and steelhead. Specifically, the project will remove and lower approximately 1.5 miles of existing levee; remove approximately 100 pile dikes on the northern side of the island, to provide unobstructed access to 40 acres of re-connected and newly excavated floodplain and tributary habitats for salmonids and lamprey. The Columbia Restoration Group is leading the project, in partnership with the Columbia Land Trust. This estuary project ranks high on the list of priorities in the estuary and will help to meet the responsibilities of the new NMFS Biological Opinion that will release concurrently with the Columbia River System EIS. Capital construction is scheduled to begin in FY 2022 and will last one year.

-Catherine Creek/Hall Ranch: Project is intended to improve off channel rearing habitat complexity for Chinook, steelhead, and bull trout by restoring dynamic channel geomorphology and habitat forming processes in Catherine Creek and Milk Creek. It will improve floodplain connectivity through removal and relocation of one mile of State Highway 203 and re-connecting 50 acres of historic Catherine Creek floodplain and channel network. The request is for a project-funding match of $3,294,616 from Bonneville against additional project investment from other Federal and State partners for a total projected project cost of $5,994,616. This project has multiple coordination points, requires an environmental impact statement and the environmental compliance process may impact to implementation timeframes where the project is currently expected to start construction in FY 2022.

The Further Consolidated Appropriations Act, 2019 (Public Law 116-94) provided Expenditure Authority for the following project:

- Steigerwald Project: The Steigerwald Floodplain Restoration Project is a collaborative project that will reconfigure the Port of Camas-Washougal's (Port) existing Columbia River levee system to reduce flood risk, reconnect 960 acres of Columbia River floodplain, and increase ecological function at the Steigerwald Lake National Wildlife Refuge. Specifically, the project will construct 1.6 miles of setback levee; completely remove 2.2 miles of existing levee; provide unobstructed access to floodplain and tributary habitats for salmonids and lamprey; and greatly reduce flood risk to the Port's Industrial Park and City of Washougal's wastewater treatment plant, which serves 15,000 residents. Bonneville is working with the lower Columbia Estuary Partnership, which is leading the project. The project will provide seven survival benefit units (~15% of the Action Agencies' total goal in the estuary). Other partners include the Port, USFWS, Washington State Department of Transportation, City of Washougal, and several private landowners. Capital construction began in FY 2020 and will last three years.

The Consolidated Appropriations Act, 2016 (Public Law 114-113) provided Expenditure Authority for the following projects:

- Shoshone Paiute Trout Hatchery: The Shoshone Paiute Tribes of the Duck Valley Reservation, Idaho, have proposed that Bonneville fund the purchase or construction of a trout hatchery. The Tribes would own and operate the hatchery to produce trout to stock the Duck Valley Reservation reservoirs. The hatchery would meet contemporary aquaculture standards and achieve fish production goals. The Tribes believe they can reduce federal reservoir stocking costs, some of which Bonneville currently pays on an annual basis.

- Spokane Tribal Hatchery: Bonneville funded construction of the Spokane Tribal Hatchery in 1989 as partial mitigation for the impacts of the FCRPS. The facility is near Wellpinit, Washington and owned and operated by the Spokane Tribe of Indians. The facility serves as a spawning, rearing, and incubation site for Kokanee salmon and rainbow trout. In June 2015, the Tribe and Bonneville signed a 20-year agreement renewing commitments to operate and maintain the facility. The renewed agreement also upgrades aging infrastructure, including groundwater pumps and rearing containers. Contracting for this work began in FY 2017 and all capital work is complete.

- Snake River Sockeye Weirs: Bonneville funds efforts implemented by the Idaho Department of Fish and Game and the Shoshone Bannock Tribes to repopulate Snake River sockeye throughout the species' historic range. The combination of increased numbers of returning adults and the increased production at the Springfield Sockeye Hatchery, has created the need for the construction, operation, and maintenance of weirs to further sockeye management objectives.

The FY 2014 Omnibus Appropriations Act (Public Law No. 113-76) provided Expenditure Authority for the following projects:

- John Day Reprogramming and Construction: The Columbia River Inter-Tribal Fish Commission (CRITFC) has proposed this project in order to balance the upriver and downriver salmon hatchery production that mitigates for the effects of John Day and The Dalles Dams. The Tribes, the Corps, and Bonneville are still analyzing the final reprogramming facilities and locations. The project area encompasses the mainstream Columbia River from the base of McNary Dam downstream to The Dalles Dam. Capital dollars for this project will integrate with the Corps funds for the construction of new or existing FCRPS hatchery facilities to accommodate the reprogramming of hatchery fish.

- Columbia River Basin White Sturgeon Hatchery: This project, proposed by the CRITFC, will mitigate for the decline of the white sturgeon population caused by consistently poor recruitment upstream of Bonneville Dam. Bonneville would fund the construction of a new facility, or the acquisition of an existing facility, to produce 15,000 - 30,000 yearling white sturgeons per year. The final project may include the collection, holding and spawning of broodstock, the rearing of wild-spawned juveniles, and the acclimation of juveniles prior to release. The site of the Yakama Nation's existing Marion Drain Sturgeon Hatchery near Toppenish, Washington has been proposed as a location. The project team is working on additional analyses to respond to Council comments and to begin the environmental review process.

- Kelt Reconditioning and Reproductive Success Evaluation Research: CRITFC is proposing a facility to recondition female steelhead (kelts) after they have spawned. The fish will be held and fed until they have re-matured and then be released into the Snake River where they will contribute to the spawning run. The capital portion of the project is expected to be constructed in the Snake River Basin, potentially at the Nez Perce Tribal Hatchery in Idaho. Pursuant to the 2008 FCRPS BiOp and Supplemental FCRPS BiOps issued in 2010 and 2014, Bonneville will implement the kelt reconditioning plan to improve the productivity of Snake River basin B-run steelhead populations that are listed for protection under the ESA. NOAA's analysis of Prospective Actions indicates that a combination of transportation, kelt reconditioning, and in-stream passage improvements (e.g., spill-flow modifications) could increase kelt returns enough to achieve a targeted six-percent increase in the number of returning Snake River B-run steelhead spawners to Lower Granite Dam. The Master Plan for the facility is currently in the second of the Council's amended, shortened, Artificial Production Three-Step Review Process.

Ongoing Projects (Expenditure Authority previously received):

- Crystal Springs Hatchery Facilities: The Crystal Springs proposal originally included production of spring/summer Chinook and Yellowstone cutthroat trout, a resident fish, at the Crystal Springs location near the American Falls Reservoir in southern Idaho. In 2019, water quality limitations were confirmed rendering the location unsuitable for anadromous production and an alternative planning approach was initiated. In an effort to maintain production goals, the Crystal Springs location remains the proposed site for a rearing and out-planting facility for up to 30,000 trout to be produced annually for a put and take Tribal fishery. The anadromous facility will likely be sited in the Panther Creek watershed with the goal of increasing the abundance of spring/summer Chinook returns to this drainage. The facilities are sponsored by the Shoshone-Bannock Tribes, who are expected to operate and manage them once complete.

- Klickitat Production Expansion: In 2008, the Klickitat River Master Plan was submitted by the Yakama Nation, reviewed by the Independent Science Review Panel, recommended with comments by the Council, and conditionally approved by Bonneville. The plan's original goals were to protect and increase naturally producing populations of spring Chinook and steelhead, localize brood collection of harvest stocks (fall chinook and coho), while protecting the biological integrity and the genetic diversity of indigenous fish stocks in the sub-basin. A component of the Master Plan was implemented in 2009, including the completion of upgrades to Lyle Falls Fishway and Castile Falls Fishway, and the construction of a new bridge at the Klickitat Hatchery. In July 2009, a new Klickitat Hatchery Complex EIS was initiated to examine options for the

development and operation of new production and supplementation facilities, acclimation alternatives, and additional upgrades to the existing hatchery facility. The Yakama Nation issued a revised Master Plan in July, 2012 that provided updates to their fish management plans. Bonneville suspended the NEPA process while the Yakama Nation refined its proposal in response to site and budgetary limitations and comments on the draft EIS. Since that time, the National Marine Fisheries Service (NMFS) has completed its Mitchell Act EIS and BiOp, helping inform its funding responsibilities in the sub-basin. Bonneville negotiated a new scope of work with the Yakama Nation, and a revised Master Plan was submitted to the Council in 2017 and approved in 2018. The new scope of work targets design and construction activities for the expansion of the current spring Chinook program only, from 600,000 to 800,000 smolt, and converting to a wild broodstock collection program, as well as general water supply and water abatement upgrades. Bonneville has initiated a new EIS process and construction will occur after Bonneville issues a NEPA ROD and alongside a three-way operations and maintenance agreement which affirms that NMFS will remain responsible for providing funding post-construction.

- Hood River Production Facility: This project has been ongoing since the early 1990s. It currently produces 150,000 spring Chinook salmon smolts and 50,000 winter steelhead smolts annually. The Powerdale Dam Fish Trap formerly provided the foundation for many of the activities associated with implementation of the Hood River Production Program. These include monitoring escapement, collecting life history characteristics, and broodstock acquisition. PacifiCorps' 2010 demolition of its Powerdale Dam and the associated fish trapping facility necessitated the development of alternative adult broodstock trapping sites. One permanent fish trap on the West Fork of the Hood River was completed in 2013, and a temporary trapping site is operational on the East Fork of the Hood River. A permanent trap site on the East Fork is currently being evaluated. The Hood River Production Program has four primary goals: 1) re-establish naturally sustaining runs of spring chinook in the Hood River; 2) re-build naturally sustaining runs of winter steelhead in the Hood River; 3) maintain genetic characteristics of Hood River fish populations; and 4) provide fish for sustainable harvest by both sport and tribal fishers.

- Mid-Columbia Coho Restoration: This Yakama Accord project is intended to re-establish naturally reproducing coho salmon populations in the Wenatchee River and Methow River sub-basins at biologically sustainable levels that also provide significant harvests. This program will construct a facility on the Wenatchee River for holding and spawning broodstock, incubating eggs, and rearing juveniles. Additional semi-natural ponds will also be constructed in the Wenatchee and Methow sub-basins for acclimating smolts prior to their release. The phased approach, including associated facilities, incorporates development of a mid-Columbia hatchery broodstock, local adaptation to tributaries in the Wenatchee and Methow Basins, and habitat restoration that will benefit coho as well as ESA-listed spring chinook, steelhead, and bull trout.

- Walla Walla Hatchery: The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) proposed the construction of the Walla Walla Hatchery . The Tribes will own and operate the hatchery, which will produce up to 500,000 spring Chinook smolts annually for release into the Walla Walla River. A 30 percent design was completed in June 2015, and a draft EIS was completed in September 2016. However, due to budget overruns, the project was reconfigured. Design and construction was successfully rebid, and construction has been on hold awaiting issuance of a NPDES permit by the state water authority. Construction started in fall 2019 and is still ongoing. The facility will hold, spawn, incubate, and rear spring Chinook on the South Fork Walla Walla River near Milton-Freewater, Oregon.

- Yakima Melvin R. Sampson Coho Facility: This hatchery was proposed by the Confederated Tribes and Bands of the Yakama Nation, and is presented in the Yakima River Subbasin Summer and Fall Run Chinook and Coho Salmon Hatchery Master Plan. The Yakama Nation will own and operate the hatchery which will produce up to 700,000 coho smolts using broodstock collected at Roza and Sunnyside dams. Bonneville holds the design and construction contract on behalf of the Yakama Nation. Bonneville published a final EIS on November 6, 2017, and a Record of Decision April 9, 2018, with construction beginning August 2018. Facility construction is expected to continue through FY 2021.

Potential non-construction capital Wildlife and Resident Fish Habitat Acquisitions (including Conservation Easements) eligible for capitalization are:

- Albeni Falls Wildlife Mitigation
- Willamette Wildlife Habitat Acquisitions
- Libby and Hungry Horse Reservoirs Resident Fish Acquisitions

- Southern Idaho Habitat Acquisitions

Activities and Explanation of Changes ($K)

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Power Services – Capital $319,759	**$307,120**	**$-12,639/-4.0%**
Associated Projects $272,493 Milestones: • Complete control room fire protection upgrades, GSU transformer instrumentation and oil water separator improvements at Bonneville Dam. • Complete trash rack crane replacement and powerhouse roof replacement at John Day Dam. • Complete transformer replacements at The Dalles Dam. • Complete spillway gate modifications at Albeni Falls Dam. • Complete security system upgrades and powerhouse gantry crane rehabilitation at Libby Dam. • Complete intake gantry crane rehabilitation and CO2 system replacement at Chief Joseph Dam. • Complete RO valve upgrade and tailrace crane rehabilitation at Dworshak Dam. • Complete intake gantry crane replacement at McNary Dam. • Complete headgate repair pit upgrade and powerhouse roof replacement at Little Goose Dam. • Complete isophase bus and housing upgrade at Lower Granite Dam. • Complete crane control upgrades, SCADA replacement and new firehouse construction at Grand Coulee Dam. • Complete P5 and P6 impeller and core replacement and rewinds at Keys Pump Generating Plant.	**$264,120** • Complete isophase bus replacement at Little Goose Dam. • Complete isophase bus upgrades at Lower Monumental Dam. • Complete switchyard rehabilitation and breaker upgrade at Roza Dam.	**$-8,373/-3.1%** • The decrease reflects a reshaping of funding needs for investment in the hydroelectric system assets.

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
• Complete SCADA replacement at Hungry Horse Dam. • Complete microwave system backbone modernization and switchyard modernization at Minidoka Dam.		
Fish & Wildlife $47,266 Milestones: • Continue implementation of the Program, BiOps and 2018 Fish Accord extension.	**$43,000** Milestones: • Continue implementation of the Program, BiOps and 2018 Fish Accord extension.	**$-4,266/-9.0%** • Fish & Wildlife will continue long-term, planned effort to reshape funding necessary to implement the BiOps, 2018 Fish Accord extension, Columbia River Basin Fish and Wildlife activities.

Transmission Services – Capital
Funding Schedule by Activity
Funding ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2022 vs FY 2021 $	FY 2022 vs FY 2021 %
Transmission Services – Capital					
Main Grid	4,816	26,122	12,592	-13,530	-51.8%
Area & Customer Services	28,221	88,584	48,590	-39,993	-45.1%
Upgrades & Additions	54,482	50,850	102,014	51,164	100.6%
System Replacements	192,743	318,912	333,889	14,977	4.7%
Projects Funded in Advance	89,450	70,107	55,775	-14,332	-20.4%
Total, Transmission Services - Capital	**369,713**	**554,576**	**552,861**	**-1,715**	**-0.3%**

Outyears ($K)

	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Transmission Services - Capital					
Main Grid	12,592	6,224	11,924	14,092	9,462
Area & Customer Services	48,590	71,562	59,622	46,972	47,312
Upgrades & Additions	102,014	147,015	150,129	75,156	85,161
System Replacements	333,889	304,705	364,304	530,108	507,812
Projects Funded in Advance	55,775	61,384	47,682	35,221	35,474
Total, Transmission Services - Capital	**552,861**	**590,890**	**633,661**	**701,548**	**685,222**

Transmission Services – Capital

Overview

Transmission Services (TS) is responsible for about 75 percent of the Pacific Northwest's high-voltage transmission. TS provides funding for all additions and upgrades (Expansion Investments), and replacements (Sustain Investments) to the Bonneville transmission system, resulting in reliable service to Northwest generators and transmission customers. The Bonneville transmission system also facilitates the delivery of power under sales and exchange agreements to and from the Pacific Northwest Region. The TS Capital Program is structured with a balanced focus on Expansion and Sustain investments.

In addition to replacing aging and obsolete equipment, TS continues to make significant infrastructure improvements and additions to the system to assure reliable transmission in the Northwest. These improvements and additions will help the Bonneville transmission system continue to comply with national reliability standards and remove constraints that limit economic trade or the ability to maintain the system. Some of the proposed TS projects may be funded through Bonneville lease-purchase agreements. The lease-purchases obligate Bonneville to make expenditures to acquire the use of the related facilities and are identified on an as needed basis. Bonneville may also make related expenditures to facilitate lease-purchase opportunities.

Expansion Investments

Expansion investments continue to make significant infrastructure improvements and additions to the Bonneville transmission system to assure reliable transmission operations in the Northwest and fall into two categories:
Internally driven Expansion requests, which are derived from system engineering studies, technology innovation research, system operations and maintenance functions, and system event analysis.
Externally driven Expansion Investment requests, which are derived from governmental initiatives and regulations, consumer demand, and the integration of customer load service and generation needs.

These investments are categorized into:

1. Main Grid – System investments affecting the major interties or internal paths and flowgates that transfer bulk power across the system.
2. Area & Customer Service – System investments related to geographical load service areas.
3. Upgrades & Additions – Upgrades are system investments that replace existing assets to increase capacity, reliability, or functionality and Additions are net new assets added to the system.
4. Projects Funded in Advance – System investments that are requested, and funded in advance, by customers.

Congressionally-approved Production Tax Credits (PTC) for renewable energy enacted in 2005 were extended through 2023. The PTC begins to phase out after 2023. The incentives created by these credits, along with Renewable Portfolio Standards (RPS) mandates implemented by the states of Oregon, Washington, and California, have spurred a large number of renewable projects interconnection requests to the Bonneville transmission system grid. As of September 30, 2020, Bonneville has interconnected a total of 5,554 MW of renewable qualified generation projects. Bonneville has more than 20,000 MW in additional renewable (wind, solar, biomass, geothermal, etc.) interconnection requests still remaining in the study queue. Solar project interconnection requests are currently making up the majority of the new requests in Bonneville's queue. The current projections are possibly 9,000 MW of renewable generation projects interconnected by 2025. Much of the remaining generation project transmission demand is the result of the Renewable Portfolio Standards and other legislations enacted by Oregon and Washington that require retail utilities to acquire more than 8,000 MW of renewable energy in the Northwest by 2025. Exports of power from the Northwest to California are limited by California laws and are expected to remain at 2,000 MW to 2,500 MW during the same period. Also in the BPA transmission interconnection request queue is approximately 1,500 MW of natural gas fired generation. Efficiency improvements to the FCRPS hydro units that qualify as renewable are also proposed between 2018 and 2024.

In June 2008, Bonneville's first Network Open Season (NOS) received 153 requests from 28 customers for 6,410 MW of new service, about three-fourths for wind energy integration. Bonneville subsequently offered 1,782 MW of new transmission service on its existing system. Bonneville identified four new Main Grid capital projects from the 2008 NOS: (1) McNary-John Day 500 kV transmission line (part of West of McNary Reinforcements Group 1); (2) Big Eddy-Knight 500 kV transmission line and substation (part of West of McNary Reinforcements Group 2); (3) Central Ferry- Lower Monumental 500 kV Reinforcement (formerly Little Goose Area Reinforcement); and (4) I-5 Corridor 500 kV Reinforcement. Construction

of the McNary-John Day 500 kV transmission line is complete and Bonneville has completed construction of the Big Eddy-Knight project and the Central Ferry-Lower Monumental 500 kV Reinforcement project. On May 18, 2017, Bonneville announced its decision to not build the I-5 Corridor Reinforcement Project. Bonneville continues to work with constituents and stakeholders to study more cost effective options to mitigate the current limitations along this path. Public meetings began in July 2017 to address alternatives to building. An update to Bonneville's Available Transfer Capability (ATC) methodology increased the available transmission service on the Westside paths by a few hundred MW. Other alternatives, such as energy storage devices, are still being evaluated.

Bonneville's 2009, 2010, 2013, 2016, 2019, and 2020 study processes for new Transmission Service Requests (TSR) total 18,363 MW, including 5,840 MW of wind project interconnection and 1,555 MW of solar project interconnection. The 2010 study process identified the Montana to Washington project, for which environmental review was begun, however, the original requests to support this project have been subsequently withdrawn and so all work on the project was terminated. Subsequent TSRs also require this project, and BPA is now undertaking Preliminary Engineering Activities on it again to move wind generation in Montana to the Northwest. The 2016 and 2019 study processes re-identified the Montana to Washington and Garrison to Ashe projects to move new wind generation in Montana to the Northwest. The requests to support the Garrison to Ashe project have been subsequently withdrawn so that project was terminated. The 2013 study process identified upgrades to the Monroe-Novelty Hill 230-kV transmission line which were re-identified for additional new requests in the 2016 study process. The 2016 study process identified network upgrades in Central Oregon, Walla Walla, Washington and across the Raver-Paul flowgate. The 2019 study process identified additional reinforcements across the Raver-Paul flowgate, the same Central Oregon and Walla Walla projects, and some significant impacts to third parties, specifically Portland General Electric and Puget Sound Energy. The 2020 study process identified an additional Schultz-Raver Series Capacitor project. Efforts are currently underway to provide required studies on capacity to requesting customers.

Sustain Investments

Sustain investments are made to maintain the health of the existing infrastructure to assure reliable transmission in the Pacific Northwest. These replacements enable continued compliance with national reliability standards, replace aging and obsolete equipment, and remove constraints that limit economic trade or the ability to maintain the transmission system.

In 2009, Bonneville Transmission Services (TS) began implementing best practice frameworks that provide a standardized structure and approach to Asset Management. As a result, TS's Asset Management Strategies, derived from the Agency's Strategic Plan, drive Bonneville's Asset Plans, which determine its capital and expense investment priorities. Sustain investments are forecasted, prioritized within asset programs, and optimized across the asset base for asset planning and approval. BPA now bundles both sustain and expand capital projects in an effort to improve execution and to lower risks and costs. TS's capital program does remain somewhat fluid and subject to changes as the complexity of the transmission system produces unexpected needs resulting from equipment failure, climate/weather incidents, changes in performance and/or operation of connected systems, outage schedules and conflicts, updated regulations, customer interconnection requests, etc. For these and other reasons, specificity with Sustain investments in the transmission system is somewhat limited.

The TS Sustain Program Asset Programs include:

1. Steel Lines – Transmission lines with steel structures including footings, insulators assemblies, vibration dampers, grounding systems, conductor, ground wire.
2. Wood Lines – Transmission lines with wood structures including cross arm systems, insulator assemblies, vibration dampers, grounding systems, conductor, ground wire.
3. Rights-of-Way – Real property including land parcels, easements, use right, access roads.
4. AC Substations – Substations managing AC current including transformers, reactors, shunt capacitors, power circuit breakers, circuit switchers, series capacitors, disconnect switches.
5. Power System Controls and System Telecommunications – Control and communication equipment including SCADA, transfer trips, fiber, communications, SONET, Telephone, RAS.
6. System Protection and Control – Control equipment including relays, Control Houses, meters.
7. DC Substations – Celilo DC converter station, Static VAR Compensators, DC control systems.
8. Control Centers – Various control equipment and software.
9. Tools and Equipment Acquisition Program (TEAP) –Tools, equipment, fleet.

10. Facilities – Non-electric facilities including warehouses, operational structures, hangar, and maintenance centers.

Notwithstanding that the capital program for TS is subject to change, Bonneville has identified several general areas where capital investments will occur.

Bonneville will continue to fund fiber optic communications facilities needed to meet Bonneville's projected operational needs. To the extent that these investments create temporary periods of excess fiber optic capacity, such dark fiber capacity can be made available to telecommunications providers and to non-profits to meet public benefit internet access needs for rural areas and other needs in Bonneville's service area. Bonneville's investments in fiber optics, including the role of the private sector in building fiber optic networks, is consistent with the "Fiber Optic Cable Plan" submitted to Congress on May 24, 2000, accompanying the FY 2000 Energy and Water Development Appropriations Act. In accordance with this plan, when possible, Bonneville will establish partnerships with fiber optic facility and service providers to meet its needs.

In December 2004, Congress passed and the President signed the Commercial Spectrum Enhancement Act (CSEA, Title II of P.L. 108-494), creating the Spectrum Relocation Fund (SRF) to streamline the relocation of federal systems from certain spectrum bands to accommodate commercial use by facilitating reimbursement to affected agencies of relocation costs. The Federal Communications Commission has auctioned licenses for reallocated federal spectrum, which will facilitate the provision of Advanced Wireless Services to consumers. Funds were made available to agencies in FY 2007 for relocation of communications systems operating on the affected spectrum. These funds are mandatory and will remain available until expended, and agencies will return to the SRF any amounts received in excess of actual relocation costs. The estimated Bonneville cost of this relocation was $48.7 million. The project was completed in November 2013 with a cost of approximately $40 million and the operational system performance was being observed during FY 2014 and early FY 2015 to determine that it has achieved comparable capability as defined under the CSEA. Bonneville determined in December 2014 that comparable capability had been achieved.

Bonneville began participating in a new spectrum relocation effort in FY 2015. The NTIA has approved and, in July 2014, web-posted federal agency relocation plans, including the Bonneville relocation plan. The FCC held an auction of this spectrum on November 13, 2014. Bonneville received an additional $5.2 million from the Spectrum Relocation Fund on July 29, 2015, to fully pay for this new relocation effort, including, as in the prior relocation, the purchase and installation of new digital radio equipment.

As part of the Homeland Security Presidential Directives, Bonneville has completed a physical security assessment of all critical facilities and is implementing security enhancements at these facilities. These security enhancements increase controlled access to Bonneville's facilities and provide video surveillance and monitoring capabilities.

Accomplishments

- The BP-20 - Rate Case final record of decision was released July 25, 2019. FERC granted final approval to proposed rates on April 17, 2020.
- Integrated 5,554 MW of renewable energy through September 2020 on Bonneville's transmission system
- Completed the Morrow Flat customer interconnection
- Completed construction of the Lower Valley Reinforcement Project
- Completed construction of the Vantage and Vitesse Projects for PacifiCorp
- Completed construction of Monroe Line Re-termination
- Completed construction of VHF Radio System Upgrade
- Completed construction of Umatilla Electrical Cooperative - Phase 2
- Completed construction of Avangrid Montague 1 Wind Project

Explanation of Changes

Bonneville's budget includes $553 million in FY 2022 for TS Capital which is a 0.3 percent decrease from the FY 2021 forecasted level. The FY 2022 budget decreases the levels for Main Grid (-$13.5 million), Area & Customer Services (-$40.0 million), and PFIA (-$14.3 million). The budget increases levels for Upgrade & Addition (+$51.2 million) and System Replacements (+$15.0 million).

Strategic Asset Management

Transmission Services provides transmission and energy services while integrating renewable resources across the Pacific Northwest. This effort is coordinated throughout Bonneville in conjunction with the newly developed Strategic Asset Management Plan (SAMP). TS continues to implement integrated detailed Asset Plans to serve the region:

1. To improve system adequacy, reliability, and availability, Bonneville has embarked on major transmission infrastructure projects. The identified projects reinforce the transmission system and help meet the region's future power needs. These projects address multiple challenges, such as integration of renewable energy, the need to relieve a number of congested transmission paths, the challenge to keep up with growing energy demands, and the need to meet changing regulatory and customer requirements.

2. Open access policy in support of competitive markets for load and generation.

3. The replacement of aging assets is vital to the reliability of the existing transmission system. To that end, TS has developed specific long-term strategies for the following asset categories:
    a. Substations AC
    b. Power System Control/System Telecommunications
    c. Wood Lines
    d. Steel Lines
    e. Rights of Way (ROW), (Land Rights, Access Roads, and Vegetation Management)
    f. System Protection and Control
    g. Control Centers
    h. Non-Electric Facilities

The following external factors present the strongest impact to overall achievement of the program's strategic goal:

- Continually changing economic and institutional conditions
- Competitive dynamics
- Ongoing changes in the electric industry
- Siting issues

Main Grid ($K)		
FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
4,816	26,122	12,592

Overview

Bonneville's strategic objectives for Main Grid projects are to assure compliance with the NERC and WECC reliability criteria, provide voltage support, provide a reliable transmission system for open access, and provide for relief of transmission system congestion. During this budgeting period, projects are planned that will provide transmission reinforcement and voltage support to major load areas that are primarily west of the Cascade Mountains.

Continued investments in Main Grid assets include:

Monroe Line Re-termination

- FY 2020. Complete construction.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Schultz-Wautoma 500KV Series Capacitors

- FY 2020. Begin construction.
- FY 2021. Continue construction.
- FY 2022. Complete construction

Montana-Washington

- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. Begin Scoping.

Continue Planning Studies to: (all years)

- Identify infrastructure additions.
- Identify projects driven by NERC and WECC reliability criteria.
- Identify system reactive needs to mitigate unacceptable low or high voltage problems and other system additions.
- Relieve transmission system congestion and integrate new generation facilities.

Area & Customer Service
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
28,221	88,584	48,590

Overview
Bonneville's strategic objective for Area and Customer Service projects is to assure that Bonneville meets reliability standards and contractual obligations to its load service areas.

Continued investments in Area & Customer Service assets include:

Hooper Springs Substation
- This project was completed in FY 2020 and is owned by Lower Valley Energy.

Midway-Grandview 115 kV Line upgrade
- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Puget Sound Area Northern Intertie (PSANI)
- FY 2020. Continue construction.
- FY 2021. Complete construction.
- FY 2022. No planned capital projects.

McNary Substation 500/230 kV Bank Addition
- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Paul Substation 500 kV Shunt Reactor Addition
- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Big Eddy Breaker Additions
- FY 2020. Begin design.
- FY 2021. Begin construction.
- FY 2022. Continue construction.

Drummond 115kV Breaker Additions
- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Midway –Ashe Double Circuit 230kV Line
- FY 2020. Begin design.
- FY 2021. Begin construction
- FY 2022. Continue contruction.

Carlton Substation Upgrade
- FY 2020. Begin design.

- FY 2021. Begin construction.
- FY 2022. Continue construction.

Conkelley Substation Retirement
- FY 2020. Complete design.
- FY 2021. Begin construction.
- FY 2022. Continue construction.

South Tri-Cities Reinforcement
- FY 2020. No planned capital projects.
- FY 2021. Begin design.
- FY 2022. Begin construction.

LaPine Substation Upgrade TSEP – 2016
- FY 2020. No planned capital projects.
- FY 2021. Begin design.
- FY 2022. Begin construction.

Longview Transformer Addition
- FY 2020. Begin design.
- FY 2021. Begin construction.
- FY 2022. Continue construction.

Continuous Activities (all years)
Continue preliminary engineering and design for miscellaneous facilities required to meet contractual obligations and maintain reliable service for Bonneville's service area.

Upgrades & Additions
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
54,482	50,850	102,014

Overview
Bonneville's strategic objectives for Upgrades and Additions are to replace older 60 Hz (Hertz) communications and controls with newer technology including fiber optics in order to maintain or enhance the capabilities of the transmission system; to implement special remedial action control schemes to accommodate new generation and mitigate immediate operational and market constrained paths; and to support communications and remedial action schemes, among other proposals.

During this budget period, Bonneville will complete design, material acquisition, construction, and activation of several fiber optics facilities to provide bandwidth capacity and high-speed data transfers to eventually replace microwave analog radios, which are technologically obsolete and nearing the end of their useful life. Temporarily, in some areas, excess dark fiber capacity is being offered for a term to telecommunications providers or to public entities such as public utilities, schools, libraries, and hospitals, providing them access to high-speed telecommunication services as a public benefit.

Continued investments in Upgrades & Additions assets include:

VHF Radio System Upgrade
- FY 2020. Complete construction.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

VCC (Vancouver Control Center)
- FY 2020. Begin Scoping and design as well as some demolition.
- FY 2021. Complete design and begin construction.
- FY 2022. Continue construction.

Bell-Boundary #DC SONET Ring Upgrade
- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Operational Megabit Ethernet (OMET) System
- FY 2020. Project on pause.

500 kV Spares at Wind Integration Substations
- FY 2020. Continue construction.
- FY 2021. Complete construction.
- FY 2022. No planned capital projects.

Continuous Activities (all years)
- Upgrading two miles of fiber between Bonneville Power House and Bonneville Control House.
- Planning, design, material acquisition, and construction of special remedial action control schemes required for interconnecting new generation projects and mitigating immediate constrained paths.
- Planning, design, material acquisition, and construction of various system additions and upgrades necessary to maintain a reliable system for Bonneville's service area.
- Construction of secondary fiber related projects and digital radio system upgrades to improve the operational telecommunication system.
- Material procurement and construction to upgrade the main fiber optic backbone system (#KC and #NC systems).

System Replacements
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
192,743	318,912	333,889

Overview
Bonneville's strategic objectives for the Sustain Program are to replace high-risk, obsolete, and maintenance-intensive facilities and equipment and to reduce the chance of equipment failure by: (1) replacing high voltage transformers and power circuit breakers which are at or near the end of their useful life; (2) replacing risky, outdated and obsolete control and communications equipment and systems, including mandated replacements due to legislation; and (3) replacing all other existing high-risk equipment and facilities affecting the safety and reliability of the transmission system. Transmission Services uses a total economic cost model to determine priorities for replacement.

Continued investments in System Replacements assets include:
Continuous Activity (all years)

Non-Electric Replacements
- Continue non-electric replacements as necessary.
- Continue the design, material acquisition, and construction for the Access Road program capital component and the Land Rights program capital component in support of the Lines and ROW Programs.
- Continue design and construction of capital improvements for identified existing facilities.
- Continue replacement of tools, equipment, and vehicle fleet.
- Replace BPA fixed-wing aircraft with a helicopter from FY 2021-2023 utilizing General Services Administration exchange sale authority.

Electric Replacements
- Continue replacement of system protection and control equipment and other substation and line facilities as needed to maintain reliability using Reliability Centered Maintenance criteria. Such replacements include relays, annunciators, oscillographs, metering, and various types of communication related equipment replacing and migrating analog to digital technology and SCADA equipment.
- Begin design and replacement of the Keeler and Maple Valley SVC units.
- Continue replacement of under-rated and high maintenance substation equipment.
- Continue replacing insulators and refurbishing foundations on 500 kV Lines.
- Continue replacement of older generations of digital equipment that is obsolete.
- Continue replacing critical, operational tools and business systems at the Dittmer and Munro Control Centers.
- Continue replacing deteriorating wood pole transmission line structures, spacer dampers, and insulators.

Projects Funded in Advance
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
89,450	70,107	55,775

Overview

This category includes those facilities and/or equipment where Bonneville retains control or ownership but which are funded or financed by a third party, revenue, or with reserves, either in total or in part.

Continued investments in PFIA assets include:

Umatilla Electrical Cooperative - Phase 2

- FY 2020. Complete construction.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Summit Ridge Wind Project

- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Bakeoven Wind Project

- FY 2020. Begin design
- FY 2021. Begin construction.
- FY 2022. Continue construction.

Quenett Creek Load Service Project

- FY 2020. Continue construction.
- FY 2021. Complete construction.
- FY 2022. No planned capital projects.

PacifiCorps' Ponderosa Project Vitesse

- FY 2020. No planned capital projects.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Midway-Ashe Line Project

- FY 2020. Begin design.
- FY 2021. Begin construction.
- FY 2022. Continue construction.

Avangrid Montague 1 Wind Project

- FY 2020. Complete construction.
- FY 2021. No planned capital projects.
- FY 2022. No planned capital projects.

Invenergy's Heppner Wind Project

- FY 2020. No planned capital projects.
- FY 2021. Begin design.
- FY 2022. Begin construction.

Morrow Solar Project

- FY 2020. No planned capital projects.
- FY 2021. Begin design.
- FY 2022. Begin construction.

2 Morrow Energy LLC's Ella 3 Wind Project
- FY 2020. Begin construction.
- FY 2021. Continue construction.
- FY 2022. Continue construction.

Whistling Ridge 230 kV Ring Bus Project
- FY 2020. No planned capital projects.
- FY 2021. Begin design.
- FY 2022. Begin construction.

Badger Canyon 1
- FY 2020. No planned capital projects.
- FY 2021. Begin design.
- FY 2022. Begin construction.

Invenergy Crider Valley Wind
- FY 2020. No planned capital projects.
- FY 2021. Begin design
- FY 2022. Begin construction.

Boyd Ridge Substation
- FY 2020. Begin design
- FY 2021. Begin construction
- FY 2022. Continue construction.

Continuous Activity (all years)
- Continue to integrate various new generation and line/load projects into Bonneville transmission grid based on requests placed and processed in accordance with transmission tariff.
- Continue planning studies to identify system impacts and needs regarding proposed new generation projects.
- Engineer and begin construction of several large wind generation interconnection substations.

Activities, Milestones, and Explanation of Changes ($K)

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Transmission Services – Capital $554,576	**$552,861**	**$-1,715/-0.3%**
Main Grid $26,122 Milestones: • Continue construction of Schultz-Wautoma 500kV Series Capacitors.	**$12,592** Milestones: • Complete construction of Schultz-Wautoma 500kV Series Capacitors.	**-$13,530/-51.8%** • The decrease is due to decreased construction planned for FY 2022.
Area & Customer Service $88,584 Milestones: • Complete construction of the Puget Sound Area Norther Intertie. • Begin construction of Big Eddy Breaker Additions. • Begin construction of Midway-Ashe Double Circuit 230kV line. • Begin construction of Carlton Substation Upgrade. • Begin construction of Conkelley Substation Retirement. • Begin design of South Tri-cities reinforcement line. • Begin design of LaPine Substation Upgrade. • Begin construction of Longview Transformer Addition.	**$48,590** Milestones: • Continue construction of Big Eddy Breaker Additions. • Continue construction of Midway-Ashe Double Circuit 230kV line. • Continue construction of Carlton Substation Upgrade. • Continue construction of Conkelley Substation Retirement. • Begin construction of South Tri-Cities Reinforcement. • Begin construction of LaPine Substation Upgrade. • Continue construction of Longview Transformer Addition.	**$-39,993/-45.1%** • The decrease reflects decreased construction planned for FY 2022.

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Upgrades & Additions $50,850 Milestones: • Complete design of Vancouver Control Center. • Complete construction of 500 kV Spares at Wind Intergration Substations.	**$102,014** Milestones: • Begin construction of Vancouver Control Center.	**$51,164/100.6%** • The increase reflects increased planned capital projects for FY 2022.
Systems Replacements $318,912 Milestones: • Continue design and construction of capital improvements for identified existing facilities. • Continue non-electric replacements as necessary. • Continue replacement of system protection and control equipment and other substation and line facilities as needed to maintain reliability using Reliability Centered Maintenance criteria.	**$333,889** Milestones: • Continue design and construction of capital improvements for identified existing facilities. • Continue non-electric replacements as necessary. • Continue replacement of system protection and control equipment and other substation and line facilities as needed to maintain reliability using Reliability Centered Maintenance criteria. Such replacements include relays, annunciators, oscillographs, metering, and various types of communication related equipment replacing and migrating analog to digital technology and SCADA equipment.	**$14,977/4.7%** • The increase reflects increased planned capital projects for FY 2022.
Projects Funded in Advanced $70,107	**$55,775**	**$-14,332/-20.4%**

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Milestone: • Continue to integrate various new generation and line/load projects into Bonneville transmission grid based on requests placed and processed in accordance with transmission tariff. • Continue planning studies to identify system impacts and needs regarding proposed new generation projects. • Engineer and begin construction of several large wind generation interconnection substations. • Begin construction of Bakeoven Wind Project. • Complete construction of Quenett Creek Load Service Project. • Begin construction of Midway-Ashe Line Project. • Begin design of Invenergy's Heppner Wind Project. • Begin design of Morrow Solar Project. • Continue construction of 2 Morrow Energy LLC's Ella 3 Wind Project. • Begin design of Whistling Ridge 230kV Ring Bus Project.	• Milestones: • Continue to integrate various new generation and line/load projects into Bonneville transmission grid based on requests placed and processed in accordance with transmission tariff. • Continue planning studies to identify system impacts and needs regarding proposed new generation projects. • Engineer and begin construction of several large wind generation interconnection substations. • Continue construction of Bakeoven Wind Project. • Continue construction of Midway-Ashe Line Project. • Begin construction of Invenergy's Heppner Wind Project. • Begin construction of Morrow Solar Project. • Continue construction of 2 Morrow Energy LLC's Ella 3 Wind Project. • Begin construction of Whisling Ridge 230 kV Ring Bus Project. • Begin construction of Badger Canyon 1. • Begin construction of Invenergy Crider Valley Wind. • Continue construction of Boyd Ridge Substation.	• The decrease reflects decreased planned PFIA capital projects for FY 2022.

Capital Information Technology & Equipment/Capitalized Bond Premium
Funding Schedule by Activity
Funding ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2021 vs FY 2020 $	FY 2021 vs FY 2020 %
Capital Information Technology (IT) & Equipment/Capitalized Bond Premium					
Capital IT & Equipment	21,144	21,744	22,002	257	1.2%
Capitalized Bond Premium	0	0	0	0	0.0%
Total, Capital IT & Equipment/Capitalized Bond Premium	**21,144**	**21,744**	**22,002**	**257**	**1.2%**

Outyears ($K)

	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Capital Information Technology (IT) & Equipment/Capitalized Bond Premium					
Capital IT & Equipment	22,002	21,052	19,721	19,056	17,386
Capitalized Bond Premium	0	0	0	0	0
Total, Capital IT & Equipment/Capitalized Bond Premium	**22,002**	**21,052**	**19,721**	**19,056**	**17,386**

Capital Information Technology & Equipment/Capitalized Bond Premium

Overview

Capital Information Technology (IT) provides for the acquisition of general and some dedicated special purpose capital information technologies, and acquisition of special-use capital and IT equipment in support of Bonneville's strategic objectives. This category also includes Bonneville's on-going efforts to facilitate delivery of a highly resilient organization able to anticipate, withstand, and effectively respond to disruptive events affecting it and its partners in the Northwest region. The four main areas of resiliency focus continue to include asset management, emergency management, crisis management, and continuity of operations.

Bonneville continues to move its IT infrastructure to a more efficient architecture. This FY 2022 Budget supports this effort. IT continues to eliminate redundancies in tools and applications, establish an agency-wide IT architecture with standardized IT purchasing criteria, standardize software licensing processes and minimize agency liabilities through stronger contracts, apply continuous improvement practices to IT project management, and implement an agency IT portfolio cost management strategy. The IT estimates in this FY 2022 Budget under Capital IT and Equipment include all IT functions within the agency except TS grid operations. See the Capital Program – TS section of this budget for additional discussion of grid operations-related IT requirements acquisitions.

Capital equipment provides for the acquisition of general and some dedicated special purchases of capital office furniture and equipment.

Bonneville can incur a bond premium when it repays a U.S. Treasury bond before the due date. When bonds are refinanced and premiums are incurred, the bond premiums can be capitalized. Historically, Bonneville generally has chosen to finance capitalized bond premiums with bonds issued to the U.S. Treasury, as envisioned by the Transmission Act.

Capital Information Technology & Equipment
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
21,144	21,744	22,002

Overview
This category includes enhancements to Bonneville's information technology processes to provide cost effective efficiencies for secure, timely, and accurate information. Investments will enable continued enhancements to Bonneville's enterprise systems that are designed to link key information systems throughout Bonneville and improve business processes. Current efforts include continued functional process improvements in areas not included in the initial development phase. Other investments include acquisition of capital office furniture and equipment, capital automated data processing (ADP) based administrative telecommunications equipment, ADP equipment (hardware), and support of capital software development for certain Bonneville programs.

Continued investments in Capital IT & Equipment assets include:
Continuous Activity (all years)
Capital system developments in support of:

- Corporate IT Projects
- IT Infrastructure Projects
- Power IT Projects
- Transmission Services IT Projects (excluding grid operations)

Capitalized Bond Premium
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
0	0	0

Overview
Continue to assess financial market and when cost-effective, refinance available bonds as prudent.

Activities, Milestones, and Explanation of Changes ($K)

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Capital Information Technology & Equipment/Capitalized Bond Premium $21,744	**$22,002**	**$257/1.2%**
Capital Information Technology & Equipment $21,744 Milestones: Capital system developments in support of: • Corporate IT Projects • IT Infrastructure Projects • Power IT Projects • Transmission Services IT Projects	**$22,002** Milestones: Capital system developments in support of: • Corporate IT Projects • IT Infrastructure Projects • Power IT Projects • Transmission Services IT Projects	**$257/1.2%** • Virtually no change for investment in the IT system assets.
Capitalized Bond Premium $0	**$0**	**$0/0.0%**

Power Services – Operating Expense
Funding Schedule by Activity
Funding ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2021 vs FY 2020 $	FY 2021 vs FY 2020 %
Power Services - Operating Expenses					
Production	858,334	944,002	871,620	-72,383	-7.7%
Associated Projects Costs	442,348	457,660	464,915	7,255	1.6%
Fish & Wildlife	225,599	249,416	246,893	-2,523	-1.0%
Residential Exchange Program	249,983	249,747	259,000	9,253	3.7%
NW Power & Conservation Council	11,180	11,956	11,545	-411	-3.4%
Energy Efficiency & Renewable Resources	140,314	156,513	155,685	-828	-0.5%
Total, Power Services - Operating Expenses	**1,927,757**	**2,069,294**	**2,009,658**	**-59,636**	**-2.9%**

Outyears ($K)

	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Power Services - Operating Expenses					
Production	871,620	925,441	949,606	972,622	993,027
Associated Projects Costs	464,915	462,680	474,016	484,842	495,299
Fish & Wildlife	246,893	246,581	246,565	246,551	246,537
Residential Exchange Program	259,000	259,000	265,346	271,406	277,260
NW Power & Conservation Council	11,545	11,797	12,086	12,363	12,629
Energy Efficiency & Renewable Resources	155,685	150,734	154,427	157,954	161,361
Total, Power Services - Operating Expenses	**2,009,658**	**2,056,233**	**2,102,046**	**2,145,738**	**2,186,112**

Power Services – Operating Expense

Overview

Production includes certain Bonneville non-federal amortization (including Energy Northwest amortization), O&M costs for federal base system power system generation resources (including a large nuclear plant (CGS), business operations, and short- and long-term power purchases[2]), acquisition of conservation, marketing of power, and oversight of the FCRPS hydroelectric projects and CGS. Bonneville develops power products and services to meet the needs of Bonneville's wholesale customers and acquires power as needed.

In FY 2018, Bonneville completed a long-term Resource Program, whose purpose is to assess BPA's future need for power and reserves and to develop an acquisition strategy to meet those projected needs. In the event that Bonneville does acquire output from a generating resource on a long-term basis, Bonneville will comply with section 6 of the Northwest Power Act and will modify its budget to reflect the acquisition.

Associated Projects Costs represents funding for operation and maintenance costs for the FCRPS hydroelectric projects, minor additions, improvements and replacements, and costs of the Corps and the Reclamation hydroelectric projects in the Pacific Northwest, which serve many purposes. All agencies emphasize efficient power production from existing facilities and improvement of the performance and availability of power generating units. Bonneville pays additional financing costs of the FCRPS facilities through its Interest Expense and Capital Transfer budget programs. Bonneville provides funding for the operations and maintenance costs that are part of the USFWS's Lower Snake River Compensation Plan (LSRCP) hatcheries. Bonneville is responsible for annual payments to the Confederated Tribes of the Colville Reservation for their contribution to the production of hydropower by the Grand Coulee Dam in accordance with the Settlement Agreement between the United States and the Colville Tribes (April 1994). Additionally, the Spokane Tribe of Indians of the Spokane Reservation Equitable Compensation Act (Public Law 116-100), enacted on December 20, 2019, provides for equitable compensation to the Spokane Tribe of Indians of the Spokane Reservation for the use of tribal land for the production of hydropower by the Grand Coulee Dam, and for other purposes. Bonneville is pleased that this longstanding issue has been resolved equitably for the Spokane Tribe. The Act provides Bonneville and Northwest electric ratepayers cost certainty on this issue as we move toward discussions of long-term power sales contracts with our utility customers. Bonneville expenditures under the settlement that would begin in FY 2021 are estimated at $6 million annually.

Bonneville's Fish and Wildlife Program provides for extensive protection, mitigation, and enhancement of Columbia River Basin fish and wildlife adversely affected by the development and operation of the FCRPS. Bonneville satisfies its fish and wildlife responsibilities by funding projects and activities designed to be consistent with the Council's Program under the Northwest Power Act. Consistent with the Council'sProgram, Bonneville also implements measures to aid in the protection of fish and wildlife in the Columbia River and its tributaries, both listed as threatened or endangered as well as unlisted, under the ESA (see ESA discussion in the Power Services – Capital Overview section).

Bonneville's mitigation expenditures will focus on activities that benefit Columbia River Basin fish and wildlife resources, following priorities established through ESA consultations, agreements with resource managers, and the Council's Program, including actions that:

- increase survival of ESA-listed and non-listed fish at FCRPS dams and reservoirs;
- increase survival of ESA-listed and non-listed fish throughout their life cycle by protecting and enhancing important habitat areas;
- protect and enhance important wildlife habitat;
- use hatcheries to contribute to conservation and recovery of ESA-listed and non-listed fish;
- provide offsite mitigation projects and habitat, passage, and other improvements that address factors limiting improvements of target species; and
- support a focused and well-coordinated research, monitoring, and evaluation program.

[2] Including expenses associated with the use of power financial instruments to hedge Bonneville's exposure to market price risk and certain index sales contract provisions as permitted by Bonneville's internal power transacting risk management guidance.

The Energy and Water Development Appropriations Act of 1996 added section 4(h)(10)(D) to the Northwest Power Act, directing the Council to appoint an ISRP "to review a sufficient number of projects" proposed to be funded through Bonneville's annual fish and wildlife budget "to adequately ensure that the list of prioritized projects recommended is consistent with the Program." The Northwest Power Act further states that "in making its recommendations to Bonneville, the Council shall consider the impact of ocean conditions on fish and wildlife populations and shall determine whether the projects employ cost effective measures to achieve program objectives." Today, most mitigation projects funded by Bonneville receive ISRP review as part of the Council recommendation process. The Council has shifted to a multi-year project review cycle during which the ISRP reviews categories of projects grouped together.

The Council's major activities include the periodic preparation of a Northwest Conservation and Electric Power Plan (a 20-year electric energy demand and resources forecast and conservation program – known as the Power Plan) and the Fish and Wildlife Program. The Northwest Power Act directs Bonneville's funding of the Council, subject to certain limits based on forecasted Bonneville power sales, be included in Bonneville's annual budget to Congress. The cost of funding the Council is recovered through Bonneville's power rates.

Bonneville's Energy Efficiency program promotes the efficient use of energy in the loads of customers and supports Bonneville's acquisition of conservation as the region's lowest cost resource. Such actions will: 1) meet energy efficiency targets; 2) achieve a least cost resource mix; 3) lessen the cost impacts of power purchases; 4) avoid the costs of ramping programs and infrastructure up and down; 5) extend the value of the FCRPS to customers; and 6) build the region's resource portfolio with energy efficiency. Bonneville is also exploring how best to integrate demand-side management, distributed generation, and other leading edge technologies into its generation and transmission planning processes.

Bonneville's Energy Efficiency program offers several ways for customer utilities to participate in energy efficiency. Program components include: (1) standard offer efficiency measures and custom projects, which result in customer proposals to conserve energy through such programs as residential weatherization; commercial lighting; heating, ventilation, and air conditioning (HVAC); industrial processes and lighting; and irrigated agriculture; (2) third-party delivery programs, such as Comfort Ready Home, Energy Smart Industrial, and the Green Motors programs; (3) programs to help regional federal installations reduce energy use, including federal hatcheries and irrigation districts, and to support the Corps of Engineers and Bureau of Reclamation in their efforts to reduce energy use; (4) efficiency achieved independently through the market or through codes and standards, i.e. Momentum Savings; and (5) market transformation through the Northwest Energy Efficiency Alliance (NEEA).

Bonneville's Energy Efficiency budgets reflect BPA's commitment to provide energy efficiency supportive of the Northwest Power and Conservation Planning Council's 7th Power Plan which forecasts Bonneville's regional customers' demand and resource strategies for the next 20 years. The 7th Power Plan's preferred resource strategy calls for the region to acquire 1,400 aMW of energy efficiency between 2016 and 2021. Bonneville is pursuing a plan to achieve a portion of that goal (530-570 aMW). BPA uses its Resource Program to complement the Council's plan, identifying BPA's specific electricity supply obligations and potential resource acquisitions.

Bonneville acquires conservation energy savings from its firm power customers under long-term Energy Conservation Agreements. Customers also perform self-funded conservation. Bonneville also provides research, evaluation, contract support, NEEA support, and emerging technology development.

The Residential Exchange Program (REP) was created by section 5(c) of the Northwest Power Act to extend the benefits of low-cost federal power to the residential and small farm loads of Pacific Northwest retail electric utilities that have high average system costs. These benefits are passed directly to the consumers. Currently, the region's six investor-owned utilities (IOUs) and two of the region's consumer-owned utilities are actively participating in the REP. Payments under the REP are made to individual IOUs based on the difference between Bonneville's utility-specific Priority Firm (PF) Exchange rates and each utility's average system cost (ASC), times a utility's residential and small farm loads. ASCs are determined in accordance with BPA's 2008 Average System Cost Methodology (ASCM). Participating retail utility ASCs are established in a public process that occurs prior to and during Bonneville's power rate cases. Bonneville's utility-specific PF Exchange rates

are determined each rate period. As described below, Bonneville and regional parties reached a settlement of the REP in 2011 under which the total amount of REP benefits available to the IOUs was established through 2028. Payments to the IOUs are made monthly based on historical invoiced exchange loads and the terms of the settlement.

Over the past decade, and prior to the settlement, regional parties filed multiple lawsuits challenging Bonneville's implementation of the REP. These lawsuits were consolidated into four cases that were stayed before the U.S. Court of Appeals for the Ninth Circuit. On July 26, 2011, Bonneville adopted a regionally supported settlement, referred to as the 2012 REP Settlement. Under the settlement, the region's six IOUs will receive about $4.1 billion in REP payments over the 17-year term of the settlement, beginning at $182.1 million in FY 2012, and increasing to $286.1 million in FY 2028. In addition to this settlement, Bonneville has reached related REP settlements with two consumer-owned utilities. A single challenge to the 2012 REP Settlement was dismissed by the U.S. Court of Appeals for the Ninth Circuit in October of 2013.

Explanation of Changes

Bonneville's budget includes $2,009.7 million in FY 2022 for Power Services operating expenses, which is an decrease of 2.8 percent over the FY 2021 forecasted level.

The FY 2022 budget decreases the level for Production (-$72.4 million), Fish & Wildlife (-$2.5 million), Planning Council (-$0.4 million), and Conservation and Energy Services (-$0.8 million) and increases the Associated Projects Costs (+$7.3 million) and Residential Exchange (+$9.3 million).

Production
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
858,334	944,002	871,620

Overview

Power Purchases: Includes power purchased to cover power supply obligations as well as balancing loads with generation from the hydro system. These power purchases can be made in the form of long-term purchases to meet BPA's contract obligations to its utility and other customers based on long-term planning requirements or they can be made within the year due to the monthly shape of the customers' loads and the monthly shape of the hydroelectric generation. Also, power purchases can be made within the month and within the day to fill temporary shortages due to fluctuations in the hydro system capability and in BPA's load.

Power Scheduling/Marketing: Scheduling and marketing (buy/sell) of electric energy with Bonneville's customers and the Pacific Northwest's interconnected utilities. Scheduling includes Power Services' implementation of physical and memo power schedules and associated transmission schedules, implementation of Electronic Tagging (ETag) in accordance with NERC and in accordance with FERC, and implementation of electronic scheduling.

Columbia Generating Station (CGS): Bonneville includes the project capability of CGS, a non-federal nuclear power plant, in the marketing of federal power to meet Bonneville's long term firm power supply obligations . CGS is on a 24-month fuel and outage cycle. Maintenance and refueling outage occurred in the spring of 2017 and 2019.

Continued investments in Production include:
Continuous Activity (all years)

- Provide oversight of all power supply contracts and related projects from which Bonneville acquires generation capability to ensure that all Bonneville approval rights are protected; coordinate, communicate, and administer agreements, issues, and programs between Bonneville and the project owners.
- Provide wind resource integration services for wind generation.
- Power Purchases.
- Power Scheduling/Marketing.
- Provide oversight of all contracts signed to date. Pursue cost-effective means to mitigate capacity demands associated with interconnecting large amounts of wind into the Bonneville system.
- Pursue acquisition of additional cost-effective generation to meet load growth.
- Provide oversight on the wind resource integration services currently purchased by public power customers and offer additional renewable resource shaping services to such customers using wind generation to serve their load.

Associated Projects
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
442,348	457,660	464,915

Overview

Support FCRPS project costs and work to strengthen interagency and regional relationships to improve project performance, supporting functions, and to better understand project resource requirements and costs. This helps to maintain FCRPS reliability and system performance, as well as to attain Bonneville's strategic business objectives.

Continued investments in Associated Projects include:

Continuous Activity (all years)

Bureau of Reclamation:

- Continue direct funding Reclamation O&M power activities.

Corps of Engineers:

- Continue direct funding Corps O&M power activities.

Fish & Wildlife ($K)		
FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
225,599	249,416	246,893

Overview

Bonneville implements a mature fish and wildlife mitigation program based on recommendations made by the region's fish and wildlife management agencies and tribes to the Council. Several recent Council reviews have made additional fish and wildlife project recommendations to Bonneville. Bonneville, in coordination with the Council, reviews new and on-going projects for consistency with the Council's Program and purposes of the Northwest Power Act. Bonneville reviews and resets project-specific funding commitments annually, including projects under the FCRPS BiOps and other agreements. Bonneville informs its funding decisions with the management objectives and priorities in the Council's Program (including ISRP reviews) and the Accords extension as it integrates their implementation with actions necessary to fulfill ESA responsibilities. Regular coordination on implementation priorities continues among Bonneville, the Council, federal resource management agencies, states, Tribes, and others.

Continued investments in Fish &Wildlife include:

Continuous Activity (all years)

- Anadromous Fish: Continue implementing both ongoing and new projects that support ESA-listed species and other measures called for under the current FCRPS BiOps, the Washington Estuary Agreement, the Kalispel Agreement, and the Willamette and Southern Idaho agreements and 2018 Fish Accord extensions. Prioritize projects that address the factors that contribute most to mitigation success and that fulfill Bonneville's responsibility for mitigating the impacts from the FCRPS. Implement and develop activities that protect and enhance tributary and estuary habitat, improve mainstream habitat, reduce potentially harmful hatchery practices on ESA-listed populations, and contribute to sustainable fisheries.
- Resident Fish: Implement activities to mitigate the impacts of the FCRPS on lamprey, sturgeon, and bull trout and promote the reproduction and recruitment of Kootenai River white sturgeon. These activities have been selected in response to the USFWS's 2000 bull trout and 2006 Libby BiOp, the Council Program, and the 2018 Fish Accord extensions.
- Mitigation using resident fish to offset anadromous fish losses (substitution): mitigate for reservoir power operation impacts to resident fish and wildlife by seeking projects that benefit both simultaneously. Those resident fish habitat acquisition projects that meet Bonneville's Capitalization Policy will be funded under the capital portion of Bonneville's Fish and Wildlife budget and credited for both fish and wildlife where appropriate.
- Wildlife: Use existing Bonneville policies to continue the current effort to mitigate wildlife in a manner consistent with the Council Program and fulfill commitments in wildlife agreements such as the Kalispel Agreement, Willamette Wildlife Agreement, and Southern Idaho Wildlife Agreement. Those wildlife projects that meet Bonneville's Capitalization Policy will be funded under the capital portion of Bonneville's Fish and Wildlife budget and credited against both wildlife and fish obligations according to Bonneville's crediting policy and applicable mitigation contracts.

Residential Exchange, Northwest Power and Conservation Council, and Energy Efficiency & Renewable Resources

($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
401,477	418,215	426,230

Overview

Residential Exchange Program (REP)

- Includes forecasted REP benefits based on the 2012 REP Settlement.

Northwest Power and Conservation Council

- Continue support of the Council activities, as directed under the Northwest Power Act, including regional power plan development and maintenance and fish and wildlife program activities.

Energy Efficiency Resources

- Conservation Purchases: Provide programmatic savings reimbursements and energy efficiency incentives to Bonneville customers to purchase conservation savings. This includes performance payments and Energy Smart Reserved Power payments for federal installations and fish hatcheries and irrigation districts.

- Conservation Infrastructure: All support for programs and operations, including third-party program implementation, contract support, market research (Momentum Savings research), evaluation, and emerging technology research.

- Market Transformation: Support for NEEA's market transformation initiatives. NEEA identifies barriers and opportunities to increase the market adoption of efficiency by leveraging its regional partnerships.

Activities, Milestones, and Explanation of Changes ($K)

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Power Services - Operating Expense $2,069,294	**$2,009,658**	**$-59,636/-2.9%**
Production $944,002 Milestones: • Continue to provide oversight of all signed contracts. • Continue to provide wind resource integration services for customer wind generation.	**$871,620** Milestones: • Continue to provide oversight of all signed contracts. • Continue to provide wind resource integration services for customer wind generation.	**$-72,383/-7.7%** • The decrease is primarily due to lower CGS and support costs.
Associated Project Costs $457,660	**$464,915**	**$7,255/1.6%**

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Milestones: • Continue direct funding of Corps and Reclamation O&M power activities.	Milestones: • Continue direct funding of Corps and Reclamation O&M power activities.	• The increase reflects changes to security, biological opinion requirements, non-routine extraordinary maintenance, WECC/NERC compliance activities, and improvements, replacements, and minor additions at the projects.

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Fish & Wildlife Costs $249,416	**$246,893**	**$-2,523/-1.0%**

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Milestones: • Continue implementing both ongoing and new projects that support ESA-listed species and other measures called for under the current FCRPS BiOps, the 2018 Fish Accord extensions, the Washington Estuary Agreement, the Kalispel Agreement, the Southern Idaho Agreement, and the Willamette Agreement.	Milestones: • Continue implementing both ongoing and new projects that support ESA-listed species and other measures called for under the current FCRPS BiOps, the 2018 Fish Accord extensions, the Washington Estuary Agreement, the Kalispel Agreement, the Willamette Agreement, and the Southern Idaho Agreement.	• The decrease in the costs reflect funding associated with the Biological Opinions, 2018 Fish Accord extension commitments, and Northwest Power Act activities.
Residential Exchange Program $249,747 Milestones: • Continue to provide REP benefits.	**$259,000** Milestones: • Continue to provide REP benefits.	**$9,253/3.7%** • The increase reflects the higher scheduled in the amount of REP payments payable to the IOUs prescribed by the Residential Exchange Settlement.
NW Power & Conservation Council $11,956 Milestones: • Continue support of the Council activities, as directed under the Northwest Power Act, including regional power plan development and maintenance, and fish and wildlife program activities.	**$11,545** Milestones: • Continue support of the Council activities, as directed under the Northwest Power Act, including regional power plan development and maintenance, and fish and wildlife program activities.	**$-411/-3.4%** • The small decrease reflects lower funding and continuing emphasis on the NW Power and Conservation Council.

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Energy Efficiency & Renewable Resources **$156,513** Milestones: • Continue close-out of the legacy conservation resource acquisition contracts, which support Bonneville's contractual obligation to serve customer loads. • Continue to support utility incentive programs. • Continue to support regional energy efficiency programs. • Continue supporting energy efficiency at direct serve federal agencies.	**$155,685** Milestones: • Continue close-out of the legacy conservation resource acquisition contracts, which support Bonneville's contractual obligation to serve customer loads. • Continue to support utility incentive programs. • Continue to support regional energy efficiency programs. • Continue supporting energy efficiency at direct serve federal agencies.	**$-828/-0.5%** • The small decrease reflects our cost cutting effort while continuing emphasis on the energy efficiency program consistent with the Power Plan.

Transmission Services – Operating Expense
Funding Schedule by Activity
Funding ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2021 vs FY 2020 $	FY 2021 vs FY 2020 %
Transmission Services - Operating Expense					
Engineering	77,155	82,877	87,805	4,927	5.9%
Operations	211,538	193,871	204,585	10,714	5.5%
Maintenance	193,118	205,026	215,804	10,778	5.3%
Total, Transmission Services - Operating Expense	**481,811**	**481,774**	**508,194**	**26,420**	**5.5%**

Outyears ($K)

	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Transmission Services - Operating Expense					
Engineering	87,805	88,535	90,705	92,778	94,780
Operations	204,585	208,000	213,287	218,336	223,213
Maintenance	215,804	218,552	223,909	229,026	233,968
Total, Transmission Services - Operating Expense	**508,194**	**515,087**	**527,901**	**540,140**	**551,961**

Transmission Services – Operating Expense

Overview

This activity provides for the transmission system services of engineering, operations, and maintenance for Bonneville's electric transmission system, and the associated power system control and communication facilities. Primary goals of this program are: 1) maintain the safety and reliability of the transmission system; 2) increase the focus on meeting customers' needs; 3) optimize the transmission system; 4) provide open access and non-discriminatory transmission service; and 5) improve Bonneville's cost effectiveness.

Explanation of Changes

Bonneville's budget includes $508.2 million in FY 2022 for TS operating expense which is a 5.5 percent increase over the FY 2021 forecasted level. The increase still continues the operation and maintenance of Bonneville's transmission assets.

The FY 2022 budget increases the levels for Engineering (+$4.9 million), Operations (+$10.7 million), and Maintenance (+$10.8 million).

Engineering ($K)		
FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
77,155	82,877	87,805

Overview

Continue efforts to identify best methods for improving system reliability and maintenance practices, and continue cost reduction efforts by identifying opportunities for low-cost reinforcement and voltage support of the existing transmission system.

Continued investments in Engineering include:

Continuous Activity (all years)

- Research and Development (R&D): Conduct research focused on technologies related to business challenges Bonneville faces including reliability, energy efficiency, and integration of renewable energy resources. Technologies of interest are identified in Bonneville's Technology Roadmaps. A portfolio of research is selected every year through Bonneville's Portfolio Decision Framework.

- System Development Planning and Analysis: Continue providing technical support and asset planning to deploy the Asset Management approach to sustain existing assets and expand the system to meet Agency objectives.

- Technical Support: Provide technical support activities, such as transmission system planning and studies to optimize portions of the system. Provide support for non-wires solutions studies and pilot projects.

- Capital-to-Expense Adjustments: Conduct annual analysis of Bonneville's outstanding capital work orders to assess whether they should be expensed. As obsolete inventory is identified and disposed of, it is expensed.

- Regulatory Fees: WECC dues and loop flow payments, Department of Commerce/National Telecommunications and Information Administration licensing costs for radio frequencies, DOE Radio Spectrum staff and contractor support, and NERC Critical Infrastructure Protection (CIP) compliance program costs. Includes membership in a regional transmission planning organization.

- Reimbursable Transactions: Enter into written agreements with federal and non-federal entities that have work or services to be performed by Bonneville staff at the expense of the benefiting entities. The projects must be beneficial, under agreed upon criteria, to Bonneville operations and to the federal or non-federal entity involved or otherwise be aligned with or supportive of Bonneville's strategic objectives. Additionally, these activities generally contribute to more efficient or reliable construction of the federal transmission system or otherwise enhance electric service to the region.

- Leased and Other Costs: Includes leases, lease purchases, and other costs of financing transmission, delivery, and voltage support facilities when such arrangements are operationally feasible and cost effective to deliver power. Leases and lease purchases enable Bonneville to continue to invest in infrastructure to support a safe and reliable system for the transmission of power. Other costs included are the accrued interest costs associated with Large Generator Interconnection Agreements (LGIA).

Operations ($K)		
FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
211,538	193,871	204,585

Overview

Substation Operations: Perform operations functions necessary to provide electric service to customers and to protect the federal investment in electric equipment and other facilities. Includes equipment adjustments, switching lines and equipment during emergencies or maintenance, isolating damaged equipment, restoring service to customers, inspecting equipment, and reading meters.

Power System Dispatching and Supporting Functions: Perform central dispatching, control, and monitoring of the electric operation of the federal transmission system. Also includes load, frequency, and voltage control of federal generating plants, and coordinating long- and short-term outages of system equipment. In addition, provides technical engineering support of dispatching function and provides all technical and systems support for Dittmer Control Center (DCC) and Munro Control Center (MCC).

Marketing and Sales: Provide management and direction of transmission rates, and provide business strategy in marketing of transmission and ancillary products and services of Transmission Services. Involve customers and constituents in the process of product and rate development. Maintain accurate and complete historical records of current and past legacy transmission agreements. Provide guidance for current and future transmission contract negotiations. Provide financial analysis of market strategies. Monitor and report on the financial health of Transmission Services. Support cost management by effective reporting and analysis of current expenditures. Ensure official budget submittals reflect current management financial strategies and adequately fund transmission programs.

Transmission Scheduling: Provide non-discriminatory, open access to the Bonneville transmission system consistent with Bonneville's Open Access Transmission Tariff (OATT). Schedule transmission capacity to eligible Bonneville customers, which include customers acquiring services under Use of Facilities (UFT), Formula Power Transmission (FPT), Integration of Resources (IR), and Part II or Part III of the OATT. Manage the reservations and scheduling of all transmission services associated with the OATT. Update practices, policies, and commercial systems to accommodate a large diversity of resources, including wind.

Continuous Activity (all years):

- Continue to operate within parameters of NERC and WECC.
- Continue support of increased compliance activities related to the reliability of the transmission system, including cyber security.
- Continue developing facilities, policies, procedures, and implementing systems to support integrating the diversity of resources into the transmission grid.
- Continue preparation for increased complexity of transmission scheduling, power system operations, and dispatching, including congestion management and outage scheduling.
- Continue developing the Dittmer Scheduling Center and Munro Scheduling Center facilities to support continuous real time scheduling operations from both facilities.
- Continue developing a long-term approach to optimize transmission availability through streamlined, cost-effective, and sustainable processes.
- Continue to address succession planning issues across key functions.
- Continue development and implementation of business systems and tools.

Maintenance
($K)

FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate
193,118	205,026	215,804

Overview

In all aspects of maintenance, Bonneville is continuing the use of Reliability Centered Maintenance (RCM) practices. The use of RCM practices is focused on improving system reliability, increasing availability, and meeting new and existing compliance regulations at lowest lifecycle costs. In addition Bonneville is deploying Asset Management to optimize maintain/replace decision making. Maintenance costs are expected to increase as Bonneville addresses the aging transmission system, meeting reliability standards, including vegetation management, and environmental constraints associated with construction, enhancement, and maintenance of the system. The Bonneville transmission system encompasses 15,238 circuit miles on over 11,860 right-of-way miles (many of these miles are through rugged, inaccessible terrain).

Continued investments in Maintenance include:
Continuous Activity (all years)

- Continue to improve performance to meet System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) targets.
- Continue refining processes and procedures for monitoring and tracking compliance activities related to the reliability of the transmission system.
- Continue to improve system availability performance through new maintenance procedures and work practices.
- Continue to develop and implement work practices and procedures for implementation of a new specialty crew using bare-hand live line practices for maintenance of high-voltage transmission lines.
- Continue increased emphasis on replacement of line hardware (life extension programs for insulators, connectors, dampers, and fiber optic cable hardware).
- Continue to prepare for the impact of an expected high attrition rate among Bonneville's aging workforce by recruiting apprentices and replacements for critical minimum crew size workload positions.
- Increase outage-scheduling planning and coordination to increase customer satisfaction and system availability.
- Maintain vegetation management levels to ensure system reliability.
- Continue access road work to provide reliable access to facilities and ensure environmental compliance.
- Continue improving environmental stewardship.

Transmission Line Maintenance: Maintain and repair 15,238 circuit miles of high voltage transmission lines, of which over 4,734 circuit miles are 500 kV transmission extra-high voltage (EHV). Maintenance of EHV lines is two and one-half times more labor-intensive than maintenance of lower transmission voltages, although more efficient in transmission of power. This responsibility includes maintaining transmission rights-of-way to ensure system reliability, safety, and environmental compliance. Adopt work practices that improve system availability, reliability, and compliance.

Right-of-Way Maintenance: Maintain over 11,860 of Bonneville's right-of-way miles. This responsibility includes vegetation management, danger tree management, and access road maintenance to ensure system reliability, safety, and environmental compliance. Adopt procedures and processes that improve system availability, reliability, environmental compliance, and reliability compliance. Continue to deploy new technologies such as LiDAR (Light Detection and Ranging) to reliably and cost-effectively manage vegetation.

Substation Maintenance: Maintain and repair the transmission system power equipment located in Bonneville's 260 substations. Work includes inspections, diagnostic testing, and predictive and condition-based maintenance.

System Protection Maintenance: Maintain relaying metering and remedial action scheme equipment used to control and protect the electrical transmission system and to meter energy transfers for the purpose of revenue billing. Additionally,

field-engineering services provide technical advice and assure the correct operation of power system relaying and special control systems used to support interregional energy transmission capabilities.

Power System Control Maintenance: Test, repair, and provide field engineering support of Bonneville's highly complex equipment, communications, and control systems, including seven major microwave systems, fiber optic systems, and other critical communications and control equipment that support the power system.

Non-Electric Plant Maintenance: Maintain and manage Bonneville's non-electric facilities. Includes site, building, and building utility maintenance; custodial services; station utility; and other maintenance service activities, as well as facilities asset management on Bonneville-owned or Bonneville-leased non-electric facilities.

Maintenance Standards and Engineering: Establish, monitor, and update system maintenance standards, policies, and procedures, and review and update long-range plans for maintenance of the electric power transmission system.

Activities, Milestones, and Explanation of Changes ($K)

FY 2021 Estimate	FY 2022 Estimate	Explanation of Changes FY 2022 vs FY 2021 Estimate
Transmission Services - Operating Expense **$481,774**	**$508,194**	**$26,420/5.5%**
Engineering $82,877 Milestones: • Continue efforts to identify best methods for improving system reliability and maintenance practices. • Continue cost reduction efforts by identifying opportunities for low-cost reinforcement and voltage support of the existing transmission system.	**$87,805** Milestones: • Continue efforts to identify best methods for improving system reliability and maintenance practices. • Continue cost reduction efforts by identifying opportunities for low-cost reinforcement and voltage support of the existing transmission system.	**$4,927/5.9%** • The increase reflects continued emphasis on system reliability standards compliance and research and development.
Operations $193,871 Milestones: • Continue to operate within parameters of NERC and WECC. • Continue support of increased compliance activities related to the reliability of the transmission system including cyber security.	**$204,585** Milestones: • Continue to operate within parameters of NERC and WECC. • Continue support of increased compliance activities related to the reliability of the transmission system including cyber security.	**$10,714/5.5%** • The increase reflects continued emphasis on reliability compliance activities, resource integration activities, key strategic initiative, security, and control center systems support.
Maintenance $205,026 Milestones: • Continue to improve performance to meet System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) targets.	**$215,804** Milestones: • Continue to improve performance to meet System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) targets.	**$10,778/5.3%** • The increase reflects implementation of facilities asset management plans, continued implementation of live-line crew, NERC/WECC compliance activities related to land rights and vegetation management, continuing maintenance program activities, including system protection, right-of-way, line maintenance, and performance improvements.

Interest, Pension, and Post-retirement Benefits
Operating Expense
Funding Schedule by Activity
Funding ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2022 vs FY 2021 $	FY 2022 vs FY 2021 %
Interest, Pension, and Post-retirement Benefits					
BPA Bond Interest (Net)	163,964	137,860	137,677	-184	-0.1%
BPA Appropriation Interest	0	0	0	0	0.0%
Corps of Engineers Appropriation Interest	42,323	42,217	44,098	1,881	4.5%
Lower Snake River Comp Plan Interest	180	180	180	0	0.0%
Bureau of Reclamation Appropriation Interest	1,148	1,146	1,146	0	0.0%
Bond Premiums Paid/Discounts (not capitalized)	(0)	11,725	600	-11,125	-94.9%
Subtotal, Interest – Operating Expense	**207,614**	**193,128**	**183,701**	**-9,428**	**-4.9%**
Additional Pension, and Post-retirement Benefits	29,475	40,124	31,273	-8,851	-22.1%
Total, Interest, Pension, and Post-retirement Benefits	**237,089**	**233,253**	**214,973**	**-18,279**	**-7.8%**

Outyears ($K)

	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Interest, Pension, and Post-retirement Benefits					
BPA Bond Interest (Net)	137,677	144,220	152,315	165,372	189,260
BPA Appropriation Interest	0	0	0	0	0
Corps of Engineers Appropriation Interest	44,098	44,920	45,325	46,631	48,682
Lower Snake River Comp Plan Interest	180	180	180	359	0
Bureau of Reclamation Appropriation Interest	1,146	1,146	1,146	1,146	1,146
Bond Premiums Paid/Discounts (not capitalized)	600	559	1,201	722	716
Subtotal, Interest – Operating Expense	**183,701**	**191,024**	**200,167**	**214,230**	**239,804**
Additional Pension, and Post-retirement Benefits	31,273	32,306	33,097	33,853	34,583
Total, Interest, Pension, and Post-retirement Benefits	**214,973**	**223,330**	**233,264**	**248,083**	**274,387**

Interest, Pension and Post-retirement Benefits
Operating Expense

Overview

Interest expense provides for interest due on bonds issued to the U.S. Treasury and appropriations repayment responsibilities. The appropriation repayments relate to capital investment in FCRPS hydroelectric generating and transmission facilities of Bonneville, and the Corps and Reclamation. Investments were financed by Congressional appropriations and Bonneville borrowings from the U.S. Treasury. Bonneville repays these amounts through revenue raised in its power sales and transmission services revenues.

Since initially receiving U.S. Treasury borrowing authority in 1974 under the Transmission Act, all of Bonneville's U.S. Treasury borrowing has been at market rates. As of October 1, 1996, all of Bonneville's repayment obligations on FCRPS appropriated investment (Corps and Reclamation FCRPS investment and Bonneville investment financed with appropriations prior to the Transmission Act that were unpaid as of September 30, 1996) were restructured and assigned new current-market interest rates. The Bonneville Appropriations Refinancing Act of 1996 (Refinancing Act) called for re-setting (reducing) the unpaid principal of FCRPS appropriations and reassigning (increasing) interest rates. New principal amounts were established as of the beginning of FY 1997 at the present value of the principal and annual interest payments Bonneville would make to the U.S. Treasury for these obligations in the absence of the legislation, plus $100.0 million. The new principal amounts were assigned prevailing market interest rates as of October 1, 1996. Bonneville's outstanding appropriations repayment obligations at the end of FY 1996 were $6.7 billion with a weighted average interest rate of 3.4 percent. The refinancing reduced the principal amount to $4.1 billion with a weighted average interest rate of 7.1 percent. Implementation of the refinancing took place in 1997 after audited actual financial data were available. Pursuant to the legislation, Bonneville submitted its calculations and interest rate assignments implementing the Refinancing Act to the U.S. Treasury for its review and approval. The U.S. Treasury approved the implementation calculations in July 1997. The Refinancing Act also calls for all future FCRPS appropriations to be assigned prevailing U.S. Treasury yield curve interest rates. Bonneville's outstanding appropriations may be prepaid prior to their stated maturities.

Interest estimates are a function of costs of U.S. Treasury borrowing to Bonneville, repayment status of outstanding FCRPS investments, and projected additions to FCRPS plant in service. These estimates may change over time depending on forecasted market conditions. The interest cost estimates include the impact of Bonneville's appropriation refinancing legislation.

Federal employees associated with the operation of the FCRPS participate in either the Civil Service Retirement System or the Federal Employees Retirement System. Employees may also participate in the Federal Employees Health and Benefit Program and the Federal Employee Group Life Insurance Program. As a Federal agency, all post-retirement activity is managed by the Office of Personnel Management; therefore, neither the assets of the plans or the accumulated plan benefits are recorded by Bonneville. Since 1997, Bonneville has made additional annual contributions to the General Fund of the U.S. Treasury (receipt account 892889) related to the Federal post-retirement benefit programs provided to employees associated with the operation of the FCRPS.

Capital Transfers
Funding Schedule by Activity
Funding ($K)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Estimate	FY 2022 vs FY 2021 $	FY 2022 vs FY 2021 %
Capital Transfers					
BPA Bond Amortization[1]	396,000	724,000	696,000	-28,000	-3.9%
Reclamation Appropriation Amortization	0	0	0	0	0.0%
BPA Appropriation Amortization	0	0	0	0	0.0%
Corps Appropriation Amortization	75,310	0	0	0	0.0%
Lower Snake River Comp Plan Amortization	0	0	0	0	0.0%
Total, Capital Transfers	471,310	724,000	696,000	-28,000	-3.9%

Outyears ($K)

	FY 2022 Estimate	FY 2023 Estimate	FY 2024 Estimate	FY 2025 Estimate	FY 2026 Estimate
Capital Transfers					
BPA Bond Amortization[1]	696,000	726,000	678,000	689,000	701,000
Reclamation Appropriation Amortization	0	0	0	0	0
BPA Appropriation Amortization	0	0	0	0	0
Corps Appropriation Amortization	0	0	0	0	0
Lower Snake River Comp Plan Amortization	0	0	0	0	0
Total, Capital Transfers	696,000	726,000	678,000	689,000	701,000

Overview

This activity conveys funds to the U.S. Treasury for repayment of certain FCRPS costs not included in the Associated Project Costs budget. Since capital transfers are cash transactions, they are not considered budget obligations.

[1] Bonneville "Bond(s)" in this FY 2021 Budget refers to all bonds issued by Bonneville to and advances received from the U.S. Treasury. This reference is consistent with section 13(a) of the Transmission Act (P.L. 93-454), which defines Bonneville bonds as all bonds, notes, and other evidences of indebtedness issued and sold by Bonneville to the U.S. Treasury.

Additional Tables

BONNEVILLE POWER ADMINISTRATION
TOTAL OBLIGATIONS/OUTLAYS
Current Services
(in millions of dollars)

BP-1 SUMMARY[1/3/]	FISCAL YEAR									
	2020		2021		2022		2023	2024	2025	2026
	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Oblig.	Oblig.	Oblig.
1 Residential Exchange Program	250	250	250	250	259	259	259	265	271	277
2 Power Services[2/]	1,730	1,730	1,403	1,403	1,338	1,338	1,388	1,424	1,457	1,488
3 Transmission Services	762	762	966	966	1,005	1,005	1,045	1,114	1,206	1,202
4 Conservation & Energy Efficiency	140	140	157	157	156	156	151	154	158	161
5 Fish & Wildlife	266	266	297	297	290	290	290	277	272	262
6 Interest/ Pension[4/]	237	237	233	233	215	215	223	233	248	274
7 Associated Project Cost - Capital	178	178	272	272	264	264	281	300	307	314
8 Capital Equipment	21	21	22	22	22	22	21	20	19	17
9 Planning Council	11	11	12	12	12	12	12	12	12	13
10 Projects Funded in Advance	89	89	70	70	56	56	61	48	35	35
11 Capitalized Bond Premiums	0	0	0	0	0	0	0	0	0	0
12 **TOTAL OBLIGATIONS/OUTLAYS**[3/]	**3,685**	**3,685**	**3,681**	**3,681**	**3,616**	**3,616**	**3,731**	**3,847**	**3,986**	**4,044**

REVENUES AND REIMBURSEMENTS

Current Services

(in millions of dollars)

BP-1 SUMMARY	FISCAL YEAR									
	2020		2021		2022		2023	2024	2025	2026
	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Oblig.	Oblig.	Oblig.
13 Revenues [5/]	3,540	3,540	3,773	3,773	3,885	3,885	3,928	3,942	3,966	3,989
14 Project Funded in Advance	89	89	70	70	56	56	61	48	35	35
15 **TOTAL**	**3,629**	**3,629**	**3,843**	**3,843**	**3,941**	**3,941**	**3,989**	**3,990**	**4,001**	**4,024**
16 **BUDGET AUTHORITY (NET)** [6/]	**39**		**102**		**130**		**149**	**258**	**328**	**295**
17 **OUTLAYS (NET)** [6/7/8]		**44**		**(160)**		**(323)**	**(259)**	**(143)**	**(15)**	**19**

These notes are an integral part of this table.

1/ This FY 2022 budget includes capital and expense estimates based on initial spending proposals from Bonneville's BP-22 IPR process.

Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

2/ Power Services doesn't include Fish & Wildlife, Residential Exchange Program, Planning Council, Conservation & Energy Efficiency and Associated Project Costs which have been shown separately for display purposes.

Bonneville makes an accounting adjustment to the production services component of FY 2020 Bonneville's audited actual obligations. This past year adjustment relates primarily to long- term obligation requirements consistent with Bonneville's FY 2020 Combined Schedules of Budgetary Resources and the GTAS FY 2020 Treasury reports for Bonneville.

3/ This budget has been prepared in accordance with PAYGO. Under PAYGO all Bonneville budget estimates are treated as mandatory and are not subject to the discretionary caps included in the Budget Control Act of 2011. These estimates support activities that are separate from discretionary activities and accounts. Thus, any changes to Bonneville estimates cannot be used to affect any other budget categories which have their own dollar caps. Because Bonneville's obligations are and will be incurred under pre-existing legislative authority, Bonneville is not subject to a "pay-as-you-go" test regarding its revision of current-law funding estimates.

For BP-1 table, the CJ reflects forecasted outlays while the yearend GTAS reflects the actual outlay in the Budget Appendix.

4/ See Interest Expense, Pension and Post-retirement Benefits and Capital Transfers section of this budget for a complete discussion of these cost estimates.

5/ Revenues, included in the Net Outlay formulation, are calculated consistent with cash management goals and assume a combination of adjustments. Assumed adjustments include the use of a combination of tools, including upcoming rate adjustment mechanisms, a net revenue risk adjustment, debt service refinancing strategies and/or short-term financial tools to manage net revenues and cash. Some of these potential tools will reduce costs rather than generate revenue, causing the same Net Outlay result. Adjustments for depreciation and 4(h)(10)(C) credits of the Northwest Power Act are also assumed.

6/ Bonneville received $48.7 million of additional budget authority in FY 2007 to accommodate the work necessary to relocate the radio spectrum consistent with the Commercial Spectrum Enhancement Act (P.L. 108-494). In accordance with Federal law, Bonneville plans to return the forecasted unused balance of approximately $8.2 million to the U.S. Treasury as soon as the National Telecommunications Information Administration notifies the Federal Communications Commission that the DOE relocation effort is complete.

7/ Net Outlay estimates are based on current cost savings to date and anticipated cash management goals. They are expected to follow anticipated management decisions throughout the rate period that, along with actual market conditions, will impact revenues and expenses. Actual Net Outlays are volatile and are reported in Report on Budget Execution and Budgetary Resources (SF-133). Actual Net Outlays could differ from estimates due to changing market conditions, streamflow variability, continued restructuring of the electric industry, and other reasons.

8/ FY 2020 Net Outlays are calculated using Bonneville's audited actual revenue. FYs 2021 to 2026 Net Outlays are based on FY 2020 initial IPR assumptions and an escalation factor from using the FY 2018 White Book Loads and Resources Report.

EXPENSED OBLIGATIONS/OUTLAYS [1,4/]
Current Services
(in millions of dollars)
FISCAL YEAR

BP-2	2020		2021		2022		2023	2024	2025	2026
	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Oblig.	Oblig.	Oblig.
1 Residential Exchange Program	250	250	250	250	259	259	259	265	271	277
2 Power Services [2/]	1,730	1,730	1,403	1,403	1,338	1,338	1,388	1,424	1,457	1,488
3 Transmission Services	482	482	482	482	508	508	515	528	540	552
4 Conservation & Energy Efficiency	140	140	157	157	156	156	151	154	158	161
5 Fish & Wildlife	226	226	249	249	247	247	247	247	247	247
6 Interest/ Pension [3/]	237	237	233	233	215	215	223	233	248	274
7 Planning Council	11	11	12	12	12	12	12	12	12	13
8 TOTAL EXPENSE	3,076	3,076	2,785	2,785	2,734	2,734	2,795	2,863	2,934	3,012
9 Projects Funded in Advance	89	89	70	70	56	56	61	48	35	35

CAPITAL OBLIGATIONS/OUTLAYS [1/]

Current Services

(in millions of dollars)

FISCAL YEAR

BP-2 continued	2020		2021		2022		2023	2024	2025	2026
	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Outlays	Oblig.	Oblig.	Oblig.	Oblig.
10 Transmission Services	280	280	484	484	497	497	530	586	666	650
11 Associated Project Cost	178	178	272	272	264	264	281	300	307	314
12 Fish & Wildlife	40	40	47	47	43	43	43	30	25	15
13 Capital Equipment	21	21	22	22	22	22	21	20	19	17
14 Capitalized Bond Premiums	0	0	0	0	0	0	0	0	0	0
15 **TOTAL CAPITAL INVESTMENTS**	**520**	**520**	**826**	**826**	**826**	**826**	**875**	**936**	**1,017**	**996**
16 **TREASURY BORROWING AUTHORITY TO**										
17 **FINANCE CAPITAL OBLIGATIONS [4/]**	**520**		**826**		**826**		**875**	**936**	**1,017**	**996**

These notes are an integral part of this table.

[1/] This FY 2022 budget includes capital and expense estimates based on initial spending proposals from Bonneville's BP-22 IPR process.

Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

[2/] Power Services doesn't include Fish & Wildlife, Residential Exchange Program, Planning Council, Conservation & Energy Efficiency and Associated Project Costs which have been shown separately for display purposes.

Bonneville makes an accounting adjustment to the production services component of FY 2020 Bonneville's audited actual obligations. This past year adjustment relates primarily to long- term obligation requirements consistent with Bonneville's FY 2020 Combined Schedules of Budgetary Resources and the GTAS FY 2020 Treasury reports for Bonneville.

[3/] See Interest Expense, Pension and Post-retirement Benefits and Capital Transfers section of this budget for a complete discussion of these cost estimates.

[4/] This budget has been prepared in accordance with PAYGO. Under PAYGO all Bonneville budget estimates are treated as mandatory and are not subject to the discretionary caps included in the Budget Control Act of 2011. These estimates support activities that are separate from discretionary activities and accounts. Thus, any changes to Bonneville estimates cannot be used to affect any other budget categories which have their own dollar caps. Because Bonneville's obligations are and will be incurred under pre-existing legislative authority, Bonneville is not subject to a "pay-as-you-go" test regarding its revision of current-law funding estimates.

BP-3

CURRENT SERVICES

(in millions of dollars)

CAPITAL TRANSFERS **FISCAL YEAR**

	2020 Payment	2021 Payment	2022 Payment	2023 Payment	2024 Payment	2025 Payment	2026 Payment
Amortization:							
18 BPA Bonds	396	724	696	726	678	689	701
19 Reclamation Appropriations	0	0	0	0	0	0	0
20 BPA Appropriations	0	0	0	0	0	0	0
21 Corps Appropriations	75	0	0	0	0	0	0
22 Lower Snake River Comp Plan Amortization	0	0	0	0	0	0	0
23 **TOTAL CAPITAL TRANSFERS**	**471**	**724**	**696**	**726**	**678**	**689**	**701**
24 **FULL-TIME EQUIVALENT (FTE)**	**2,743**	**3,000**	**3,000**	**3,000**	**3,000**	**3,000**	**3,000**

PROGRAM & FINANCING SUMMARY

Current Services

(in millions of dollars)

Identification Code: 89-4045-0-3-271

		2020	2021	est. 2022	2023	2024	2025	2026
Program by activities:								
	Operating expenses:							
0.01	Power Services	1,287	944	872	925	950	973	993
0.02	Residential Exchange Program	250	250	259	259	265	271	277
	Associated Project Costs:							
0.05	Bureau of Reclamation	153	152	154	152	155	159	162
0.06	Corps of Engineers	240	253	253	253	259	265	270
0.07	Colville Settlement	18	23	22	22	23	23	24
0.08	Spokane Settlement	0	0	6	5	6	6	6
0.19	U.S. Fish & Wildlife Service	32	30	31	31	32	32	33
0.20	Planning Council	11	12	12	12	12	12	13
0.21	Fish & Wildlife	226	249	247	247	247	247	247
0.23	Transmission Services	482	482	508	515	528	540	552
0.24	Conservation & Energy Efficiency	140	157	156	151	154	158	161
0.25	Interest	208	193	184	191	200	214	240
0.26	Pension and Health Benefits [1/]	29	40	31	32	33	34	35
0.91	**Total operating expenses [2/]**	**3,076**	**2,784**	**2,733**	**2,795**	**2,863**	**2,934**	**3,012**
	Capital investment:							
1.01	Power Services	178	272	264	281	300	307	314
1.02	Transmission Services	280	484	497	530	586	666	650
1.04	Fish & Wildlife	40	47	43	43	30	25	15
1.05	Capital Equipment	21	22	22	21	20	19	17
1.06	Capitalized Bond Premiums	0	0	0	0	0	0	0
1.07	**Total Capital Investment [3/]**	**520**	**826**	**826**	**875**	**936**	**1,017**	**996**
2.01	Projects Funded in Advance	89	70	56	61	48	35	35
10.00	**Total obligations [4/]**	**3,685**	**3,680**	**3,615**	**3,731**	**3,847**	**3,986**	**4,044**

These notes are an integral part of this table.

[1/] See Interest Expense, Pension and Post-retirement Benefits and Capital Transfers section of this budget for a complete discussion of these cost estimates.

[2/] Assumes expense obligations, not accrued expenses.

Power Services doesn't include Fish & Wildlife, Residential Exchange Program, Planning Council, Conservation & Energy Efficiency and Associated Project Costs which have been shown separately for display purposes.

Bonneville makes an accounting adjustment to the production services component of FY 2020 Bonneville's audited actual obligations. This past year adjustment relates primarily to long- term obligation requirements consistent with Bonneville's FY 2020 Combined Schedules of Budgetary Resources and the GTAS FY 2020 Treasury reports for Bonneville.

[3/] Assumes capital obligations, not capital expenditures.

[4/] This FY 2022 budget includes capital and expense estimates based on initial spending proposals from Bonneville's BP-22 IPR process.

For purposes of this table, this FY 2022 budget reflects, for FY 2020, actual third party financing expense only for PFIA.

Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

Program and Financing (continued)

Current Services

(in millions of dollars)

		2020 est.	2021	2022	2023	2024	2025	2026
Financing:								
1000	Unobligated balance available, start of year. [5/]	13	11	10	0	0	0	0
1050	Unobligated balance available, end of year.[5/]	11	10	8	0	0	0	0
1900	**Budget authority (gross)**	**3,684**	**3,945**	**4,071**	**4,138**	**4,247**	**4,329**	**4,319**
Budget Authority:								
1400	Permanent Authority: Authority to borrow from Treasury (indefinite) [6/]	765	826	826	875	936	1,017	996
1600	Contract Authority	2,519						
1800	Spending authority from off-setting collections	3,629	3,843	3,941	3,989	3,990	4,001	4,024
1825	Portion applied to debt reduction	(396)	(724)	(696)	(726)	(678)	(689)	(701)
1850	**Spending authority from offsetting collections (adjusted)**	**400**	**3,119**	**3,245**	**3,263**	**3,312**	**3,312**	**3,323**
900	Total obligations	3,685	3,681	3,616	3,731	3,847	3,986	4,044
4110	Outlays (gross)	3,673	3,681	3,616	3,731	3,847	3,986	4,044
Adjustments to budget authority and outlays:								
	Deductions for offsetting collections:							
4120	Federal funds	(55)	(90)	(90)	(90)	(90)	(90)	(90)
4121	Interest on Federal Securities	(2)	(2)	(2)				
4123	Non-Federal sources	(3,574)	(3,753)	(3,851)	(3,899)	(3,900)	(3,911)	(3,934)
4130	Total, offsetting collections	(3,629)	(3,843)	(3,941)	(3,989)	(3,990)	(4,001)	(4,024)
4160	**Budget authority (net)**	**39**	**102**	**130**	**149**	**258**	**328**	**295**
4170	**Outlays (net) [7/8/]**	**44**	**(160)**	**(323)**	**(259)**	**(143)**	**(15)**	**19**

These notes are an integral part of this table.

[5/] Reflects estimated cost for radio spectrum fund.

[6/] The Permanent Authority: Authority to borrow (indefinite) from the U.S. Treasury amounts reflect both Bonneville's capital program financing needs and either the use of, or creation of, deferred borrowing. Deferred borrowing is created when, as a cash and debt management decision, Bonneville uses cash from revenues to liquidate capital obligations in lieu of borrowing at that time from the U.S. Treasury. This temporary use of cash on hand instead of borrowed funds creates the ability in future years to borrow money, when fiscally prudent. The FY 1989 Energy and Water Development Appropriations Act (P.L. 100-371 0f 7/19/88) confirmed that Bonneville has authority to incur obligations in excess of U.S. Treasury borrowing authority and cash in the BPA fund. Total includes BPA's self-financing activities and funds for Radio Spectrum Relocation. In addition, BPA has negotiated with the U.S. Treasury access to a $750 million short term note as part of the $7.7 billion borrowing authority.

[7/] Net Outlay estimates are based on current cost savings to date and anticipated cash management goals. They are expected to follow anticipated management decisions throughout the rate period that, along with actual market conditions, will impact revenues and expenses. Actual Net Outlays are volatile and are reported in Report on Budget Execution and Budgetary Resources (SF-133). Actual Net Outlays could differ from estimates due to changing market conditions, streamflow variability, continued restructuring of the electric industry, and other reasons.

Revenues, included in the Net Outlay formulation, are calculated consistent with cash management goals and assume a combination of adjustments. Assumed adjustments include the use of a combination of tools, including upcoming rate adjustment mechanisms, a net revenue risk adjustment, debt service refinancing strategies and/or short-term financial tools to manage net revenues and cash. Some of these potential tools will reduce costs rather than generate revenue, causing the same Net Outlay result. Adjustments for depreciation and 4(h)(10)(C) credits of the Northwest Power Act are also assumed.

This budget has been prepared in accordance with PAYGO. Under PAYGO all Bonneville budget estimates are treated as mandatory and are not subject to the discretionary caps included in the Budget Control Act of 2011. These estimates support activities that are separate from discretionary activities and accounts. Thus, any changes to Bonneville estimates cannot be used to affect any other budget categories which have their own dollar caps. Because Bonneville's obligations are and will be incurred under pre-existing legislative authority, Bonneville is not subject to a "pay-as-you-go" test regarding its revision of current-law funding estimates.

[8/] FY 2020 Net Outlays are calculated using Bonneville's audited actual revenue. FYs 2021 to 2026 Net Outlays are based on FY 2020 initial IPR assumptions and an escalation factor from using the FY 2018 White Book Loads and Resources Report.

BONNEVILLE POWER ADMINISTRATION
BPA STATUS of U.S. TREASURY BORROWING
CURRENT SERVICES

BP-4A

Fiscal Year

	2020				2021			
	Net Capital Obs	Net Capital Obs Subject to BA	Net Capital Expend.	Bonds Out-Standing	Net Capital Obs	Net Capital Obs Subject to BA	Net Capital Expend.	Bonds Out-Standing
Start-of-Year: Total	4,223	3,681	5,122	5,280	4,347	3,805	5,246	5,649
Plus: Annual Increase								
Cum.-Annual Treasury Borrowing	520	520	520	765	826	826	826	826
Treasury Borrowing (Cash)								
Less:								
BPA Bond Amortization	396	396	396	396	724	724	724	724
Net Increase/(Decrease):	124	124	124	369	102	102	102	102
Cum.-End-of-Year: Total	4,347	3,805	5,246	5,649	4,449	3,907	5,348	5,751
Total Remaining Treasury Borrowing Amount				2,051				1,949
Total Legislated Treasury Borrowing Amount				7,700				7,700

These notes are an integral part of this table.

In any given year, Bonneville may issue lower principal amount of bonds to the U.S. Treasury than forecast depending on net revenues, borrowing costs, and other cash management factors. In such cases, Bonneville accumulates a deferred borrowing balance that it accesses as necessary in the future.

Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

In this FY 2022 budget, Bonneville "bond(s)" refers to all bonds issued by Bonneville to and advances received from the U.S. Treasury. This reference is consistent with section 13 (a) of the Transmission Act, which defines Bonneville bonds as all bonds, notes, and other evidences of indebtednesses issued and sold by Bonneville to the U.S. Treasury.

As in the past, Bonneville may pursue future restructuring of total debt as opportunities arise.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

Bonneville reserve financing of $15 million annually was part of TS capital-PFIA for FYs 2018-2019.

Cumulative advance amortization payments as of the end of FY 2020 are $5,819 million.

Total includes BPA's self-financing activities and funds for Radio Spectrum Relocation. In addition, BPA has negotiated with the U.S. Treasury access to a $750 million short term note as part of the $7.7 billion borrowing authority.

BONNEVILLE POWER ADMINISTRATION
BPA STATUS of U.S. TREASURY BORROWING
CURRENT SERVICES
(in millions of dollars)

BP-4B

	2022				2023			
	Net Capital Obs	Net Capital Obs Subject to BA	Net Capital Expend.	Bonds Out-Standing	Net Capital Obs	Net Capital Obs Subject to BA	Net Capital Expend.	Bonds Out-Standing
Start-of-Year: Total	4,449	3,907	5,348	5,751	4,579	4,037	5,478	5,881
Plus: Annual Increase								
Cum.-Annual Treasury Borrowing	826	826	826	826	875	875	875	875
Treasury Borrowing (Cash)								
Less:								
Total BPA Bond Amortization	696	696	696	696	726	726	726	726
Net Increase/(Decrease):								
Total	130	130	130	130	149	149	149	149
Cum.-End-of-Year: Total	4,579	4,037	5,478	5,881	4,728	4,186	5,627	6,030
Total Remaining Treasury Borrowing Amount				1,819				1,670
Total Legislated Treasury Borrowing Amount				7,700				7,700

These notes are an integral part of this table.

In any given year, Bonneville may issue lower principal amount of bonds to the U.S. Treasury than forecast depending on net revenues, borrowing costs, and other cash management factors. In such cases, Bonneville accumulates a deferred borrowing balance that it accesses as necessary in the future.

Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

In this FY 2022 budget, Bonneville "bond(s)" refers to all bonds issued by Bonneville to and advances received from the U.S. Treasury. This reference is consistent with section 13 (a) of the Transmission Act, which defines Bonneville bonds as all bonds, notes, and other evidences of indebtednesses issued and sold by Bonneville to the U.S. Treasury.

As in the past, Bonneville may pursue future restructuring of total debt as opportunities arise.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

Bonneville reserve financing of $15 million annually was part of TS capital-PFIA for FYs 2018-2019.

Cumulative advance amortization payments as of the end of FY 2020 are $5,819 million.

Total includes BPA's self-financing activities and funds for Radio Spectrum Relocation. In addition, BPA has negotiated with the U.S. Treasury access to a $750 million short term note as part of the $7.7 billion borrowing authority.

BONNEVILLE POWER ADMINISTRATION
BPA STATUS of U.S. TREASURY BORROWING
CURRENT SERVICES
(in millions of dollars)

BP-4C Fiscal Year

	2024				2025			
	Net Capital Obs	Net Capital Obs Subject to BA	Net Capital Expend.	Bonds Out-Standing	Net Capital Obs	Net Capital Obs Subject to BA	Net Capital Expend.	Bonds Out-Standing
Start-of-Year: Total	4,728	4,186	5,627	6,030	4,986	4,444	5,885	6,288
Plus: Annual Increase								
Cum.-Annual Treasury Borrowing	936	936	936	936	1,017	1,017	1,017	1,017
Treasury Borrowing (Cash)								
Less:								
Total BPA Bond Amortization	678	678	678	678	689	689	689	689
Net Increase/(Decrease):								
Total	258	258	258	258	328	328	328	328
Cum.-End-of-Year: Total	4,986	4,444	5,885	6,288	5,314	4,772	6,213	6,616
Total Remaining Treasury Borrowing Amount				1,412				1,084
Total Legislated Treasury Borrowing Amount				7,700				7,700

These notes are an integral part of this table.

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Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

In this FY 2022 budget, Bonneville "bond(s)" refers to all bonds issued by Bonneville to and advances received from the U.S. Treasury. This reference is consistent with section 13 (a) of the Transmission Act, which defines Bonneville bonds as all bonds, notes, and other evidences of indebtednesses issued and sold by Bonneville to the U.S. Treasury.

As in the past, Bonneville may pursue future restructuring of total debt as opportunities arise.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

Bonneville reserve financing of $15 million annually was part of TS capital-PFIA for FYs 2018-2019.

Cumulative advance amortization payments as of the end of FY 2020 are $5,819 million.

Total includes BPA's self-financing activities and funds for Radio Spectrum Relocation. In addition, BPA has negotiated with the U.S. Treasury access to a $750 million short term note as part of the $7.7 billion borrowing authority.

BONNEVILLE POWER ADMINISTRATION
BPA STATUS of U.S. TREASURY BORROWING
CURRENT SERVICES
(in millions of dollars)

BP-4D

	Fiscal Year 2026			
	Net Capital Obs	Net Capital Obs Subject to BA	Net Capital Expend.	Bonds Out-Standing
Start-of-Year: Total	5,314	4,772	6,213	6,616
Plus: Annual Increase				
Cum.-Annual Treasury Borrowing	996	996	996	996
Treasury Borrowing (Cash)				
Less:				
Total BPA Bond Amortization	701	701	701	701
Net Increase/(Decrease):				
Total	295	295	295	295
Cum.-End-of-Year: Total	5,609	5,067	6,508	6,911
Total Remaining Treasury Borrowing Amount				789
Total Legislated Treasury Borrowing Amount				7,700

These notes are an integral part of this table.

In any given year, Bonneville may issue lower principal amount of bonds to the U.S. Treasury than forecast depending on net revenues, borrowing costs, and other cash management factors. In such cases, Bonneville accumulates a deferred borrowing balance that it accesses as necessary in the future.

Capital funding levels reflect external factors such as the significant changes affecting West Coast power and transmission markets, along with planned infrastructure investments designed to address the long-term needs of the region.

In this FY 2022 budget, Bonneville "bond(s)" refers to all bonds issued by Bonneville to and advances received from the U.S. Treasury. This reference is consistent with section 13 (a) of the Transmission Act, which defines Bonneville bonds as all bonds, notes, and other evidences of indebtednesses issued and sold by Bonneville to the U.S. Treasury.

As in the past, Bonneville may pursue future restructuring of total debt as opportunities arise.

Budget estimates included in this budget are subject to change due to rapidly changing economic and institutional conditions in the evolving electric utility industry.

Bonneville reserve financing of $15 million annually was part of TS capital-PFIA for FYs 2018-2019.

Cumulative advance amortization payments as of the end of FY 2020 are $5,819 million.

Total includes BPA's self-financing activities and funds for Radio Spectrum Relocation. In addition, BPA has negotiated with the U.S. Treasury access to a $750 million short term note as part of the $7.7 billion borrowing authority.

BONNEVILLE POWER ADMINISTRATION
POTENTIAL THIRD PARTY FINANCING TRANSPARENCY
(in millions of dollars)

BP-5

		Fiscal Year						
Transmission Services - Capital		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Main Grid	Requirements	5	26	13	6	12	14	9
Area & Customer Services		28	89	49	72	60	47	47
Upgrades & Additions		54	51	102	147	150	75	85
System Replacements		193	319	334	305	364	530	508
Projects Funded in Advance		89	70	56	61	48	35	35
Total, Transmission Services - Capital		370	555	553	591	634	702	685
Associated Project Costs - Capital								
Associated Project Costs	Requirem	178	272	264	281	300	307	314
Projects Funded in Advance[1/]		0	0	0	0	0	0	0
Total, Associated Project Costs - Capital		178	272	264	281	300	307	314
Federal and Non-Federal Funding								
Projects Funded in Advance	Source	89	70	56	61	48	35	35
U.S. Treasury Borrowing Authority		459	757	761	811	886	973	963
Scenario								
Projects Funded in Advance[1/]	Scenario	0	0	0	0	0	0	0
Third Party Financing		70	121	124	132	146	167	162
Alternate Treasury Borrowing Authority		NA	636	637	678	739	807	801

These notes are an integral part of this table.

1/ In this instance, Projects Funded in Advance represents prepayment of Power customers' bills reimbursed by future credits and third party non-federal financing for Conservation initiatives. Also this category includes those facilities and/or equipment where Bonneville retains control or ownership which are funded or financed by a third party, revenue, or with reserves, either in total or in part.

The table above shows both the potential use of U.S. Treasury borrowing authority for transmission capital projects based on this FY 2022 budget and the use adjusted for potential third-party financing to fund appropriate capital expenditures when feasible in lieu of U.S. Treasury borrowing. Estimates included in this FY 2022 budget are uncertain and may change due to revised capital investment plans, changing economic conditions, and an evolving financial market environment. The estimates of third-party financing included in the table show a reduction in the use of U.S. Treasury borrowing and do not reflect the actual notional third party financing commitment Bonneville may enter into in that particular year. The difference of reduction in use of U.S. Treasury borrowing and the actual notional third party financing commitment is primarily due to the difference in the timing of financing transactions between U.S. Treasury and third-party financing for capital projects with multi-year construction schedules.

Bonneville's Third Party Financing for Transmission Services consists primarily of lease-purchase agreements, which are capitalized obligations that enable Bonneville to acquire the use of transmission facilities over time. Bonneville also undertakes the construction and installation of facilities from funds that customers advance to Bonneville for construction of BPA-owned facilities that assist the customers in obtaining necessary transmission service from Bonneville. These customers receive monetary payment credits in bills for transmission services from Bonneville up to the amount of funds advanced to Bonneville, plus interest.

Bonneville's historical Third Party Financing amounts may vary over time due to re-assignment of certain lease-purchase agreements to Treasury Financing.

Bonneville Status of U.S. Treasury Borrowing with Potential Third Party Financing & PFIA Scenario

With the potential use of third party financing assumed in the scenario above, Bonneville's total remaining U.S. Treasury Borrowing Amount would be extended to the following amounts. See BP-4 BPA Status of Treasury Borrowing- Current Services.

	Fiscal Year						
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Start-of-Year: Total Bonds Outstanding	5,280	5,649	5,630	5,636	5,652	5,763	5,925
Plus:							
U.S. Treasury Borrowing (Cash)	765	826	826	875	936	1,017	996
Less:							
Potential Third Party Financing & PFIA	70	121	124	132	146	167	162
BPA Bond Amortization	396	724	696	726	678	689	701
Net Increase/(Decrease) Bonds Outstanding:	369	(19)	6	16	111	162	132
Cum.-End-of-Year: Total	5,649	5,630	5,636	5,652	5,763	5,925	6,057
Total Remaining U.S. Treasury Borrowing Amount	2,051	2,070	2,064	2,048	1,937	1,775	1,643
Total Legislated U.S.Treasury Borrowing Amount	7,700	7,700	7,700	7,700	7,700	7,700	7,700

U.S. TREASURY PAYMENTS

(in millions of dollars)

		FISCAL YEAR						
		2020	2021	2022	2023	2024	2025	2026
A.	**INTEREST ON BONDS & APPROPRIATIONS**							
	Bonneville Bond Interest							
1	Bonneville Bond Interest (net)	136	138	138	144	152	165	189
2	AFUDC [1/]	28	35	36	39	42	47	53
	Appropriations Interest							
3	Bonneville	0	0	0	0	0	0	0
4	Corps of Engineers [2/]	42	42	44	45	45	47	49
5	Lower Snake River Comp. Plan	0	0	0	0	0	0	0
6	Bureau of Reclamation [3/]	1	1	1	1	1	1	1
7	Bond Premiums paid/Discounts (not capitalized)	0	12	1	1	1	1	1
8	**Total Bond and Approp. Interest**	**208**	**228**	**220**	**230**	**242**	**261**	**294**
B.	**ASSOCIATED PROJECT COST**							
9	Bureau of Reclamation Irrigation Assistance	24	15	16	13	15	14	21
10	Bureau of Rec. O & M [4/]	1	0	0	0	0	0	0
11	Corps of Eng. O & M [4/]	2	0	0	0	0	0	0
12	L. Snake River Comp. Plan O & M [4/]	0	0	0	0	0	0	0
13	**Total Assoc. Project Costs**	**27**	**15**	**16**	**13**	**15**	**14**	**21**
C.	**CAPITAL TRANSFERS**							
	Amortization							
14	Bonneville Bonds [6/]	396	724	696	726	678	689	701
15	Bureau of Reclamation Appropriations	0	0	0	0	0	0	0
16	Corps of Engineers Appropriations	75	0	0	0	0	0	0
17	Lower Snake River Comp. Plan	0	0	0	0	0	0	0
18	Bonneville Appropriations	0	0	0	0	0	0	0
19	**Total Capital Transfers [/8]**	**471**	**724**	**696**	**726**	**678**	**689**	**701**
D.	**OTHER PAYMENTS**							
20	Unfunded Post-Retirement Liability [5/]	29	40	31	32	33	34	35
21	**TOTAL TREASURY PAYMENTS**	**736**	**1,007**	**963**	**1,001**	**968**	**998**	**1,050**

These notes are an integral part of this table.

1/ This interest cost is capitalized and included in BPA's Transmission System Development, System Replacements, and Associated Projects Capital programs. AFUDC is financed through the sale of bonds.

2/ Includes interest on construction funding for Corp of Engineers (Corps) fish bypass facilities at Corps dams in the Columbia River Basin, including Lower Monumental, Ice Harbor, and The Dalles.

3/ Includes payments paid by Reclamation to the U.S. Treasury on behalf of Bonneville.

4/ Costs for power O&M is funded directly by Bonneville as follows (in millions):

FISCAL YEAR	2020	2021	2022	2023	2024	2025	2026
Bureau of Reclamation	153	152	154	152	155	159	162
Corps of Engineers	240	253	253	253	259	265	270
Subtotal Bureau and Corps	393	404	406	404	414	424	433
Lower Snake River Comp. Plan	32	30	31	31	32	32	33
Total	425	435	437	435	446	456	466

5/ See Interest Expense, Pension and Post-retirement Benefits and Capital Transfers section of this budget for a complete discussion of these cost estimates.

6/ In this FY 2022 budget, Bonneville "bond(s)" refers to all bonds issued by Bonneville to and advances received from the U.S. Treasury. This reference is consistent with section 13 (a) of the Transmission Act, which defines Bonneville bonds as all bonds, notes, and other evidences of indebtednesses issued and sold by Bonneville to the U.S. Treasury.

Does not include Treasury bond premiums on refinanced Treasury bonds.

8/ FY 2020 data reflects audited actual capital transfer.

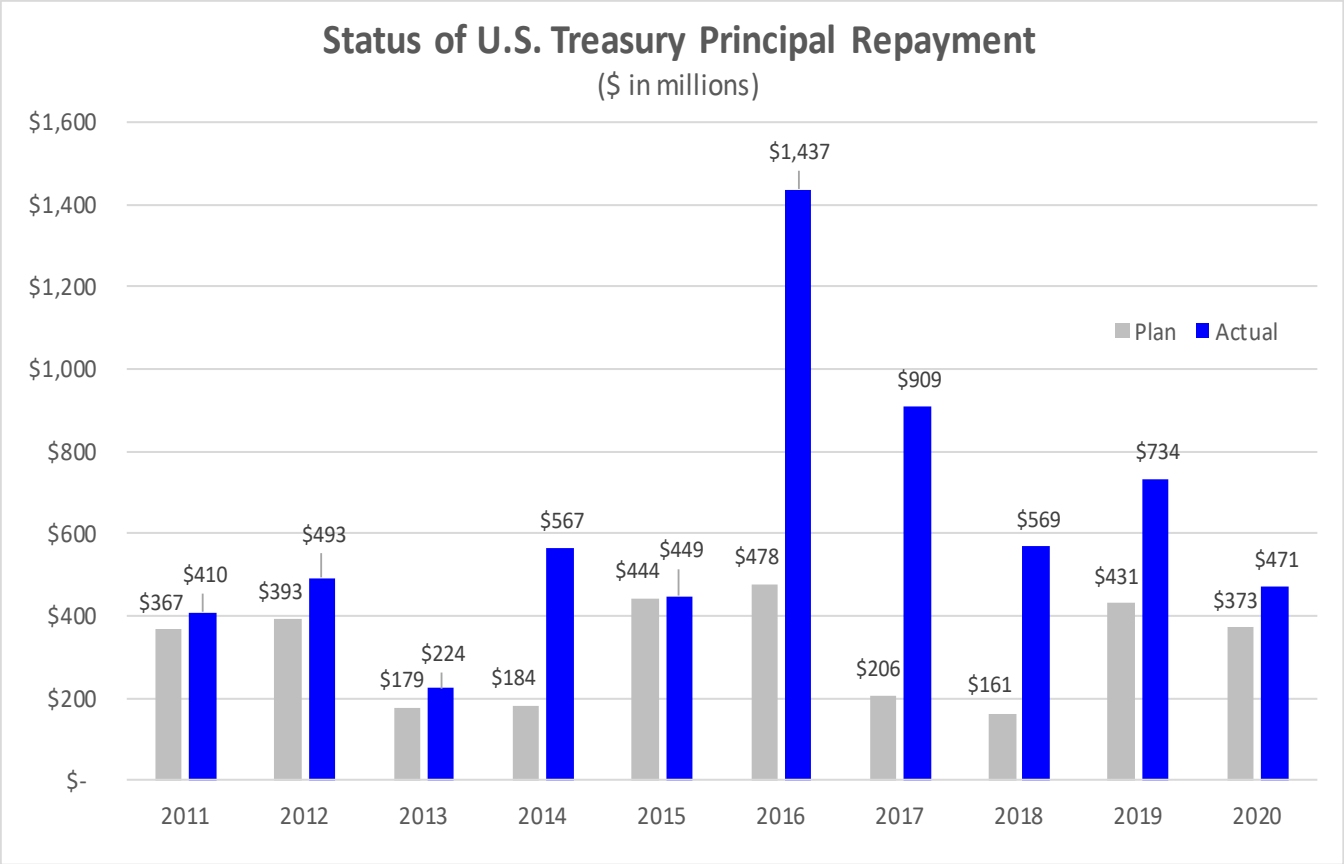


Chart Notes

[1/] This chart displays principal repayment only.

[2/] U.S. Treasury payment outyear estimates for planned amortization of principal are based on rate case estimates when available and are planned amortization for future rate case periods. These estimates may change due to revised capital investment plans, actual U.S. Treasury borrowing, and advanced amortization payments. Bonneville's aggregate FY 2020 payment to the U.S. Treasury was approximately $736 million. This was the 37th consecutive year that Bonneville made its scheduled payments to the U.S. Treasury on time and in full. The payment included $471.3 million in principal, which included $20 million in early retirement of higher interest rate U.S. Treasury debt, $208 million for interest, $24.1 million in irrigation assistance payments, and $29.5 million in pension and post-retirement benefits.

[3/] FYs 2002-2012 payments include portions of advance amortization amounts consistent with Bonneville's capital strategy plan and the Bonneville /Energy Northwest debt optimization program.

[4/] Advance amortization due to sale of transmission facilities includes $12.7 million in FY 2003, $5.3 million in FY 2006, $2.0 million in FY 2011, $0.4 million in FY 2013 and $0.4 million in FY 2014, and $0.6 million in FY 2017.

[5/] The cumulative balance of advance amortization payments as of the end of FY 2020 was in excess of $5.8 Billion.

[6/] FYs 2014-2020 include advance amortization under the Regional Cooperation Debt initiative with Energy Northwest (EN) under which EN extended maturities on Bonneville-backed debt which enabled the early amortization of higher cost appropriations.

OBJECT CLASSIFICATION STATEMENT

(in millions of dollars)

		ESTIMATES		
		2020	**2021**	**2022**
11.1	Full-time permanent	234	261	257
11.3	Other than full-time permanent	1	1	1
11.5	Other personnel compensation	70	78	77
11.9	**Total personnel compensation**	**304**	**340**	**334**
12.1	Civilian personnel benefits	160	179	176
13.0	Benefits for former personnel	0	0	0
21.0	Travel and transportation of persons	3	3	3
22.0	Transportation of things	1	1	1
23.1	Rental payments to GSA	0	0	0
23.2	Rents, other	31	35	35
23.3	Communication, utilities & misc. charges	10	11	11
25.1	Consulting Services	80	89	88
25.2	Other Services	2,658	2,528	2,483
25.5	R & D Contracts	3	4	4
26.0	Supplies and materials	41	46	45
31.0	Equipment	48	54	53
32.0	Lands and structures	78	87	86
41.0	Grants, subsidies, contributions	37	42	41
43.0	Interest and dividends	233	260	256
99.0	**Total obligations**	**3,685**	**3,680**	**3,615**

Estimate of Receipts
(in millions of dollars)

	Fiscal Year						
	2020	2021	2022	2023	2024	2025	2026
Reclamation Interest	1	1	1	1	1	1	1
Reclamation Amortization	0	0	0	0	0	0	0
Reclamation O&M	1	0	0	0	0	0	0
Reclamation Irrig. Assist.	24	15	16	13	15	14	21
Revenues Collected by Reclamation	-16	-7	-7	-7	-7	-7	-7
Distributed in Treasury Account (credit)							
Colville Settlement (credit)	-5	-5	-5	-5	-5	-5	-5
Total 1/ Reclamation Fund	**5**	**4**	**5**	**2**	**4**	**3**	**10**
Corps O&M							
CSRS	29	40	31	32	33	34	35
Total 2/ Repayments on miscellaneous costs	**29**	**40**	**31**	**32**	**33**	**34**	**35**

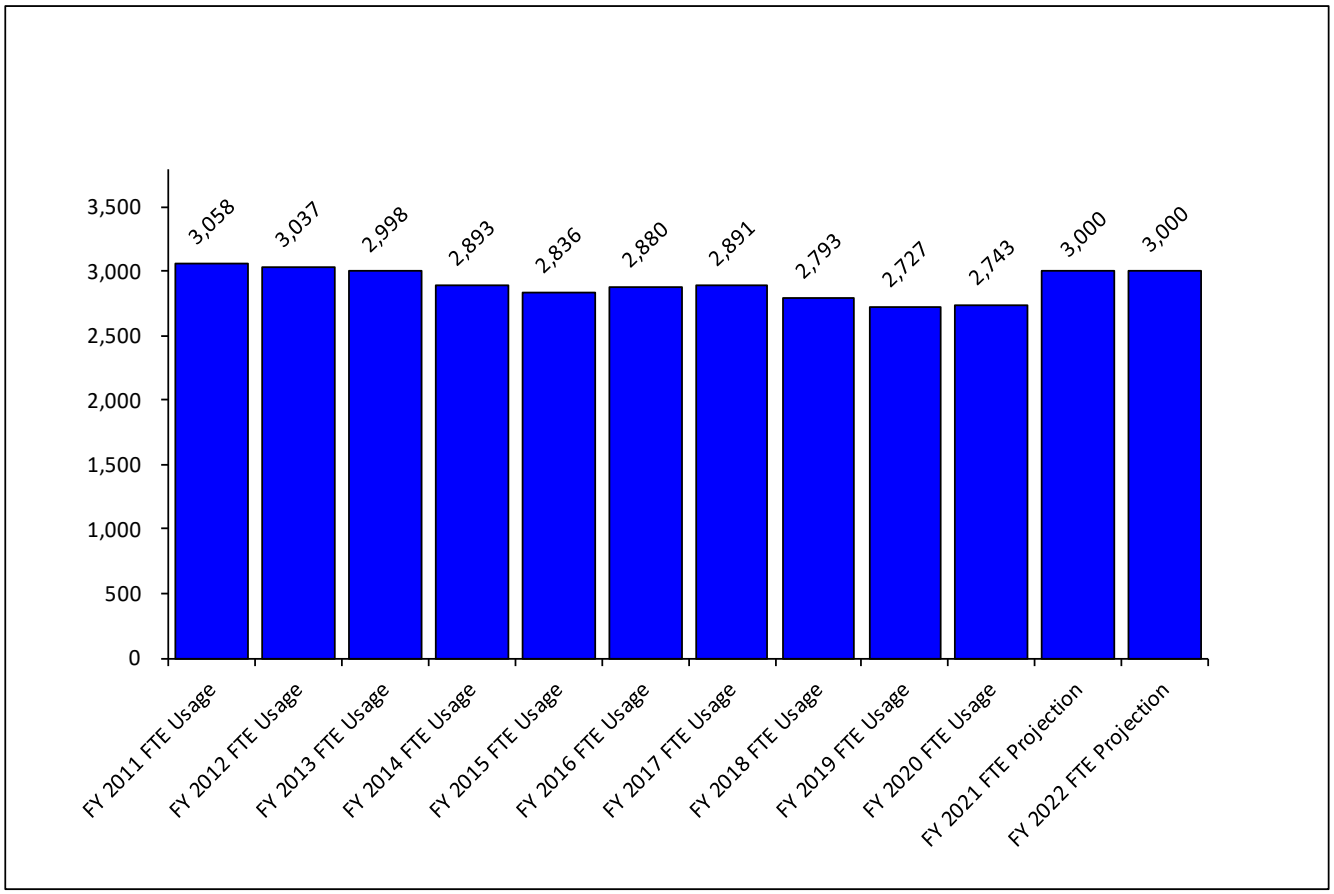
1/ Includes amortization of appropriations and irrigation assistance, and interest costs for Reclamation. The cost of power O&M for Reclamation is no longer included in Proprietary Receipts due to Direct Funding by Bonneville. Represents transfer to Account #895000.26

2/ The costs of power O&M for the Corps and Lower Snake River Comp. Plan are no longer included in Proprietary Receipts due to Direct Funding by Bonneville. Represents transfers to Account #892889, Repayments on misc. recoverable costs, not otherwise classified. Costs for power O&M is funded directly by Bonneville as follows (in millions)

	2020	2021	2022	2023	2024	2025	2026
Bureau of Reclamation	153	152	154	152	155	159	162
Corps of Engineers	240	253	253	253	259	265	270
Lower Snake River Comp. Plan	32	30	31	31	32	32	33
Total	**425**	**435**	**437**	**435**	**446**	**456**	**466**

See Interest Expense, Pension and Post-retirement Benefits and Capital Transfers section of this budget for a complete discussion of these cost estimates.

BONNEVILLE FTE



These notes are an integral part of this chart.

1. Actual FTE data is consistent with DOE personnel reports.

2. FTE outyear data are estimates and may change. Bonneville is facing a dynamic and changing transmission marketplace and operations while, at the same time, many of its employees are eligible to retire in the near future. It is important that Bonneville continue to attract and retain skilled individuals to meet the growing demands of a competitive and rapidly changing industry. Accordingly, FTE estimates may need to be adjusted in the future.

3. As of October 21, 2020 DOE HR staff has reported FY 2020 BPA's FTE usage at 2,743.

Total Cost of BPA Fish & Wildlife Actions

COST ELEMENT	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CAPITAL INVESTMENTS [1/]										
BPA FISH AND WILDLIFE	90.2	57.5	52.1	37.4	21.4	16.0	5.4	30.7	22.3	40.2
BPA SOFTWARE DEVELOPMENT COSTS	0.8	0.4	0.0	0.1	1.4	1.2	1.4	0.8	0.0	0.0
ASSOCIATED PROJECTS (FEDERAL HYDRO)	103.0	114.5	103.6	101.7	81.4	34.1	58.9	51.8	55.5	106.6
TOTAL CAPITAL INVESTMENTS	**193.9**	**172.3**	**155.7**	**139.2**	**104.1**	**51.4**	**65.7**	**83.2**	**77.9**	**146.7**
PROGRAM EXPENSES										
BPA DIRECT FISH AND WILDLIFE PROGRAM	221.1	248.9	239.0	231.8	258.2	258.1	254.7	258.7	240.4	238.1
FISH & WILDLIFE SOFTWARE EXPENSE COSTS			0.2	0.3	0.1	0.0	0.0	0.1	0.0	0.0
SUPPLEMENTAL MITIGATION PROGRAM EXPENSES [2/]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REIMBURSABLE/DIRECT-FUNDED PROJECTS [3/]										
O & M LOWER SNAKE RIVER HATCHERIES	24.5	22.0	28.7	31.0	30.9	28.6	26.0	31.4	26.7	31.9
O & M CORPS OF ENGINEERS	40.3	41.1	39.2	47.8	46.4	48.2	46.8	47.5	48.9	46.3
O & M BUREAU OF RECLAMATION	5.0	5.3	5.6	6.6	2.6	6.0	7.0	5.5	8.7	5.8
NW POWER AND CONSERVATION COUNCIL ALLOCATED @ 50%	4.5	4.6	5.0	4.9	4.9	5.4	5.4	5.5	5.6	5.6
SUBTOTAL (REIMB/DIRECT-FUNDED)	74.3	73.0	78.5	90.3	84.9	88.2	85.2	89.9	89.9	89.6
TOTAL OPERATING EXPENSES	**295.3**	**321.9**	**317.70**	**322.40**	**343.17**	**346.34**	**339.90**	**348.65**	**330.30**	**327.66**
PROGRAM RELATED FIXED EXPENSES [4/]										
INTEREST EXPENSE	79.2	80.6	89.1	83.4	89.2	85.6	58.6	41.0	39.7	32.5
AMORTIZATION EXPENSE	28.3	30.2	35.7	38.7	41.3	42.5	42.5	43.4	45.1	46.7
DEPRECIATION EXPENSE	19.6	20.7	18.6	19.2	20.1	20.1	20.3	20.8	21.0	21.1
TOTAL FIXED EXPENSES	**127.2**	**131.5**	**143.4**	**141.3**	**150.6**	**148.2**	**121.4**	**105.1**	**105.8**	**100.3**
GRAND TOTAL PROGRAM EXPENSES	**422.5**	**453.4**	**461.1**	**463.7**	**493.7**	**494.6**	**461.3**	**453.7**	**436.1**	**428.0**
FORGONE REVENUES AND POWER PURCHASES										
FOREGONE REVENUES	156.7	152.2	135.5	122.7	195.8	76.6	9.6	2.9	174.4	33.4
BPA POWER PURCH. FOR FISH ENHANCEMENT	70.7	38.5	85.8	196.2	67.5	50.3	(20.5)	24.3	177.6	150.0
TOTAL FOREGONE REVENUES AND POWER PURCHASES	**227.4**	**190.7**	**221.3**	**318.9**	**263.3**	**126.9**	**(10.9)**	**27.2**	**352.0**	**183.4**
TOTAL PROGRAM EXPENSES, FOREGONE REVENUES, & POWER PURCHASES	**649.9**	**644.1**	**682.4**	**782.6**	**757.0**	**621.5**	**450.4**	**480.9**	**788.1**	**611.5**
CREDITS										
4(h)(10)(C)	(85.3)	(77.0)	(84.1)	(103.9)	(77.7)	(72.6)	(53.7)	(70.1)	(98.2)	(95.5)
FISH COST CONTINGENCY FUND	-	-	-	-	-	-	-	-	-	-
TOTAL CREDITS	**(85.3)**	**(77.0)**	**(84.1)**	**(103.9)**	**(77.7)**	**(72.6)**	**(53.7)**	**(70.1)**	**(98.2)**	**(95.5)**

This information has been made publicly available by BPA on 10/30/2020. The figures shown are consistent with audited actuals that contain Agency approved financial information, except for forgone revenues and power purchases which are estimates and do not contain Agency approved financial information

1/ Capital Investments include both BPA's direct Fish and Wildlife Program capital investments, funded by BPA's Treasury borrowing, and "Associated Projects", which include capital investments at Corps of Engineers' and Bureau of Reclamation projects, funded by appropriations and repaid by BPA. The negative amount in FY 1997 reflects a decision to reverse "plant-in-service" investment that was never actually placed into service. The annual expenses associated with these investments are included in "Program-Related Fixed Expenses", below.

2/ Includes High Priority and Action Plan Expenses and other supplemental programs.

3/ "Reimbursable/Direct-Funded Projects" includes the portion of costs BPA pays to or on behalf of other entities that is determined to be for fish and wildlife purposes.

4/ "Fixed Expenses" include depreciation, amortization and interest on investments on the Corps of Engineers' projects, and amortization and interest on the investments associated with BPA's direct Fish and Wildlife Program.

GENERAL PROVISIONS-DEPARTMENT OF ENERGY
[(INCLUDING TRANSFER OF FUNDS)]

SEC. 301. (a) No appropriation, funds, or authority made available by this title for the Department of Energy shall be used to initiate or resume any program, project, or activity or to prepare or initiate Requests For Proposals or similar ar-rangements (including Requests for Quotations, Requests for Information, and Funding Opportunity Announcements) for a program, project, or activity if the program, project, or activity has not been funded by Congress.

(b) (1) Unless the Secretary of Energy notifies the Committees on Appropriations of both Houses of Congress at least 3 full business days in advance, none of the funds made available in this title may be used to-

(A) make a grant allocation or discretionary grant award totaling $1,000,000 or more;

(B) make a discretionary contract award or Other Transaction Agreement totaling $1,000,000 or more, including a contract covered by the Federal Acquisition Regulation;

(C) issue a letter of intent to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B); or

(D) announce publicly the intention to make an allocation, award, or Agree-ment in excess of the limits in subparagraph (A) or (B).

(2) The Secretary of Energy shall submit to the Committees on Appropriations of both Houses of Congress within 15 days of the conclusion of each quarter a report detailing each grant allocation or discretionary grant award totaling less than $1,000,000 provided during the previous quarter.

(3) The notification required by paragraph (1) and the report required by paragraph (2) shall include the recipient of the award, the amount of the award, the fiscal year for which the funds for the award were appropriated, the account and program, project, or activity from which the funds are being drawn, the title of the award, and a brief description of the activity for which the award is made.

(c) The Department of Energy may not, with respect to any program, project, or activity that uses budget authority made available in this title under the heading "Department of Energy-Energy Programs", enter into a multiyear contract, award a multiyear grant, or enter into a multiyear cooperative agreement unless-

(1) the contract, grant, or cooperative agreement is funded for the full period of performance as anticipated at the time of award; or

(2) the contract, grant, or cooperative agreement includes a clause conditioning the Federal Government's obligation on the availability of future year budget authority and the Secretary notifies the Committees on Appropriations of both Houses of Congress at least 3 days in advance.

(d) Except as provided in subsections (e), (f), and (g), the amounts made available by this title shall be expended as authorized by law for the programs, projects, and activities specified in the "Final Bill" column in the "Department of Energy" table included under the heading "Title III-Department of Energy" in the ex-planatory statement described in section 4 (in the matter preceding division A of this consolidated Act).

(e) The amounts made available by this title may be reprogrammed for any program, project, or activity, and the Department shall notify[, and obtain the prior approval of,] the Committees on Appropriations of both Houses of Congress at least 30 days prior to the use of any proposed reprogramming that would cause any program, project, or activity funding level to increase or decrease by more than $5,000,000 or 10 percent, whichever is less, during the time period covered by this Act.

(f) None of the funds provided in this title shall be available for obligation or expenditure through a reprogramming of funds that-

(1) creates, initiates, or eliminates a program, project, or activity;

(2) increases funds or personnel for any program, project, or activity for which funds are denied or restricted by this Act; or

(3) reduces funds that are directed to be used for a specific program, project, or activity by this Act.

(g)(1) The Secretary of Energy may waive any requirement or restriction in this section that applies to the use of funds made available for the Department of Energy if compliance with such requirement or restriction would pose a substan-tial risk to human health, the environment, welfare, or national security.

(2) The Secretary of Energy shall notify the Committees on Appropriations of both Houses of Congress of any waiver under paragraph (1) as soon as practic-able, but not later than 3 days after the date of the activity to which a require-ment or restriction would otherwise have applied. Such notice shall include an explanation of the substantial risk under paragraph (1) that permitted such waiver.

(h) The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

SEC. 302. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 3094) during fiscal year [2021] 2022 until the enactment of the Intelligence Authorization Act for fiscal year [2021] 2022.

SEC. 303. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of Enterprise Assessments to ensure the project is in compliance with nuclear safety require-ments.

SEC. 304. None of the funds made available in this title may be used to approve critical decision-2 or critical decision-3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

SEC. 305. Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), upon a determination by the President in this fiscal year that a regional supply shortage of refined petroleum product of significant scope and duration exists, that a severe increase in the price of refined petroleum product will likely result from such shortage, and that a draw down and sale of refined petroleum product would assist directly and significantly in reducing the adverse impact of such shortage, the Secretary of Energy may draw down and sell refined petroleum product from the Strategic Petroleum Reserve. Proceeds from a sale under this section shall be deposited into the SPR Petroleum Account established in section 167 of the Energy Policy and Conservation Act (42 U.S.C. 6247), and such amounts shall be available for obligation, without fiscal year limitation, consistent with that section.

[SEC. 306. (a) Of the offsetting collections, including unobligated balances of such collections, in the "Department of Energy-Power Marketing Administra-tion-Colorado River Basins Power Marketing Fund, Western Area Power Admin-istration", $21,400,000 shall be transferred to the "Department of the Interior-Bur-eau of Reclamation-Upper Colorado River Basin Fund" for the Bureau of Reclam-ation to carry out environmental stewardship and endangered species recovery efforts.

(b) No funds shall be transferred directly from "Department of Energy-Power Marketing Administration-Colorado River Basins Power Marketing Fund, Western Area Power Administration" to the general fund of the Treasury in the current fiscal year.]

TITLE V-GENERAL PROVISIONS
(INCLUDING TRANSFER OF FUNDS)

SEC. 501. None of the funds appropriated by this Act may be used in any way, directly or indirectly, to influence congressional action on any legislation or appro-priation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913.

[SEC. 502. (a) None of the funds made available in title III of this Act may be transferred to any department, agency, or instrumentality of the United States Government, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a depart-ment, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(b) None of the funds made available for any department, agency, or instrumentality of the United States Government may be transferred to accounts funded in title III of this Act, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(c) The head of any relevant department or agency funded in this Act utilizing any transfer authority shall submit to the Committees on Appropriations of both Houses of Congress a semiannual report detailing the transfer authorities, except for any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality, used in the previous 6 months and in the year-to-date. This report shall include the amounts transferred and the purposes for which they were transferred, and shall not replace or modify existing notification require-ments for each authority.]

SEC. [503]*502*. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations).

SEC. [504]*503*. (a) None of the funds made available in this Act may be used to maintain or establish a computer network unless such network blocks the viewing, downloading, and exchanging of pornography.

(b) Nothing in subsection (a) shall limit the use of funds necessary for any Federal, State, Tribal, or local law enforcement agency or any other entity carrying out criminal investigations, prosecution, or adjudication activities.

[SEC. 505. (a) Requirements relating to non-Federal cost-share grants and co-operative agreements for the Delta Regional Authority under section 382D of the Agricultural Act of 1961 and Consolidated Farm and Rural Development Act (7 U.S.C. 2009aa-3) are waived for grants awarded in fiscal year 2020 and in sub-sequent years in response to economic distress directly related to the impacts of the Coronavirus Disease (COVID-19).

(b) Requirements relating to non-Federal cost-share grants and cooperative agreements for the Northern Border Regional Commission under section 15501(d) of title 40, United States Code, are waived for grants awarded in fiscal year 2020 and in subsequent years in response to economic distress directly related to the impacts of the Coronavirus Disease (COVID-19).

(c) Requirements relating to non-Federal cost-share grants and cooperative agreements for the Denali Commission are waived for grants awarded in fiscal year 2020 and in subsequent years in response to economic distress directly re-lated to the impacts of the Coronavirus Disease (COVID-19).]

SEC. [506]*504*. Of the unavailable collections currently in the United States Enrichment Corporation Fund, [$291,000,000] $415,670,000 shall be transferred to and merged with the Uranium Enrichment Decontamination and Decommis-sioning Fund and shall be available only to the extent provided in advance in ap-propriations Acts.