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, [$3,460,000,000]*$3,826,116,000*, to remain available until expended: Provided, That of such amount, [$223,000,000]*225,623,000* shall be available until September 30, [2024]*2025*, for program direction.

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 2022 Enacted[1]	FY 2023 Enacted[1]	FY 2024 Request	FY 2023 Request vs FY 2022 Request
3,200,000	3,460,000	3,826,116	+366,116

Overview

The Office of Energy Efficiency and Renewable Energy (EERE) is the largest investor in clean energy technology development in the Federal Government. EERE's mission is to accelerate the research, development, demonstration, and deployment (RDD&D) 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 opportunity 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.

EERE's FY 2024 investment strategy continues its focus on five programmatic priority areas[2] that are central pillars in lowering the U.S. greenhouse gas (GHG) profile:

- Decarbonizing the electricity sector: To transition to a carbon pollution-free electricity sector by 2035, EERE will support technologies that will allow the U.S. to generate all U.S. electricity from clean, renewable sources.
- Decarbonizing transportation across all modes: air, sea, rail, and road: EERE will develop, demonstrate, and deploy technologies that can cost-effectively decarbonize all modes of transportation, including electrification of on-road vehicles, sustainable aviation fuel, and hydrogen fuel cells for long-haul heavy-duty trucks.
- Decarbonizing energy-intensive industries: EERE's focus is reducing GHG emissions across the industrial sector, with an emphasis on the highest-emitting sectors (e.g., iron/steel, cement/concrete, chemicals, food production).
- Reducing the carbon footprint of buildings: EERE will use a multi-prong approach to reducing the carbon footprint of the U.S. building stock by 50 percent by 2035 while maintaining or improving affordability, comfort, and performance – first, by decarbonizing the power grid, which in turn decarbonizes the electricity that serves buildings; second, by electrifying a significant share of building end uses that currently use fossil fuels, such as space and water heating; and finally, by significantly improving the efficiency of buildings and equipment, including heating and lighting systems, as well as the building envelope.
- Decarbonizing the agriculture sector, specifically focused on the nexus between energy and water: EERE's focus is reducing GHG emissions in the agricultural sector through development of biofuels, greater efficiency of off-road agricultural vehicles, on-site production of animal waste to clean energy, and better understanding and prediction of water flow to design more water and energy efficient irrigation systems. This work will be additive and complementary to the Department of Agriculture's work.

In addition, the following four crosscutting principles, or key emphasis areas, drive EERE work:

- Building the clean energy economy in a way that benefits all Americans. The Department must address environmental injustices that disproportionately affect communities of color, low-income communities, and indigenous communities.
- Fostering a diverse STEM workforce. The Department will increase awareness of clean energy job opportunities at minority-serving institutions and ensure that organizations receiving EERE funding are thinking through diversity and equity in their own work.
- Developing more robust workforce training opportunities to build a pipeline for permanent, good-paying jobs for the clean energy workforce.
- Working closely and learning from state and local governments.

[1] Includes funding for the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office Manufacturing and Energy Supply Chains (MESC), appropriated to EERE but managed by the Undersecretary for Infrastructure.
[2] Please note because investments can support multiple priority areas, there is overlap among the totals.

Complementing individual program efforts, the Request includes several jointly-developed, -managed, and -funded investments designed to advance these key emphasis areas.

In FY 2024, EERE will continue partnering across the Department to provide crosscutting support for the Communities Local Energy Action Program (LEAP), an initiative designed to help low-income, energy-overburdened communities – and, in particular, communities that are experiencing direct environmental justice impacts or direct economic impacts from a shift away from historical reliance on fossil fuels – take direct control of their clean energy future.

Highlights and Major Changes in the FY 2024 Budget Request

In FY 2024, EERE will invest $3,826,116,000 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 described above, and through the lens of its four key emphasis areas. The Request prioritizes increased investments to reduce emissions drastically in the near term, while investing in research to ensure American leadership and competitiveness in advanced clean energy technology. Through its Corporate Support pillar that serves as the central organization for all EERE products, services, processes, and systems, EERE will continue to streamline and enhance its operations; recruit, equip, and retain the workforce necessary to execute its mission; and conduct rigorous analysis and evaluations of its portfolio.

Sustainable Transportation & Fuels supports research, development, demonstration & deployment **(**RDD&D**)** to increase access to domestic, clean transportation fuels and improve the energy efficiency, convenience, and affordability of transporting people and goods.

Vehicle Technologies supports RD&D of efficient and sustainable transportation technologies that will improve energy efficiency, fuel economy, and enable America to use less petroleum. This Request prioritizes expanding demonstration and deployment projects to accelerate the nationwide adoption and deployment of electric vehicles and charging infrastructure, especially to benefit underserved communities. Increased funding continues research for next generation lithium-ion batteries, develops new recycling processing technologies, and scales up lithium battery recycling, and addresses decarbonizing non-road sectors.

Bioenergy Technologies advances technologies that convert domestic biomass and other waste resources into affordable, low-carbon biofuels and bioproducts. This Request increases support for Sustainable Aviation Fuel (SAF) RDD&D, including funds to construct and operate integrated biorefineries at demonstration scale that are capable of producing SAFs, and identify alternative pathways and feedstocks.

Hydrogen and Fuel Cell Technologies supports efforts to enable widespread adoption of hydrogen and fuel cell technologies. The Request focuses on RD&D to enable more affordable and durable fuel cell systems for vehicle and stationary markets. The Request increases RD&D of clean hydrogen production, delivery, and storage, including materials development, and integration with diverse net-zero emissions generation sources to support the Hydrogen Energy EarthShot and the H2@Scale initiative – this includes increased funding to demonstrate the use of low greenhouse gas (GHG) hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production.

Renewable Energy supports RDD&D to reduce the costs and accelerate the integration and utilization of renewable energy technologies as part of a reliable, secure, and resilient, fully decarbonized electricity system by 2035 and a net zero energy system by 2050.

Renewable Energy Grid Integration supports system-wide planning and operation of grids with high levels of variable renewable energy and includes improved technologies, tools, data, and operational practices as well as system-level simulations and demonstrations to validate the safety, reliability, and affordability of power systems.

Solar Energy Technologies accelerates the development and deployment of solar technologies – creating many thousands of good-paying jobs in the process – while supporting the reliability, resilience, and security of the U.S. electric grid. The Request increases funding for demonstration of technologies to operate and control a power system with

increasing levels of solar energy. It also includes investments in technologies to operate and control a power system with increasing levels of solar energy.

Wind Energy Technologies 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. The Request prioritizes (1) Near-term Offshore Wind (NOW) initiative, which is focused on accelerating near-term fixed-bottom offshore wind development through R&D and (2) the Floating Offshore Wind Accelerated Research and Development (FORWARD) program, a major body of R&D supporting the DOE Floating Offshore Wind EarthShot. In addition, the Request continues increased support for cross-technology investments that leverage wind energy technologies.

Water Power Technologies supports a broad portfolio of research activities to strengthen the body of scientific and engineering knowledge and support industry efforts to develop, maintain, and deploy hydropower and marine energy technologies at all scales. The Request focuses primarily on increasing hydropower flexibility for the grid. It increases funding for early-stage demonstrations in irrigation modernization and technologies to expand demonstrations and technical assistance for new, low-impact hydropower by investing in demonstration of technologies to power nonpowered dams or infrastructure. This includes the launch of one or more Regional Energy-Water Facilities to focus on validating and testing technologies and solutions to scale water and energy management solutions for potential commercial use.

Geothermal Technologies supports the deployment of geothermal energy in both the electric and non-electric sectors to help reach a carbon pollution-free electricity sector by 2035 and a net-zero economy by 2050. The Request prioritizes increased funding for the Enhanced Geothermal EarthShot as well as a new portfolio focused on advanced materials and high temperature components to enable downhole development in Enhanced Geothermal Systems (EGS) environments. Efforts will increase focus on the R&D and validation of new drilling and zonal isolation techniques that are required to reduce costs and achieve the DOE target. The Request also continues support for the Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE) consortium.

Buildings & Industry supports RDD&D of high impact technologies to increase energy efficiency, transform the grid edge to support all sector decarbonization goals, and reduce on-site emissions from our nation's homes, buildings, and industrial facilities while also strengthening U.S. manufacturing competitiveness and producing thousands of good-paying jobs.

Industrial Efficiency and Decarbonization accelerates the innovation and adoption of cost-effective technologies to increase energy efficiency and reduce GHG emissions in the U.S. industrial sector. This Request increases investment in industry-specific decarbonization RD&D with initiatives focusing on energy and emission-intensive industries. It also increases investments in priority cross-sector technologies for decarbonization based on the DOE Industrial Decarbonization Roadmap, including support of the Industrial Heat EarthShot. The Request supports continued technical assistance to increase the adoption of decarbonization technologies, including an expanded Onsite Energy program and an increased focus on energy-intensive sectors in the Better Plants and Better Climate Challenges.

Advanced Manufacturing and Materials Technologies invests in next-generation energy-related materials and manufacturing technologies needed to drive U.S. industrial competitiveness and enable economy-wide decarbonization by 2050. The Request includes an increase for advanced manufacturing and materials research to develop technologies, such as processing, separations, and recycling technologies, needed to improve the availability of critical materials and increase the resilience of materials supply chains. The Request also increases circular economy-related research supporting design for recyclability, recycling, and remanufacturing processes for multiple material classes. In addition, the Request supports advances in additive manufacturing and smart manufacturing, as well as manufacturing advances for high performance materials, emerging battery technologies, and power electronics.

Building Technologies invests in high-impact RDD&D, adoption acceleration, and regulatory mechanisms to achieve a decarbonized building sector by 2050 by reducing the energy intensity of buildings and direct emissions from buildings, while enhancing integration of buildings with a low carbon grid. The Request increases RD&D to lower the equipment and

installation cost and accelerate the adoption of heating and cooling technologies that minimize emissions. The Request increases RD&D on the transformation of the grid edge with buildings as the point of grid interaction with heat pumps, building envelope and controls, electric transportation, and on-site solar and storage through Connected Communities. The Request expands engagement and support of local communities and organizations to rapidly scale equitable building retrofits through the Buildings Upgrade Prize and expanded Better Buildings and Better Climate Challenges.

Corporate Support Programs include a range of activities to continuously improve EERE organizational efficiency, effectiveness, and responsiveness, with a focus on human capital, systems and tools, program and project management, and laboratory facilities and infrastructure as part of EERE's stewardship of the National Renewable Energy Laboratory (NREL) in Golden, Colorado. This investment also includes support for crosscutting strategic programs that advance the EERE mission.

Facilities and Infrastructure ensures that EERE fulfills its role as the steward of NREL by maintaining and upgrading key research and support infrastructure to not only enable the development of innovative technology solutions but also attract world-class research scientists**.** The Request prioritizes:

- Increased investments in the Advanced Research in Integrated Energy Systems (ARIES) initiative, focused on solving the complex problem of controlling interactions between millions of distributed assets.
- 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.
- Conduct extensive planning for future construction of the 18th National Laboratory facility. DOE will apply the proposed funding to scale up an existing research facility at an Historically Black College and University (HBCU) or Minority-Serving Institution (MSI) or towards construction of an entirely new research facility at an HBCU, MSI, or consortium of such institutions, creating a pathway to National Laboratory designation.

Program Direction 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, data management, IT and systems support, and Headquarters (HQ) and field site non-laboratory facilities and infrastructure.

Strategic Programs support high-impact, integrative activities most efficiently executed by a single crosscutting organization, in coordination with EERE technology programs and other DOE offices. This includes support for crosscutting strategic analysis, activities that inform key audiences and stakeholders about EERE work to enable a clean energy economy, and work to address high energy costs, reliability, and inadequate infrastructure challenges faced by islands and remote communities as part of the Energy Transitions Initiative. The Request also includes funding to expand international collaboration and coordination.

Energy Efficiency and Renewable Energy
($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted	
				$	%
Sustainable Transportation & Fuels					
Vehicle Technologies	420,000	455,000	526,942	71,942	16%
Bioenergy Technologies	262,000	280,000	323,000	43,000	15%
Hydrogen and Fuel Cell Technologies	157,500	170,000	163,075	(6,925)	-4%
Renewable Energy					
Renewable Energy Grid Integration	40,000	45,000	59,066	14,066	31%
Solar Energy	290,000	318,000	378,908	60,908	19%
Wind Energy	114,000	132,000	385,000	253,000	192%
Water Power	155,300	179,000	229,769	50,769	28%
Geothermal Technologies	109,500	118,000	216,000	98,000	83%
Buildings & Industry					
Advanced Manufacturing	403,000				
Advanced Materials & Manufacturing Technologies		183,500	241,497	57,997	32%
Industrial Efficiency & Decarbonization		266,500	394,245	127,745	48%
Building Technologies	307,500	332,000	347,841	15,841	5%
Corporate Support					
Program Direction	172,184	186,000	225,623	39,623	21%
Strategic Programs	20,000	21,000	57,759	36,759	175%
Facilities and Infrastructure	148,000	205,000	277,391	72,391	35%
Operations and Maintenance	*93,590*	*102,370*	*118,865*	*16,495*	*16%*
Facility Management	*46,410*	*57,630*	*66,526*	*8,896*	*15%*
Establish DOE 18th National Laboratory	*0*	*0*	*35,000*	*+35,000*	*100%*
21-EE-001-Energy Materials and Processing at Scale (EMAPS)	*8,000*	*45,000*	*57,000*	*12,000*	*27%*
Subtotal	**2,598,984**	**2,891,000**	**3,826,116**	**935,116**	**32%**
Congressionally Directed Spending	77,047				
Total, EERE Organization	**2,676,031**	**2,891,000**	**3,826,116**	**935,116**	**32%**
Undersecretary for Infrastructure (EERE Appropriated funding)					
State and Community Energy Programs Total	453,973	493,000			
Manufacturing and Energy Supply Chains Total	15,999	19,000			
Federal Energy Management Program Total	53,997	57,000			
Grand Total, EERE Appropriation	**3,200,000**	**3,460,000**	**3,826,116**	**366,116**	**11%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $76,033,310; STTR $10,416,555
- FY 2023 Enacted: SBIR: $62,406,624; STTR $8,775,932
- FY 2024 Request: SBIR: $95,171,000; STTR: $13,385,000

Bipartisan Infrastructure Law (BIL) Investments

The Office of **Energy Efficiency and Renewable Energy (EERE)** was appropriated funds through the Infrastructure Investment and Jobs Act (IIJA) (P.L. 117-58). Not all IIJA activities will be managed by the organization to which funds were appropriated. In February 2022, the Department announced an organizational realignment, establishing new Office of the Under Secretary for Infrastructure (S3). This realignment was intended to establish a structure to effectively implement the clean energy investments provided through IIJA. In the FY 2023 Request, funding from EERE was functionally realigned to stand up four new offices: State and Community Energy Programs (SCEP), Manufacturing and Energy Supply Chains (MESC), Federal Emergency Management Program (FEMP), and Grid Deployment Office (GDO). Activities are itemized below.

Appropriated Funding Organization	**FY 2022 IIJA Funding**	**FY 2023 IIJA Funding**	**FY 2024 IIJA Funding**	**Managing Organization**
Energy Efficiency and Renewable Energy (EERE)				
Lithium-Ion Battery Recycling Prize Competition	$10,000,000			EERE
Battery and Critical Mineral Recycling - Battery Recycling RD&D	$60,000,000			EERE
Electric Drive Vehicle Battery Recycling and Second-Life Applications Program	$40,000,000	$40,000,000	$40,000,000	EERE
Clean Hydrogen Manufacturing Recycling Research, Development, and Demonstration Program	$100,000,000	$100,000,000	$100,000,000	EERE
Clean Hydrogen Electrolysis Program	$200,000,000	$200,000,000	$200,000,000	EERE
Pumped Storage Hydropower Wind and Solar Integration and System Reliability Initiative	$10,000,000			EERE
Cost-effective Codes Implementation for Efficiency and Resilience	$45,000,000	$45,000,000	$45,000,000	EERE
Hydropower Research, Development, and Demonstration	$36,000,000			EERE
Marine Energy Research, Development, and Demonstration	$70,400,000			EERE
National Marine Energy Centers	$40,000,000			EERE
Enhanced Geothermal Systems Demonstrations	$84,000,000			EERE
Wind Energy Technology Program	$60,000,000			EERE
Wind Energy Technology Manufacturing Recycling Research, Development, and Demonstration Program	$40,000,000			EERE
Solar Energy Research and Development	$40,000,000			EERE
Advanced Solar Energy Manufacturing Initiative	$20,000,000			EERE
Solar Energy Technology Recycling Research, Development, and Demonstration Program	$20,000,000			EERE
Total, EERE Program	**$875,400,000**	**$385,000,000**	**$385,000,000**	**EERE**
Office of the Under Secretary for Infrastructure (S3)				
Assisting Federal Facilities with Energy Conservation Technologies Grant Program	$250,000,000			FEMP

Appropriated Funding Organization	FY 2022 IIJA Funding	FY 2023 IIJA Funding	FY 2024 IIJA Funding	Managing Organization
Hydroelectric Efficiency Improvement Incentives	$75,000,000			GDO
Hydroelectric Production Incentives	$125,000,000			GDO
Maintaining and Enhancing Hydroelectricity Incentives	$276,800,000	$276,800,000		GDO
Advanced Energy Manufacturing and Recycling Grant Program	$150,000,000	$150,000,000	$150,000,000	MESC
Battery and Critical Mineral Recycling - Retailers as Collection Points	$15,000,000			MESC
Battery and Critical Mineral Recycling - State and Local Programs	$50,000,000			MESC
Battery Manufacturing and Recycling Grants	$600,000,000	$600,000,000	$600,000,000	MESC
Battery Material Processing Grants	$600,000,000	$600,000,000	$600,000,000	MESC
Energy Efficient Transformer Rebates	$10,000,000			MESC
Extended Product System Rebates	$10,000,000			MESC
Implementation Grants for Industrial Research and Assessment Centers	$80,000,000	$80,000,000	$80,000,000	MESC
Industrial Research and Assessment Centers	$30,000,000	$30,000,000	$30,000,000	MESC
State Manufacturing Leadership	$50,000,000			MESC
Building, Training, and Assessment Centers	$10,000,000			SCEP
Career Skills Training	$10,000,000			SCEP
Energy Auditor Training Grant Program	$40,000,000			SCEP
Energy Efficiency and Conservation Block Grant Program	$550,000,000			SCEP
Energy Efficiency Materials Pilot Program	$50,000,000			SCEP
Energy Efficiency Revolving Loan Fund Capitalization Grant Program	$250,000,000			SCEP
Grants for Energy Efficiency Improvements and Renewable Improvements at Public School Facilities	$100,000,000	$100,000,000	$100,000,000	SCEP
State Energy Program	$500,000,000			SCEP
Weatherization Assistance Program	$3,500,000,000			SCEP
Total, S3 Program	**$7,331,800,000**	**$1,836,800,000**	**$1,560,000,000**	**S3**
Total, EERE IIJA Coordination	**$8,207,200,000**	**$2,221,800,000**	**$1,945,000,000**	

Inflation Reduction Act (IRA) Investments

The Office of **Energy Efficiency and Renewable Energy (EERE)** was appropriated funds through the Inflation Reduction Act of 2022 (IRA) (PL 117-169) to support critical facilities and infrastructure activities, as shown in the table below.

Appropriated Funding Organization	FY 2022 IRA Funding	Managing Organization
Energy Efficiency and Renewable Energy (EERE)		
National Laboratory Infrastructure – Sec 50172(d)	$150,000	EERE
Total, EERE Program	**$150,000**	

Appropriated Funding Organization	FY 2022 IRA Funding	Managing Organization
Office of the Under Secretary for Infrastructure (S3)		
Domestic Manufacturing Conversion Grants – Sec. 50143	$2,000,000	MESC
Home Energy Performance-Based, Whole-House Rebates – Sec. 50121	$4,300,000	SCEP
High-Efficiency Electric Home Rebate Program, State Energy Office Grants – Sec 50122(a)(1)(A)	$4,275,000	SCEP
High-Efficiency Electric Home Rebate Program, Indian Tribes Grants – Sec. 50122 (a)(1)(B)	$225,000	SCEP
State-Based Home Efficiency Contractor Training Grants – Sec. 50123	$200,000	SCEP
Assistance for Latest Building Energy Code Adoption – Sec. 50131(a)(1)	$330,000	SCEP
Assistance for Zero Energy Code Adoption – Sec. 50131(a)(2)	$670,000	SCEP
Total, S3 Program	**$12,000,000**	
Total, EERE IRA Coordination	**$12,150,000**	

Additional Activities Managed by EERE

EERE is involved in oversight and implementation of $300 million of IIJA funds to facilitate a collaborative Joint Office between DOE and the U.S. Department of Transportation that supports the deployment of zero-emission, convenient, accessible, equitable transportation infrastructure. The Joint Office aligns and leverages resources and expertise across the two departments. It is a critical component in the implementation of the BIL, providing support and expertise to a multitude of programs that seek to deploy a network of electric vehicle chargers, zero-emission fueling infrastructure, and zero-emission transit and school buses.

Solar Energy

Overview

The Office of Energy Efficiency and Renewable Energy's (EERE) Solar Energy Technologies Office (SETO) accelerates the research, development and deployment of solar technologies while supporting the reliability, resilience, and security of the U.S. electric grid. The FY 2024 Request focuses on the complete roadmap of solar energy implementation: advanced research and development (R&D) to invigorate American technological leadership; validation of new technologies; supporting industry's development of a robust American supply chain; ensuring that there is a trained American workforce employed in the industry; reducing barriers to deployment; contributing to the decarbonization of the industrial sector and overall economy; supporting community resilience; and working to ensure the benefits of the transition to clean energy are shared with historically marginalized communities and 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. Meeting the 2035 goal for a carbon pollution-free electricity sector may require solar to supply approximately 40 percent of U.S. electricity, up from 4 percent today.[1] To reach a carbon pollution-free electricity sector, annual solar deployment needs to grow by 20 percent each year for the rest of the decade and be maintained to 2035. The domestic solar manufacturing sector likely needs to grow significantly as well. Today less than 20 percent of solar modules deployed in the U.S. are domestically made, and solar hardware installed in the U.S. averages only 40 percent domestic content, mostly in the form of the support structures (racking and trackers), not active components (e.g., photovoltaic (PV) modules and inverters). The lack of a full and robust domestic supply chain makes the U.S. reliant on China and Southeast Asia and susceptible to global supply chain disruptions from a variety of factors. Growing domestic manufacturing will create good-paying, stable jobs with the option to join a union and bargain collectively, while also increasing domestic energy security.

Currently, 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 ownership, and enhanced community resilience. Further unlocking solar energy's potential as an electricity source requires continued cost reductions, developing technologies to open new markets, removing barriers to deployment, growing the domestic supply chain, 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, and the direct production of industrial process heat and solar fuels.

Today over 130 GW_{DC} of solar technology have been deployed across the U.S.,[2] a 60-fold increase since 2010. This increase in deployment has been a source of significant job growth, with the industry employing 334,000 workers in 2021.[3] Continued reductions in the cost of solar electricity are essential to enabling further growth in solar deployment and greater electricity affordability for consumers nationwide. As the regional supply of solar electricity increases, 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. The costs of solar must continue to fall to make this broadly affordable. Accordingly, DOE recently accelerated its cost targets for utility-scale PV and Concentrating Solar Power (CSP) systems without subsidies – targets that could make solar electricity the lowest cost form of electricity in the U.S. with cost reductions of 50-60 percent from 2020 benchmarks for PV and CSP.[4]

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. Learning to plan and reliably operate a grid with high penetrations of these resources requires R&D and demonstration. Further, PV technologies and other distributed energy resources (DERs) are fundamentally changing the distribution system. They are creating new

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[1] DOE Solar Futures Study. www.energy.gov/eere/solar/solar-futures-study.
[2] Wood Mackenzie/SEIA U.S. Solar Market Insight® https://www.seia.org/us-solar-market-insight.
[3] "US Energy Employment Report," Department of Energy. USEER 2022 Main Body.pdf (energy.gov).
[4] V. Ramasamy et al., "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2021," NREL Technical Report, November 2021.

challenges related to generation and load forecasting, real time situational awareness, control coordination, system protection, and cyber-security. They 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, including those historically underserved by the energy system. 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"), which can include burdensome permitting; complex, lengthy, and expensive interconnection processes; lack of affordable financing; lack of locally available trained workers; and land-use competition for ground-mounted systems. In addition, nearly 50 percent of the population does not have the option to install their own solar energy system because they lack adequate roof or land space for placement or rent their housing. Addressing each of these barriers requires engaging with state and local governments, utilities, the solar industry, local communities, and other stakeholders on improved permitting and interconnection processes, innovative financing mechanisms, workforce training programs, and innovative siting strategies.

Highlights of the FY 2024 Budget Request

The Solar Energy Technologies Program will support a portfolio of research, development, demonstration, and deployment (RDD&D) activities in FY 2024, including:

- Investment to spur development across the U.S. solar supply chain and to catalyze solar innovation through the American-Made Solar Prize with the goal of growing the domestic solar manufacturing value chain.
- Development of dynamic models and tools for planning and operating a grid with rapidly increasing amounts of solar generation to enable an affordable, reliable, resilient, and secure carbon-free electric grid.
- Advancement of high efficiency PV technologies, cadmium telluride and perovskites, and improve durability and drive cost reductions toward the 2030 goal of $0.02/kWh while lasting 50 years.
- Improvement of interconnection and siting processes of solar and other clean energy technologies (with the Wind Office) and supporting growth of community solar with meaningful benefits such as low- to moderate-income access, greater household savings, resiliency, community ownership, and workforce development.
- Investment in 'Generation 3 CSP' technologies with a particular emphasis on piloting novel, large scale, autonomous heliostat fields and developing systems for use in industrial processes.
- SETO is involved in several DOE-wide crosscutting initiatives, including the following:
    - Industrial Decarbonization to support RD&D of low- and high-temperature systems difficult to decarbonize through electrification;
    - Clean Energy Technology Manufacturing to support the development of a sustainable, robust, and resilient American solar supply chain;
    - Hydrogen to support RD&D of concentrating solar thermal power systems that can be used for hydrogen production or in conjunction with hydrogen as a chemical feedstock;
    - Energy-Water to support the development of solar thermal desalination systems; Energy-Storage to focus on thermal energy storage as well as integration of battery storage and PV;
    - Critical Minerals to address potential PV deployment limitations related to materials scarcity; and
    - Grid Modernization to support RD&D of grid integration technologies at the bulk power and distribution system levels.

Within all SETO subprograms, 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. In addition, funds will be used to support efforts such as merit/peer reviews, data collection and dissemination, technical assistance, and technology to market activities.

Solar Energy
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Solar Energy					
Concentrating Solar Power Technologies	60,000	60,000	70,000	+10,000	+17%
Photovoltaic Technologies	75,000	77,000	77,908	+908	+1%
Systems Integration	50,000	55,000	79,000	+24,000	+44%
Balance of Systems Soft Cost Reduction	60,000	56,000	77,000	+21,000	+38%
Manufacturing and Competitiveness	45,000	70,000	75,000	+5,000	+7%
Total, Solar Energy	**290,000**	**318,000**	**378,908**	**+60,908**	**+19%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $9,899,640; STTR: $1,339,871
- FY 2023 Enacted: SBIR: $8,092,000; STTR: $1,138,000
- FY 2024 Request: SBIR: $10,349,000; STTR: $1,455,000

Solar Energy Explanation of Major Changes ($K)	FY 2024 Request vs FY 2023 Enacted
Concentrating Solar Power Technologies: Increased funding will emphasize a pilot of advanced heliostat technologies for low-cost collection of high-temperature solar-thermal energy for electricity generation and industrial applications. Funding increase will also support additional R&D on high temperature power cycle components and processes for electricity generation.	**+10,000**
Photovoltaic Technologies: No significant net change in funding request. FY 2024 will increase funding for efficiency improvements to accelerate the next generation of solar cell devices because current structures are reaching efficiency limits. Funding for materials availability is reduced while the program awaits results of recent IIJA investments.	**+908**
Systems Integration: The FY 2024 Request increases funding for demonstration of technologies to operate and control a power system with increasing levels of solar energy. Funding for resilience and security is flat while awaiting results of projects funded in FY 2023 and prior years.	**+24,000**
Balance of Systems Soft Cost Reduction: The FY 2024 Request includes an increase in funding to research the impacts of, and equitable solutions for, large-scale solar siting. In addition, there is a requested increase in funding for the National Community Solar Partnership to expand the accessibility of solar energy to all Americans.	**+21,000**
Manufacturing and Competitiveness: The FY 2024 Request includes a modest increase to develop innovative product ideas that can substantively increase U.S. domestic manufacturing across the full solar supply chain, open new market segments, and expand private investment in America's manufacturing sector.	**+5,000**
Total, Solar Energy	**+60,908**

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 RD&D 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 CSP technologies can efficiently incorporate long durations of thermal energy storage, they 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. Significantly increasing 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 subprogram coordinates its work with the Industrial Efficiency and Decarbonization Office to align with their Industrial Decarbonization Roadmap.

Thermal Systems R&D: This activity supports RD&D to test and integrate the components 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), including the receiver, heat transport media, and thermal energy storage systems. 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. To support the development of the Gen3 CSP megawatt-scale test facility, this activity will primarily, though not exclusively, focus on solid particles as the heat transfer medium. This activity also includes RD&D of thermal energy storage technologies in support of the Energy Storage Grand Challenge and Long Duration Storage Energy Earthshot, including work on a low-cost particle thermal storage media being developed for use in Gen3 CSP systems.

Power Cycles R&D: This activity supports RD&D of power cycles capable of net thermal-to-electric efficiency of 50 percent or greater. Support is particularly focused on power cycles that use supercritical carbon dioxide (CO_2) as the working fluid and have a capital cost of $900/kW-electric or lower, working in collaboration with FECM and NE. This activity also includes the development of primary heat exchangers that can transfer heat between high temperature thermal energy storage and supercritical CO_2.

Solar Collector R&D: This activity supports RD&D 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: This activity supports RD&D of industrial processes driven by solar thermal energy. Activities include both low-temperature systems focused on low-cost embodiments of existing technologies, and the development of components and system designs for high-temperature systems that are difficult to decarbonize through electrification. Low temperature systems in the range of 100 to 400 °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.

Concentrating Solar Power Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Concentrating Solar Power Technologies $60,000,000	**$70,000,000**	**+$10,000**
Thermal Systems R&D $20,851,000	$13,100,000	-$7,751,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing and analyzing high temperature components and systems related to Gen3 CSP and long-duration thermal storage among other projects.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing and analyzing high temperature components and systems related to Gen3 CSP and long-duration thermal storage among other projects.	• The decrease in funding reflects completion of some FY 2022-24 lab projects.
• Funding will focus on continued development of CSP systems and components, with a focus on long-duration thermal energy storage and development of solid particle-based heat transfer.	• A competitive solicitation will focus on high-temperature components and systems to enable cost-effective receivers and thermal energy storage for a range of CSP applications.	• The decrease in this program reflects a focus on a smaller subset of problems than in FY 2023 as the activity awaits results from ongoing projects.
• Support to the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories (SNL).	• Support to the NSTTF at SNL.	• No significant change.
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in thermal systems are eligible.	• Funding for FY 2024 competitive solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in thermal systems are eligible.	• No significant change.
Power Cycles R&D $4,794,000	$10,800,000	+$6,006,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing primary heat exchangers for advanced CO_2 power cycles.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing primary heat exchangers for advanced CO_2 power cycles.	• No significant change.
• No funds requested. Continue managing competitively selected projects from prior years to integrate high-efficiency, long-duration pumped thermal energy storage (PTES)	• A competitive solicitation will focus on continued development of materials and designs for primary heat exchangers for advanced CO_2 power cycles.	• The increase reflects new R&D awards that develop high temperature power cycle components and processes for CSP.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
technologies with advanced supercritical CO_2 power cycles.		
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in power cycles are eligible.	• Funding for FY 2024 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in thermal systems are eligible.	• No significant change.
Solar Collector R&D $15,299,000	$28,500,000	+$13,201,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. This work will focus on developing optical components and improved optical characterization methods for CSP collector fields.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. This work will focus on developing optical components and improved optical characterization methods for CSP collector fields.	• No significant change.
• Continue funding of a National Laboratory consortium test facility on heliostat development and validation.	• Continue funding of a National Laboratory consortium test facility on heliostat development and validation.	• No significant change.
	• A competitive solicitation will aim to pilot and de-risk novel, fully integrated autonomous heliostat fields, building on capabilities developed in the Heliostat Consortium	• New initiative to focus on solar collector cost and performance.
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in solar collectors are eligible.	• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in solar collectors are eligible.	• No significant change.
Industrial Applications R&D $19,056,000	$17,600,000	-$1,456,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on researching novel pathways for the solar thermal production of ammonia and hydrogen as a means to progress towards decarbonization of the chemical industry.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on researching novel pathways for the solar thermal production of ammonia and hydrogen as a means to progress towards decarbonization of the chemical industry.	• No significant change.
• Continue development of solar-thermal-driven industrial processes for decarbonizing the industrial sector. FY 2023 efforts will emphasize	• A competitive solicitation will continue to develop systems and components for solar-thermal-driven industrial processes. FY 2024 efforts will respond to strategic RD&D needs	• Decrease in funding reflects prioritization of other activity areas while SETO assesses progress of ongoing research and development supported with FY 2022 and FY 2023 funding.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
more mature demonstrations to accelerate deployment.	identified within crosscutting Energy Earthshots as well as compliment research thrusts from the awards made within the FY 2022 Solar Industrial Decarbonization FOA topic.	
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in industrial applications are eligible.	• Funding for FY 2024 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in industrial applications are eligible.	• No significant change.

Solar Energy
Photovoltaic Technologies

Description
Achieving the President's 2035 goal for a carbon pollution-free power sector requires a large growth in total U.S. photovoltaic (PV) capacity and annual deployment rate. 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. The PV subprogram supports RD&D 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. Since 2010, 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 characterization techniques. Furthermore, the PV subprogram identifies and works to overcome material and environmental constraints that could inhibit the rapid acceleration of PV deployment such as the availability of silver (Ag), as well as the disposal and recycling of PV systems.

Conversion Efficiency R&D: This activity supports R&D to increase the power conversion efficiency and reduce the manufacturing costs of PV cells and modules, spanning established and emerging materials. Two solar cell absorber materials receive specific focus in this research area – cadmium telluride (CdTe) and perovskites. Cadmium telluride (CdTe) is the largest domestically manufactured PV technology and the second most deployed technology, behind silicon-based solar modules. Perovskites are a promising next-generation PV technology currently being researched in labs across the country with the potential to achieve high efficiencies at low costs. Strategic investments in these technologies now can reduce PV costs and position the U.S. to be a global leader in solar manufacturing for years to come. This activity also includes research in improved PV system design to increase energy production 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: This activity supports RD&D to better understand and mitigate performance degradation of PV systems to enable 50-year lifetimes, resilience to extreme weather conditions, and application in dual-use settings, such as PV on agricultural land and building integrated PV systems (BIPV). Activities include 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. The subprogram's support 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.

Materials Availability R&D: This activity supports R&D to better understand how the availability and environmental impacts of key materials used in PV systems could constrain domestic PV manufacturing and deployment, and R&D to mitigate these materials constraints to enable rapid scale-up of the domestic solar industry. Activities include efforts to 1) reduce the use of silver (Ag), tellurium (Te), and indium (In) in modules; 2) advance materials recovery techniques; 3) develop PV systems that are easily recycled; and 4) improve long-term reliability and manufacturing of lead-free modules. The work in this activity is also supported by the Infrastructure Investment and Jobs Act (IIJA) (Section 41007(c)(3)).

Photovoltaic Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Photovoltaic Technologies $77,000,000	**$77,908,000**	**+$908,000**
Conversion Efficiency R&D $42,020,000	$35,288,000	-$6,732,000
• Funding to maintain FY 2022-24 projects to advance PV cell and module performance for National Laboratory research programs that were initiated in FY 2022.	• Funding to maintain FY 2022-24 projects to advance PV cell and module performance for National Laboratory research programs that were initiated in FY 2022	• The decrease reflects the completion of some FY 2022-24 lab projects.
• Funding for 1-year innovative seedling R&D projects focused on material constraints and reducing PV system waste at end of life.	• Funding for FY 2024 FOA topic on 1-year innovative projects for PV research.	• No significant change.
• Funding for FY 2023 FOA on thin film PV to increase performance.	• Funding for FY 2024 FOA Topic to address high efficiency cell and modules.	• No significant change.
• Funding for additional competitive projects to augment the CdTe consortium and maintain CdTe consortium research support at NREL.	• Funding for additional competitive projects to augment the CdTe consortium and maintain CdTe consortium research support at NREL.	• No significant change.
Durability R&D $31,194,000	$37,620,000	+$6,426,000
• Funding to maintain DuraMat consortium under new scope of work for FY 2022 – FY 2024. In FY 2023, the consortium will run an external solicitation for external participation, validate an accelerated testing approach using fielded module data, and develop a new analytical technique to support the planned work in FY 2024.	• 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 significant change.
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on researching PV degradation pathways, develop standard tests, and mitigation strategies.	• Funding to maintain FY 2022-24 projects to advance PV cell and module performance for National Laboratory research programs that were initiated in FY 2022.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Funding to support research building on durability work and expanding into non-destructive balance of material testing, resilient operation, durability of dual-use PV systems, and PV system power-electronics durability. An additional FOA will support funding to research thin film PV durability that focuses on perovskite and CdTe technologies.	• Funding for FY 2024 FOA Topic to address durability of high efficiency cell and modules.	• Increase in funding will focus efforts on the reliability and durability of high efficiency photovoltaic modules and cells.
• Additional competitive projects that augment the existing CdTe consortium will be funded. Funding requested to maintain CdTe consortium research support at NREL under the FY 2022-2024 core agreement.	• Additional support for the CdTe research and industrial consortium to support projects on increasing the long-term durability of the CdTe systems to enable greater LCOE reduction.	• No significant change.
Materials Availability R&D $3,786,000	$5,000,000	+$1,214,000
• Research on reducing the use of silver (Ag) and other limiting materials in modules, materials recovery techniques for PV systems, developing systems that are easily recycled, and long-term reliability and manufacturing of lead-free modules.	• Fund additional work looking at how to reduce materials usage in high efficiency PV devices.	• Increase in funding for additional R&D projects.

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 RD&D of technologies that better enable solar energy to support the reliability, resilience, and security of the electric power system. Meeting the President's goal for a carbon-free power sector may require solar to provide approximately 40 percent of U.S. electricity by 2035.[1] This entails continued rapid growth of solar PV deployment, which supplies only 4 percent of U.S. electricity today. PV technologies cause challenges for power system operation due to their variable nature, fast-responding power electronics, and their deployment on both the bulk power and distribution systems. There are over 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 evolving rapidly with the deployment of digital sensors and communication networks and the integration of new distributed energy technologies.

PV, 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 experience times where wind and PV can supply over half of the instantaneous power. As deployment of these technologies further increases, it is critical that they can provide essential grid services such as voltage and frequency regulation. These capabilities have been demonstrated in isolated testing, but more RD&D will help grid operators and regulators to rely on these technologies to support all aspects of grid reliability.

The SI subprogram addresses the key technical challenges in solar grid integration by focusing on power system planning, generation variability, 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, it advances 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 solar interconnection requirements, testing, and validation methods.

Planning and Modeling R&D: As more PV is added onto the electric grid, utilities and power system operators need to plan for a variety of scenarios to balance electricity generation from solar and other sources with customer demand. This activity focuses 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 upgrades, interconnection requirements and reliability standards. This activity supports projects that 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: As PV's share of electricity generation increases, utilities and power system operators need real-time information about and control capabilities for this generation to reliably operate the grid. This activity focuses on hardware and software technologies to enable real-time situational awareness and coordinated control to ensure system reliability during normal and abnormal operating conditions. It supports projects that address challenges in power electronic devices, sensing and communication, system protection and fault recovery, dynamic power flow control, grid services, and data analytics using artificial intelligence and machine learning.

Resilience and Security R&D: The deployment of distributed PV and other DERs can provide greater resilience to energy infrastructure and community services. This activity focuses on technologies that integrate distributed PV, energy storage, and other DERs to provide continuity of electric power service for critical infrastructure and critical loads and to reduce the magnitude and/or duration of disruptive events such cyberattacks, hurricanes, floods, and wildfires. This activity supports projects that advance the detection and situational awareness of threats and enhance PV and the power system's capabilities of anticipating, absorbing, adapting to, and/or rapidly recovering from a potentially disruptive event.

[1] DOE Solar Futures Study. www.energy.gov/eere/solar/solar-futures-study

Systems Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Integration $55,000,000	**$79,000,000**	**+$24,000,000**
Planning and Modeling R&D $11,514,000	$30,000,000	+$18,486,000
• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on dynamic models for PV and power systems, high resolution measurement data, solar resource forecast and integration, reliability standards, and testing and validation.	• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on dynamic models for PV and power systems, high resolution measurement data, solar resource forecast and integration, reliability standards, and testing and validation.	• No significant change.
• Funding to support competitively selected projects to develop better methodologies and software tools for grid planners to conduct long-term power system planning for integration of high amounts of solar at the distribution and bulk grid levels. This includes the better incorporation of weather models for resource adequacy assessment during extreme events. This effort will also support innovations in grid planning process. This is an EERE and OE collaboration.	• Funding to support new competitively selected projects to develop uniform and standardized methodologies, tools, and processes for grid planners and solar project developers to interconnect and integrate high amounts of solar in near- and long-term system planning. This includes the better incorporation of weather models for resource adequacy assessment, accurate modeling of solar PV plant controllers, and stability and contingency analysis. This is an EERE and OE collaboration.	• The increase will expand this area of research with stronger focus on demonstration and collaboration with industry.
Operation and Control R&D $38,505,000	$44,000,000	+$5,495,000
• Funding to develop better tools for grid operators to reliably monitor and control a power system that has high amounts of solar generation at the distribution and bulk grid levels. This includes the better incorporation of weather forecasts and real-time measurements for predicting solar irradiance and other variable renewables generation as well as loads. This is an EERE and OE collaboration.	• Funding to support new competitively selected projects to develop and field demonstrate new tools for grid operators to reliably monitor and control a power system that has high amounts of inverter-based solar generation at the distribution and bulk grid levels. Topics may include improvement and integration of load and generation resource forecasting, enhanced situation awareness of the entire grid (including DERs), advanced sensing technologies, power electronic controls, and evaluation of the impact	• The increase will expand this area of research with stronger focus on demonstration and emphasis in advanced sensing technologies and power electronics controls.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	to market operations. This is an EERE and OE collaboration. • Fund new competitively selected projects to demonstrate the benefits of operational flexibility from multiple technologies including solar PV, electric vehicle, grid-interactive building, energy storage, and other DERs to improve clean energy deployment, grid reliability, and economic efficiency. This is an EERE and OE collaboration.	• New joint-effort which builds on the previous Connected Communities activities.
Resilience and Security R&D $4,981,000	$5,000,000	+$19,000
• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on addressing cybersecurity challenges in solar grid integration including technology development, standard development, testing and validation, and information sharing.	• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on addressing cybersecurity challenges in solar grid integration including technology development, standard development, testing and validation, and information sharing.	• No significant change.

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, labor, project development, customer acquisition, financing, and other related costs. Taken together, soft costs constitute about 65 percent of total system prices for residential PV systems, 57 percent of commercial PV systems, and 36 percent of utility-scale systems.[1] Reaching the DOE 2030 solar cost targets will require significant reductions in soft costs without impacting the wages, benefits, safety, and quality of work.

Reducing soft costs requires engaging with community organizations, state and local governments, Tribes, developers, utilities, and other stakeholder groups to understand barriers; develop collaborative research, tools, and processes; and broadly disseminate results and best practices to enable replication and scalability. For example, improving permitting for large-scale solar development and host communities requires collaborative research and engagement on topics such as solar planning and zoning, environmental impacts and benefits, land use competition, and innovative siting practices.

Rooftop solar offers opportunities across the country for consumers to save money on electricity bills and reap other benefits such as local energy resiliency. 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, and SETO aims to enable community solar to power 5 million households with one billion dollars in savings by 2025.

The solar industry has been one of the fastest growing employment sectors over the past decade, providing 334,000 jobs in 2021. SETO builds partnerships across the clean energy workforce, supports strong skills development, and increases the ease for new people to enter the clean energy workforce, with a particular focus on frontline communities, military veterans, returning citizens, and those currently or formerly working in fossil fuel industries. SETO's efforts will increase access to all clean energy workforce careers, including pathways to family-sustaining wage positions and labor organization membership. SETO coordinates with other EERE offices and the Departments of Labor and Education on shared priorities.

Data, Modeling, and Analysis: This activity focuses on 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 includes data and analysis to increase market transparency, assess solar plus storage value in providing reliability and resiliency, expand access to solar energy, evaluate alternative siting approaches, and open new markets.

Technical Assistance and Stakeholder Tools: This activity supports technical assistance to help solar stakeholders reduce soft costs and overcome barriers to solar and solar plus storage deployment. This includes technical assistance on solar siting, interconnection, community solar, permitting, workforce training, and financing solar for low-income households. Stakeholders include state, local, and tribal governments; the solar industry; utilities; public utility commissions; community-based organizations; and others. This activity also supports the development of an online enrollment platform to facilitate low-income participation in community solar.

STEM and Workforce Development: This activity supports cross-EERE STEM and workforce programs to enable diverse workers to benefit from the clean energy economy. This activity also includes a program placing participants at organizations to conduct research and stakeholder engagement activities that facilitate the deployment and the integration of solar energy onto the electric grid, as well as a competition that prepares college students for careers in clean energy.

[1] V. Ramasamy et al., "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2021," NREL Technical Report, November 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.

Balance of Systems Soft Cost Reduction

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Balance of Systems Soft Cost Reduction $56,000,000	**$77,000,000**	**+$21,000,000**
Data, Modeling, and Analysis $10,887,000	$22,000,000	+$11,113,000
• Maintain National Laboratory FY 2022-24 projects to advance data, modeling, and analysis for the reduction of solar soft costs.	• Funding to maintain FY 2022-24 national lab projects and support new competitively selected projects to advance data, modeling, and analysis for the reduction of solar soft costs.	• No significant change.
• Support EERE and cross-DOE data, tools, and analysis projects to facilitate the widespread integration of renewables in a resilient, reliable power system.	• Support competitive solicitation to research the impacts of solar energy on communities and the environment and enable innovative and equitable solutions for solar siting.	• Increase in funding reflects new projects which will focus on addressing solar siting impacts.
Technical Assistance and Stakeholder Tools $37,313,000	$49,250,000	+$11,937,000
• Expand the National Community Solar Partnership by launching the National Community Solar Partnership Community Power Accelerator prize which supports pre-development and other gap funding needs to bring community solar with local benefits to market.	• Continue to expand the National Community Solar Partnership Community Power Accelerator by providing prize funding to support pre-development and other gap funding needs for the rapid deployment of community solar that includes local benefits.	• Increase in funding to support a Prize Challenge for the Community Power Accelerator.
• Expand the National Community Solar Partnership and continue technical assistance and research to reduce barriers to rapid deployment while meeting the target of increased access to low-income households, increased energy savings, increased job creation, increased consumer awareness, and resiliency.	• Continue to expand the reach of the National Community Solar Partnership focused on capacity building and technical assistance for community-based solar and clean energy deployment with local benefits.	• New projects focused on building local capacity for community solar development.
• Develop and launch an online platform to improve and make easier low-income household enrollment in community solar programs.	• Continue support for the low-income household community solar enrollment tool.	• No significant change.
• Support additional multi-stakeholder team participation in the Solar Energy Innovation	• Support additional multi-stakeholder team participation in the Solar Energy Innovation	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Network and the replication of solutions developed in previous rounds of the program.	Network and the replication of solutions developed in previous rounds of the program.	
• Provide local governments, utilities, and other stakeholders with technical assistance on solar grid interconnection via the Interconnection Innovation Exchange (i2x).	• Support the Interconnection Innovation Exchange (i2X), a technical assistance program to enable improved interconnection of clean energy technologies to the grid (with WETO).	• Decrease in funding to focus on technical assistance while FY 2023 funded projects are carried out.
• Support technical assistance to help regulators address barriers to the affordable and equitable deployment of solar and other clean energy technologies (with EERE and OE).	• Support technical assistance to help regulators address barriers to the affordable and equitable deployment of solar and other clean energy technologies (with EERE and OE).	• No significant change.
• Provide local governments, utilities, and other stakeholders with technical assistance on solar siting.	• Support technical assistance to states, local governments, federal agencies, and other stakeholders to overcome barriers to siting solar and other renewable energy (with EERE)	• No significant change.
• Provide local governments, utilities, and other stakeholders with technical assistance on permitting via SolarAPP+.	• Support technical assistance to enable local jurisdictions to adopt the SolarAPP+, which automates permitting for residential solar and energy storage, and expand its features.	• Reduced funding required as the SolarAPP+ becomes financially self-sustaining in FY 2024.
• Projects and technical assistance to facilitate solar deployment on Tribal lands.	• Continue cross-cutting office work on energy and environmental justice initiatives.	• No significant change.
• Continued support for research into wildlife and ecosystem impacts of solar energy systems.	• No funding requested.	• Continue to monitor ongoing work to identify future opportunities.
STEM & Workforce Development $7,800,000	$5,750,000	-$2,050,000
• Fund competitive awards to advance workforce goals related to curriculum development and dissemination.	• Continue to monitor and evaluate impacts of prior year awards to advance workforce goals related to curriculum development and dissemination. • Development of a Technical Assistance program that supports the expansion of the clean energy workforce and the solar industry.	• No funding requested but will continue to monitor and evaluate impacts from prior years with the goal to identify future year opportunities for funding. • New FY 2024 program will complement FY 2023 competitive solicitation. Reduction in funding reflects the lower cost of technical assistance as compared to the regional partnerships funded in FY 2023, which will continue through completion.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support the Clean Energy Innovator Fellowship program, which funds recent graduates and energy professionals to work with public utility commissions, municipal and cooperative utilities, and grid operators to advance clean energy solutions.	• Support the Clean Energy Innovator Fellowship program, which funds recent graduates and energy professionals to work with public utility commissions, municipal and cooperative utilities, and grid operators to advance clean energy solutions.	• No significant change.

Solar Energy
Manufacturing and Competitiveness

Description
The Manufacturing and Competitiveness (MC) subprogram supports entrepreneurs and companies in developing and commercializing new and advanced solar technologies that can grow and diversify the U.S. solar industry, increase U.S. competitiveness in solar energy manufacturing, and accelerate progress toward a carbon-free power sector by 2035. The MC subprogram helps companies with promising solar technologies survive funding gaps in the development cycle of new technologies.

Today less than 20 percent of modules installed in the U.S. are manufactured domestically, leaving the domestic industry and energy consumers beholden to foreign-dominated supply chains. Increasing domestic content and supply chains for PV hardware and product components including inverters; thin film modules; and polysilicon ingots, wafers, and cells for silicon modules will keep more value in the U.S. economy and create good-paying manufacturing jobs with the free and fair option to join a union and bargain collectively. Decreasing reliance on imported goods also reduces supply uncertainty and cost 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. With passage of the Inflation Reduction Act of 2022 and recently granted Defense Production Act authority for DOE on PV technologies, the U.S. is poised to see substantial growth in manufacturing across the solar supply chain. This presents a unique opportunity for the Solar MC subprogram to support existing and new entrants and to accelerate time to market for innovative products and components.

The MC subprogram utilizes prize programming and the American Made Network to catalyze new businesses pursuing innovative technologies. Manufacturing and value chain RD&D efforts advance and validate technology progress to enable subsequent private sector funding to scale into production. This includes the 19th round of the successful Incubator program, which provides early-stage assistance to small businesses developing and validating technology prototypes. This Request focuses on supporting advanced solar technologies to reduce the dependence on foreign-controlled supply chain segments, particularly those with ties to unacceptable labor practices. The overall focus will be on reducing solar costs while solidifying domestic material, equipment, and product supply chains. Programming will address advanced versions of industry-leading technologies like crystalline silicon and cadmium telluride as well as emerging technologies like perovskites, while also including support for upstream and downstream components.

<u>American-Made Challenges</u>: This activity supports prize programming and associated support structures such as the American Made Network to seed new solar technologies and increase America's market share for added-value manufacturing. The work focuses 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 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.

<u>Manufacturing and Value Chain</u>: This activity supports cooperative agreements and grants focused on developing and validating new and advanced solar technologies with a focus on those which can be domestically manufactured. Funding targets the full value chain including innovative approaches to producing solar cell components, cells, and module materials; new tracking technologies; power electronics; and technologies to reduce maintenance costs. This activity also aims to supports efforts to bring more private capital funding into solar energy technology development and ensure well trained workers are ready to enter the workforce as opportunities grow. Overall, the goal is to help companies sufficiently de-risk technologies and commercial approaches to enable investment and commercialization by private sector entities and to develop a holistic domestic supply chain that is not dependent on foreign-controlled supply chains.

Manufacturing and Competitiveness

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Manufacturing and Competitiveness $70,000,000	**$75,000,000**	**+$5,000,000**
American-Made Challenges $6,500,000	$12,000,000	+$5,500,000
• Continue to run the American-Made Solar Prize (Hardware & Software) to support innovators in launching new products that advance the solar industry and support U.S. manufacturing.	• Continue to run the American-Made Solar Prize to support innovators in launching new products that advance the solar industry and support U.S. manufacturing.	• No significant change.
	• Develop prize programming to support the domestic expansion of solar manufacturing focused on topics like manufacturing processes, manufacturing tooling, and manufacturing workforce development.	• Expanded prize awards to support U.S. solar manufacturing.
• Continue support for the American Made Network which provides support to applicants, participants, and awardees that are part of SETO funding programs via access to technical expertise, help with application construction, access to tools and equipment, and more.	• Continue support for the American Made Network.	• No significant change.
Manufacturing and Value Chain R&D $63,500,000	$63,000,000	-$500,000
• Continue support for 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. This includes supply chain development for advanced versions of industry-leading technologies such as silicon and cadmium telluride, the transition of new technologies from the lab to manufacturing such as Perovskites, and support for scaling complimentary and supporting supply chain technologies like	• Continue support to accelerate 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. Programming will address advanced versions of industry-leading technologies like crystalline silicon and cadmium telluride and emerging technologies like perovskites, while also including support for upstream and downstream component.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
equipment and other PV module and system components.		
• Support targeted work in emerging sectors of the solar industry to include, but not exclusive to, the manufacturability and demonstration of building integrated PV, use of robotics technologies in system construction and manufacturing, floating PV, the co-location of PV with agriculture, virtual power plants, and PV applications in the transportation sector.	• Continue to support targeted work in emerging sectors of the solar industry to include, but not exclusive to, the manufacturability and demonstration of building integrated PV, use of robotics technologies in system construction and manufacturing, floating PV, the co-location of PV with agriculture, virtual power plants, and PV applications in the transportation sector.	• Slight reduction from FY 2023.

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 27 percent of total U.S. energy demand[3] and over 17 percent of average U.S. household expenditures[4], making it, as a percentage of spending, the costliest 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[5] and, as a result, has surpassed electricity generation to become the largest source of CO_2 emissions in the country[6]. 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 in decarbonizing the transportation sector and address the climate crisis by driving innovation and deploying clean transportation technologies, all while maintaining transportation service quality and safety.

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 (including automated and connected vehicles as well as innovations in efficiency-enhancing connected infrastructure); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; 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.

Highlights of the FY 2024 Budget Request

- VTO will identify new battery chemistry and cell technologies with the potential to reduce the cost of electric vehicle battery cells, in support of EVs and batteries across clean energy applications. Focus on developing processing technologies and related promising near-term approaches for reducing the cost of lithium-ion batteries; the scale-up of lithium battery technologies such as no-cobalt/no-nickel cathodes, lithium metal anodes, and solid-state systems to reduce constraints from scarce materials; and alternatives to lithium-based high-capacity batteries.
- VTO will continue to fulfill statutory requirements for providing alternative fuel information. Seek to validate data, technologies, and systems in the field, serving as an important feedback loop to inform future VTO research planning. Support national Science, Technology, Engineering, and Mathematics (STEM) education objectives through an advanced vehicle technology competition to provide hands-on training to university students and prepare them for the future workforce.
- VTO will address the challenge of transportation electrification through powertrain and vehicle charging technologies and the interaction of electrified vehicles with the overall electric grid. Emphasize work with stakeholder groups and partnerships to guide RDD&D decisions and efforts that can demonstrate benefits to all communities.
- VTO will create and deploy breakthrough modeling, simulation, and high-performance computing-enabled data analytics to support the development of new transportation-system technologies, which have the potential to improve energy productivity

[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] U.S. Energy Information Administration. Monthly Energy Review, 2022, https://www.eia.gov/totalenergy/data/monthly/index.php
[4] Davis, Stacy C., and Robert G. Boundy. Transportation Energy Data Book: Edition 39. Oak Ridge National Laboratory, 2020, https://doi.org/10.2172/1767864
[5] Transportation Energy Data Book 39th Edition, ORNL, 2021. Table 2.3 Distribution of Energy Consumption by Source and Sector, 1973 and 2019.
[6] Environmental Protection Agency, Draft U.S. Inventory of Greenhouse Gas Emissions and Sinks, 1990-2019, Table 2-11. Electric Power-Related

through new mobility solutions including connected, shared, and automated vehicles. Identify feasible system-level pathways to improve mobility energy productivity and support the equitable transition to a net-zero economy by 2050.

- VTO will 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 for weight reduction and efficiency improvements in electric powertrain and suspension components.
- VTO will continue developing technologies to decarbonize off-road, rail, marine an aviation sectors by efficiently using electrification, including integration of hybrid and plug-in hybrid powertrains, and engines using renewable fuels, such as advanced biofuels, renewable hydrogen, and e-fuels, to significantly reduce GHG emissions while achieving near-zero criteria emissions.
- VTO will develop energy efficient powertrain technologies that will improve commercial vehicles through projects related to SuperTruck, a VTO crosscut, which will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.
- VTO will conduct technical-, economic-, and interdisciplinary analyses using advanced vehicle and transportation data that result in insights critical to informing Vehicle Technologies' targets and program planning.
- VTO is involved in several crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing to develop and scale up efforts related to solid state processing and new joining technologies for multi-material structures in vehicles and batteries;
    - Energy Storage including 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 plug-in electric vehicle batteries;
    - Critical Mineral and Materials to research battery recycling and develop substitutes for graphite and nickel by enabling silicon anodes and for developing near term lithium chemistries that require very low or no cobalt; and
    - Grid Modernization to develop secure vehicle-grid connection and communication technologies, as well as high power grid-tied charging systems.

The 2024 Budget continues 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 will ensure that, to the extent consistent with applicable law, VTO will focus on developing efficient combustion and fuels technology for hard to electrify segments of the transportation sector, such as off-road vehicles, including construction, agriculture and forestry, and rail, marine and aviation that can use 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 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Vehicle Technologies					
Battery and Electrification Technologies	200,000	211,500	266,016	+54,516	+26%
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies	35,000	35,000	35,579	+579	+2%
Materials Technology	45,000	42,500	45,000	+2,500	+6%
Energy Efficient Mobility Systems	54,000	54,000	54,000	+0	+0%
Technology Integration & Deployment	80,000	106,000	117,162	11,162	+11%
Data, Modeling, and Analysis	6,000	6,000	9,185	+3,185	+53%
Total, Vehicle Technologies	**420,000**	**455,000**	**526,942**	**+71,942**	**+16%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $10,519,875; STTR: $2,627,554
- FY 2023 Enacted: SBIR: $12,809,000; STTR: $1,801,000
- FY 2024 Request: SBIR: $14,942,314; STTR: $2,101,263

Vehicle Technologies
Explanation of Major Changes
($K)

	FY 2024 Request vs FY 2023 Enacted
Vehicle Technologies	
Battery and Electrification Technologies: The increase will support data and tool development, paired with technical assistance to stakeholders to enable vehicle grid integration capabilities. The Request will also continue support for R&D to reduce EV battery cell cost to achieve EV cost parity with internal combustion engine (ICE) vehicles through expanded R&D focused on lithium metal, solid state, and next generation lithium-ion battery technologies; and reduce or eliminate dependence on critical materials such as cobalt, nickel, and graphite, thereby mitigating battery supply chain risks.	**+54,516**
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies: The increase will focus on RD&D efforts to reduce GHG emissions from large vehicles that are difficult to decarbonize, and RD&D to assess the impact of renewable fuels on emission control catalyst performance and durability for medium- and heavy-duty non-road engines.	**+579**
Materials Technology: The increase will support an additional focus on R&D related to reduced embodied energy and design for recyclability across material types. FY 2024 work will inform efforts in out-years. Continue to support key advances in materials development and manufacturing to decrease lifecycle GHG emissions and manufacturing cost of electrified vehicles supporting the transition to electric light duty vehicles.	**+2,500**
Energy Efficient Mobility Systems (EEMS): No significant change.	**0**
Technology Integration & Deployment: Increase in funding will support the continued expansion and capacity building of the Clean Cities network to expand community involvement and work with underserved communities to meet Justice 40 goals. The increase will also be used to develop and implement new projects that will address barriers to accelerate vehicle electrification. Increased funding will also be used to expand technical assistance activities through Clean Cities, Communities to Clean Energy, Community-Led Innovation Center, and the Joint Office of Energy and Transportation. There will be increased support to the Clean Cities Coalition's cooperative agreements and engagement with regional and local partners.	**+11,162**
Data, Modeling, and Analysis: Increase in funding will support data collection and analysis to quantify impacts of increased electric vehicle penetration on job creation, vehicle-grid integration, and environmental justice communities. 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 2024, projects will continue to support analytical capabilities and tools unique to DOE's National Laboratories.	**+3,185**
Total, Vehicle Technologies	**+71,942**

Vehicle Technologies
Battery and Electrification Technologies

Description
The Battery and Electrification Technologies subprogram supports the decarbonization of transportation across all modes and serves to increase American advancement/manufacturing of battery technology. Efforts continue to support R&D activities to lower the cost, improve the sustainability, and increase the convenience of plug-in electric vehicle (PEVs). Work is done with National Laboratories, academia, and industry to improve batteries and electric drive systems.

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 three 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 cathode, anode, and electrolyte materials (currently accounting for 50-70 percent of PEV battery cost) and the development of advanced high capacity battery technologies, such as lithium metal anodes, solid-state electrolytes, sulfur-based cathodes, and other alternatives to lithium-based batteries that have the potential to significantly reduce weight, volume, and cost reduction of over 85 percent compared to a 2008 baseline, 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. Battery recycling R&D includes the development of innovative battery materials recycling and reuse technologies, and the Battery Recycling Prize, both of which aim to assure sustainability and domestic supplies of key battery materials and minerals.

Electric Drive R&D: The Electric Drive R&D activity supports R&D for extreme high-power density electric drive systems that have the potential to enable radical new vehicle architectures by dramatic volume/space reductions and increased durability and reliability. The cost of electric traction drive systems, including power electronics and electric motors, will be reduced through high-density integration technologies, novel circuit topologies, new materials for high-density electric motors, and leveraging high performance computing for modeling and optimization. VTO will use electric traction drive system design, integration, and testing to verify performance and progress towards meeting R&D targets.

Electrification R&D: The Electrification R&D activity supports R&D to understand the potential impacts on, and benefits of, EV 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 EV charging, charge management, Distributed Energy Resources (DER) integration, grid services, and cyber-physical security technologies for reliable and cost-effective high-power and wireless charging of light-, medium-, and heavy-duty electric vehicles. This includes technical support and research for technologies related to cybersecurity for electric vehicle charging/supply equipment, and integration with the electric grid.

Battery and Electrification Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Battery and Electrification Technologies $211,500,000	**$266,016,000**	**+$54,516,000**
Battery R&D $146,500,000	$192,500,000	+$46,000,000
• Continue researching next generation battery materials such as lithium-ion, Lithium metal and Lithium Sulfur based chemistries, including solid-state material systems. Expand research for material processing and characterization, including high voltage, high energy cathodes. This early-stage materials research complements Infrastructure Investment and Jobs Act (IIJA) manufacturing investments by maintaining a pipeline of future technologies that will be competitive and contain less critical materials for the next generation of electric drive vehicle batteries. • Accelerate early-stage research for a new class of battery cell materials that contain no cobalt and no nickel. Work with Industry to begin cell evaluations supporting the scale-up of these new materials. This early-stage cell research complements IIJA manufacturing investments by validating battery material and materials system research at a stage that potentially could be adopted and manufactured by the same facilities. • Continue growing joint industry and lab work through the existing Recycling Center. Expand on the most promising reuse and recycling business model innovations from the Lithium-Ion Battery Recycling Prize.	• Continue research projects for next generation battery materials such as Lithium metal and Lithium Sulfur based chemistries. Research will expand to include other alternatives to lithium-based batteries that can meet key performance metrics for weight, volume, and cost, while achieving further improvements in cycle life. • Focus on improvements to lithium-ion cell materials and material processing that promises near-term impacts to battery life, energy density, fast-charge performance, and eliminates or reduces critical materials. • Grow industry and lab work on advanced battery technologies through strategic lab partnerships and open, competitively selected agreements with industry and research partners.	• The increase will focus on improving the performance and reducing the cost of critical materials free active materials. Specifically lowering the cost of silane derived silicon, enabling low-cost micro-silicon, and improving the performance of cobalt free cathodes. Additionally, the increase will support an expansion of fundamental work on sodium ion batteries while also starting to investigate full cell sodium ion electrochemical couples. • The increase will support precompetitive battery cells work specifically designed for medium and heavy-duty truck performance requirements.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Electric Drive R&D $22,500,000	$22,500,000	+$0
• Complete early-stage research targeting the development of technologies that will enable low-cost, high-power density electric drive systems. Projects will advance electric drive systems and meet development targets for lower cost and higher performance. Key research areas include wide bandgap power semiconductors, semiconductor packaging, passive devices, motor materials including improved copper conductors, and electromagnetic and thermal analysis. • Integrate disparate technical advancements into a system context. This validates vehicle-level improvements and provides critical feedback to subcomponent researchers. • SuperTruck III: Provide the second year of planned funding for projects selected in FY 2021 and support additional awards. The aim of the projects is to develop energy efficient powertrain technologies that will improve commercial vehicles. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	• Continue research and development activities to further increase the power density and efficiency of electric drive systems while aiming for further cost reduction to drive greater technology acceptance. • Conduct competitive work with laboratories, industry, and research partners to address key technology gaps in electric drive system performance, including reducing or eliminating critical materials. • Continue support for SuperTruck projects selected in FY 2021 and support additional awards. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	• No change.
Electrification R&D $42,500,000	$51,016,000	+$8,516,000
• Continue a laboratory research consortium to address the challenges of electric vehicle grid integration across light, medium, and heavy-duty vehicle applications. Technical focus areas include smart charge management, high power charging, wireless charging, cybersecurity, and testing standards. • In support of the Cybersecurity crosscut, continue projects to develop secure vehicle-grid	• Continue a laboratory research consortium funded in FY 2023. • Continue projects to develop lower cost and innovative vehicle charging concepts and technologies. • Work with utility and local partners to address the unique challenges and opportunities	• The increase will address technical challenges to vehicle-grid integration. This will include development and demonstration of optimized charge management technologies, adaption of grid infrastructure to support universal electrifications and bidirectional grid services capabilities, improved cyberposture of interactions within the charging ecosystem, and

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
connection and communication technologies. Additional projects will also address cybersecurity needs for vehicle charging and charging infrastructure resilience. • Working with utility and local partners, these projects will address the unique challenges and opportunities presented by the concentration of vehicle charging loads. • SuperTruck III: Develop energy efficient powertrain technologies that will improve commercial vehicles. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	presented by the coordination and concentration of vehicle charging loads. • Continue working with utility and local partners to address the unique challenges and opportunities presented by the coordination and concentration of vehicle charging loads. • Support for SuperTruck projects selected in FY 2021 and support additional awards. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	collaborative work with stakeholders to address interoperability.

Vehicle Technologies
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies

Description
The Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies subprogram supports RD&D of new propulsion and vehicle technologies in applications that reduce GHG emissions and achieve a net-zero economy by 2050. These technologies include electrified and hybrid systems as well as powertrains that can use renewable fuels, such as advanced biofuels, hydrogen, and e-fuels. The subprogram also works on optimization of high efficiency engines and emission control systems that can use low GHG, renewable fuels, and the integration of electrified and hybrid powertrains into these vehicles in furtherance of emissions reductions.

The subprogram supports a multi-lab initiative, in close collaboration with industry and academia, to achieve goals for decarbonization of the non-road sector. The subprogram will apply the unique facilities and capabilities at the National Laboratories, including high performance computing (HPC) and hardware in-the-loop resources, to create knowledge, new concepts, and research tools that industry can use to improve non-road powertrains that will provide efficiency improvements and GHG and criteria emission reductions. The subprogram will coordinate with and use expertise from other agencies, Program Offices, and VTO subprograms as needed.

The subprogram will support industry needs to develop predictive, high-fidelity sub-models and simulation tools that are scalable and can leverage future exascale computing capabilities. The activity will fund research of renewable fuel properties and utilization, in coordination with the Bioenergy Technologies Office, using chemical kinetics modeling of different molecules to determine their impact on combustion efficiency and emissions.

Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies $35,000,000	**$35,579,000**	**+$579,000**
• Commercial Off-Road Powertrains, Fuels and Emission Control R&D: Support use of 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 capabilities to improve the understanding of advanced combustion processes and emissions formation inside engines using low-carbon and renewable biofuels including hydrogen and DME. Integrate hybridized/electrified powertrains to further improve efficiency and reduce GHG and criteria emissions with advanced emission control technologies. • Heavy-duty Consortium: Support a multi-lab effort focusing on improving rail, marine and aviation engine efficiency, compatibility with low-carbon and renewable fuels including hydrogen, 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 and integration of hybrid/electric powertrains.	• Continue to support a multi-lab effort focusing on improving off-road, rail, marine and aviation engine efficiency, compatibility with renewable fuels, and fuel effects on emission control systems. Use experimental data and high-performance computing algorithms to improve combustion processes and emissions formation inside engines using renewable biofuels. 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. Integrate hybridized/electrified powertrains to further improve efficiency and reduce GHG and criteria emissions. Conduct research to improve conversion efficiency, durability and reduce need for critical minerals (i.e., platinum group metals) in emission control systems. • Conduct competitive solicitations with industry and universities to increase the use of renewable fuels, such as advanced biofuels and hydrogen, in medium- and heavy-duty engines used in off-road, rail, marine and aviation to reduce GHG and criteria emissions. Improve potential for electrification/hybridization to further reduce emissions.	• The increase will support RD&D of non-road technologies. Some subactivities in the Heavy-duty Consortium activity merged into this activity, to include research on rail, marine and aviation technologies.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Rail, Maritime and Aviation Engine R&D: Conduct efforts with industry and universities to utilizes electrification and hybridization and to improve the efficiency of large engines and their ability to utilize low-carbon and renewable fuels such as advanced biofuels and hydrogen to reduce GHG and criteria emissions.		

Vehicle Technologies
Materials Technology

Description
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 less battery power to achieve the same range, which in turn reduces battery cost, material needs, and reduces the GHG emissions from battery production. Multi-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 GHGs, and the Materials Technology subprogram supports research, development, and deployment to increase recyclability and reduce the overall embodied energy of vehicles. Materials will 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.

The Materials Technology subprogram goals are:

- Enable a 25 percent weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2020 baseline by 2030, at less than $5/kg-saved; 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: This activity supports research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites, novel lightweight materials, 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. Polymer composites have the potential to reduce component weight by up to 70 percent but suffer from high raw material and manufacturing costs. Increased use 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. 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. Overall embodied energy of vehicles will be reduced by increasing the implementation and recyclability of lightweight metals through localized processing and alloy design for recyclability.

Powertrain Materials: 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 2024, 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. The Powertrain Materials portfolio is closely aligned with other VTO 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.

Materials Technology

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Materials Technology $42,500,000	**$45,000,000**	**+$2,500,000**
Lightweight Materials $35,500,000	$38,000,000	+$2,500,000
• Complete research 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. • Support polymer composite materials research including the operation of the Carbon Fiber Technology Facility (CFTF) and the Composites Core Program targeting core innovation science R&D, high- volume manufacturing. • Research advanced processing techniques to tailor localized microstructure and properties of metal alloys to increase penetration of lightweight metals and address challenges for recyclability. • Competitively select and award 3-5 projects to advance the state of the art for the development and processing of lightweight metals including novel architectures and manufacturing methods to decrease weight at low cost.	• Continue to fund early stage applied research on Lightweight Metals, Polymer Composites, and Joining of Dissimilar Materials. This research will address challenges such as reducing cost, integration with high volume manufacturing, improved predictive modeling, and a new focus on reduced embodied energy and design for recyclability across all material types. • Develop and demonstrate the application of lightweight materials for Medium Duty (MD)/Heavy Duty (HD) vehicles.	• Increased funding will support a new competitive solicitation for reduction of embodied energy and recyclability focus area in addition to existing research areas.
Powertrain Materials $7,000,000	$7,000,000	$0
• Research 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.	• Continue to fund research on materials development relevant to increased efficiency and decreased manufacturing cost of electric powertrain applications. This research will address the materials property requirements of challenging electric vehicle powertrain	• No change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Research affordable, recyclable, high conductivity materials for lightweight electric powertrain components. Address the materials property requirements of challenging electric vehicle powertrain components such as inverters, motors, and gear-train. • R&D to improve freight efficiency and reduce emissions from MD/HD vehicles and incorporate advanced materials for light-weighting, hybridization and electrification. This effort will support work on lightweight powertrain materials to reduce fuel consumption through more efficient operation.	components such as inverters, motors, and gear-train through research on affordable, recyclable, high conductivity materials.	

Vehicle Technologies
Energy Efficient Mobility Systems

Description
The Energy Efficient Mobility Systems (EEMS) subprogram supports RDD&D 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 (AI)-based transportation control systems to accelerate the transition to a zero carbon-emission transportation future. The EEMS subprogram also develops and uses 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 populations and energy communities, benefit from the development and deployment of clean transportation technologies.

Computational Modeling and Simulation: Activities 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. EEMS will continue a focused effort to engage with state and local organizations to deploy systems-level tools for mobility design and planning. This activity will accelerate the transition of tools and capabilities developed through SMART Mobility and other initiatives to be used by local governments, policy makers, and transportation planners. Activities also includes the development of core evaluation tools and mobility testbed facilities to 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: Activities include developing technology solutions that improve the mobility energy productivity of both passenger and freight movement through the development of connectivity, communication, automation, and other transportation solutions that are enabled by artificial intelligence and advanced computing technologies. EEMS will support national lab and industry research and development and engage with local stakeholders to conduct demonstration and deployment of advanced cooperative driving automation systems. These projects will remove technical barriers and accelerate the efficiency and mobility benefits of cooperative driving automation. EEMS will also coordinate with other VTO subprograms and the Hydrogen Fuel Cell Technologies Office to continue to support industry projects under the SuperTruck III initiative, improving the energy and operational efficiency of moving freight with medium and heavy-duty trucks. EEMS will also coordinate with other agencies to research and develop solutions to improve the efficiency and convenience of public transit systems, leveraging the benefits of this shared mode to accelerate the path to transportation decarbonization and provide mobility access.

Energy Efficient Mobility Systems

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy Efficient Mobility Systems $54,000,000	**$54,000,000**	**$0**
Computational Modeling and Simulation $28,000,000	$28,000,000	$0
• Conduct SMART Mobility research to develop a suite of transportation system-level modeling, simulation, design, and planning capabilities ready to be deployed to local stakeholders. • A new deployment emphasis on System-Level Tools for Design and Planning will focus on Transition tools developed from SMART Mobility, AI for Mobility, and other previous initiatives to local city/state transportation planners and decision-makers. • Initiate new national lab core capabilities and tools in mobility simulation, evaluation, and data selected through competitive lab call in the previous year.	• Apply high-potential SMART Mobility capabilities as part of a suite of transportation system-level modeling, simulation, design, and planning capabilities to deliver systems-level energy insights for local stakeholders. • Leverage deployment emphasis for real-world applications of System-Level Tools for Design and Planning will focus on Transition tools developed from SMART Mobility, AI for Mobility, and other previous initiatives in coordination with local city/state transportation planners and decision-makers. • Target support for new and complementary computational modeling and simulation that addresses gaps in existing modeling capability portfolio.	• No significant change • Build on and complete existing slate of computational modeling and simulation by addressing lessons learned across SMART Mobility technology suite.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Connectivity and Automation Technologies $26,000,000	$19,000,000	-$7,000,000
• Conduct demonstration and deployment of advanced Cooperative Driving Automation (CDA) systems that use vehicle-to-vehicle and vehicle-to-infrastructure communications to reduce transportation energy consumption by over 20 percent. • Conduct R&D to improve the efficiency and convenience of public transit, integrating this shared mode into the broader zero-carbon transportation system though electric-drive transit vehicles, transit system optimization, and more efficient intermodal transitions. • Continue funding selected projects previously awarded under the cross-cutting VTO and HFTO SuperTruck III solicitation.	• Continue demonstration and deployment of advanced Cooperative Driving Automation (CDA) systems that use vehicle-to-vehicle and vehicle-to-infrastructure communications to reduce transportation energy consumption by over 20 percent. • Continue RD&D to improve the efficiency and convenience of public transit, integrating this shared mode into the broader zero-carbon transportation system though electric-drive transit vehicles, transit system optimization, and more efficient intermodal transition. • Continue funding selected projects previously awarded under the cross-cutting VTO and HFTO SuperTruck III solicitation.	• Continue previous technology development, demonstration, and application efforts. • Prioritize building on previous R&D efforts while reducing stakeholder engagement efforts, which are currently in a sustainable place. • Build on previous SuperTruck III efforts.
Workforce Development and Clean Energy Mobility Solutions for Underserved Communities $0	$7,000,000	+$7,000,000
•	• Connect and enhance previous support for Clean Energy Mobility Solutions for Underserved Communities and separate complementary support for Workforce Development by targeting projects that explicitly link clean energy workforce development and clean energy outcomes in underserved communities.	• The increase will initiate a new activity to link workforce development and clean energy outcomes in underserved communities.

Vehicle Technologies
Technology Integration & Deployment

Description
The Technology Integration & Deployment subprogram supports the decarbonization of the transportation sector through various initiatives that accelerate the adoption of EVs and charging infrastructure. The program covers a broad technology portfolio that includes alternative fuels (e.g., advanced biofuels, electricity, hydrogen and, 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 & Deployment subprogram offers technical assistance, information resources, online training, and an array of data and analysis tools. At the local level, the subprogram manages and supports the Clean Cites coalitions that leverage these national resources to create networks of community stakeholders and provide hands-on technical assistance to communities and fleets. Clean Cities serves as a backbone for partnering with cities, towns, and rural areas across the country on clean transportation technology.

Technical Assistance and Demonstration: Support projects that provide information, insight, online tools, and technology assistance to cities, states, and regions working to implement clean transportation solutions 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 2024, the activity will provide funding to support technical assistance activities that support the Communities to Clean Energy initiative. The activity will continue to provide technical support to the State and Alternative Fuel Provider regulatory program.

Data Collection and Dissemination: 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 2024, the activity 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 activity challenges 14 university teams to apply advanced powertrain systems, as well as connected and automated vehicle technology, to improve efficiency, safety, and consumer appeal. In FY 2024, student teams will complete and implement their vehicle design through hardware development and engineering and planning will commence for the next iteration of EcoCar with an emphasis on diversity, equity, and inclusion. The activity will continue to support and expand Workforce Development activities that address the needs of first responders, codes and safety officials, and automotive technicians.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Technology Integration & Deployment $106,000,000	**$117,162,000**	**+$11,162,000**
Technical Assistance $94,000,000	$105,162,000	+$11,162,000
• Track covered fleet compliance with annual alternative fuel vehicle acquisition requirements, in accordance with Title V of the Energy Policy Act of 1992. • Increase direct funding to expand the Clean Cities Coalition's 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. • Initiate funding support and technical assistance to communities in analyzing clean energy transportation needs • Initiate funding to support the Integrated Heavy-Duty ZEV Fueling Corridor Demonstration project. • Fund and implement 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. Projects for consumers in underserved communities are a high priority. • New competitively awarded projects will focus on EV Charger Deployment with States to support the Administration's 500K EV Charging initiative. • Initiate a Smart Charging Vehicle-Grid Integration Project to demonstrate smart charging and business	• Track covered fleet compliance with annual alternative fuel vehicle acquisition requirements, in accordance with Title V of the Energy Policy Act of 1992. • Continue to support the Clean Cities Coalition's cooperative agreements to work in states and 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. • Fund support and technical assistance to communities in analyzing clean energy transportation needs. • No additional funds requested for Integrated Heavy Duty ZEV Fueling Corridor Initiative as it was a single year request for FY 2023. • Fund a new round 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 hazards using distributed solar, energy storage, EVs, and other DERs (joint EERE-OE effort).	• Expand technical assistance activities to Clean Cities, Communities to Clean Energy, Community-Led Innovation Center and the Joint Office of Energy and Transportation. • Integrated Heavy Duty ZEV Fueling Corridor Initiative completed as it was a single year activity in FY 2023. • Increase Clean Cities collaboration with underserved communities to address environmental justice and meet the Justice 40 goals. • Implement projects which develop educational content and implement a brand-neutral outreach campaign to increase consumer familiarity with EV charging technology and terminology, increase consumer awareness of electric vehicle charging equipment availability, and dispel EV charger myths. • Fund a new round of competitively selected projects to address on-going barrier to the acceleration of EV's. Topic may include No Home Charing, MD/HD Fleet Electrification and EV Workforce Development.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
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. • 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 hazards using distributed solar, energy storage, EVs, and other DERs (joint EERE-OE effort). • Funding for Super Truck III demonstration projects.		
Data Collection and Dissemination $8,000,000	**$8,000,000**	**+$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, continue to 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 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 significant change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• 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	•	•
STEM and Workforce Development $4,000,000	$4,000,000	$0
• Implement the next EcoCar student competition. The EcoCar EV Challenge will challenge teams to apply innovative solutions to address equity and electrification challenges in the future of mobility, advanced powertrain, charging, and thermal systems to use grid electricity intelligently.	• Implement year 3 of the EcoCar EV Challenge.	• Teams will focus on vehicle design to develop connected and automated on-board sensors and bi-directional connectivity to implement energy efficient automated control systems.

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 2024, 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 VTO's efforts and are an integral part of transportation and vehicle modeling and simulation. For modeling activities, the subprogram supports the creation, maintenance, and use of vehicle and system models to explore energy impacts of new technologies relevant to the VTO 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

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $6,000,000	**$9,185,000**	**+$3,185,000**
• Continue to 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. • Solicit external (non-DOE/ Lab) perspectives, methods, and projects for increasing access to low-carbon mobility for underserved communities, through a combination of data collection, modeling, and related analysis on vehicle consumer markets with an emphasis on underserved communities and used vehicle markets, as well as EV infrastructure awareness and expected charging behavior.	• Continue to 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. • Solicit external (non-DOE/ Lab) perspectives, methods, and projects for increasing access to low-carbon mobility for underserved communities, through a combination of data collection, modeling, and related analysis on vehicle consumer markets with an emphasis on underserved communities and used vehicle markets, as well as EV infrastructure awareness and expected charging behavior.	• Initiate efforts to identify cost-efficient and equitable transportation decarbonization scenarios to inform and prioritize technology investments, with emphasis on underserved communities. Increase data collection and analysis regarding increased EV penetration to quantify impacts on economy, grid, and communities.

Advanced Materials and Manufacturing Technologies

Overview

The Advanced Materials and Manufacturing Technologies Office (AMMTO) supports innovation for advanced materials and manufacturing technologies that drive competitive domestic manufacturing for products needed to decarbonize the economy. AMMTO has three subprograms focusing on next-generation materials and processes, secure and sustainable materials, and energy technology manufacturing and its workforce.

AMMTO plays a strategic role in building a strong, revitalized domestic manufacturing sector through investments in research, development and demonstration (RD&D) activities, as well as technical assistance and workforce training. AMMTO actively partners with the Nation's manufacturing innovation community, including companies (for-profit and not-for-profit), individuals, universities, laboratories, state/local governments, and consortia. AMMTO activities depend on merit-based selection and peer-reviewed results.

In the FY 2023 Budget Request, EERE's manufacturing and industry sector-related activities were structured across four technical subprograms: Industrial Efficiency and Decarbonization; Clean Energy Manufacturing; Material Supply Chains; and Technical Assistance and Workforce Development in a single Advanced Manufacturing Office (AMO). In the FY 2024 Request, EERE further sharpens and focuses its manufacturing portfolio, reorganizing the Advanced Manufacturing Office into two programs with associated control points aligned with the two organizational offices established in FY 2023: the AMMTO and the Industrial Efficiency and Decarbonization Office (IEDO). This reorganization was performed to position the two new organizations to better achieve the goals and purposes articulated for manufacturing and industry programs in the Energy Act of 2020. As part of the reorganization process, DOE considered input from external stakeholders and prior peer review feedback. IEDO focuses on RD&D for technologies that reduce emissions in the industrial sector for globally competitive decarbonized manufacturing in the U.S. AMMTO focuses on RD&D for advanced materials, advanced devices, and new processing technologies. These investments foster competitive U.S. manufacturing that delivers the products and technologies to decarbonize multiple end-use sectors in the full economy (buildings, industry, transportation, electric power). In addition to increasing U.S. manufacturing competitiveness, AMMTO's work results in more secure and resilient supply chains.

To strengthen the competitiveness of the U.S. manufacturing enterprise, AMMTO proposes a three-pillar budget structure: Next-Generation Materials and Processes; Secure and Sustainable Materials; and Energy Technology Manufacturing and Workforce. Within each subprogram, AMMTO focuses on the advancement of technology with high potential for impact, identified through engagement with stakeholders, informed by strategic analysis, and guided by roadmaps to target knowledge gaps and barriers, ultimately providing a pathway to adoption by industry.

Much of the work within AMMTO impacts and connects to other offices throughout DOE. AMMTO collaborates and coordinates with offices within the Office of the Under Secretary for Science and Innovation, including the Office of Fossil Energy and Carbon Management (FECM) on critical materials; the Office of Electricity (OE) on energy storage; and the Office of Science (SC) on semiconductors and microelectronics. The office also collaborates with other EERE offices on specific technology applications, including the Bioenergy Energy Technologies Office, Vehicle Technologies Office, the Wind Power Technologies Office, and IEDO. In addition, AMMTO collaborates with Offices within the Office of the Under Secretary for Infrastructure (S3) on RD&D and workforce development efforts to maximize economy-wide decarbonization and energy efficiency and enable secure, sustainable, and resilient domestic supply chains.

Highlights of the FY 2024 Request

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

- Invest in research and develop advanced manufacturing technologies such as additive manufacturing, forging, casting and other processes and techniques that enable a competitive U.S. manufacturing sector, particularly for clean energy applications such as large near net shape metal components used in offshore wind, water power, and other energy applications.
- Invest in RD&D on highly conductive materials that drive efficiency gains in several applications, including motors, electrical delivery systems, waste heat recovery, and others.

- Continue funding the Critical Materials Collaborative, as authorized in the Energy Act of 2020, to provide a centralized entity for multidisciplinary, collaborative, critical materials R&D, including pilot projects and testbeds, to reduce supply risk and improve supply resilience for materials and technologies necessary for the clean energy transition.
- Expand circular economy support to advance design for recyclability, efficient material use, recycling technologies, and reuse of raw materials in manufacturing for materials and products, including polymers, metals, fibers, and electronics.
- Research and develop manufacturing innovations to address technical challenges and barriers to achieve lower cost, higher performance, and accelerated deployment of clean energy technologies, such as long duration energy storage systems, wide bandgap semiconductors, and highly efficient semiconductors.
- Train the manufacturing workforce of the future through regional education initiatives, Manufacturing USA Institute education and workforce development programs, and the Lab Embedded Entrepreneurship Program (LEEP).
- AMMTO is involved in several crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing crosscut through RD&D to develop manufacturing technologies for long duration storage, power electronics and highly efficient microelectronics; composite wind turbine blades and other clean energy technologies; new materials for high conductivity application and harsh service conditions, smart manufacturing, additive manufacturing, and roll-to-roll manufacturing, recycling, design for recyclability, and other circular economy approaches;
    - Critical Minerals crosscut through R&D and pilot projects and testbeds that verify economics of scaled continuous operations in real world conditions needed to diversify supply, developing substitutes, improving reuse/recycling, and more efficient use;
    - Energy-Storage crosscut through investments on innovation related to incorporating energy storage into manufacturing processes and/or facilities to manage power and thermal energy and reduce industrial greenhouse gas (GHG) emissions;
    - Grid Modernization crosscut through investments in the development and demonstration of highly-conductive materials that can provide significant efficiency improvements to the grid and grid-connected applications; and Industrial Decarbonization crosscut through a variety of R&D investments.

Advanced Materials and Manufacturing Technologies
Funding ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Advanced Materials and Manufacturing Technologies (AMMTO)					
Next-Generation Materials & Processes	103,544	90,000	90,000	0	0%
Secure & Sustainable Materials	66,530	40,000	91,497	+51,497	+78%
Energy Technology Manufacturing & Workforce	50,444	53,500	60,000	+6,500	+12%
Total, Advanced Materials and Manufacturing Technologies	**220,518**	**183,500**	**241,497**	**+57,997**	**+32%**
Industrial Efficiency & Decarbonization Office (IEDO)					
Energy- and Emission-Intensive Industries	98,790	131,000	195,000	+64,000	+49%
Cross-Sector Technologies	52,709	90,500	141,245	+50,745	+56%
Technical Assistance & Workforce Development	30,983	45,000	58,000	+13,000	+29%
Total, Industrial Efficiency & Decarbonization Office	**182,482**	**266,500**	**394,245**	**+127,745**	**+48%**

Note: Industrial Efficiency and Decarbonization Office (IEDO) added to the table to show the Request to re-organize Advanced Manufacturing Office (AMO) Budget into two control points aligned with the two organizational offices established in FY 2023: the AMMTO and the IEDO. Numbers in FY 2023 and earlier are estimates prior to the bifurcation of the office.

SBIR/STTR:
FY 2022 Transferred: SBIR: $7,451,207; STTR: $972,809
FY 2023 Enacted: SBIR: $4,453,741; STTR: $588,929
FY 2024 Request: SBIR: $6,717,000; STTR: $945,000
Note: Please see Industrial Efficiency and Decarbonization Technologies (IEDO) for the balance of AMO SBIR/STTR funding

Proposed FY 2024 Budget Structure

	Advanced Materials and Manufacturing Technologies (AMMTO)			
	Next-Generation Materials & Processes	**Secure & Sustainable Materials**	**Energy Technology Manufacturing & Workforce**	**Total**
FY 2023 Budget Structure				
Advanced Manufacturing (AMO)				
Industrial Efficiency and Decarbonization				**0**
Clean Energy Manufacturing	55,000		42,000	**97,000**
Material Supply Chains	35,000	91,497		**126,497**
Technical Assistance and Workforce Development			18,000	**18,000**
Total	**90,000**	**91,497**	**60,000**	**241,497**

Note: Please see Industrial Efficiency and Decarbonization Technologies (IEDO) for the balance of AMO funding

Advanced Materials and Manufacturing Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Next-Generation Materials & Processes: The Request prioritizes the development of manufacturing processes, such as those advanced by DOE's Manufacturing Demonstration Facility (MDF). Resources emphasize support for technologies to produce cost-effective near net-shape objects needed for multiple clean energy technologies. The Request also supports additional work to address smart manufacturing throughout the manufacturing sector. Materials and processing RD&D also will focus on highly conductive materials for efficiency improvements across the economy and structural materials for clean energy technologies.	0
Secure & Sustainable Materials: The Request includes an increase that will prioritize research to advance manufacturing and materials technologies relevant to the circular economy. RD&D activities emphasize manufactured materials design with consideration of their full life, developing new recycling processes, and addressing circular supply chain challenges for materials important to clean energy technologies. The Request also increases AMMTO critical materials investments, with focus on research, development and pilot scale demonstrations aimed at increasing availability and resiliency of critical materials used in clean energy application.	+51,497
Energy Technology Manufacturing & Workforce: This Request increases investment in RD&D for the manufacture of long duration storage technologies, power electronics needed for electrification, and highly efficient microelectronics. The subprogram will continue to support workforce development programs and technical assistance, as well as the Lab Embedded Entrepreneurship Program, which provides innovators with lab access and entrepreneurship training.	+6,500
Total, Advanced Materials and Manufacturing Technologies	**+57,997**

Advanced Materials and Manufacturing Technologies
Next-Generation Materials & Processes

Description

The Next-Generation Materials & Processes subprogram will focus RD&D support on evolving advanced manufacturing materials and processes that increase U.S. manufacturing competitiveness in clean energy technologies, with an emphasis on materials and manufacturing processes that benefit multiple energy technology applications. This work will support economy-wide decarbonization. Key materials and processes include structural composites, high conductivity materials, materials for harsh service conditions, additive manufacturing, smart manufacturing, and high performance computing. This subprogram will support applied RD&D projects and consortia—cost-shared with companies and research organizations—that focus on generating solutions to specific materials and technology challenges to advance domestic manufacturing while reducing our Nation's carbon footprint. This RD&D will be selected through competitive solicitations using merit review.

Advanced Manufacturing Processes and Systems: This activity will support foundational manufacturing processes such as additive manufacturing, roll-to-roll manufacturing, automation, digitalization, and cybersecurity. These manufacturing process innovations can improve U.S. competitive advantage across a variety of industries important to manufacturing of clean energy technologies. The Manufacturing Demonstration Facility (MDF) works on additive manufacturing and related processes for clean energy technologies. Casting and forging processes will be worked on to revitalize domestic supply chains, particularly for large, near net shape components needed in clean energy applications. Manufacturing digitalization, made secure by cybersecurity advancements, will be essential to U.S. manufacturing competitiveness and resilient supply chains. In addition, high-performance computing for manufacturing (HPC4Mfg) programs enable direct access to high-performance computing assets and expertise at national laboratories to U.S. manufacturers (with a focus on small and medium sized firms) to accelerate scale-up and adoption of new material and process technologies with high impact potential in clean energy applications.

High Performance Materials: This activity will support materials with improved performance necessary for decarbonization and clean energy. Specific RD&D will enable advancements high conductivity metals, and high-strength and low-weight materials. The activity will also support RD&D for composite materials for wind energy and other clean energy applications. Additional work will focus on developing materials used in extreme or harsh conditions, with a focus on high temperature service environments required for decarbonized heat, thermal storage, and other clean energy applications.

Next-Generation Materials & Processes

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Next-Generation Materials & Processes **$90,000,000**	**$90,000,000**	$0
Advanced Manufacturing Processes and Systems $64,500,000	$55,000,000	-$9,500,000
• Continue additive manufacturing and carbon fiber composites research through the MDF.	• Leverage MDF to address cross-cutting manufacturing challenges and enable a domestic supply chain for clean energy technologies such as wind and hydropower. Pursue joint funding from other DOE offices (WETO, NE), agencies (DOD) and private partners that benefit from MDF work.	• Reduction of funding for demonstrations in the use of nanocellulosic feedstocks to manufacture clean energy components and building technologies to prioritize funding for RD&D that addresses challenges in cross-cutting manufacturing technologies. Modest reduction in funding for MDF.
• Support new methods for manufacturing products such as agile manufacturing, additive manufacturing, and the manufacture of carbon fiber from low-cost precursors, and support innovative Advanced Materials and Manufacturing Technologies to enable manufacturing supply chains to be nimble, responsive, and adaptive to disruption, change and opportunity.	• Use the National Smart Manufacturing Strategic Plan[1] and proceedings from the Workshop series on Options for a National Plan for Smart Manufacturing[2] to guide funding of RD&D in manufacturing digitalization technology that improves energy efficiency, reduces emissions, and improves supply chain resilience.	• No change in funding.
• Support high performance computing-based solutions that apply modeling, simulation, and data analysis to industrial processes and products to improve energy performance and substantially reduce carbon.	• Support HPC4Mfg program that provides access to leading edge national lab capabilities in modeling, simulation, and data analysis for industrial processes, materials, and products to improve energy performance and/or improve other dimensions of manufacturing performance	• No change in funding. Will support computational models and analysis for materials design and manufacturing performance and scale up for clean energy technologies.

[1] DOE National Smart Manufacturing Strategic Plan (2022), https://www.energy.gov/sites/default/files/2022-07/National%20Smart%20Manufacturing%20Strategic%20Plan%20-%202022_0.pdf

[2] National Academies of Sciences Engineering and Medicine, Workshop Series on Options for a National Plan on Smart Manufacturing (2023), https://www.nationalacademies.org/our-work/options-for-a-national-plan-for-smart-manufacturing

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	and scale up, such as quality, yield, and throughput.	
• No funding	• Fund RD&D that addresses challenges in cross-cutting manufacturing technologies, such as castings and forgings of large, near net shape components and roll-to-roll manufacturing, that have the potential for high impact across multiple clean energy technology sectors.	• Increase will support priority cross cutting manufacturing technologies that have high impact across multiple clean energy technology sectors.
• Fund development of advanced tooling for lightweight automotive components	• No funding	• Deprioritizing work on automotive components.
High Performance Materials $25,500,000	$35,000,000	+$9,500,000
• Fund competitively selected R&D projects to develop improved performance for materials necessary for decarbonization and clean energy, such as high conductivity metals and industrial materials that can operate in harsh service environments. Continue to support CABLE high conductivity materials activities. to help build an equitable, clean-energy future.	• In support of economy-wide decarbonization, fund R&D on materials with high thermal and/or electrical conductivity with a broad range of applications, including motors, CHP systems, and waste heat recovery.	• Modest increase in funding in high conductivity materials in support of economy-wide decarbonization.
	• Funding for R&D to develop materials that enable energy efficiency improvements and emissions reduction through their use in harsh service environments, particularly high temperature applications that are needed for decarbonized heat and thermal storage.	• Modest increase in funding for materials for high temperature and other harsh service environments needed for economy-wide decarbonization.
	• Fund work on structural composites for clean energy applications, including for offshore wind	

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Fund composite materials R&D in collaboration across EERE and DOE for technologies including wind.	blades and platforms. Manage the Carbon Fiber Technology Facility (CFTF) in conjunction with this work.	• Modest decrease in funding for composites for technologies that have matured to commercial viability to prioritize efforts described above.

Advanced Materials and Manufacturing Technologies
Secure & Sustainable Materials

Description

The Secure and Sustainable Materials subprogram focuses on the advancement of material supply chains and process technologies that promote economy-wide decarbonization. This includes addressing the critical materials supply chain challenges by developing alternatives to reduce their demand and by promoting pathways for domestic supply, recycling, and processing of these materials. The subprogram also invests in supply chain sustainability through circular economy approaches, including advancing recycling processes and design for recyclability. RD&D in this subprogram will support secure decarbonized supply chains, advance environmental justice by reducing environmental emissions, and drive improvements in energy and resource efficiency for a competitive U.S. manufacturing sector. AMMTO will coordinate and collaborate across DOE offices and participate in interagency coordination in both of these areas.

Critical Materials: This activity continues funding for a centralized entity, created in FY 2023, for multidisciplinary, collaborative, critical materials R&D as required in Section 7002 (g) of the Energy Policy Act of 2020. The Critical Materials Collaborative will support RD&D investments to reduce supply risk and improve supply chain resilience for materials and technologies necessary for the clean energy transition. Critical materials to be addressed include rare earths, lithium, cobalt, and gallium, with applications such as magnets in electric vehicles and wind turbines, batteries, efficient lighting, and semiconductors. Strategies include diversifying supply, developing substitutes, material efficiency, and improving reuse/recycling. The activity will also support pilot projects and testbeds that verify economics of continuous operations in real world conditions. Areas of interest for these projects include highly selective separation, metal reduction, magnet manufacturing, materials recovery from secondary and unconventional sources, material reuse, more efficient use, and balanced coproduction. These activities create and advance technologies that are the pipeline into the demonstration programs supported by Manufacturing and Energy Supply Chains (MESC), Fossil Energy and Carbon Management (FECM) and other DOE offices and funded in Base and Infrastructure Investment and Jobs Act appropriations. As such, AMMTO has strong coordination with these offices on critical materials activities.

Circular Economy Technologies: The circular economy—an economy that keeps materials, products, and technologies in circulation for as long possible—is essential for economy-wide decarbonization and material security. This activity will support RD&D that advances the circular economy of materials important for clean energy technologies through design for recyclability, new material development, reuse and recycling, with a particular focus on energy- and emissions-intensive materials. These approaches have the potential to mitigate up to 40 percent of global GHG emissions and can reduce other environmental impacts as well. Material classes include metals, polymers, fibers, fiber reinforced polymer (FRP) composite materials, and e-waste. RD&D efforts will be guided by consistent life cycle analysis methodology to inform high impact opportunities to reduce carbon and other emissions across product life cycles. In addition, this effort will support the development of life cycle embodied carbon analysis tools for use by industry and other partners.

Secure & Sustainable Materials

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Secure & Sustainable Materials $40,000,000	**$91,497,000**	**+$51,497,000**
Critical Materials $26,0000,000	$50,000,000	+$24,000,000
• Establish Critical Materials Collaborative for high priority critical materials, including pilot projects and testbeds to reduce supply risk and improve supply resilience for materials and technologies necessary for the clean energy transition.	• Continue funding of the Critical Materials Collaborative, which includes activities that span research, development, and pilot demonstration. Work will advance technologies that reduce supply chain risk and increase supply resilience for materials needed for clean energy applications.	• Increase in funding supports the Critical Materials Institute and additional activities under the Critical Materials Collaborative that span research, development, and pilot demonstration for efficient material production and recycling, as well as production of alternatives.
Circular Economy Technologies $14,000,000	$41,497,000	+$27,497,000
• Continuation of the BOTTLE Consortium and the expansion of R&D projects to address recycling challenges such as sorting and separations; along with efforts to apply circular economy principles to polymers and fiber reinforced polymer (FRP) composite materials.	• Significant additional funding to advance RD&D for the circular economy across more material classes, including recycling and design for recycling of composites, plastics, fibers, e-waste, and metals, aligned with EPA's National Recycling Strategy[3]. Funding also to support tools for embedded carbon life cycle analysis. Building on the BOTTLE Consortium's success and industry interest, and guided by the Strategy for Plastics Innovation[4], support technologies needed to adopt plastic recycling and sustainable design solutions, with a focus on sorting and separation issues.	• New RD&D investments for circular economy-related efforts across composites, plastics, fibers, e-waste, and metals leveraging prior investments in Manufacturing USA Institutes and regional solutions. New work on tools for embedded carbon life cycle analysis, in support of industrial decarbonization.

[3] EPA National Recycling Strategy 2023, https://www.epa.gov/recyclingstrategy

[4] DOE Strategy for Plastics Innovation 2023, https://www.energy.gov/entity%3Anode/4394292/strategy-plastics-innovation

Advanced Materials and Manufacturing Technologies
Energy Technology Manufacturing and Workforce

Description
This subprogram will focus on advancements in manufacturing research and demonstration for technologies—such as energy storage systems, power electronics, and highly efficient microelectronics—that are critical for achieving economy-wide decarbonization. Investments will support manufacturing innovations to improve performance and address barriers to achieve lower manufacturing cost that can accelerate the path of these technologies to market. The subprogram will also support the formation of entrepreneurial ecosystems to nurture emerging industries, as well as multilevel workforce development. This approach to manufacturing innovation supports the Administration's commitment to ensuring the clean energy future is Made in America by workers with good jobs and fair opportunity, with an emphasis on benefiting disadvantaged communities and underrepresented populations. Investments will be prioritized based on analysis, cross-DOE planning, and input from industry to accelerate the path to deployment in support of economy-wide decarbonization.

Semiconductors, Electronics, and Other Technology Manufacturing: Cross-cutting technologies enable clean energy technologies to be deployed in multiple industrial sectors. Informed by analysis and stakeholder engagement, this activity will invest in development of lower cost, higher efficiency wide bandgap semiconductors that are critical to power management of industrial motors and electric vehicle motors. In addition, the activity is investing in manufacturing technologies needed to produce high efficiency microelectronics.

Energy Conversion and Storage Manufacturing: Supporting a decarbonizing grid requires long duration storage technologies. Achieving cost and performance targets of the Department of Energy's (DOE) long duration storage shot requires manufacturing advances. This activity will invest in flow battery manufacturing across various chemistries, such as in electrolyte processing technologies to extend the operational lifetime and electrode engineering to increase the power density.

Entrepreneurial Ecosystems and Advanced Manufacturing Workforce: Diverse networks of manufacturers in emerging technology areas and/or across supply chains can help accelerate innovation and manufacturing scale up. This activity will support people and communities to catalyze expertise in information systems, and to business and entrepreneurial ecosystems This activity will support technical assistance for development of clean energy manufacturing capacity. It will be informed by a roadmap, currently under development by AMMTO, and will support participants at varying career levels, engage underserved communities, and integrate activities across EERE programs. All educational and workforce development activities will include a focus on diversity and inclusion.

Energy Technology Manufacturing and Workforce

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy Technology Manufacturing and Workforce $53,500,000	**$60,000,000**	**+$6,500,000**
Energy Conversion and Storage Manufacturing $20,500,000	$24,000,000	+$3,500,000
• Develop 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.	• This activity focuses on RD&D investments to catalyze manufacturing scale up of emerging battery technologies. For flow batteries, the focus will be on electrolyte processing technologies to extend the operational lifetime and electrode engineering to increase the power density. For solid state batteries, the focus will be on processing thin lithium metal layers, developing standard fixturing, and standard testing protocols.	• Modest increase in funding of battery manufacturing RD&D to increase the range of emerging chemistries addressed.
Semiconductors, Electronics, and Other Technology Manufacturing_ $15,500,000	$18,000,000	+$2,500,000
• Clean energy manufacturing R&D in collaboration across EERE and DOE for technologies including highly efficient semiconductors, power electronics.	• Manufacturing RD&D for the high voltage power electronics needed for transportation and other applications. Manufacturing RD&D for high efficiency microelectronics.	• Modest increase in funds to address manufacturing barriers for power electronics.
Entrepreneurial Ecosystems and Advanced Manufacturing Workforce $17,500,000	$18,000,000	+$500,000
• Train the clean energy innovators and manufacturing energy management workforce of the future. Provide additional resources and trainings to increase the impact of existing workforce-related programs, including within energy communities, underserved communities, and tribal communities. Expand programs targeted at community colleges and technical schools, apprenticeship programs, and resources focused on reskilling and upskilling existing workers. Support projects led by early-career	• Train the clean energy innovators of the future through the Lab-Embedded Entrepreneurship Program. Provide technical assistance resources and related investment to support scaling up manufacturing of emerging high-impact clean energy and energy efficiency technologies and related innovation ecosystems. Begin to implement a manufacturing workforce development program guided by a roadmap that AMMTO is developing. The roadmap supports participants at varying career levels, engages	• No significant funding change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
post-doctoral researchers to address fundamental manufacturing decarbonization challenges.	underserved communities, and integrates activities.	

Hydrogen and Fuel Cell Technologies

Overview

Hydrogen and fuel cell technologies have a key role in addressing the climate crisis, enabling America's leadership in clean energy technology, and creating equitable opportunities for all Americans. Aligned with the Administration's goals for a carbon-free grid by 2035 and net-zero emissions by 2050, the benefits of hydrogen and fuel cell technologies will be significant in hard to decarbonize sectors, and span across transportation, power, industrial and chemical production applications.

In FY 2024, the Hydrogen and Fuel Cell Technologies Office (HFTO) will focus on research, development, demonstration, and deployment (RDD&D) of hydrogen production, storage and distribution, and end use technologies, including fuel cells, to make clean hydrogen affordable and accessible for all Americans. HFTO RDD&D activities align with broader programs at the HFTO and DOE Hydrogen Program level, including H2@Scale and the Hydrogen Energy Earthshot, and focus on reducing cost, achieving technology at scale, strengthening supply chain resilience, fostering workforce development, supporting environmental justice and coordinating collaborative and strategic partnerships including those with the national laboratories, the DOE Hydrogen Program Offices, Federal agencies, state and local governments, industry, and non-governmental partners.

Highlights of the FY 2024 Request

- Focus on applied fuel cell component and systems RD&D with emphasis on the Million Mile Fuel Cell Truck consortium (M2FCT) to enable fuel cells for long haul trucks.
- Emphasize applied RD&D on materials, components, systems, and process development to enable both the Hydrogen Shot goal of $1/kg of clean hydrogen and hydrogen storage and infrastructure technologies.
- No funding requested for electrolysis work, as it is funded under the Infrastructure Investment and Jobs Act's (IIJA) Clean Hydrogen Electrolysis provision.
- Focus on medium- and heavy-duty transportation, industrial and chemical applications, grid energy storage and power generation, and safety, codes, and standards. Evaluate marine, rail, aviation, and off-road equipment (e.g., mining construction, and agriculture equipment), and fuel cell systems for fast charging battery electric vehicles, steel and ammonia production, and integrate megawatt-scale electrolyzers with clean sources and store clean hydrogen for various applications.
- Focus data, modeling, and analysis on life cycle emissions and co-locating high volume hydrogen production and end use, in coordination with other DOE offices.
- Continue crosscutting initiatives, including the following:
    - Industrial Decarbonization to enable affordable carbon-free hydrogen to address hard-to-decarbonize industrial and chemical applications such as ammonia and steel production;
    - Clean Energy Technology Manufacturing to develop manufacturing processes for carbon fiber for on-board physical storage and hydrogen refueling components;
    - HFTO's entire portfolio contributes to the Hydrogen Crosscut;
    - Energy Storage including hydrogen production, hydrogen storage, advanced fuel cell technologies and systems integration RD&D;
    - Critical Minerals to reduce Platinum Group Metals (PGM) catalysts for fuel cells and hydrogen production technologies; and
    - Grid Modernization to research hybrid wind to hydrogen and includes funding for the National Renewable Energy Laboratory's Advanced Research on Integrated Energy Systems (ARIES) program.

Hydrogen and Fuel Cell Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Hydrogen and Fuel Cell Technologies					
Fuel Cell Technologies	30,000	30,000	25,000	-5,000	-17%
Hydrogen Technologies	61,000	67,000	61,000	-6,000	-9%
Systems Development & Integration	63,500	70,000	74,075	+4,075	+6%
Data, Modeling & Analysis	3,000	3,000	3,000	0	0%
Total, Hydrogen and Fuel Cell Technologies	**157,500**	**170,000**	**163,075**	**-6,925**	**-4%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $4,189,028; STTR: $704,360
- FY 2023 Enacted: SBIR: $5,024,000; STTR: $706,500
- FY 2024 Request: SBIR: $4,816,800; STTR: $677,363

Hydrogen and Fuel Cell Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Hydrogen and Fuel Cell Technologies	
Fuel Cell Technologies: Reduces R&D on materials and components to prioritize systems integration for heavy-duty transportation and stationary applications.	**-5,000**
Hydrogen Technologies: Reduces emphasis on activities related to liquid fueling components and liquid hydrogen storage tanks to prioritize gaseous hydrogen technologies in alignment with industry's near-term focus.	**-6,000**
Systems Development & Integration: Increases funding for demonstrations of new transportation applications (e.g., marine, rail, off-road, medium-duty) and heavy-duty hydrogen fueling infrastructure. Shifts focus from Grid Energy Storage and Power Generation to prioritize demonstrations of end use applications within Industrial and Chemical Applications.	**+4,075**
Data, Modeling & Analysis: No significant changes.	**0**
Total, Hydrogen and Fuel Cell Technologies	**-6,925**

Hydrogen and Fuel Cell Technologies
Fuel Cell Technologies

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.) to enable competitiveness with incumbent and other advanced technologies. RD&D is focused on key materials and components that can 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, one longer-term objective is to reduce the amount of PGMs while meeting durability, efficiency, and other performance requirements.

Materials and Component R&D: Supports membrane electrode assembly (MEA) and stack components. The primary areas of focus are catalysts, electrodes, membranes, and ionomers, which are critical to reaching the subprogram's targets. Improving fuel cell durability, efficiency, and performance will address priorities beyond transportation including grid resiliency, energy storage, and national space mission priorities. The program's M2FCT and ElectroCat National Laboratory consortia will continue to provide unique capabilities in synthesis, characterization, and computation to competitively selected projects.

Systems Integration R&D: Includes integrating MEAs and other stack components developed in the Materials and Component R&D key activity, into systems. Efforts include the developing and demonstrating fuel cell stacks and BOP components with manufacturability and sustainability in mind. Innovative concepts will be explored to enable optimal performance through better integration of components into subsystems and full systems across applications. Efforts are supported by modeling and will incorporate stack and BOP standardization approaches, and energy storage (e.g., unitized reversible fuel cells). Advances in these areas will enable the U.S. to retain global leadership, strengthen the supplier base, and expand domestic manufacturing capability.

Fuel Cell Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Fuel Cell Technologies $30,000,000	**$25,000,000**	**-$5,000,000**
Materials and Component R&D $23,000,000	$18,000,000	-$5,000,000
• Continue accelerating R&D on low-PGM MEAs with enhanced durability to enable meeting cost and durability targets across heavy-duty applications.	• Continue R&D on low-PGM MEAs with enhanced durability to enable meeting cost and durability targets across heavy-duty applications.	• No Significant Change.
• Continue R&D on PGM-free catalysts and electrodes (ElectroCat) to enable meeting cost and durability targets across applications.	• Focus R&D on most promising PGM-free catalysts and electrodes from prior year projects (ElectroCat) to enable meeting cost and durability targets.	• No Significant Change.
• Continue R&D beyond early-stage concepts, in coordination with M2FCT (e.g., gas diffusion layers) to strengthen the domestic supply base.	• Support RD&D to strengthen the domestic supply base in coordination with M2FCT.	• No Significant Change.
• Continue R&D on MEA components and MEAs to improve the durability and efficiency of MEAs for heavy-duty applications meeting ultimate targets.	• Continue R&D on MEA components and MEAs to improve durability and efficiency of MEAs for heavy-duty applications.	• Reduces activities on materials and components R&D to prioritize systems integration for heavy-duty applications while materials work from prior year projects is completed.
Systems Integration R&D $7,000,000	$7,000,000	$0
• Continue RD&D and systems integration, including stack and BOP components and manufacturing and standardization approaches to strengthen the domestic supply chain relevant to reversible and stationary fuel cells.	• Focus RD&D and systems integration relevant to stationary and transportation fuel cells to enable economies of scale across applications.	• Prioritizes R&D on reversible fuel cells and technologies for heavy-duty applications
• Demonstrate fuel cells for stationary power generation applications and reversible fuel cells for resiliency to support critical loads and disadvantaged communities	• Continue systems integration and demonstration of next generation fuel cells with potential to meet cost and durability.	• No Significant Change.
• Continue analysis on assessing hydrogen and fuel cell targets for various applications as well as status to guide future RD&D.	• Assess hydrogen and fuel cell target for various applications to guide future RD&D.	• No Significant Change

Hydrogen and Fuel Cell Technologies
Hydrogen Technologies

Description
The Hydrogen Technologies subprogram supports RD&D enabling clean, low-cost, and environmentally sustainable hydrogen production, storage, and infrastructure technologies to achieve the DOE Hydrogen Shot goal of $1/kg clean hydrogen by 2031. Key activities include addressing cost and performance of materials, components and systems related to hydrogen production, transport, storage, and dispensing across a range of technologies and applications.

Production R&D: Aligned with the Administration's climate goals and achieving the Hydrogen Shot goal, this activity addresses advanced water splitting pathways, while electrolysis activities are funded through the BIL's Clean Hydrogen Electrolysis Program. The key focus is reducing the modeled cost of clean hydrogen via direct photo-electrochemical (PEC), and high-temperature thermochemical pathways. This activity leverages the capabilities within the DOE National Laboratories through the multi-laboratory consortium HydroGEN. It also supports technologies with the potential to leapfrog those available commercially today. Approaches include dark-fermentation processes; microbial electrolysis; and hybrid systems that leverage nuclear, and renewable resources – including technologies that use biomass or industrial waste streams.

Storage R&D: This activity supports RD&D on advanced technologies for efficient, high-density, safe, and cost-effective hydrogen storage for stationary, transport, and mobile applications. RD&D activities include reducing the cost of carbon fiber composite tanks, and on advanced, innovative liquid hydrogen storage technologies. In FY 2024, activities will emphasize bulk and high-capacity storage technologies, including materials-based carriers for hydrogen transport and storage and other innovative concepts supported by the multi-laboratory Hydrogen Materials Advanced Research Consortium (HyMARC).

Infrastructure R&D: This activity supports work on materials, components, and processes to enable a low-cost, safe, and efficient hydrogen infrastructure to enable achieving the overall cost target for produced, delivered, and dispensed hydrogen across sectors. In FY 2024, emphasis will be on bulk and high-capacity delivery pathways, including pipelines. RD&D investigating and developing hydrogen compatible materials (e.g., metals, polymers) will continue in collaboration with the H-Mat consortium. Activities will be coordinated with FECM.

Hydrogen Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydrogen Technologies $67,000,000	**$61,000,000**	**-$6,000,000**
Production R&D $15,000,000	$15,000,000	$0
• Continue advanced water splitting R&D through HydroGEN and shift electrolysis efforts including H2NEW to BIL.	• Shift advanced non-electrolysis R&D technologies to component integration and reactor concepts as opposed to materials discovery.	• No significant change.
Storage R&D $22,000,000	$19,000,000	-$3,000,000
• Continue developing technologies to enable hydrogen use in medium- and heavy-duty transportation. Initiate activities for onboard liquid hydrogen storage and refueling for MD/HD applications.	• Focus RD&D on bulk and high-capacity materials-based carrier systems for hydrogen transport and storage and other innovative concepts.	• Reduces liquid hydrogen activities until data is collected from prior year projects. Prioritizing bulk and high-capacity technologies for storage and transport applications in alignment with industry priorities on gaseous hydrogen in the near-term.
Infrastructure R&D $30,000,000	$27,000,000	-$3,000,000
• Continue H-Mat materials compatibility RD&D, including impact of hydrogen blending on performance.	• Continue H-Mat materials compatibility RD&D.	• No significant change.
• Refocus HyMARC with a greater emphasis on higher TRL materials and system-level consideration.	• Continue HyMARC with focus on carriers that can transport hydrogen at high densities at low pressure and that do not require cryogenic temperatures, potentially for exports/alternate delivery approaches.	• Shifts focus to carriers that can transport hydrogen, potentially for applications such as export.
• Continue R&D on hydrogen fueling technologies, with an emphasis on liquid hydrogen handling, to accelerate progress on meeting needs for industrial and heavy-duty transportation applications.	• Focus on bulk and high-capacity infrastructure technologies for hydrogen transport applications, including pipelines and fueling component technologies.	• Reduces liquid hydrogen fueling component activities until data is collected from prior year projects. Prioritizing high-capacity infrastructure technologies for hydrogen transport applications, including pipelines, in alignment with industry priorities on gaseous hydrogen in the near-term.

Hydrogen and Fuel Cell Technologies
Systems Development & Integration

Description
The Systems Development and Integration subprogram focuses 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 in support of Hydrogen Shot and realize the H2@Scale vision. This includes focusing on integrating clean energy systems (i.e., grid energy storage and power generation), decarbonizing industrial and chemical processes, and demonstrating medium- and heavy-duty transportation applications. The subprogram also enables 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.

Activities focus on accelerating the transition from RD&D to commercial viability by addressing the challenges of integrating components and systems for optimal performance, affordability, and durability and are coordinated with other DOE offices. For example, hybridized systems, such as coupling thermal sources with electrolyzers, can help reduce electricity requirements and improve efficiencies while the co-location of large-scale hydrogen generation with utilization can minimize the cost of transport and storage.

Transportation: Transportation activities will focus on demonstrating medium- and heavy-duty fuel cell applications. RDD&D will accelerate the development of fuel cell electric trucks and buses to reduce emissions and improve energy and operational efficiencies while providing operating range and fueling times on par with incumbent technologies. New market opportunities for hydrogen and fuel cells in heavy-duty transportation sector such as marine, rail, aviation, and off-road equipment (e.g., refuse trucks, mining vehicles) as well as modular, dispatchable fueling and fuel cell systems for fast charging battery vehicles, will continue to be evaluated and will include a demonstration. Transportation activities will be coordinated with EERE's Vehicle Technologies Office (VTO).

Industrial and Chemical Applications: Within hard-to-decarbonize industrial and chemical processes, this activity will focus RDD&D on demonstrating clean hydrogen's potential as a feedstock (e.g., ammonia production), or direct reducing agent (e.g., steel production), or to provide heat to industrial applications (e.g., steel and cement production).

Grid Energy Storage and Power Generation: This activity will focus on hybrid systems, grid integration, and energy storage of hydrogen to enable grid stability/resiliency, avoid curtailment, and produce low-cost, clean hydrogen. FY 2024 work includes integration of multi-megawatt water electrolyzers coupled with renewable energy and baseload nuclear sources.

Safety, Codes and Standards: This activity conducts R&D to enable the development of codes and standards for adoption of hydrogen and fuel cell technologies in support of H2@Scale and ensures safety considerations are incorporated into RDD&D projects, best practices are developed, and lessons learned are shared. Depending on the application, specific issues such as the amount of hydrogen that may be stored at a given location, the required hydrogen metering/flow rates, transport of hydrogen in tunnels, or the footprint restrictions onsite, must be addressed. Hydrogen behavior upon release at certain conditions (e.g., temperatures/pressures) must be understood to inform development of codes and standards. In addition, the global harmonization of codes and standards is critical to ensure a robust and competitive U.S. supply chain to serve domestic and international markets.

Systems Development & Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Development & Integration $70,000,000	**$74,075,000**	**+$4,075,000**
Transportation $29,000,000	$40,000,000	+$11,000,000
• Continue funding 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 SuperTruck as well as analyzing opportunities for other heavy-duty transportation sectors such as marine, rail, and off-road equipment.	• Continue funding industry-led teams focused on improving energy and operational efficiency of moving freight with medium- and heavy-duty fuel cell electric trucks in support of SuperTruck. • Support demonstration of another heavy-duty transportation application such as marine, rail, or off-road equipment. • Support fuel cell demonstrations for bus and fast charging electric vehicle applications. • Support high-flow, heavy-duty hydrogen fueling infrastructure.	• Increases funding for demonstrations of new applications (e.g., marine, rail, off-road, medium duty) and heavy-duty hydrogen fueling infrastructure.
Industrial and Chemical Applications $10,000,000	$16,000,000	+$6,000,000
• Continue industry-led projects to demonstrate use of clean hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production, in collaboration with other offices.	• Increase investment in industry-led projects to demonstrate use of clean hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production, and for thermal processing applications.	• Increases funding to demonstrate use of hydrogen for thermal processing required for industrial applications.
Grid Energy Storage and Power Generation $16,000,000	$8,075,000	-$7,925,000
• Continue 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, clean hydrogen. Specific focus will be placed on developing micro-grids for underserved communities.	• Continue 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, clean hydrogen.	• Reduces funding for grid integration with hydrogen technologies to prioritize demonstration for industrial end use activities.
• Continue systems integration and validations to guide R&D. Support NREL's Advanced	• Support systems integration and validation work, including ARIES effort, and net zero campus RD&D.	• Reduces systems integration to prioritize demonstration for an industrial end use application.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Research on Integrated Energy Systems (ARIES) effort and net zero campus RD&D.		
• Continue manufacturing related projects to help reduce the cost and improve the durability of fuel cells, electrolyzers, and other hydrogen components.	• No funding requested	• Transitions manufacturing related projects for fuel cells and electrolyzers to IIJA with FOA released in late FY 2023.
Codes and Standards $15,000,000	$10,000,000	-$5,000,000
• Continue 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.	• Continue R&D that enables development of codes and standards with an emphasis on large-scale novel hydrogen end use applications, and ensure activities include safety considerations.	• No Significant Change.
• Further develop and share best practices and lessons learned by pursuing education, training, and workforce development activities.	• Continue developing and sharing best practices and lessons learned through education, training, and workforce development activities	• Reduces activities on workforce development to focus on R&D needs including sensor development, and codes and standards.
• Further develop resources to address regulatory and permitting barriers to hydrogen deployments. • Continue work on sensor development and leak quantification.	• Continue addressing regulatory barriers. • Continue work on sensor development and leak quantification.	• No Significant Change. • No significant change.

Hydrogen and Fuel Cell Technologies
Data, Modeling, and Analysis

Description
The Data, Modeling, and Analysis subprogram performs analytical research that informs HFTO's RDD&D direction and prioritization. Analyses include assessing impacts of hydrogen and fuel cell technologies on sustainability and decarbonization metrics, identifying synergies and interactions with other energy sectors, as well as assessing R&D gaps.

In FY 2024, the subprogram will increase emphasis on regional impacts and opportunities for low-cost clean hydrogen supply, including environmental justice metrics and transition scenarios, to inform targeted R&D and deployments.
The subprogram develops, refines, and uses analytical models and tools, and develops program milestones and technology readiness goals. Modeling and analysis elucidate the total cost of ownership of hydrogen and fuel cell technologies in specific sectors, cost and performance requirements to displace incumbent fuels, regional impacts of deployments on criteria pollutant emissions and water resources, potential for job creation, and impacts on national climate goals.

Analysis efforts leverage outside activities, through coordination with other offices and agencies and support peer reviews and relevant activities under relevant legislation, including analyses supporting the interagency working group on hydrogen and fuel cells and public-private partnerships, such as the 21st Century Truck Partnership.

Data, Modeling and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling & Analysis $3,000,000	**$3,000,000**	**$0**
• Continue analytical research supporting national roadmap, that assesses regional impacts of hydrogen and fuel cell technologies (e.g., criteria pollutants, water).	• Perform analytical research to assess regional environmental impacts of hydrogen and fuel cell technologies and how changes in the energy system will affect future deployments.	• No significant change.
• Continue analysis of hydrogen for industrial applications, long-duration energy storage, synthetic fuels, and export opportunities, jobs, and address decarbonization and global sustainability impacts.	• Conduct analyses of hydrogen for industrial applications, long-duration energy storage, synthetic fuels, and export opportunities.	• No significant change.
• Continue to assess program milestones and technology readiness goals.	• Continue to assess program milestones and targets and refine targets as required.	• No significant change.
• Continue 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.	• Continue to assess cost and benefits (e.g., job creation, emission reductions) of hydrogen and fuel cell technology deployments to inform first-of-a-kind demonstrations.	• No significant change.

Energy Efficiency and Renewable Energy Research and Development
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Vehicles Technologies				
SBIR	11,734	12,809	14,942	+2,133
STTR	1,650	1,801	2,101	+ 300
Bioenergy Technologies				
SBIR	8,131	8,643	10,042	+1,399
STTR	1,143	1,215	1,412	+197
Hydrogen and Fuel Cell Technologies				
SBIR	4,776	5,024	4,817	-207
STTR	672	707	677	-30
Solar Energy				
SBIR	7,387	8,092	10,349	+2,257
STTR	1,039	1,138	1,455	+317
Wind Energy				
SBIR	2,837	3,704	9,001	+5,297
STTR	399	521	1,266	745
Water Power				
SBIR	4,627	5,147	6,781	+1,634
STTR	651	724	954	+ 230
Geothermal Technologies				
SBIR	3,146	3,146	5,231	+2,085
STTR	442	442	736	+294
Industrial Efficiency & Decarbonization				
SBIR	0	0	11,224	NA
STTR	0	0	1,578	NA
Advanced Materials & Manufacturing Technologies				
SBIR	0	0	6,717	NA
STTR	0	0	945	NA
Advanced Manufacturing				
SBIR	11,238	10,651	0	-10.651
STTR	1,580	1,498	0	-1,498
Building Technologies				
SBIR	5,830	5,191	5416	+225
STTR	820	730	762	+32
Total, SBIR	59,706	62,407	84,520	+22,113
Total, STTR	8,396	8,776	11,886	+3,110

Water Power

Overview

The Water Power Technologies Office (WPTO) administers a broad portfolio of activities to strengthen the body of technical knowledge and support for industry efforts to develop, demonstrate, and deploy hydropower and marine energy technologies at all scales. To advance water power, WPTO supports research, development, demonstration, and deployment (RDD&D) across industry, academia, and the National Laboratories through a wide variety of mechanisms and other innovative partnership approaches to accomplish its objectives.

America has vast marine energy and hydropower resources, and there is enormous potential to enhance the existing fleet, expand into new markets and applications for hydropower, increase generation and flexibility across the Nation's sizable hydropower and pumped storage fleet, and develop and demonstrate new hydropower and marine energy. In FY 2024, WPTO will focus on key areas of opportunity, include retrofitting existing hydropower facilities and powering non-powered dams to cost-effectively increase generation and flexibility; developing next generation pumped energy storage systems; launching a new effort to seed and establish Regional Energy-Water Demonstration facilities; and advancing marine energy technology to support new and growing industries utilizing waves, currents, tides, and gradient differentials (ocean thermal, pressure, and salinity).

For both marine energy and hydropower, realizing the potential of water power requires understanding how systems are changing with the climate. 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. In FY 2024, WPTO will build on its efforts to quantify hydrologic and climate change impacts to hydropower by working with local communities demonstrating and deploying advanced hydrologic sensors in watersheds across the U.S. to better characterize climate change variations on watersheds and improve ecological resilience and energy-water security. Moreover, WPTO plans to explore the potential for how oceans can be an environmentally appropriate sink for carbon, 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.

Community-centric development is critical to advance water power systems, particularly in the instances of remote, underserved, rural, tribal, and/or isolated communities. In FY 2024, WPTO will build out its portfolio of technical assistance and demonstrations with communities and power providers, including supporting the Energy Transitions Initiative Partnership Project, supporting small hydropower developers in evaluating alternative values of hydropower, building out partnerships with local irrigation districts and municipalities to deploy digital planning tools, and partnering with communities with energy and water data needs to deploy advanced hydrologic sensors and sensor networks.

In support of both community-centric development and to field validate energy-water system technologies and approaches needed to address regional and local-scale energy-water systems in a changing climate, WPTO will establish a new subprogram, Regional Energy-Water Testing and Validation. This subprogram will focus on demonstrating technologies and solutions to scale water and energy management solutions that address needs in specific watershed regions. This subprogram will address gaps between systems-level energy-water research and field deployment and will require a combination of regional and integrated modeling assessment, as well as coordination between EERE and other DOE offices to integrate and scale existing technologies. This will also include support for advancing nationwide climate and hydrologic modeling predictions to identify and study individual regions experiencing acute energy-water issues and deploy tools to help the hydropower industry understand climate-driven impacts.

To support demonstration and deployment of water power technologies, WPTO will increase support for harnessing the broader innovation ecosystem in support of commercialization of near-term and early-stage technologies. In FY 2024, WPTO will grow its portfolio of work to support incubators and accelerators in the private sector to support commercialization of a broad range of technologies and entrepreneurs; identify options to build on National Laboratory-focused commercialization opportunities; and develop metrics to measure, track, and evaluate commercialization strategies.

As a key emphasis area, workforce training and preparedness is important across both hydropower and marine energy. Investments associated with workforce development will support training and develop good paying clean energy jobs for the American people, especially workers and communities impacted by the energy transition, and those historically underserved by the energy system and overburdened by pollution. The hydropower sector has an aging workforce but offers pathways to well paid, stable jobs. 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. In support of both fields, in FY 2024, WPTO will support collegiate competitions to attract new students to the sectors, as well as provide funding to universities to seed new concepts in marine energy and hydropower.

Highlights of the FY 2024 Request

WPTO will pursue the following major activities in FY 2024 to support the EERE strategic priority of initiating a path to achieve a carbon pollution-free electricity sector no later than 2035:

- Demonstrate technologies to support hydropower flexibility and new pumped storage hydropower (PSH) development, and develop the tools and analysis to increase power system model enhancements to reflect hydropower more accurately.
- Develop technologies designed to lower costs while increasing the efficiency of low-head hydropower by supporting new designs and demonstrations of new and cost-effective technologies necessary for powering non-powered dams.
- Develop digital tools to assist the Nation's irrigation districts in using hydropower to support irrigation modernization and partnering with local irrigation districts.
- Fund scoping, planning grants, and ultimately selection of one or more Regional Energy-Water Demonstration Facilities focused on validating and testing technologies and solutions to scale water and energy management solutions that address needs in specific watershed regions. Develop 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.
- Support design, fabrication, and testing of marine energy conversion devices at a range of sizes (including grid-scale and non-grid-scale technologies).
- Continue 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.
- Provide technical assistance and support demonstrations through the Energy Transition Initiative Partnership Project (ETIPP) to engage with underserved remote and islanded communities.
- WPTO is involved in several DOE-wide crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing to fund foundational and application-based research for advanced manufacturing opportunities for hydropower;
    - Energy-Water through the regional testing facilities and to support developing digital tools to assist local irrigation districts on modernization projects and advanced sensors;
    - Energy-Storage to provide funding for hydropower hybrid demonstrations and studies to quantify emission and cost reductions enabled by increased hydropower flexibility and new pumped storage hydropower (PSH) development;
    - Carbon Dioxide Removal to investigate the role of marine energy in marine carbon dioxide removal (mCDR); and
    - Grid Modernization to provide funding for hydropower hybrid demonstrations to quantify emission and cost reductions enabled by increased hydropower flexibility and new PSH development.

Water Power
Funding ($K)

	FY 2022 Enacted[1]	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Water Power					
Hydropower Technologies	43,300	59,000	74,769	+15,769	+27%
Marine Energy Technologies	112,000	120,000	105,000	-15,000	-13%
Regional Energy-Water Testing and Validation	0	0	50,000	+50,000	+100%
Total, Water Power	**155,300**	**179,000**	**229,769**	**+50,769**	**+28%**

SBIR/STTR:

- FY 2022 Transferred: SBIR $13,059,189; STTR $810,677
- FY 2023 Enacted: SBIR $5,147,000; STTR $724,000
- FY 2024 Request: SBIR $6,781,000; STTR $954,000

[1] This excludes funding for EPACT Sec 242 funding which is managed by the Under Secretary for Infrastructure

Water Power
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Water Power	
Hydropower Technologies: The FY 2024 Request increases funding for demonstrations in irrigation modernization and technologies to increase hydropower flexibility for the grid. The subprogram will expand demonstrations and technical assistance for new, low-impact hydropower by investing in demonstration of technologies to power nonpowered dams or infrastructure. Building on previous years' scoping and planning, the subprogram will expand the portfolio to analyze hydrologic and climate change impacts to hydro, as well as invest in the environmental and dam safety systems to modernize the existing hydropower fleet. The subprogram will reduce funding in hybrids systems, shifting some of the previously funded technical assistance and hybrids demonstration focus to the Renewable Energy Grid Integration program to focus efforts on grid integration and less on hydropower specific activities.	**+15,769**
Marine Energy Technologies: The FY 2024 Request prioritizes marine energy technology commercialization, including business and technology incubation support to developers and startups, offset with a reduction in funding for the construction of the open water test facility. The Request continues to support controls and advancements in materials and manufacturing, device design and fabrication to serve remote coastal and islanded communities based on outcomes of the ETIPP cohorts, as well as wave energy demonstrations at PacWave[1]. The subprogram also continues support for 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.	**-15,000**
Regional Energy-Water Testing and Validation: The FY 2024 Request creates a new subprogram within the Water Power Program supporting regional testing and validation for energy-water technologies systems and approaches. This includes the launch of one or more Regional Energy-Water Demonstration Facilities to focus on validating and testing technologies and solutions to scale water and energy management solutions that address needs in specific watershed regions.	**+50,000**
Total, Water Power	**+50,769**

[1] PacWave (formerly known as the Pacific Marine Energy Center South Energy Test Site) is an Energy Department-funded, grid-connected, full-scale test facility for wave energy conversion technologies being constructed off the coast of Oregon by a team led by Oregon State University—the first facility of its kind in the United States. https://www.energy.gov/eere/water/pacwave

Water Power
Hydropower Technologies

Description
As the Nation's first renewable source of electricity, hydropower has provided clean, low-cost electricity for over a century. In 2022, hydroelectricity accounted for about 6.3 percent of U.S. utility-scale electricity generation and 29.4 percent of utility-scale renewable electricity generation. Pumped storage hydropower (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. The Hydropower Technologies subprogram supports the U.S. hydropower and PSH industry by supporting RDD&D that responsibly develops new low-impact hydropower; supports grid reliability and the integration of other energy resources; modernizes and safely maintains existing assets; promotes environmental sustainability; and supports energy-water systems resilience.

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 can integrate multiple social, environmental, and energy benefits, while realizing value and revenue from a variety of sources. The Hydropower Technologies subprogram supports the deployment of new hydropower by advancing technologies that can decrease costs and increase the value of powering non-powered dams, developing new stream reaches, and modernizing irrigation systems. 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 nonpowered dams can increase renewable energy production but advances in technologies and validation of systems are needed to incentivize deployment of hydropower. This activity builds on prior work in Standard Modular Hydropower and other designs to demonstrate new technologies for nonpowered dams and provide technical assistance for the hydropower community and developers to identify sites best suited for retrofits. This activity also supports technology validation in a field setting with a scoping assessment for building and maintaining a hydropower test facility that will increase adoption of novel technologies by the hydropower industry and increase regulatory agencies' confidence in novel technologies with validated performance data.

Besides power generation, dams provide 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] To facilitate this effort, this activity builds on prior year efforts with working with irrigations districts to inform development of digital planning tools and demonstration sites.

Grid Integration: Both hydropower and PSH 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 when it is needed most. However, providing these grid-responsive services can create wear and raise operational costs for hydropower and PSH facilities. This activity aims to understand and quantify the economic value of these services and the additional costs or technical requirements of operating hydropower systems to provide these services for 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, addressing critical technical barriers to effective operation of

[1] https://www.energy.gov/eere/water/articles/new-way-modernize-irrigation-infrastructure-and-generate-renewable-energy

hydropower resources, and identifying technology solutions that will preserve or enhance hydropower capabilities to deliver services or system benefits competitively.

Through its HydroWIRES Initiative, the subprogram is expanding its efforts to develop new strategies and technologies 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. This includes supporting technology advancements for flexibility, improving how hydropower is represented and understood in energy modeling, and building a national assessment of the potential for hydropower and PSH to support an evolving grid. HydroWIRES maintains support for technical assistance efforts to capture the full range of values that hydropower and PSH plants can provide to power grids, river basins, and nearby communities.

Existing Hydropower: Today the average hydropower plant is 64 years old,[1] and as the fleet continues to age, maintaining efficient and cost-effective operations and ensuring the security – including cybersecurity – of our critical energy infrastructure becomes increasingly challenging. Building on previous efforts, this activity advances digital tools to support modernizing the fleet. To support the existing fleet, this activity also assesses and addresses climate change impacts, environmental sustainability, and relicensing. The Office's work on existing hydropower reservoir management can create opportunities to advance climate resilience and adaptation for remote or socioeconomically vulnerable communities by analyzing infrastructure design and water management, enhancing environmental sustainability, and ultimately building socioeconomic resilience in these communities. To advance a framework for understanding climate change at the local level, this activity supports work with communities on energy and water data needs, including identifying up to three sites for deploying advanced hydrologic sensors and sensor networks.

Environmental sustainability is another critical challenge that requires fundamental research to understand hydropower's effects on the environment. Improving the environmental performance of hydropower facilities requires novel monitoring and mitigation technologies, particularly related to fish passage. Since 2005, the Federal Energy Regulatory Commission (FERC) has ordered mandatory fishway prescriptions for project relicenses for upstream or downstream passage in approximately 27 percent of hydropower facilities. To meet this order, WPTO has initiated high-priority fundamental research on fish passage at hydropower dams to understand fish behavior, movement, and lifecycles and to create information and tools to increase fish survival through hydropower structures.

Finally, non-federally owned hydropower facilities require a license from FERC to operate with license terms that typically last for 30-50 years. Relicensing provides communities opportunities to redefine goals for recreation, environmental impacts and mitigation, energy production, and revenue. Environmental measures can account for up to 30 percent of the Federal wholesale power rate, and solutions for effective environmental outcomes and cost reductions are essential. This activity develops tools and analyses that can assist applicants for FERC licenses and other hydropower stakeholders.

Data, Modeling, and Analysis: To advance the state of the hydropower industry, a robust innovation ecosystem must exist to support developers in commercialization, a strong workforce, engagement among a broad set of stakeholders, and publicly available data to inform scientists and market forces alike. This activity seeks to broaden the base of innovators who can address technical challenges in hydropower and support the industry's need to recruit given its aging workforce. The work builds on prior efforts to commercialize promising hydropower technologies, including transitioning lab-developed technologies to industry and carrying out market analyses to identify and engage with relevant end-users. Additionally, this activity supports technology transitions in the private sector through funding a network of incubator and accelerators that mentor promising startups and technology developers in hydropower.

[1] https://www.eia.gov/todayinenergy/detail.php?id=30312#

Hydropower Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydropower Technologies $59,000,000	**$74,769,000**	**+$15,769,000**
New Low Impact Hydropower $11,000,000	$24,500,000	+$13,500,000
• Support access to the Manufacturing Demonstration Facility at ORNL or other facilities to support advanced manufacturing, as well as launch. Launch a solicitation focused on advanced manufacturing techniques applied to hydropower.	• Fund projects to leverage advancements in advanced manufacturing to address the key challenges in maintaining the existing fleet infrastructure and enabling new small hydropower designs.	• Funding will provide a more specific and targeted focus for manufacturing opportunities identified through extensive stakeholder engagement.
• Support designs for powering nonpowered dams (NPDs), with the intent of leading into a demonstration funding opportunity to support the advancement of these designs. Assess costs and benefits of adding hydropower to NPDs. Partner with private sector developers and municipalities to implement demonstration projects.	• Fund demonstrations of technologies based on previous year designs and new designs and technical assistance for industry and community partners to utilize lab developed tools for identifying hydropower development opportunities at key NPD sites. Partner with private sector developers and municipalities to demonstrate concepts through real-world hydropower projects.	• Increased funding to expand on past work in conceptual designs for NPD technologies and establishing framework for assessing costs and benefits of adding hydropower to NPDs.
• Partner with Bureau of Reclamation, Army Corps of Engineers, and the Tennessee Valley Authority to begin a 2- to 3-year effort to fund the construction of a hydropower test facility or facilities that will incentivize developers to design and develop new hydropower technologies by reducing financial risk and providing access to technical expertise inherent in the testing process. WPTO will release a competitive funding opportunity in FY 2023 to support the search for a network director to manage the hydropower test facility or facilities.	• Fund beginning of Phase II of the Hydropower Test Facility Development to include pre-engineering design of multiple test sites and implementation of the network director based on a FY 2023 competitive funding opportunity.	• Building on the scoping study performed by Oak Ridge National Laboratory, continued funding will support completion of pre-engineering designs for a potential Federal Hydropower Test Facility site(s).
Grid Integration $22,000,000	$23,000,000	+$1,000,000

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Provide funding to support research into new component-level technology advancements to increase hydropower flexibility.	• Provide funding to demonstrate new component-level technology advancements to increase hydropower flexibility.	• New funding in FY 2024 will help advance the technologies necessary to increase hydropower's flexibility for future grid resiliency.
• Commence a comprehensive, national-scale study on hydropower and PSH's evolving role in the power system and future potential, taking advantage of significant modeling enhancements and including technology opportunities. After the publication of the study, next steps would be developing regional roadmaps—through state and local-scale stakeholder workshops—to map out opportunities for hydropower in different U.S. geographic, hydrologic, and market regions.	• Continue national-scale study on hydropower and PSH's evolving role in the power system and future potential, taking advantage of significant modeling enhancements, and including technology opportunities.	• Reduced funding in FY 2024 to continue the Hydropower Futures Study on using new modeling capabilities to understand hydropower's evolving role in the power system and prioritize technology improvements.
• Continue PSH technology R&D to advance promising concepts to the testing phase to demonstrate PSH's contribution to hydropower's flexibility potential.	• No funding requested in FY 2024.	• Projects will be selected and funded in FY 2023 and will not require funding in FY 2024.
• Expand the PSH Valuation Guidebook framework to accommodate non-power values such as those resulting from water use for multiple purposes, and would include broader economic, health, and cultural values defined by relevant communities.	• No funding requested in FY 2024.	• Funding is not requested as technical assistance provided in FY 2023 will continue with prior year funding in FY 2024.
• Not funded in FY 2023 Enacted.	• Fund development of new model enhancements to better capture hydropower's capabilities and application of these capabilities to utility operations and planning processes.	• New funding in FY 2024 will aid in achieving utility-, state-, or regional-level renewable deployment or decarbonization goals through enhanced representation in models used in planning.
• Support technical assistance to the broader hydropower community, including collaboration with cross-office initiatives on remote communities and broader generation and transmission planning processes.	• Continue technical assistance to the broader hydropower community, including collaboration with cross-office initiatives on remote communities and broader generation and transmission planning processes.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Existing Hydropower $14,000,000	$19,769,000	+$5,769,000
• Establish the tools and partnerships necessary to build toward an Intelligent Watersheds major initiative, which includes 1) advancing monitoring technology through smart environmental sensors and sensor networks, 2) building capacity that will seed future Intelligent Watersheds focused on environmental resilience, and 3) pursing joint work with the Office of Science that expands and applies research to watershed planning.	• Partner with communities with energy and water data needs to identify three sites for deployment of advanced hydrologic sensors and sensor networks.	• Funding in FY 2024 will continue to support work that improves interagency coordination of applied R&D focused on response and adaptation to climate extremes like drought.
• Launch demonstrations, like self-powered Fish Tag lab project and eDNA Demo for FERC relicensing lab project.	• No funding requested in FY 2024.	• Demonstrations will continue with prior year funds.
• Develop and deploy a pilot program(s) of the digital twin capability focused on O&M reduction and market optimization in order to refine the concept and further develop industry confidence in the technology benefit and value.	• Complete Digital Twin pilot study focused on O&M market optimization.	• Funding in FY 2024 will complete industry partnerships to demonstrate effectiveness in reducing O&M costs and market optimization.
• Leverage the SCADA mapping and controls monitoring capability of the Digital Twin effort to help detect abnormal activity in the OT network.	• Fund development of cyber-digital surrogates to detect abnormal activity in hydropower operational network.	• Funding in FY 2024 will continue partnering with industry to leverage actual operational data to allow for physics-based monitoring for a more accurate assessment of network intrusion.
• Competitive funding opportunity on fish passage for restoration to support design and deployment of solutions to move fish above and below dams, evaluate environmental effects, or develop comprehensive technical restoration plans include partnering with tribal communities where species maintain economic and cultural importance.	• R&D to advance innovative fish passage and protection technologies developed in FY 2022 with an emphasis on demonstrations. Initiate work to advance water quality modeling and mitigation with inputs from novel tools and data streams.	• Funding in FY 2024 will support development and validation of novel fish and environmental monitoring tools with hydropower partners with an emphasis on technology transfer and commercialization.
• Not funded in FY 2023 Enacted.	• Initiate work on advanced sensors and artificial intelligence for improved dam safety and dam inspections processes.	• New funding supports advanced sensors with respect to dam safety will lead to much needed data on effects of climate change on water infrastructure.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $10,000,000	$7,500,000	-$2,500,000
• 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.	• Complete work on a "reimagined" Hydropower Vision Roadmap. Monitor progress toward goals in the Hydropower Vision Roadmap.	• Reduced funding level reflects the lower level of effort necessary to support completion of work started and carried out in FY 2023.
• Support certification programs, curricula sharing, and provide training and other development opportunities to minority workforce entrants, vets, and transitioning workers from adjacent sectors. Support a new hydropower collegiate competition as well as analysis to inform a new/updated hydro workforce report.	• Support certification programs, curricula sharing, and provide training and other development opportunities to minority workforce entrants, vets, and transitioning workers from adjacent sectors. Support hydropower collegiate competition. Conduct analysis to inform a new/updated hydro workforce report.	• Funding will support the second year of the Hydropower Collegiate Competition and will support evaluation of other opportunities to support industry workforce needs and skills development, such as through a hydropower fellowship program or a certification program.
• Develop analysis and programs to commercialize promising hydropower technologies, including supporting National Laboratory research and private sector industry technologies.	• Develop analysis and programs to commercialize promising hydropower technologies, including supporting National Laboratory research and private sector industry technologies.	• Continue to develop programs to fund technology transitions, including in the private sector through funding a network of incubator and accelerators that mentor promising startups and technology developers in hydropower.
• Continue to expand and improve HydroSource. Support, a publicly available database to support improved decision-making and basin-wide management of river resources.	• Add/update datasets and perform maintenance to existing tools. Develop Climate Vulnerability Tool from 9505 data. Support existing maintenance of platform and conduct stakeholder engagement to increase usage.	• No significant change.
EPAct Section 242/243 $2,000,000	$0	-$2,000,000
• Funding supports the Congressionally directed implementation of the Energy Policy Act of 2005, Sections 242 & 243.	• No funding requested	• Administration of the Hydropower Incentives program now resides with the Grid Deployment Office within DOE.

Water Power
Marine Energy Technologies

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 56 percent of the electricity generated by those states in 2021. The Nation's Pacific and Caribbean territories and freely associated states add an additional 4,100 TWh/yr of ocean energy resource.[1] Developing just one-sixth of the available wave energy in the five Pacific states could power more than five million homes. Marine energy – particularly tidal energy – can serve as 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 a near-term solution for distributed energy for isolated and islanded communities. Through the Powering the Blue Economy (PBE) initiative, the subprogram 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.[2]

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. Significant engineering, operational, economic, and regulatory challenges exist. The Marine Energy subprogram invests in RDD&D to develop innovative components, structures, materials, systems, and manufacturing approaches and to support development and utilization of testing infrastructure for systematic validation by industry at multiple scales. The subprogram aggregates, analyzes, and disseminates data to enable industry to develop cheaper and more effective monitoring instrumentation and ultimately to increase permitting and regulatory process efficiencies.

Materials and Components R&D: Marine energy technologies face difficult engineering challenges specific and inherent to the marine energy environment. This activity supports RDD&D to tackle these challenges to rapidly improve and reduce costs. Advanced controls is a major programmatic focus, as improvements in advanced controls can provide significant increases in energy capture, and recent advances have doubled the energy capture of previous methods. Research will continue to support DOE's commitment to a joint DOE-Navy project targeting advanced controls, National Laboratory support for competitively selected industry awards that develop new marine energy control systems, and foundational research at the Nation's universities into advanced materials, components, operations, and maintenance.

This activity is also developing the first-ever national wave classification metrics and site-specific marine energy characterization, akin to what DOE has provided historically for the wind and solar industries, which will refine and expand on the high-resolution wave and tidal resource data that assist in identifying project sites, inform design requirements, maximize energy capture, reduce project uncertainty and risk, and thereby reduce LCOE.

[1] 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
[2] "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

System Integration and Validation: Research, design, and validation are needed to reduce cost and improve performance of marine energy technologies at a range of sizes and technology readiness. Investment in 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 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.

Support for the PBE initiative will continue, including desalination systems for remote communities and disaster relief and recovery; demonstration of marine-energy-powered ocean observing systems; and, through ETIPP, on-the-ground assistance on resource assessment, grid integration analyses, and vetting of technology fit to help communities chart pathways to energy resiliency. In addition, this activity supports deployable systems to address plastics waste in U.S. rivers and waterways and investigation into marine-powered carbon dioxide removal (CDR) and aquaculture opportunities. Finally, this activity will demonstrate and deploy grid-scale marine energy projects to validate performance toward a fully decarbonized electric grid. This includes a focus on building systems that use the PacWave open-ocean wave energy test facility to advance wave energy system demonstration.

Testing & Reliability: To accelerate deployment, strategic investment into infrastructure access at the National Laboratories and other marine energy test sites is needed to de-risk technologies through in-water validation of prototype performance, efficiency, and reliability across a wide range of sea states including extreme conditions. This involves testing proof-of-concept systems in laboratory and ocean settings to understand performance characteristics, identifying and mitigating reliability risks, and providing data to inform future RDD&D of next-generation designs across the industry. The Office 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) and enable access to dedicated testing infrastructure, such as PacWave, to reduce the inefficiency associated with each developer investing in testing cables and permits. This activity supports analysis and prediction 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, and Analysis: To accelerate the development of marine energy, there is a need for new commercialization approaches, strategic engagement mechanisms with industry and new entities, new approaches to reach universities and students with potential concepts to advance the state of marine energy. There is also a need to make marine energy data public while ensuring database integrity. To enable commercialization in the blue economy, WPTO will fund a network of incubators and accelerators to support developers and startups and better connect end users to the market. Recognizing the need to engage underserved universities, the Office continues to seed promising research pathways and support more undergraduate and graduate research students in marine energy. Finally, this activity will continue to maintain and improve its public databases, web tools, and analytical reports, ensuring DOE marine energy informational resources are easily accessible and usable by all potential users.

Marine Energy Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
Marine Energy Technologies $120,000,000	**$105,000,000**	**-$15,000,000**
Materials and Components R&D $23,000,000	$21,988,000	-$1,012,000
• Continued National Laboratory R&D into controls and power take-offs for marine devices following up on the strategy developed in recent FYs to dramatically reduce costs and/or increase energy capture R&D on controls and power take-offs for MHK devices.	• Continued National Laboratory R&D into controls and power take-offs for marine devices to dramatically reduce costs and/or increase energy capture R&D on controls and power take-offs for marine energy devices.	• Reduced funding to shift to university-focused research.
• Continue support with and increased focus on foundational R&D modeling tools and methodologies for device and array performance. R&D of advanced materials and components and new approaches for O&M of marine energy projects.	• Fund foundational modeling tools and methodologies, advanced materials, and components. Strengthen and engage universities and marine centers identifying capability gaps broadly affecting industry.	• Increased focus on foundational R&D supporting a balanced approached at universities and national labs.
• 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.	• Continue development of the first-ever national wave classification metrics and site-specific marine energy characterization, with a focus on new sites and locations applicable to Powering the Blue Economy (PBE) technologies.	• Reduced funding with an overall focus on characterization of new sites such as remote coastal communities.
Systems Integration & Validation $32,000,000	$40,682,000	+$8,682,000
• Continue to advance the state of the art and push high potential designs of marine energy devices, in particular those serving the blue economy. Support will continue for the OceanObs Prize as well as innovative research at small businesses.	• Demonstration of grid-scale systems from designs funded in prior years for wave energy systems at PacWave and assistance in scoping from ETIPP communities to in-water tests, with a particular focus on wave energy systems. Continued advancement of design and build of systems developed by small businesses with end users.	• Increased funding for in-water demonstrations of grid-scale devices at PacWave and for small businesses and support for co-developed marine energy systems for blue economy purposes.
• Design and develop flexible material Wave Energy Conversion (WEC) and support the INnovating Distributed Embedded Energy Prize (InDEEP) Prize to validate and demonstrate novel concepts. Continue to build on flexible material WEC design	• Design and develop flexible materials and support the InDEEP Prize to validate and demonstrate novel concepts. Execute the InDEEP Prize (prize scoping launched in FY 2022; prize opening FY 2023) to validate and	• Reduced funding for the second phase of the prize for teams to build and assess performance of concepts developed in the previous phase launched in FY 2023.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
and development as well as continued WaveSparc work to develop novel concepts.	demonstrate the potential of novel concepts developed.	
• Research potential marine energy solutions for aquaculture and CDR, continuing the strategy and roadmap development of supporting blue economy applications, and continued support of the Pioneer Array.	• Advance systems aligned with the Powering the Blue Economy initiative. In partnership with Woods Hole Oceanographic Institution complete design, build, and test of a small electricity producing wave energy converter (WEC) test article to augment the solar and wind energy powering an oceanographic buoy in the Pioneer Array. Fund wave powered desalination R&D. Develop resilient design pathways through analyzing and potentially prototyping integrated coastal breakwater WECs.	• Increased funding for testing and design of systems aligned with Powering the Blue Economy.
Testing & Reliability $49,000,000	$21,990,000	-$27,010,000
• As directed by FY 2023 Enacted Appropriations, fund the costs of construction of the PacWave Open Water Test Facility.	• No funding requested.	• Funds for construction of the facility were provided in prior fiscal years.
• Continue support of TEAMER, a rolling test campaign supported in collaboration with U.S. universities and National Laboratories for early-stage marine energy systems.	• Expand the TEAMER program facility network through additional network organizations and capabilities upgrades, as well as increasing and diversifying the applicant pool.	• FY 2024 funding will result in access to new network facilities and capabilities by a larger number of developers and researchers.
• 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.	• Assist industry developers during in-water deployments by collecting robust environmental data around operating marine energy devices.	• No significant change.
• Continue support for upgrades to test infrastructure at marine energy technology testing sites based on the testing needs roadmap.	• Support for upgrades to test infrastructure at marine energy technology testing sites based on a testing needs roadmap.	• No significant change.
Data, Modeling, and Analysis $16,000,000	$20,340,000	+$4,340,000
• Begin support of commercialization assistance through development of a network of incubators	• Build on initial investments made in prior years to advance commercialization assistance	• Increased funding in FY 2024 supports marine energy technology commercialization; business

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
and accelerators for blue economy and marine energy innovation and entrepreneurship, support technology transfer at national labs; and broaden support for researchers – particularly disadvantaged students and universities – through projects at universities.	through marine energy and blue economy incubator networks and accelerators, national lab technology transfer; and support disadvantaged students and universities.	and technology incubation support to developers and startups; and seeding promising research pathways at universities.
• Continue the Marine Energy Collegiate Competition to identify promising, near-term blue economy applications and develop tabletop-scale prototypes.	• Support marine energy workforce development, including the Marine Energy Collegiate Competition and Graduate Student Research Program.	• No significant change.
• Continue to support National Laboratory analysis of R&D challenges and opportunities for remote and coastal communities (Powering the Blue Economy).	• Fund National Laboratory analysis of R&D challenges and opportunities for remote and coastal communities (Powering the Blue Economy).	• No significant change.
• Make program-funded research and testing results widely accessible through databases and tools such as PRIMRE.	• Make program-funded research and testing results widely accessible through databases and tools such as PRIMRE.	• Increased funding to maintain and improve upon marine energy program public databases, web tools, and analytical reports, ensuring DOE marine energy informational resources made easily accessible and usable.

Water Power
Regional Energy-Water Testing and Validation

Description
Energy security and water resilience are increasingly challenged by a changing climate and growing pressures from agricultural, industrial, and community demands. Climate change is manifested in the water cycle through events that include droughts, floods, melting snowpack, fire, and more, which create stress in the Nation's aging water and energy systems as they are currently designed. Intensifying water scarcity and overabundance across watersheds impact these systems in ways that are region-specific.

To advance technologies and approaches that ameliorate regional water challenges, in-field validation, testing, and pre-commercial demonstration of technology solutions are needed. Validation of technologies requires testing at a regional and subregional scale. This includes technology solutions that can simultaneously address water quantity and quality, wastewater, energy, and terrestrial and aquatic ecosystem issues within a given catchment area, while strengthening local communities with emphasis on those underserved.

Within regions and watersheds, diverse stakeholders, including local utilities and regulators, industry, agriculture, and communities, exert energy and water demands that shift and grow over time in response to economic, social, and policy pressures. But historically, research at the nexus of energy and water has focused on piecemeal case studies or one-size fits all national assessments without either in-field demonstration or integration of actual solutions. Creating regionally-focused, stakeholder-intensive development and demonstration of energy-water systems is critical for adopting water-smart technologies, advancing place-based solutions that allow for better watershed-level decision-making, and increasing confidence in performance of novel research while developing a local and diverse workforce.

WPTO's existing investments in infrastructure, regional climate and hydrologic modeling, and integrated energy-water assessments make regional energy-water testing and validation a logical next step in the translation and deployment of R&D into pre-commercial demonstration. WPTO's existing portfolio of R&D has advanced climate and hydrologic modeling predictions nationwide, identified and studied regions experiencing acute energy-water issues, and deployed tools to help the water power industry understand climate-driven impacts. This regionalized, systems perspective approach will integrate not only energy and water management, but also enhance communities' climate resilience and build on WPTO's mission to advance water power technologies.

<u>Regional Energy-Water Demonstration Facilities</u>: To address the need for pre-commercial testing and validation of technologies and approaches to deepen understanding of energy-water connections, the primary activity proposed is a multi-year investment in Regional Energy-Water Demonstration Facilities. One or more facilities are envisioned as transdisciplinary and interagency efforts designed around the needs of stakeholders in defined watersheds or regions. Each facility will focus on translating recent R&D outcomes – from hydroclimate prediction to novel desalination and treatment technologies to integrated systems management – to demonstration and scale water management solutions according to the needs of a specific region. A regional facility would develop new business models for solving water challenges that incorporates stakeholders like local utilities and regulators, industries, and communities in the earliest phase of system design. The demonstration facilities will provide multi-stakeholder partnership environments to de-risk and test technologies for pre-commercial demonstrations at scale and reduce costs for local utilities and governments. The training and education components of each facility will also enable the development of a diverse and local workforce ready to manage 21st century water systems.

Regional Energy-Water Testing and Validation

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
Regional Energy-Water Testing and Validation $0	**$50,000,000**	**+$50,000,000**
Regional Energy-Water Demonstration Facilities $0	$50,000,000	+$50,000,000
• Not funded in FY 2023 Enacted.	• Launch scoping and first solicitation to establish one of more Regional Energy-Water Demonstration Facilities. This includes funding scoping through the National Laboratories, a workshop series with the National Academies, scoping grants to up to 20 regional parties nationwide, and ultimately down-selecting to one of more Regional Energy-Water Demonstration Facilities.	• New effort to test and validate energy-water focused technologies and approaches at the regional and subregional scale, leveraging prior work and current efforts to translate climate and hydrologic modeling to actionable science and local decision-making, integrate early- to late-stage technologies at scale, collect data using real-time smart sensors, and enhance local and regional economies and workforces with the overall goal of building resilient water and energy systems.

Energy Efficiency and Renewable Energy
Research and Development ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Basic	0	0	0	0
Applied	676,784	836,967	1,275,590	+438,623
Development	1,378,725	607,327	817,959	+210,632
Subtotal, R&D	**2,055,509**	**1,444,291**	**2,093,549**	**+649,255**
Equipment	20,262	38,775	66,526	+27,751
Construction	73,421	1,688	57,000	+55,312
Total, R&D	**2,149,192**	**1,484,754**	**2,217,075**	**+732,218**

Renewable Energy Grid Integration

Overview

Achieving the nation's goals of a decarbonized electricity sector by 2035 and a net-zero economy by 2050 will require unprecedented increases in electricity generation from renewable energy resources, with the bulk of this new generation likely to come from wind and solar power.[1] To ensure the long-term reliability and resilience of the electricity system, the planning and operations of the power system must evolve to accommodate resources that are variable rather than dispatchable and based on power electronics rather than physically synchronized with the grid. To that end, the Renewable Energy Grid Integration (REGI) program in FY 2024 focuses on a holistic approach to grid integration challenges across many technologies and systems. These challenges include:

- Planning a Decarbonized Grid: This requires accommodating the increase of variable generation, addressing changes in system dynamic behavior, and addressing bidirectional flows of electricity from distributed energy resources and the seams between transmission and distribution.
- Developing Tools and Technologies to Operate a Decarbonized Grid: This requires determining viable pathways to a decarbonized grid; ensuring resource adequacy throughout the transition to a decarbonized power system; supporting the electrification of transportation, industrial, and other loads; and mitigating the growing threats from the impact of climate change and other physical and cyber threats.
- Addressing Infrastructure Needs and Interdependencies: This includes improving renewable energy project siting and permitting processes, as well as developing a better understanding of how to deploy additional system capacity; increase existing transmission capacity use; and account for the interdependencies between electricity, fuels, communication, and other infrastructures.
- Accommodating Diverse Markets, Policies, and Business Models: This includes supporting the development of market products and regulations that can support the integration of variable renewable energy by facilitating the mutual matching of generation and load, allowing for the optimization of energy storage, and ensure long-term incentives for power system flexibility and resource adequacy.

Addressing these challenges requires new technologies; improved data, tools, and models; and new analysis that directly supports decision-makers responsible for the planning, operation, regulation, and policies of the grid as a whole. To support system-wide decisions, it is critical that Office of Energy Efficiency and Renewable Energy's (EERE) efforts mirror the integration of the grid and themselves be developed and implemented in a way that integrates across technologies and offices.

For that reason, the EERE's REGI program-supported projects will be coordinated across the Renewable Power sector, leveraging staff and expertise within the wind, solar, geothermal, and water program offices, and coordinated closely with the grid-focused R&D in EERE's Sustainable Transportation and Energy Efficiency pillars and the Office of Electricity (OE). EERE's Grid Integration work will contribute to the Grid Modernization Initiative, focused specifically on technologies and tools that directly facilitate the integration of variable renewables and the value of dispatchable renewables like hydropower and geothermal. Further, investments in State and Local partnerships will support state and local governments with the necessary resources to be more effective in facilitating affordable and resilient clean energy and efficiency goals. Investments associated with Energy and Environmental Justice will support approaches and processes to reach new groups of Americans historically underserved by the energy system.

Highlights of the FY 2024 Budget Request

The Renewable Energy Grid Integration program will pursue the following major activities in FY 2024:

- Provide direct engagement with and support to local community organizations to help realize affordable, equitable pathways that meet local renewable energy objectives. Provide detailed planning support and simulated operations through national laboratory facilities. Cities and communities across the U.S. have committed to meeting their electricity needs with 100 percent clean energy. However, the paths to reach those goals are not always clear and will vary based on different priorities within communities (e.g., emphasis on local generation, threats to resiliency, costs, tax base needs). Successfully integrating larger amounts of renewable energy into a local power system requires both

[1] Solar Futures Study: www.energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf

deep technical expertise and local knowledge through in-depth partnerships with communities, developing cohorts to enhance peer-to-peer learning, and through short-term technical engagements.

- Scale up support for several DOE-wide crosscutting initiatives, focusing on Grid Modernization to expand power system planning and operations support to utilities and communities; provide analysis-based technical assistance to power system operators and regulators; demonstrate expanded provision of reliability services from wind and solar generation; and support the goals and objectives developed in the Grid Modernization Initiative.
- Support the transition to higher levels of variable, power-electronic-based resources, distributed generation, and electrification of load by developing and disseminating the data, modeling and simulation tools, and critical analysis required to support power system planning and operations. Analysis areas will include system interdependencies within and among power system infrastructures and other interrelated systems such as communications and transportation networks, which can have profound implications for the reliability and security of the energy system. Outputs will support a wide range of actors and institutions that shape the evolution of the U.S. electric grid. Activities will be coordinated closely with other technical assistance (TA) efforts in EERE, OE, the Office of Cybersecurity, Energy Security, and Emergency Response (CESER), and across the Department.
- Provide direct technical assistance and funding to states, local governments, tribes, and communities to build capacity for siting and permitting decisions around large-scale clean energy projects and infrastructure. Increasingly, state energy offices and commissions are being asked to address issues with local governments and communities on a suite of topics such as planning and zoning, environmental permitting, and land use. DOE will work with the National Laboratories and state government offices to create ready-to-use tools and guidance materials for stakeholders, increase access to trainings, and provide technical assistance to implement new energy initiatives.

Renewable Energy Grid Integration
Funding ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Renewable Energy Grid Integration	40,000	45,000	59,066	+14,066	+31%
Total, Renewable Energy Grid Integration	**40,000**	**45,000**	**59,066**	**+ 14,066**	**+ 31%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $0; STTR: $0
- FY 2023 Enacted: SBIR: $0; STTR: $0
- FY 2024 Request: SBIR: $256,000; STTR: $36,000[1]

Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Renewable Energy Grid Integration: Prioritize increase of FY 2024 investments to directly support decision-makers responsible for the planning, operation, regulation, and policies of the grid as a whole. This includes improved data, tools and models, new analysis, and local demonstrations, with projects focused both on common high priority technical areas and local-level system objectives. Specific projects include analysis-based technical assistance, technical assistance for siting and permitting of renewable energy projects, support for community-level grid planning, and the implementation of the Grid Modernization Initiative.	**+14,066**
Total, Renewable Energy Grid Integration	**+ 14,066**

[1] FY 2024 is the first year REGI is proposing to demonstrate expanded provision of reliability services from wind and solar generation. REGI was new in FY22, and in FY22 and FY23, has not supported projects beyond a deployment focus.

Renewable Energy Grid Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Renewable Energy Grid Integration $45,000,000	**$59,066,000**	**+$14,066,000**
• Provide detailed planning support, simulated operations through national lab facilities, and direct engagement with local community organizations through the Clean Energy to Communities Program to help integrate larger amounts of renewable energy into local power systems.	• Continue implementing the Clean Energy to Communities program to assist through community-led innovation to cities, communities, and utilities.	• Additional funding will accelerate clean energy solutions for communities in FY 2024 with a new round of community partnerships and topical cohorts.
• Develop planning tools and power electronics technologies as well as support the implementation of the Grid Modernization Initiative.	• Continued support for developing planning tools and power electronics technologies as well as support the implementation of the Grid Modernization Initiative.	• Additional funding will reinstate technical assistance for utilities to be able to analyze grid interactions.
• Support WETO and SETO to launch R-STEP (Renewable energy Siting through Technical Engagement and Planning), to provide technical assistance directly to State Energy Offices and local communities and build capacity for siting activities.	• Grow R-STEP as EERE's flagship siting program and plan for round two; continue to develop TA solutions and disseminate learnings to key energy stakeholders engaged in siting, permitting, and community acceptance.	• Additional funding will support collaboration with states and federal agencies and research on energy siting challenges, and will allow R-STEP to reach additional States and local communities to accelerate renewable energy deployment.
• Develop technical assistance solutions for a variety of stakeholders in key areas including distribution system planning, resource adequacy, electricity markets, and resilience to enhance grid reliability, decarbonization, affordability, and equity.	• Within the Department, EERE closely collaborates with OE and the Grid Deployment Office to cooperatively develop systematic solutions for emerging electricity system challenges with decision makers.	• The increase will accelerate the development of systematic solutions for emerging electricity system challenges, as well as allow the program to assist a wider array and larger number of stakeholders.
• Develop improved data, modeling and simulation tools, and provide new critical analysis required to support power system planning, operation and regulation with high levels of renewables.	• Continue funding analysis to determine the optimal path to decarbonize the electric power system while building resilience.	• Additional funding for new analysis will accelerate our clean energy analysis efforts in FY 2024 and provide guidance to industry.

Program Direction

Overview

Program Direction enables EERE to maintain and support a world-class Federal workforce and the necessary internal infrastructure to execute the EERE mission. The FY 2024 Program Direction Request provides resources for the EERE workforce; program and project management; oversight activities; contract administration; IT equipment, systems, and support; and Headquarters (HQ) and field site non-laboratory facilities and infrastructure.

Highlights of the FY 2024 Budget Request

The FY 2024 EERE Program Direction Budget Request will:

- Support 710 FTEs at Headquarters, the Golden Field Office, and the National Energy Technology Laboratory.
- Support efficient, effective, and responsive EERE operation, including IT, data, financial, and facilities management; and
- Support project management, oversight, and procurement across EERE's full portfolio of projects, including closing out completed financial assistance awards.

Salaries and Benefits: 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 a functional and efficient manner. The Request assumes a 5.2 percent federal staff pay increase, annualization of increase from 2023, as well as increased funding to support up to 710 FTEs. This FTE level reflects the shift of the Federal Energy Management Program (FEMP) and the Weatherization and Intergovernmental Programs (WIP) to the new Undersecretary for Infrastructure and additional transfers of smaller programs from within Water Power Technology Office and the Advanced Manufacturing Office.

Support Services: The Request includes funds for contract support to implement programmatic priorities across the EERE portfolio.

Other Related Expenses: The Request includes funding for information technology systems development and continued improvements to data management capabilities that enable data-driven decision-making. The Request also provides an increase for information technology needs to ensure that the EERE workforce can execute its mission efficiently and effectively in a hybrid work environment.

Program Direction
Funding ($K)

	FY 2022 Enacted[1]	FY 2023 Enacted[2]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Program Direction					
Washington Headquarters					
Salaries and Benefits	87,905	92,259	99,497	+7,238	8%
Travel	2,685	2,917	4,278	+1,361	47%
Support Services	5,561	7,563	9,076	+1,513	20%
Other Related Expenses	30,682	32,873	51,708	+18,835	57%
Total, Washington Headquarters	**126,833**	**135,612**	**164,559**	**+28,947**	**21%**
Golden Field Office					
Salaries and Benefits	19,943	20,931	22,574	+1,642	8%
Travel	575	625	917	+292	47%
Support Services	3,835	5,216	6,259	+1,043	20%
Other Related Expenses	3,452	3,698	5,817	+2,119	57%
Total, Golden Field Office	**27,806**	**30,471**	**35,566**	**+5,096**	**17%**
National Energy Technology Laboratory					
Salaries and Benefits	6,903	7,245	7,814	+568	8%
Travel	192	208	306	+97	47%
Support Services	4,391	5,971	7,165	+1,194	20%
Other Related Expenses	6,060	6,492	10,212	+3,720	57%
Total, National Energy Technology Laboratory	**17,546**	**19,917**	**25,497**	**+5,580**	**28%**
Total Program Direction					
Salaries and Benefits	114,751	120,436	129,885	+9,449	8%
Travel	3,452	3,750	5,500	+1,750	47%
Support Services	13,787	18,750	22,500	+3,750	20%
Other Related Expenses	40,194	43,064	67,738	+24,674	57%
Total, Program Direction	**172,184**	**186,000**	**225,623**	**+39,623**	**21%**

[1] The FY 2022 Enacted appropriations for EERE included a total of $209.45 million for Program Direction. The total in this table excludes funding transferred to the Undersecretary for Infrastructure for the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office of Manufacturing and Energy Supply Chains (MESC).
[2] The FY 2023 Enacted appropriations for EERE included a total of $186.0 million for Program Direction. The total in this table excludes funding for the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office of Manufacturing and Energy Supply Chains (MESC), which was managed by the Undersecretary for Infrastructure.

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Federal FTEs	**585**	**681**	**667**		
Additional Office of Fossil	44				
Energy's FTEs at NETL		42	**43**		
Total EERE-funded FTEs[1]	**629**	**723**	**710**	**+35**	**5%**
Support Services					
Technical Support	9,419	9,649	11,579		
Management Support	8,884	9,101	10,921		
Total, Support Services	**18,303**	**18,750**	**22,500**	**+3,750**	**20%**
Other Related Expenses					
Other Services	25,029	23,766	37,383		
Working Capital Fund (WCF)	20,324	19,298	30,355		
Total, Other Related Expenses	**45,353**	**43,064**	**67,738**	**+24,674**	**57%**

[1] Includes FTEs supported within the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office of Manufacturing and Energy Supply Chains (MESC) in FY 2022 and FY 2023.

Program Direction
($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Program Direction $186,000	**$225,623**	**+$39,623**
Salaries and Benefits $120,436	$129,885	+$9,449
• The Request will support a Federal workforce of 675 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 2023 workforce level.	• The Request will support 710 FTEs by providing resources for program and project management, administrative support, contract administration, and human capital management.	• The slight increase accounts for a planned 5.2 percent pay raise and associated costs for the planned FTE level.
• The Request also will support costs associated with Federal employee benefits, including health insurance costs and retirement allocations in FERS.	• The Request also will support costs associated with Federal employee benefits, including health insurance costs and retirement allocations in FERS	• No significant change.
Travel $3,750	$5,500	+$1,750
• The Request will support travel funding in support of project management and close-outs where the use of virtual meeting technologies or other telepresence is not practical for oversight of EERE funded projects.	• The Request will support travel funding in support of project management and close-outs where the use of virtual meeting technologies or other telepresence is not practical for oversight of EERE projects.	• The increase (2 percent) is to account for increasing travel costs across the board.
Support Services $18,750	$22,500	+$3,750
• 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 represents the expected increase in labor rates for all three of EERE's three main support service contracts. The level of support will be roughly equivalent to FY 2023.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Other Related Expenses $43,064	$67,738	+$24,674
• 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).	• 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 (NETL). 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.	• The increase mirrors the planned increase in personnel and increasing automation efforts around budget and operations systems. The increase also reflects an increase in EERE's contribution to the WCF.

Bioenergy Technologies

Overview

The Bioenergy Technologies Office (BETO) conducts research, development, and demonstration activities (RD&D) to enable a diverse supply of renewable waste streams and biomass as well as cost-effective conversion technologies nationwide emphasizing later stage demonstration to accelerate deployment of biofuels and bioproducts. As part of a comprehensive strategy to decarbonize all modes of transportation, BETO is primarily focused on production of "drop-in" biofuels that serve hard-to-electrify modes such as aviation and marine. The program also supports RD&D on converting biomass into high-value chemicals and products in support of decarbonizing the chemical industry, sustainable development of bioenergy crops, and the use of residues and low carbon agriculture practices to support climate smart agriculture.

The U.S. transportation sector overwhelmingly relies on petroleum, which supplies over 90 percent of its energy needs.[1] Aviation, marine, and heavy-duty vehicles account for 37 percent of transportation energy use.[2] These modes 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 carbon-dioxide (CO_2) emissions. The Departments of Energy, Transportation, and Agriculture launched a government-wide Sustainable Aviation Fuel (SAF) Grand Challenge in September 2021.[3] The Grand Challenge aims to reduce cost, enhance sustainability, and expand domestic production and use of SAF to meet greater than 10 percent of domestic aviation fuel demand by 2030, and 100 percent of domestic aviation fuel demand by 2050.

The U.S. has the potential to sustainably produce enough renewable carbon resources to meet the demand for SAF and a variety of carbon-based chemicals. The availability and cost of renewable carbon resources vary geographically, and each resource type, such as agricultural waste, forestry waste, municipal solid waste, and purpose-grown energy crops, has its own unique technology challenges, market barriers and opportunities. BETO manages its R&D portfolio to enable the production of biofuels and bioproducts from the entire range of renewable carbon resources—demonstrating and supporting scale-up of the most viable, commercially-ready production systems, while continuing R&D on new production pathways that will be essential to meeting long-term decarbonization goals.

Highlights of the FY 2024 Request

- Increased funding for the scale-up of promising technical pathways that produce cost effective biofuels with a priority on the production of SAF. The major focus of the effort is to build demonstration-scale integrated biorefineries to de-risk technologies that will put the transportation sector on the trajectory for net-zero emissions by 2050. The successful scale-up and commercial deployment of these integrated biorefineries will contribute to decreasing CO_2 emissions by 450 million metric tons (MMT) per year by 2050.
- Increased funding for applied R&D on near- to mid-term technologies for production of low-carbon sustainable aviation and diesel fuels from a variety of feedstocks including through refinery integration of bio-oils derived from pyrolysis and hydrothermal liquefaction, as well as improved biological and catalytic processes for conversion of one- and two-carbon molecules (including CO_2) to fuels.
- Increased funding for RD&D to demonstrate the effectiveness of improved agronomic practices on reducing the carbon intensity of biomass resources across regional agronomic landscapes to generate predictive modeling tools and guidelines to support carbon negative feedstock supply chains.
- BETO is involved in several crosscutting initiatives, including the following:
    - Industrial Decarbonization to develop valuable chemicals and materials that can replace petrochemicals with renewable alternatives such as bioderived polymers and plastics;
    - Clean Energy Technology Manufacturing to replace petrochemicals with renewable alternatives such as bioderived polymers;
    - Energy-Water to provide technical assistance to communities on wet waste management strategies to address local challenges; and

[1] https://www.eia.gov/energyexplained/use-of-energy/transportation.php.
[2] Davis, Stacy C., and Robert G. Boundy. Transportation Energy Data Book: Edition 39. Oak Ridge National Laboratory, 2020, https://doi.org/10.2172/1767864.
[3] https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/09/fact-sheet-biden-administration-advances-the-future-of-sustainable-fuels-in-american-aviation.

- Biotechnology to develop bioengineering techniques to optimize production of fuels, chemicals, and materials in microbes.

BETO 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 R&D 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 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted	FY 2024 Request vs FY 2023 Enacted
Bioenergy Technologies					
System Development and Integration	70,500	92,600	145,500	+52,900	+57%
Renewable Carbon Resources (previously Feedstock and Algal System Technologies)	82,000	77,900	68,000	-9,900	-13%
Conversion Technologies	100,000	100,000	100,000	+0	+0%
Data, Modeling, and Analysis	9,500	9,500	9,500	+0	+0%
Total, Bioenergy Technologies	**262,000**	**280,000**	**323,000**	**+43,000**	**+15%**

SBIR/STTR:

- FY 2022 Transferred: SBIR $8,018,233; STTR $1,371,100
- FY 2023 Enacted: SBIR $8,643,000; STTR $1,215,000
- FY 2024 Request: SBIR $10,042,000; STTR $1,412,000

Bioenergy Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Bioenergy Technologies	
Systems Development and Integration: The increase in funding for this subprogram will support the upgrades to the Integrated Biorefinery Process Development Unit at NREL. The increase will also support pilot- and demonstration-scale biorefineries with a focus on producing sustainable aviation fuel (SAF), increasing the number of new biomass feedstocks that can be processed to final fuels, and new efforts to address persistent challenges in preprocessing and handling high-impact, biomass feedstocks such as corn stover.	**+52,900**
Renewable Carbon Resources (previously Feedstock and Algal System Technologies): Reduction in funding reflects the use of prior year funds for algae cultivar screening, optimization, and verification.	**-9,900**
Conversion Technologies: No major changes.	**+0**
Data, Modeling, and Analysis: No major changes.	**+0**
Total, Bioenergy Technologies	**+43,000**

Bioenergy Technologies
Systems Development and Integration

Description
The Systems Development and Integration subprogram (SDI) supports cost-shared RD&D with partners in industry, academia, and the National Laboratories focused on the development, testing, and verification of technologies at engineering-scale and includes 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: This activity will fund the development, testing, and verification at engineering-scale, of new technology and feedstock pathways for integrated biorefineries to reduce technology uncertainty through cost-shared pre-pilot, pilot- and demonstration-scale biorefinery projects with industry. BETO will continue implementing its multi-year strategy to fill the pipeline as technologies are ready to scale, ultimately demonstrating enough feedstock-conversion variations, or production pathways, to support commercialization and meet the SAF Grand Challenge goal of 35 billion gallons per year SAF production by 2050.

Funds will initiate the upgrading of the integrated biorefinery process development unit at NREL to increase safety and enabling partnerships with industry to advance innovations at scale.

Fuels and Co-Products R&D: This activity area will identify fuel properties that can enhance engine efficiency and reduce emissions for multiple end uses, including SAFs, marine shipping, freight rail, medium- and heavy-duty vehicles, and non-road applications. This activity will support analysis, in coordination with the Department of Agriculture, the Department of Transportation, and other Biomass R&D Board agencies to accelerate the commercialization of SAFs.

Systems Development and Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Development and Integration $92,600,000	**$145,500,000**	**+$52,900,000**
Production Process $92,368,000	$140,500,000	+$48,132,000
• Funding supports scale-up of biofuel production technologies at the pilot- and demonstration-scale with a focus on SAF. This includes algae-related demonstration activities.	• Scale-up of biofuel production technologies focusing on SAF to achieve BETO's goal for the successful construction and operation of at least four demonstration-scale integrated biorefineries by 2030.	• Increase will support the scale-up of multiple additional feedstock-conversion pathways with a focus on SAFs, including down-selects from existing awards.
• Continue work to focus primarily on process development units to verify R&D to produce drop-in biofuels from biomass feedstocks. New work will focus on technologies related to improving performance of lab capabilities to support technology scale-up, as well as the development of aviation, rail, and marine biofuels.	• Continue work using national laboratory process development units to verify R&D to produce drop-in biofuels for aviation, marine and rail from biomass feedstocks.	• Increases in this activity will support the equipment purchases and necessary improvements at the NREL Integrated Biorefinery Facility (IBRF).
• Continue efforts 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.	• Prior year funding will support projects in this activity from previous competitive funding in 2022 and 2023.	• No funding is requested in order to prioritize development of new feedstock-conversion pathways to SAF.
• Initiate an activity to focus on challenges in processing high impact feedstocks, from the bale yard inside the plant into various types of conversion reactors. This initial effort will investigate feedstocks and conversion technologies that are expected to begin deployment post-2030.	• Address challenges in processing high impact feedstocks, from the bale yard inside the plant into various types of conversion reactors at relevant engineering scales.	• Increase will support the scaleup of technologies to process challenging feedstocks such as agricultural residues and energy crops that are essential to meet long-term goals for domestic SAF production.
Fuels and Co-Products R&D $232,000	$5,000,000	+$4,768,000

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support R&D and analysis, in coordination with the Department of Agriculture, the Department of Transportation, and other Biomass R&D Board agencies to accelerate the commercialization of SAFs.	• Continue R&D, analysis, and interagency partnerships to accelerate the commercialization of SAFs and explore non-CO_2 climate impacts of SAF formulations.	• Efforts will expand to assess how SAF blends can reduce the formation of contrails.
• Funding feasibility analyses to identify potential opportunities and challenges for the production and use of biofuels in the marine and rail sectors.	• Continue feasibility analyses for marine and rail sectors.	• No significant change

Description

To achieve SAF targets, the U.S. will need to produce enough sustainable, conversion-ready feedstocks including terrestrial-, waste, and aquatic- feedstocks. The goal of the Renewable Carbon Resources subprogram is to conduct R&D to enable the deployment of feedstocks for bioenergy applications. No single bioenergy feedstock can be sustainably produced at the volumes necessary to displace petroleum-derived fuels and chemicals. This subprogram addresses the unique technical challenges posed by each class of feedstock.

The Renewable Carbon Resources subprogram supports R&D in the following two activities:

Terrestrial and Waste Feedstocks R&D: This activity includes R&D, cross-cutting analysis, resource assessments, and workforce development efforts to lower the production costs and improve convertibility of terrestrial and waste resources. This includes: feedstock production, preprocessing, supply chain analysis, and the development of methods to identify, quantify, and mitigate supply chain risk for terrestrial and waste resources. This activity aims to increase the type and availability of feedstocks, including energy crops. 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. Technoeconomic and life-cycle analysis is also supported by this activity. This R&D will lower cost and reduce risk by improving the operational reliability of equipment and process operation of integrated biorefineries, and the throughput and quality of finished products.

Aquatic Feedstocks R&D: This activity includes R&D, cross-cutting analysis, resource assessments, and workforce development activities to lower the production costs and improve yields of aquatic resources, including pond-cultivated algal systems. This includes: developing stable, high-yielding algal cultivars that resist predators suitable for farming operations; developing processes and technologies for microalgae crop protection; understanding the interface between harvested algae biomass and conversion processes, including the potential for water and nutrient recycle; improving carbon dioxide delivery and utilization; and integrating systems to optimize productivity and yield. This activity also supports technoeconomic and life-cycle analysis.

Renewable Carbon Resources

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Renewable Carbon Resources $77,900,000	**$68,000,000**	**-$9,900**
Terrestrial and Waste Feedstocks R&D $45,229,000	$48,000,000	+$2,771,000
• Continue research on supply chain analysis and developing methods to identify, quantify, and mitigate supply chain risk.	• Continue research on supply chain analysis and developing methods to identify, quantify, and mitigate supply chain risk.	• No significant change
• R&D will produce a series of analyses that build upon the *Billion Ton Study* 2016 and addresses carbon sequestration, environmental justice, climate change, and end uses such as SAFs.	• Continue R&D that builds upon the Billion Ton Study.	• No significant change
• R&D will focus on the interface of carbon management and how sustainable agriculture, biogenic carbon drawdown and forestry can advance decarbonization priorities. Conduct preliminary assessment on barriers and opportunities on the use of energy crops to produce SAFs.	• Initiate R&D on employing climate smart agricultural practices across a variety of agronomic regions and energy crops to increase the amount of sustainable energy crops available for SAF.	• Increase funding for sustainable agriculture R&D and field testing of purpose-grown energy crops that are critical to reaching the Program's outyear SAF volumetric targets.
• Continue research under the Feedstock-Conversion Interface Consortium (FCIC) to improve the operational reliability of integrated biorefineries through increased understanding of biomass materials and the fundamental properties that govern feedstock behavior, energy density, and conversion performance.	• Complete research under the FCIC to improve the operational reliability of integrated biorefineries and identify future R&D strategies and priorities for FY 2025 and beyond to address challenges in feedstock handling and preprocessing.	• No significant change
• Continue research on harvest logistics and biomass analytics.	• Continue research on harvest logistics and biomass analytics.	• No significant change.
Aquatic Feedstocks $32,671,000	$20,000,000	-$12,671,000
• The Development of Integrated Screening, Cultivar Optimization, and Verification Research (DISCOVR) Consortium will focus on improving areal productivity and reducing biomass	• DISCOVR Consortium research to enable the production of sustainable, cost-effective, and conversion-ready algae feedstocks will continue using prior year funds	• No funds are requested. The DISCOVR consortium 3-year work plan was fully-funded up front in FY 2023 in order to increase funding for scale-up of integrated biorefineries.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
production costs, including developing crop protection strategies to prevent pond crashes.		
• Continue research on applications of foundational genomics for algae strains to harness algal diversity to improve productivity and quality.	• Continue research on applications of foundational genomics for algae strains to harness algal diversity to improve productivity and quality.	• No significant change
• State of technology cultivation trials will continue to verify R&D progress	• No funds are requested for state of technology cultivation trials.	• Funding for state of technology cultivation trials has been reprioritized to accomplish additional R&D to enable the production of sustainable, cost-effective, and conversion-ready algae feedstocks.
• Continue research in sustainable algae cultivation and opportunities to provide ecosystem services like wastewater treatment.	• Continue research in sustainable algae cultivation to increase sustainable energy crops available for SAF production. Algae cultivation to address ecosystem services like wastewater treatment will continue to be of interest.	• Increased focus on field testing of regionally-appropriate energy crops that are critical to reaching the Program's outyear SAF volumetric targets.

Bioenergy Technologies
Conversion Technologies

Description
The Conversion Technologies subprogram supports applied R&D to convert biomass and waste feedstocks into transportation fuels and bio-based chemicals and products. Conversion research explores concepts in both biological (using biological organisms) and thermochemical (using heat, pressure, and chemical catalysis) routes to convert biomass, waste feedstocks, and other complex organic polymers into drop-in biofuels (SAF, marine fuels, and renewable diesel), fuel components, and chemical intermediates of interest to hard-to-decarbonize areas of the economy. This research lowers technology uncertainty and establishes a knowledge base that supports industry to demonstrate and deploy novel technologies for their unique market opportunities. This applied research supports multiple biorefinery configurations that industry may pursue.

Bio-Processing R&D: Funding will continue to support R&D to reduce the time and cost for developing and implementing biological conversion of biomass and other materials into industry-relevant fuels, intermediates, 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, applies synthetic biology tools and machine learning developed over the past few years to create commercial organisms for the production of SAF and bio-product intermediates.

Catalysts R&D: Funding will continue to support R&D to reduce the time and cost required to develop new inorganic catalysts for conversion of biomass and other relevant feedstocks 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, as well as research to understand the performance and cost of various catalytic materials, support structures, and preparation methods. A principle implementing entity for the effort is the multi-lab ChemCatBio (CCB) consortium. This activity also supports research of electrocatalytic conversion of CO_2 to intermediates and use of chemical catalysis for conversion of intermediates to fuels, chemicals, and bioproducts.

Deconstruction and Synthesis R&D: This activity conducts R&D on technologies to convert biomass to fuels and products via well-defined conversion technology pathways. The activity investigates more energy efficient and cost-effective techniques for disassembling biomass feedstocks, employing the rich, functional nature of biomass, separating the constituents, and identifying catalytic, biochemical, and hybrid pathways to desired products (including those with enhanced performance characteristics). Additionally, this activity includes development of novel techniques for process measurement and control to benefit the R&D and industry.

Waste or residue materials is a widely available and relatively affordable feedstock for the production of fuels and products. 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 develops technologies to 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.

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 biobased processes or require costly and time-consuming trial and error approaches. The Bioprocessing Separations consortium under this activity is developing novel separation techniques specific to biorefineries.

Conversion Technologies
Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Conversion Technologies $100,000,000	**$100,000,000**	**+0**
Bio-Processing R&D $31,322,000	$34,000,000	+2,678,000
• The Agile BioFoundry will revise and implement their strategic plan to apply Design–Build–Test–Learn (DBTL) tools toward a focused set of organisms for the production of SAF via ethanol and lipids and production of chemical intermediates that can significantly reduce GHG emissions and demonstrate industrially-relevant titers, rates and yields. Continued work will expand Artificial Intelligence (AI) and machine learning and software capacity to improve the predictive design of organisms and pathways.	• Continue to execute the new strategic plan using DBTL tools, AI and machine learning to achieve commercially viable rate, titer and yield to specific product molecules using a focused set of organisms and with greater industrial partnership. Continue to expand artificial intelligence, machine learning and software capacity to improve the predictive design of organisms and pathways. The Advanced Biofuels and Bioproducts Process Development Unit (ABPDU) will continue the successful partnership with industry and other national labs to complete intermediate scale up of organisms and processes.	• The increase will explore the ABPDU's potential. R&D efforts will focus on developing specific organisms with defined products vs. generic design-build-test-learn tools and beach-head molecules.
• Biochemical conversion R&D will investigate carbon negative (or low carbon intensive) products/chemicals through the deconstruction of diverse types of biomass feedstocks.	• Biochemical conversion R&D will investigate carbon negative (or low carbon intensive) products/chemicals through the deconstruction of diverse types of biomass feedstocks.	• No significant change
Catalyst R&D $31,500,000	$33,500,000	+$2,000,000
• The Chemical Catalysis for Bioenergy (CCB) consortium will continue to accelerate catalyst and process development for bioenergy applications with a focus on SAF, marine/heavy duty fuels, and renewable chemicals. CCB will maintain and expand efforts on enabling technologies and core catalyst optimization capabilities such as ethanol and C1/C2 conversion to SAF that are instrumental in the decarbonization of transportation and industry. Catalyst	CCB will continue to accelerate catalyst and process development for bioenergy applications with a focus on SAF, marine/heavy duty fuels, and bioproducts. Enabling technologies and core catalyst optimization such as ethanol and C1/C2 conversion to SAF are instrumental in the decarbonization of transportation and industry. Catalyst performance and cost improvements should enable fuel pathways that reduce GHG emissions up to 70 percent compared to	• The increase will support research efforts focused on the most promising pathways to end-products through catalyst scale-up, syngas conditioning, and removing barriers to refinery processing of bio-derived intermediates.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
performance and cost improvements should enable fuel pathways that reduce GHG emissions up to 70 percent compared to petroleum fuels/products, at market competitive costs.	petroleum fuels/products, at market competitive costs.	
• Continue R&D on strategies to convert CO_2 to intermediates and subsequent intermediate upgrading to fuels and chemicals.	• Complete initial phase of R&D on the conversion of CO_2 to intermediates and upgrading to fuels and chemicals that could supply SAF (or other products that are difficult to decarbonize) to the market by 2050. Establish research priorities for FY 2025 and beyond.	• No significant change
Deconstruction and Synthesis R&D $37,178,000	$32,500,000	-$4,678,000
• Continue biochemical conversion R&D with focus on conversion of lignocellulosic biomass to upgradable intermediates primarily in the areas of improvements to pretreatment and hydrolysis.	• Continue biochemical conversion R&D with focus on conversion of lignocellulosic biomass to upgradable intermediates primarily in the areas of improvements to pretreatment and hydrolysis.	• No significant change
• Continue research, modeling and analysis on strategies to convert wet wastes to fuels, bio-based chemicals and products.	• Continue research, modeling and analysis on strategies to convert wet wastes to fuels, bio-based chemicals and products.	• No significant change
• Increase 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.	• Continue 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.	• No significant change
• Funding for industry partnerships to develop and commercialize renewable chemicals with a focus on lignin utilization.	• Projects selected in FY 2023 will continue using prior year funds.	• No funds are requested in order to prioritize funding for scale-up of integrated biorefineries.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Continue technical assistance for local governments/municipalities to address challenges related to management of organic wastes. Fund feasibility studies on the use of organic wastes to produce renewable natural gas or hydrogen for use in municipal fleets.	• Technical assistance program for local governments/municipalities to address challenges related to management of organic wastes will continue.	• No funds requested for feasibility studies to produce renewable fuels for municipal fleets. Technical assistance work will continue.
• The BOTTLE consortium, jointly funded with the Advanced Materials and Manufacturing Technologies Office, will continue to develop biobased plastics designed with superior recyclability and biodegradability as well as new methods to recycle and upcycle existing plastic waste.	• The BOTTLE consortium, jointly funded with the Advanced Materials and Manufacturing Technologies Office, will continue to develop biobased plastics designed with superior recyclability and biodegradability as well as new methods to recycle and upcycle existing plastic waste.	• No significant change
• Funding for research and testing of high-efficiency, low-emission wood stoves.	• Projects selected in FY 2023 will continue using prior year funds.	• No funds are requested for wood stoves in order to prioritize funding to address R&D challenges for the conversion of biomass to fuels and renewable chemicals.
• Performance-advantaged Bioproducts (PAB) R&D will focus on scaling up the identification and production of products that can be produced from biomass with some performance advantage over incumbent petroleum-based products with a focus on decreasing carbon intensity compared to the incumbent petroleum product by at least 20 percent while also being produced at a reduced cost.	• Performance-advantaged Bioproducts (PAB) R&D will continue to focus on scaling up the identification and production of products that can be produced from biomass with some performance advantage over incumbent petroleum-based products.	• No significant change
• Lignin valorization research to support cost effective biofuel production will continue through catalytic, solvent-assisted, and biological processes.	• Lignin valorization research to support cost effective biofuel production will continue through catalytic, solvent-assisted, and biological processes.	• Reduced funding for Lignin-to-products and fuels activities to focus on more promising pathways.

Bioenergy Technologies
Data, Modeling, and Analysis

Description
The Data, Modeling, and Analysis subprogram activities provide quantitative analysis to inform BETO's decisions regarding the future direction and scope of its 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 GHG emissions reductions for the least cost.

The subprogram's sustainability activities focus 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.

Data, Modeling, and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $9,500,000	**$9,500,000**	**+$0**
• Continue strategic 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 decarbonization of transportation, industry, and agriculture.	• Continue strategic 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 decarbonization of transportation, industry, and agriculture.	• No significant change
• Continue analysis initiated in FY 2022 to identify ways to address administration priorities in equity and environmental justice.	• No funding requested.	• Analysis completed in FY 2023. Findings from this analysis will be incorporated BETO project and portfolio management.
• Biomass can meet needs in reducing GHG This new analysis will examine the most impactful use of biomass to meet the administration goal of a 100 percent clean energy economy by 2050.	• Continue analysis on the optimal use of biomass to reduce GHG emissions across all sectors of the economy.	• No significant change
• Update models and tools (including the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies model and the Water Analysis Tool for Energy Resources model) to continue high-priority sustainability research and analyses.	• Update models and tools (including GREET and WATER) to continue high-priority sustainability research and analyses.	• No significant change
• Continue bioenergy sustainability research to quantify environmental and social sustainability benefits and identify and fill knowledge gaps related to land and water resources.	• Continue bioenergy sustainability research to quantify environmental and social sustainability benefits and identify and fill knowledge gaps related to land and water resources.	• No significant change

Industrial Efficiency and Decarbonization

Overview

The Industrial Efficiency and Decarbonization Office (IEDO) accelerates the innovation and adoption of cost-effective technologies to increase energy efficiency and reduce greenhouse gas (GHG) emissions in the U.S. industrial sector (non-power sectors). IEDO has three subprograms focusing on sector-specific technology innovation, cross-sector decarbonization technologies, and technical assistance and workforce development.

IEDO plays a strategic role in building a strong decarbonized economy through investments in research, development and demonstration (RD&D) activities, as well as technical assistance and workforce development. IEDO partners with corporations, nonprofits, individuals, universities, laboratories, state/local governments, and consortia. IEDO activities depend on merit-based selection and peer-reviewed results.

In the FY 2023 Budget, EERE's manufacturing and industry sector-related Budget Request was structured across four technical subprograms: Industrial Efficiency and Decarbonization; Clean Energy Manufacturing; Material Supply Chains; and Technical Assistance and Workforce Development under a single Advanced Manufacturing Office (AMO). In the FY 2024 Request, EERE further sharpens and focuses its manufacturing portfolio, reorganizing the Advanced Manufacturing Office into two programs with associated control points aligned with the two organizational offices established in FY 2023: the Advanced Materials and Manufacturing Technologies Office (AMMTO) and IEDO. This reorganization was performed to position the two new organizations to better achieve the goals and purposes articulated for manufacturing and industry programs in the Energy Act of 2020. As part of the reorganization process, DOE considered input from external stakeholders and prior peer review feedback. AMMTO focuses on RD&D for technologies that foster competitive U.S. manufacturing for clean energy products to decarbonize multiple end-use sectors in the economy (buildings, industry, transportation, electric power). IEDO focuses on RD&D for technologies that decarbonize manufacturing in the U.S. and globally, as well as technical assistance to support manufacturers in operational improvements and implementation of new technologies.

To achieve decarbonization in the industrial sector, IEDO is organized into three subprograms: Energy- and Emissions-Intensive Industries; Cross-Sector Technologies; and Technical Assistance and Workforce Development. Within each subprogram, IEDO focuses on technical areas with high potential for impact and leverages all four strategies outlined in the DOE Industrial Decarbonization Roadmap.[1] The technical focus areas are identified through engagement with stakeholders, and supported by strategic analysis to target knowledge gaps and barriers that, if addressed through RD&D or other investments, can be adopted by industry to achieve cost-effective decarbonization of the industrial sector.

Strongly informed by input from industrial partners in the private sector, IEDO coordinates its RD&D efforts across the Department, particularly with the Office of Clean Energy Demonstrations (OCED), which delivers clean energy technology demonstration projects at scale in partnership with the private sector to accelerate deployment, market adoption, and the equitable transition to a decarbonized energy system.

Robust two-way engagement with industry stakeholders, research institutions, states, communities, and workforce representatives (e.g., unions) informs future investments and program activities in the areas of decarbonization, workforce development, underserved communities, communities negatively impacted by industrial emissions, and others.

Highlights of the FY 2024 Request

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

- Increased industry-specific decarbonization investments with initiatives focusing on the chemicals, forest products, iron and steel, cement, and other high carbon-emitting industries such as food processing, including a newly expanded effort to utilize carbon dioxide (CO_2) as a feedstock for commodity chemicals, through processes like the electrochemical production of ethylene.
- Ramped up investments in priority cross-sector technologies for decarbonization based on the DOE Industrial Decarbonization Roadmap, including thermal-process electrification, in support of the Industrial Heat EarthShot initiative.

[1] DOE Industrial Decarbonization Roadmap. Report to Congress, September 2022. https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.

- Increased investment in applied R&D for water and wastewater treatment technologies that reduce GHG emissions.
- Continue technical assistance to increase the adoption of decarbonization technologies and advanced energy and water efficiency technologies and practices across the industrial sector. Expanded programs include an Onsite Energy program that will assist manufacturers in assessing the cost-effectiveness of a broad range of onsite energy resources (e.g., photovoltaics, solar thermal, geothermal, bioenergy, distributed wind, battery storage, thermal energy storage) at their facilities.
- IEDO is involved in several crosscutting initiatives, including the following:
  - Carbon Dioxide Removal crosscut which includes work in a new FY 2024 effort focused on utilization of CO_2 as a feedstock for commodity chemicals such as ethylene;
  - Hydrogen crosscut through investment in process innovations to advance the economic use of low-carbon hydrogen for industrial processes;
  - Energy-Water crosscut through advancements in decarbonization of water and wastewater treatment systems through R&D and pilot scale demonstration;
  - Energy Storage crosscut through innovation related to incorporating energy storage into manufacturing processes and/or facilities to manage power and thermal energy and reduce industrial GHG emissions.
  - Industrial Decarbonization crosscut through industry-specific decarbonization investments focused on the chemicals, forest products, iron and steel, cement, and food and beverage productions, ramped up investments in priority cross-sector technologies, and expanded technical assistance programs including DOE's Better Climate Challenge.

Industrial Efficiency & Decarbonization
Funding ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Industrial Efficiency & Decarbonization (IEDO)					
Energy- and Emissions-Intensive Industries	98,790	131,000	195,000	+64,000	+49%
Cross-Sector Technologies	52,709	90,500	141,245	+50,745	+56%
Technical Assistance and Workforce Development	30,983	45,000	58,000	+13,000	+29%
Total, Industrial Efficiency & Decarbonization	**182,482**	**266,500**	**394,245**	**127,745**	**+48%**
Advanced Materials and Manufacturing Technologies (AMMTO)					
Next-Generation Materials & Processes	103,544	90,000	90,000	0	0%
Secure & Sustainable Materials	66,530	40,000	91,497	+51,497	+129%
Energy Technology Manufacturing & Workforce	50,444	53,500	60,000	+6,500	+12%
Total, Advanced Materials and Manufacturing Technologies	**220,518**	**183,500**	**241,497**	**+57,997**	**+32%**

Note: Advanced Materials and Manufacturing Technologies (AMMTO) added to the table to show the Request to re-organize Advanced Manufacturing Office (AMO) budget into two control points aligned with the two organizational offices established in FY 2023: the AMMTO and the IEDO. Numbers in FY 2023 and earlier are estimates prior to the bifurcation of the office,

SBIR/STTR:
FY 2022 Transferred: SBIR: $6,289,000; STTR: $765,000
FY 2023 Enacted: SBIR: $6,139,259; STTR: $901,071
FY 2024 Request: SBIR: $11,224,000; STTR: $1,578,000
Note: Please see Advanced Materials and Manufacturing Technologies (AMMTO) for the balance of AMO SBIR/STTR funding

Proposed FY 2024 Budget Structure

	Industrial Efficiency & Decarbonization (IEDO)			
	Energy- and Emissions-Intensive Industries	**Cross-Sector Technologies**	**Technical Assistance and Workforce Development**	**Total**
FY 2023 Budget Structure				
Advanced Manufacturing (AMO)				
Industrial Efficiency and Decarbonization	195,000	141,245	13,000	**349,245**
Clean Energy Manufacturing	0	0	0	**0**
Material Supply Chains	0	0	0	**0**
Technical Assistance and Workforce Development	0	0	45,000	**45,000**
Total	**195,00**	**141,245**	**58,000**	**394,245**

Industrial Efficiency & Decarbonization
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Energy- and Emissions-Intensive Industries: The increase will focus on reducing GHG emissions from energy- and emissions-intensive industries through RD&D for next generation low carbon technologies in industry-specific applications. The subprogram increases the research portfolio focused on utilization of CO_2 as a feedstock for chemicals production efforts while continuing to prioritize efforts in four other key industries.	+64,000
Cross-Sector Technologies: The Request increases investments in solving manufacturing challenges that are critical for achieving industrial decarbonization across multiple sub-sectors, informed by the industrial decarbonization roadmap and thermal process intensification analyses. The Request prioritizes RD&D to address decarbonization of industrial process heating, efforts to utilize low carbon fuels and feedstocks, and other emerging energy efficiency technologies. The Request increases RD&D investments in high priority thermal process and systems efficiency innovation, and increases funding to develop equipment and related technologies to advance industrial capabilities to use low carbon fuels and feedstocks.	+50,745
Technical Assistance and Workforce Development: The Request increases technical assistance for the accelerated implementation of decarbonization technologies and water efficiency projects and practices with an increased focus on energy-intensive industries.	+13,000
Total, Industrial Efficiency & Decarbonization	**+127,745**

Industrial Efficiency & Decarbonization
Energy- and Emissions-Intensive Industries

Description
The Energy- and Emissions-Intensive Industries subprogram targets subsectors of U.S. industry with the highest energy consumption and the highest emissions. The subprogram features sector-focused RD&D activities to accelerate the commercial readiness of emerging, net-zero emissions technologies for the most energy- and carbon-intensive industries. The subprogram identifies specific RD&D challenges based on the DOE Industrial Decarbonization Roadmap, stakeholder input, alignment with the program's key activity areas, and potential energy, carbon, and economic impacts related to subsequent industrial adoption.

Chemicals, Forest Products, and Related Industries: This activity will address energy use and carbon emissions from chemicals, paper and forest products, and related industries, which rely heavily on process heating as well as separation processes to produce a wide variety of products. Example topic areas include novel reactor, process, and catalyst designs; use of alternative feedstocks and electrochemical processes; and drying methods. Technology advancements can enable energy and cost savings, reduce water usage, and lower carbon footprints. This activity supports RD&D for industry-specific technologies to improve energy efficiency; eliminate process emissions; pursue electrification; and integrate clean fuels, feedstocks, and energy sources. Specifically, the program pursues an initiative focusing on the underlying RD&D challenges to effectively use CO_2 as a feedstock in place of fossil resources. The program will advance processes like the electrochemical production of ethylene from CO_2, replacing incumbent processes, in which ethylene ranks as the building block with the highest carbon emissions. RD&D focuses on the underlying challenges to scale-up including product selectivity, mass transfer limitations, electrode stability, ion conductivity, catalyst durability, and reactor design. If these foundational barriers can be overcome, future electrochemical production of fuels, nitrogen-based fertilizers, and commodity chemicals can substantially contribute to decarbonization of the chemicals industry and enable a circular economy.

Iron and Steel, and Other Metals Industries: This activity will address energy use and carbon emissions from iron and steel manufacturing, which rely on high temperatures and carbon as a reductant in production processes. Example topic areas include novel melting and heating approaches and alternative reductants for iron production. Technology advancements to be explored include alternative injection and plasma-heating technologies in the blast furnaces and high efficiency steel reheating coupled with recycling heat and waste energy. This activity supports RD&D for industry-specific technologies to improve energy efficiency; eliminate process emissions; pursue electrification; and integrate clean fuels, feedstocks, and energy sources.

Cement, Food Products, and Other Industries: This activity will address energy use and carbon emissions from other energy-intensive industrial sub-sectors, with the cement and concrete industry, and food and beverage production/processing, as the highest emitting and therefore highest priorities for this activity. Example topic areas include exploring zero carbon cement production routes, CO_2 mineralization in building materials, alternative cement/concrete formulations, and novel heating and drying technologies in food and beverage processing. Technology advancements can enable energy and cost savings, reduced water usage and a lower carbon footprint. This activity supports RD&D for industry-specific technologies to improve energy efficiency; eliminate process emissions; pursue electrification; and integrate clean fuels, feedstocks, and energy sources.

Energy- and Emissions-Intensive Industries

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy- and Emission-Intensive Industries $131,000,000	**$195,000,000**	**+$64,000,000**
Chemicals, Forest Products, and Related Industries $53,000,000	$85,000,000	+$32,000,000
• Support industrial decarbonization activities, including research, development and pilot-scale demonstrations, to rapidly advance technologies and enable an accelerated timeline for achieving carbon emission reductions. Focus on decarbonization of the chemicals, iron and steel, cement, and food products industries.	• Support RD&D projects to evaluate the use of alternative chemical feedstocks and advanced separations to address chemical industry priorities in the Industrial Decarbonization Roadmap. Pursue RD&D efforts in forest products industries such as efficient paper drying technologies and valorization of industry waste streams.	• Increase will initiate a new and expanded focus on utilization of carbon dioxide focus for production of fuels, and other commodity chemicals, especially through the use of electrochemical methods.
Iron and Steel, and Other Metals Industries $38,000,000	$50,000,000	+$12,000,000
• Support industrial decarbonization activities, including research, development and pilot-scale demonstrations, to rapidly advance technologies and enable an accelerated timeline for achieving carbon emission reductions. Focus on decarbonization of the chemicals, iron and steel, cement, and food products industries.	• Support RD&D projects to explore innovative routes to produce carbon reductants using low-carbon methods for iron production, and address production system integration challenges. Begin development of lower carbon process heating solutions specific to steel industry such as increasing renewable hydrogen composition in blast furnaces and improvements in electric induction reheating furnace designs.	• Increase will support innovative technologies that enable deep decarbonization for both ore-based and scrap-based iron and steelmaking operations.
Cement, Food Products, and Other Industries $40,000,000	$60,000,000	+$20,000,000
• Support industrial decarbonization activities, including research, development and pilot-scale demonstrations, to rapidly advance technologies and enable an accelerated timeline for achieving carbon emission reductions. Focus on decarbonization of the chemicals, iron and steel, cement, and food products industries.	• Conduct RD&D on the use of low carbon fuels and electrification technologies to decarbonize heat required for calcination in cement manufacturing; and investigate new cement formulations and aggregate production from various ore carbonates. For food manufacturing, pursue R&D to evaluate a suite of electrification technologies for drying, dewatering and heating for energy- and carbon-intensive food production processes.	• Increase will support innovative technologies to address decarbonization opportunities in additional industry sectors such as glass and other energy intensive industries.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	Conduct RD&D efforts to advance novel melting technologies and utilize low carbon fuels in glass and other industries.	

Industrial Efficiency & Decarbonization
Cross-Sector Technologies

Description

The Cross-Sector Technologies subprogram supports RD&D addressing energy efficiency and emissions reduction technologies and approaches with broad application across the industrial sector. These include thermal processes and systems, enabling technologies for low carbon fuels and feedstocks, and emerging efficiency and other decarbonization technologies. Process and equipment technologies were identified as priorities in the DOE Industrial Decarbonization Roadmap, DOE's Thermal Process Intensification Workshop, and DOE's Industrial Decarbonization Request for Information. The subprogram also supports RD&D for energy and emissions reductions from water and wastewater treatment. The subprogram continues to identify the specific research challenges based on stakeholder input, alignment with the program's key technology areas and analytical assessments, and potential energy, carbon, and economic impacts.

Thermal Processes and Systems: This activity will address opportunities to reduce energy consumption and GHG emissions in process heating operations for the industrial sector. In 2018, process heating in manufacturing was estimated to account for over 7 quads of energy use and nearly 300 million metric tons of onsite GHG emissions.[2] Informed by analysis and stakeholder engagement, this activity invests in a suite of targeted technology RD&D for highest cross-sector decarbonization impact. Example topic areas include advances in membranes and other efficient separation technologies, furnace and process control technologies, high-temperature industrial heat pumps, process intensification that contributes energy efficiency improvements, and electrification for thermally intensive operations. This activity is closely coordinated with the Industrial Heat EarthShot initiative.

Energy & Emissions Reductions from Water and Wastewater Treatment: Water and wastewater treatment produce significant GHG emissions from energy use as well as non-energy related emissions; the latter accounted for over 40 million metric tons of CO_2-equivalent emissions in 2020.[3] This activity supports RD&D of technologies that reduce CO_2, CH_4, and N_2O GHG emissions and recover resources from municipal wastewater treatment processes and systems. Areas of focus for RD&D investment include technologies to replace secondary aeration such as anaerobic membrane bioreactors, alternative forms of nitrogen removal, and technologies to reduce sludge formation. In addition to reducing emissions, these technologies lower energy requirements and reduce energy costs.

Emerging Efficiency and Other Decarbonization Technologies: This activity will explore innovative energy efficiency and decarbonization technology concepts with applications in multiple industrial sectors to improve industrial production system efficiencies, process yield, and recovery of thermal energy. Additional activities include energy systems analysis and modeling to inform improvements in industrial production system and process efficiency, and smart manufacturing technical assistance to facilitate operational energy efficiency improvements and decarbonization across industrial production operations in multiple sectors.

Enabling Technologies for Low Carbon Fuels and Feedstock: This activity will address opportunities to facilitate the use of low carbon solutions in industry and replace existing carbon-based fuels and feedstocks in multiple industrial sectors. Informed by analysis and stakeholder engagement, this activity invests in a suite of targeted technology RD&D for highest decarbonization impact. Example topic areas include development of advanced controls, burners, and other industrial furnace equipment capable of utilizing bio-derived fuels, hydrogen, or low carbon wastes and byproducts. Efforts also include development of industrial onsite energy storage systems and flexible combined heat and power (CHP) systems that rely on low carbon fuels.

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[2] 2018 Manufacturing Energy and Carbon Footprints, All Manufacturing Sector. DOE AMO. December 2021. https://www.energy.gov/sites/default/files/2022-01/2018_mecs_all_manufacturing_energy_carbon_footprint.pdf.

[3] See Table 7.7 in "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2020." EPA 2022. https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf.

Cross-Sector Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Cross-Sector Technologies $90,500,000	**$141,245,000**	+$50,745,000
Thermal Processes and Systems $38,500,000	$71,245,000	+$32,745,000
• Pursue priority cross-cutting technologies for decarbonization based on industrial decarbonization roadmap and analyses, potentially including electrochemical processes, innovative separations and CO_2 reuse.	• Fund RD&D activities informed by the industrial decarbonization roadmap, thermal process intensification analyses, and the Industrial Heat EarthShot. These RD&D areas include advanced membranes and other efficient separation technologies, advanced furnace and process control technologies, high-temperature industrial heat pumps, and electrification of thermally intensive industrial processes.	• Increase will support RD&D for high priority thermal process and systems efficiency innovation, such as advanced non-thermal separation processes and electric thermal process equipment technologies.
Energy & Emissions Reductions from Water and Wastewater Treatment $20,000,000	$30,000,000	+$10,000,000
• Fund the third year of the five-year Energy Water Hub. Fund competitively selected, merit-based research projects to decarbonize water and wastewater treatment, with a focus on agricultural waters.	• Fund RD&D projects to decarbonize water and wastewater treatment, including technologies that are alternatives for secondary aeration and nitrogen removal.	• Increase will allow for an expansion of focus to support a portfolio of water and wastewater research, development, and pilot-scale demonstration projects to drive water sector decarbonization. No additional funds are required for the Energy Water Desalination Hub, which is already funded through FY 2024.
Emerging Efficiency and Other Decarbonization Technologies $17,000,000[4]	$20,000,000	+$3,000,000
• Pursue priority cross-cutting technologies for decarbonization based on industrial decarbonization roadmap and analyses, potentially including electrochemical processes, innovative separations and CO_2 reuse.	• Pursue RD&D on emerging efficiency and decarbonization technology concepts to significantly improve industrial production system efficiencies, process yield, and recovery of thermal energy. Conduct analysis and modeling to inform innovations and improvements in	• Increase will allow funding to advance ambitious technology concepts and increase capabilities to utilize associated modeling and analysis to significantly improve energy efficiency and reduce emissions in industrial production systems.

[4] Numbers in FY 2023 and earlier are estimates prior to the bifurcation of the office

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	industrial production system and process efficiency in multiple industry sectors.	
Enabling Technologies for Low Carbon Fuels and Feedstock $15,000,000	$20,000,000	+$5,000,000
• Decarbonized combined heat and power: RD&D and technical assistance for hydrogen or renewably fueled CHP for industry.	• Fund RD&D projects to rapidly advance technologies to enable cross-sector use of low carbon fuels and feedstocks, including development of process control and combustion equipment capable of utilizing bio-derived fuels, hydrogen, or other low carbon wastes and byproducts.	• Increase will allow funding to develop combustion equipment and related technologies to advance industrial capabilities to utilize low carbon fuels and feedstocks.

Industrial Efficiency & Decarbonization
Technical Assistance and Workforce Development

Description
This subprogram supports technical assistance and development of transformational tools to help manufacturers reduce their energy and carbon intensity, adopt energy management programs, and develop targets for energy efficiency, productivity, carbon reductions, and waste/water use reduction. Core programs include the Better Plants Challenge, Better Climate Challenge, Energy Management Programs (50001[5] Ready and Superior Energy Performance), and the Combined Heat and Power (CHP) Deployment Program. The subprogram identifies the specific technology deployment challenges and workforce development opportunities for focus based on stakeholder input, alignment with the program's technology areas, and potential energy, carbon, and economic impacts.

Increasing the adoption of decarbonization technologies and advanced energy and water efficiency technologies and practices across the industrial sector is accelerated by technical assistance, including promoting the adoption of energy management programs that feature targets for energy efficiency, productivity, carbon reductions, and waste/water use reduction practices. In FY 2024, the Better Plants Challenge and Better Climate Challenge are supporting initiatives for energy-intensive manufacturers, peer exchange working groups, and training opportunities. The Industrial Technology Validation (ITV) initiative partners with DOE's National Labs to objectively validate performance in dynamic industrial environments in order to de-risk implementation of emerging technologies. Additional activities include the extension of existing publicly available state-of-the-art tools for manufacturers including the 50001 Ready Navigator[6] and MEASUR energy calculator and analysis tool suite to address emerging topics such as carbon reduction, resiliency, and cybersecurity. All technical assistance activities will include targeted support for disadvantaged communities to support the Justice40 initiative and ensure technical assistance is equitably and openly available.

Industrial partners are increasingly seeking technical assistance to identify and deploy technology solutions that can reach clean energy targets, replace outdated equipment, and balance resilience requirements. To meet these evolving needs, the subprogram will leverage and adapt the successful CHP Deployment Program model to incorporate a broader range of onsite energy resources (such as photovoltaics, solar thermal, geothermal, bioenergy, distributed wind, battery storage, thermal energy storage, etc.). The CHP Technical Assistance Partnerships (TAPs) will shift into the Onsite Energy TAPs in order to bring expanded expertise and analytical capabilities to assist manufacturers with a more comprehensive set of onsite energy solutions.

Advanced manufacturing processes are demanding more from workers in the form of technical skills, experience with computer-automated processes, and expertise in energy information management systems. This subprogram includes a focused workforce development program that provides support for reskilling and upskilling workers through mentoring and on-the-job training to increase the number of qualified technical employees with skills operating and maintaining new decarbonization technologies. All educational and workforce development activities include a focus on diversity and inclusion, and reskilling programs that will be specifically targeted toward underserved communities, energy communities, and tribal communities to aid in their transition to the clean energy economy. IEDO is actively coordinating on workforce development activities with Department of Labor (DOL) and Department of Commerce (DOC), including a strong collaboration with DOC's Manufacturing Extension Partnerships.

[5] https://www.iso.org/iso-50001-energy-management.html
[6] The 50001 Ready Navigator is an online application that provides step-by-step guidance for implementing and maintaining an energy management system in conformance with the ISO 50001 Energy Management System Standard.

Technical Assistance and Workforce Development

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Technical Assistance and Workforce Development $45,000,000	**$58,000,000**	**+$13,000,000**
Technical Assistance and Workforce Development $45,000,000	$58,000,000	+$13,000,000
• Provide technical assistance for the implementation of energy and water efficiency projects and practices, including increased technical assistance to disadvantaged communities, Equity, Environmental and Energy Justice communities, and areas with high industrial emissions. Expand the Better Plants Challenge and Energy Management Programs to include initiatives related to energy-intensive manufacturers, carbon reduction, technology validation, and training opportunities.	• Provide technical assistance to support the adoption of decarbonization technologies and advanced energy and water efficiency technologies and practices across the industrial sector, including targeted assistance to disadvantaged communities with high industrial emissions. Leverage the Better Climate Challenge to augment technical assistance opportunities for energy-intensive manufacturers that are pursing decarbonization. Efforts will target technology validation of emerging decarbonization technologies and approaches, as well as tool and resource development.	• Increase will support an expansion of the Industrial Technology Validation (ITV) initiative from a pilot scale activity into a full program that engages with manufacturers to validate emerging efficiency and decarbonization technologies in real-world settings.
• Provide technical resources, tools, and implementation guidance to manufacturers that are pursuing onsite renewable energy generation or energy storage projects.	• Scale-up onsite energy initiative from pilot activities to full-scale program implementation. Complete the transition of the CHP Deployment Program and CHP Technical Assistance Partnerships (TAPs) into the Onsite Energy Program and Onsite Energy TAPs.	• Increase will support the expansion of the CHP TAP program into the Onsite Energy TAP program, which expands technical assistance beyond CHP systems to other types of onsite energy systems, with a focus on renewable thermal technologies.
• Train the clean energy innovators and manufacturing energy management workforce of the future. Focus on programs targeted at community colleges, technical schools, and apprenticeship programs within underserved communities.	• Fund workforce development activities focused on reskilling and upskilling workers to operate and maintain emerging decarbonization technologies.	• Increase will support the scaling of regional workforce development programs to have broader national level impacts and focus on workers from disadvantaged communities.

Strategic Programs

Overview

Strategic Programs funds high-impact and crosscutting activities most efficiently executed by a single crosscutting organization, in coordination with EERE technology programs and other DOE offices. Strategic Programs consists of four subprograms: Technology-to-Market and Communities, Strategic Analysis, Communications and Outreach, and International. Investments in these programs ensure that all EERE technology advancements support consistent approaches and processes to reach key stakeholders to address high energy costs, reliability, and inadequate infrastructure challenges.

The Program also supports the EERE key emphasis areas. Investments associated with Good Jobs & Workforce Development will support training and continue to develop good paying clean energy jobs for the American people, especially workers, communities impacted by the energy transition, and those historically underserved by the energy system and overburdened by pollution. Investments associated with Diversity, Equity, Inclusion and Accessibility in STEM Fields support outreach and will raise awareness of clean energy research and job opportunities at minority-serving institutions and minority-focused professional organizations and ensure that organizations receiving EERE funding are thinking through outreach opportunities in diversity and equity in their own work. Investments in Communities and Energy Transitions will support community-based organizations, regional partners, and state and local governments with the necessary resources to be more effective in facilitating affordable and resilient clean energy and efficiency goals. Investments associated with Energy Equity and Environmental Justice will support approaches and processes to reach new groups of Americans historically underserved by the energy system, and ensure funding is addressing community needs in the manner most appropriate for their space.

Highlights of the FY 2024 Request:

This Request supports key efforts that contribute to achieving its high-level goals:

- In FY 2024, EERE will continue to administer Energy Transitions Initiative (ETI) activities and expand the scale and impact of ETI investments to apply the lessons learned from island and remote communities to a broader set of underserved, disadvantaged, and historically hard to reach communities.
- Increases in Good Jobs & Workforce Development and Diversity, Equity, Inclusion, and Accessibility in STEM Fields are responsive to demonstrated Congressional interest in expanding and increasing EERE's investment in developing a diverse clean energy workforce for the future and will fund several Prizes and a Workforce Development program.
- EERE Strategic Analysis programs will shift toward a model where equity and environmental justice are integral to funded analysis work; Strategic Analysis will continue its emphasis on the Decarbonizing Energy through Collaborative Analysis of Routes and Benefits (DECARB) program, which aims to conduct analysis at the intersections between key emissions sectors; and Strategic Analysis will continue work on innovative cross-cutting analyses of advanced technologies and systems.
- EERE will build off the FY 2023 international program to focus on multilateral engagements to provide technical assistance to, and research collaboration with, countries and regions as efficiently as possible.
- EERE will increase outreach and engagement opportunities aligned with clean energy programs highlighted in the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA); 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 contribute to the establishment of a Foundation for Energy Security and Innovation to engage with the private sector to raise funds that support the creation, development, and commercialization of innovative technologies that address tomorrow's energy challenges.
- Strategic Programs is involved in several additional crosscutting initiatives, including the following:
    - Industrial Decarbonization crosscut through investments to develop data and analysis tools for difficult to decarbonize sectors of the economy, such as industry, and identify key opportunities for economic growth and job creation in the decarbonized U.S. economy; and
    - Energy-Storage crosscut through investments to support the Energy Storage Grand Challenge (ESGC) Policy & Valuation Track, which provides data, tools, and technical analysis that help policymakers and other energy system decision-makers maximize the value of energy storage.

Strategic Programs
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Strategic Programs					
Technology-to-Market and Communities	3,000	5,500	35,759	+30,259	+550%
Strategic Analysis	10,000	8,500	11,000	+2,500	+29%
Communications and Outreach	7,000	5,500	7,000	+1,500	27%
International	0	1,500	4,000	+2,500	+167%
Total, Strategic Programs	**20,000**	**21,000**	**57,759**	**+36,759**	**+175%**

Strategic Programs
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Strategic Programs	
Technology-to-Market and Communities: The increase supports ETI activities to expand the base suite of models to account for a broader set of community contexts identified by the expanded communities brought into the portfolio. The increase will also support efforts in Good Jobs & Workforce Development and Diversity, Equity, Inclusion and Accessibility in STEM Fields. The increase will also support EERE's contribution to the Foundation for Energy Security and Innovation.	**+30,259**
Strategic Analysis: The increase will support the development of new cross-sectoral decarbonization analysis capabilities and build upon a new program evaluation data platform.	**+2,500**
Communications and Outreach: Funding will increase communications and outreach activities to achieve greater impact on target audiences and expanded reach, including outreach to disadvantaged and energy communities.	**+1,500**
International: The increase is due to substantial growth in opportunities to collaborate internationally to expand U.S. clean energy technologies. The Request includes funding to support consultation and coordination with DOE International Affairs and international partners to meet key Secretarial and Administration priorities and commitments to fight climate change.	**+2,500**
Total, Strategic Programs	**+36,759**

Strategic Programs
Technology-to-Market and Communities

Description
The Request supports the Energy Transitions Initiative (ETI) and other activities in EERE key emphasis areas. ETI's core mission is to facilitate self-reliant communities by addressing high energy costs, reliability concerns, 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 in America's hardest to reach communities. Investments associated with Good Jobs & Workforce Development will support training and develop good paying clean energy jobs for the American people – especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution. Investments associated with Diversity, Equity, Inclusion and Accessibility in STEM Fields support outreach and will raise awareness of clean energy research and job 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.

The Request also supports EERE's contribution to the Foundation for Energy Security and Innovation to engage with the private sector to raise funds that support the creation, development, and commercialization of innovative technologies that address tomorrow's energy challenges.

Technology-to-Market and Communities

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Technology-to-Market $5,500,000	**$35,759,000**	**+$30,259,000**
• Funding for successful Energy Transitions Initiative and the Energy Transition Initiative Partnership Program.	• Continue to administer ETI activities and expand the scale and impact of ETI investments to apply the lessons learned from island and remote communities to a broader set of underserved, disadvantaged, and historically hard to reach communities. In addition, EERE will collaborate with other DOE elements on the Communities Local Energy Action Program (Communities LEAP) started in 2021. This opportunity for community-driven clean energy transitions is specifically open to low-income, energy-burdened communities that are also experiencing either direct environmental justice impacts, or direct economic impacts from a shift away from historical reliance on fossil fuels. • Support two Prizes and a pilot research program to address complex clean energy R&D challenges. Expand Community Energy Coalition Prize to provide 15-20 awards for building capacity within communities to improve community representation in energy decision-making. Additional 5-10 awards through a Prize for addressing clean energy challenges using approaches based on citizen science. Additional funding for 1-3 competitive awards focused on public health implications of clean energy development, integrated with multi-agency approaches to public health. • Support Prizes that focus on diversity in STEM in clean energy industries. The HBCU Inspire,	• Increased funding will continue support for ETI and include new Prizes and a Workforce Development program. The increases in these areas are responsive to Congressional interest in expanding and increasing EERE's investment in developing a diverse clean energy workforce for the future. • Increased funding for Foundation for Energy Security and Innovation to engage with the private sector to raise funds that support the creation, development, and commercialization of innovative technologies that address tomorrow's energy challenges.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	Initiate, and Integrate Prize will support between 2-4 awards to fund research infrastructure and capability improvements at HBCU recipients. The Clean Energy Careers for All Prize will support multiple organizations in the implementation of various programming that will lead to increasing the diversity of the future STEM clean energy workforce. • Continued support for the Clean Energy Innovators Fellows Program, and new support for a Workforce Accelerator Program to expand and standardize training activities for high-skill, high-wage, or in-demand industry sectors related to clean energy and climate mitigation developing national training standards leading to industry-recognized credentials, and place-based labor-management training pilots.	

Strategic Programs
Strategic Analysis

Description
The Strategic Analysis (SA) subprogram performs gap-filling and corporate analyses associated with EERE technologies and systems; 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 2024, SA will support analyses to evaluate a wide array of potential integrated technical pathways – across the electricity, buildings, industrial, transportation and agricultural sectors – to achieve key milestones toward the Administration's decarbonization goals. Analytical efforts will focus on developing tools and using a variety of metrics to determine a pathway's viability, the potential impact of EERE R&D, and the implications for how the clean energy economy benefits all Americans, creating good paying jobs for the American people – especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution. These analyses will inform EERE R&D planning and serve as a resource for EERE stakeholders involved in the unprecedented deployment of clean energy technologies.

To focus on execution of EERE analytical work, SA created DECARB, a multi-lab coordination team to implement a multi-year work plan that outlines what new capabilities are required to comprehensively address economy-wide decarbonization. In FY 2024, the multi-lab team will continue to conduct cross-sectoral analysis and develop new analytical capabilities while coordinating with activities happening across DOE, as well as engage external stakeholders to ensure that strategies can inform EERE and real-world planning.

SA will continue to support cross-cutting DOE initiatives. Specifically, a joint EERE, Office of Electricity, and Grid Deployment Office "Grid Solutions" effort, which aims to systematically provide support across several critical topic areas: integrated distribution system planning, resource adequacy, electricity markets, and regional planning. SA will support this program by developing foundational capabilities (data, tools, analysis) that can be used to increase the effectiveness of the technical assistance provided by other program offices or used directly by a wide array of electricity decision makers. SA will also continue to support analysis used to inform the Energy Storage Grand Challenge and Energy Earthshots.

Additionally, in FY 2024, SA will continue to lead efforts to ensure that EERE is maximizing the impact of its research dollars, tracking the impacts of EERE investments relative to priority metrics, 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.

Strategic Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Strategic Analysis $8,500,000	**$11,000,000**	**+$2,500,000**
• Finalize analysis of comprehensive nationwide analysis of pathways to carbon free electricity and integrate with analysis of pathways to decarbonize transportation, buildings, and industry.	• Build upon decades of investments in analysis of renewable power and develop new high-resolution capabilities to examine economy-wide (both supply- and demand-side) decarbonization pathways, with a focus on improving analyses of cross-sectoral interactions for energy cost, deployment, environmental impact, and equity.	• Increase in funding will support the development of new cross-sectoral decarbonization analysis capabilities and build upon a new program evaluation data platform. Strategic Analysis will also continue to fund the compilation of new data sets, enhance and integrate models/tools, and conduct analysis to address remaining research gaps.
• Support technical assistance efforts for renewable integration and grid modernization to enable stakeholders to make data-driven decisions around clean energy pathways, transmission buildouts, and market as well as policy solutions.	• Continue to invest in key analytical capabilities to enable best-in-class technical assistance, including making tools and models widely usable by others and publishing foundational datasets with high leverage across a broad array of analytical use cases. • Expand data and analysis tools for difficult to decarbonize sectors of the economy, especially agriculture, industry, and freight transportation modes, identifying key opportunities for economic growth and job creation in the decarbonized U.S. economy.	
• Complete development of analytical tools to enable EERE programs and external stakeholders to maximize U.S. energy job creation and minimize job transitions.	• Leverage capabilities to support EERE programs and external stakeholders and take lessons learned from key use cases to support continual improvement in analytical capabilities. Build upon a new evaluation data platform with EERE program metrics, data pipelines, analytics, and automation to improve data collection practices and data aggregation systems.	

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Continue to provide analytical support for the Energy Storage Grand Challenge in coordination with cross sector analysis examining pathways to decarbonization.	• Continue to provide analytical support for the Energy Storage Grand Challenge in coordination with cross sector analysis examining pathways to decarbonization.	
• Support Justice40 Initiative by initiating the development of tools and methodologies to measure and inform EERE efforts to foster equity and environmental justice. These tools and methodologies will help EERE quantify progress against established EERE priority metrics and collect qualitative information to help inform planning and decision making.	• Continue to support Justice40 initiative by integrating equity and environmental justice priorities across the analysis portfolio.	

Strategic Programs
Communications and Outreach

Description
The Communications and Outreach subprogram provides strategic communications leadership, coordination, and operation support for EERE and the Department by developing and disseminating information and associated impacts to key stakeholders, 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 2024 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 climate crisis. This includes increased support for collaboration with tribal communities as well as disadvantaged and energy burdened 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.
- Supporting outreach and engagement opportunities aligned with clean energy programs highlighted in IIJA and IRA.
- Developing and implementing strategic communications plans and messages that reflect EERE's mission, vision, and goals.
- Supporting EERE's programs in communicating the impacts of their work and why it matters.
- Working across EERE technology offices and programs to develop and execute effective communications narratives and campaigns that inform about EERE opportunities and resources and highlight EERE's accomplishments and successes.
- Supporting EERE's senior leaders to communicate EERE's message through 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 website 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 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Communications and Outreach $5,500,000	**$7,000,000**	**$1,500,000**
• Continue EERE's focus on strategic communications planning and implementation to have a greater impact on target audiences. Create new language and messaging that is easily accessible to audiences. Increase analysis and reporting of metrics to measure and improve the effectiveness and engagement of communications products and campaigns. • Expand EERE's digital, web-based, graphic, video, and 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 climate crisis. 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.	• Continue to increase EERE's focus on strategic, proactive media engagement, including regional and local outlets, to ensure communities are seeing the positive impacts of EERE's work. • Continue to expand capabilities in social media, website, and graphic design to ensure expanded reach and accessibility of EERE news, successes, activities, and programs. • Demonstrate the benefits of EEREs work through various communications channels—utilizing metrics and analysis to inform future outreach and engagement strategies. • Continue to engage with, assemble, and educate stakeholders about EERE's priorities and investments by hosting events with key stakeholders and tribes. • Continue to develop strategies and implement proactive communications and stakeholder engagement activities—focusing on EERE funding activities, as well as programs and successes, and their positive impacts on Americans.	• Increased outreach to bilingual audiences and more documents produced that are in Spanish as well as English. • Increase outreach and engagement opportunities aligned with clean energy programs highlighted in IIJA and IRA; the increase supports collaboration and outreach to tribal governments as well as disadvantaged and energy communities in line with the objectives of the Justice40 Initiative. • Provide website enhancements and upgrades, including search engine optimization, user experience, Google Analytics and metrics reporting, and overall website design, including web best practices, information architecture, and technologies to ensure user-centered content and design. • Expand on stakeholder email strategy and capabilities, building templates, and identifying best practices. • Provide training opportunities to technology offices on communications strategy and best practices, media engagement, and more.

Strategic Programs
International

Description:
The International subprogram aims to increase the speed and scale of clean energy deployment to promote deep decarbonization through international collaboration with strategic partners. Activities under this subprogram lead to deep decarbonization efforts in partner countries to meet the climate challenge, with opportunities for exports of U.S. clean energy technology and services.

The subprogram's activities coordinate with DOE's Office of International Affairs and the Departments of State, Commerce, and Transportation, to implement expert-driven technical assistance in the areas of sustainable transportation, renewable power, and energy efficiency that otherwise does not exist in the Federal government. The subprogram also coordinates and collaborates with U.S. clean energy technology manufacturers and service providers when appropriate.

The International subprogram's market priming activities focus on economies and regions that are significant emitters of greenhouse gases and have great opportunities for emissions reductions across major sectors: electric power, commercial buildings, residential buildings, industrial facilities, and transportation. These activities include technical collaborations to establish business cases for adopting codes, standards, and advanced EERE technologies. The subprogram also supports efforts to demonstrate and deploy emerging U.S. products and services, enabling early commercial success and facilitating U.S. companies competing in global markets.

The International subprogram encourages and arranges coordination between the U.S. and developed nations (e.g., the UK, France, Japan, and Germany) to leverage clean energy technology research, development, and innovation to encourage and speed deployment of such technologies.

The International subprogram measures impacts of collaborative engagement activities designed to deliver decarbonization solutions by tracking their effect on real or projected GHG emissions, investment in clean energy projects in partner countries, and/or renewable energy or energy efficiency policy changes (such as adoption of U.S. industry-preferred standards or rating systems for technologies such as windows or solar photovoltaics; successful development and implementation of more stringent building codes, etc.).

International

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
International Coordination $1,500,000	**$4,000,000**	**+$2,500,000**
• The Request will allow EERE to implement technical assistance projects with target countries in areas of geothermal energy and energy efficiency, and to coordinate research, development, and innovation collaboration with developed and developing countries, in consultation and coordination with DOE International Affairs to meet key Secretarial and Administration priorities and commitments to fight climate change.	• The Request will allow EERE to implement technical assistance projects with an increased number of countries, including via multilateral fora, on a wider range of clean energy needs; and to coordinate research, development, and innovation collaboration with developed and developing countries. The Request also includes funding to support consultation and coordination with DOE International Affairs to meet key Secretarial and Administration priorities and commitments to fight climate change.	• The increase supports greater international and federal government needs for EERE's areas of technical expertise, necessitating more capacity to engage in international technical assistance than in FY 2023, as well as an FY 2024 approach with greater engagement with multilateral fora to provide efficient technical assistance and research collaboration that supports as many countries and regions as possible.

Wind Energy

Overview

The Wind Energy Technologies Office (WETO) invests in a diversified portfolio of wind energy research, development, demonstration, and deployment activities that enable and accelerate the innovations necessary to advance offshore, land-based, and distributed wind systems, reduce the cost of wind energy, drive deployment, and facilitate the integration of high-levels of wind energy with the electric grid.

With continued innovation, wind energy has the potential to cost-competitively contribute between 35 and 45 percent of U.S. electricity in less than two decades, up from about 10 percent of all U.S. electric power in 2022. Wind energy can also contribute to grid reliability and resiliency, as well as the generation of clean fuels to help transition the U.S. economy to net-zero emissions in the transportation, buildings, industrial, and agricultural sectors, supporting growth in good-paying jobs and domestic manufacturing 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 U.S. as a global leader in wind energy development at home and abroad.

Across all its wind energy development objectives, WETO emphasizes three common and overarching themes:

- Reduce the cost of wind energy for all wind applications (offshore, land-based utility-scale, and distributed);
- 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, sustainable, and equitable development and delivery of wind energy resources; and
- Enable and facilitate the interconnection and integration of substantial amounts of wind energy into the dynamic and rapidly evolving energy system that is cost-effective, cybersecure, reliable, and resilient, and includes systems integrated with other energy technologies and energy storage.

Highlights of the FY 2024 Request

- The Department of Energy, in partnership with the Departments of the Interior, Commerce, and Transportation, recently announced the Floating Offshore Wind EarthShot, a new initiative to strengthen U.S. leadership in floating offshore wind (OSW) design, development, and manufacturing. The Floating Offshore Wind Shot sets the ambitious goal to reduce the construction and operating cost of floating OSW energy by at least 70 percent to $45 per megawatt-hour by 2035 for deep sites far from shorelines. As part of this effort, WETO will continue and expand upon investments started in FY 2023 as part of the Floating Offshore Wind Accelerated Research and Development (FORWARD) initiative. FORWARD is a major body of R&D aimed at unlocking floating OSW in U.S. waters greater than 60 meters in depth where approximately 66 percent of the Nation's offshore resources are located.
- Continued and expanded investments proposed in FY 2023 as part of the Near-term Offshore Wind (NOW) initiative with the goal of accelerating the near-term deployment of fixed-bottom OSW through research to lower costs, build a domestic supply chain, and address challenges to siting, permitting, and offshore transmission.
- Continued R&D targeting solutions to reduce environmental and siting barriers to land-based wind development including emphasis on wildlife impact assessment and deterrent tools and technologies, specifically for bats and eagles, and wind turbine-radar interference mitigation activities.
- Continued support for social science research, community engagement, and technical assistance to identify and understand impacts of land-based and OSW energy development on inland and coastal communities, and to help those communities overcome barriers to siting and permitting wind energy projects.
- WETO is involved in several DOE-wide crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing to address the issues and challenges associated with turbine scaling for both land-based and OSW technologies;
    - Hydrogen to support multi-office collaboration in hybrid system design, hardware, control, and demonstration to hybrid systems involving combinations of technologies;
    - Energy-Storage to support multi-office collaboration in hybrid system design, hardware, control, and demonstration to hybrid systems;
    - Critical Minerals to provide funding for analysis and technology innovation efforts to both understand the vulnerabilities of the wind energy supply chain to critical materials and to mitigate those vulnerabilities; and

- Grid Modernization to prioritize RD&D in offshore transmission analysis and technology advancement, grid reliability and resilience analysis, wind control and cybersecurity research, and crosscutting demonstrations in grid operator tools and hybrid energy systems.

Wind Energy
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Wind Energy					
Offshore Wind	63,200	73,200	225,987	+152,787	+209%
Land-Based Wind	31,800	31,800	79,649	+47,849	+150%
Distributed Wind	10,000	13,000	18,161	+5,161	+40%
Systems Integration	7,113	11,000	50,972	+39,972	+363%
Data, Modeling, and Analysis	1,887	3,000	10,231	+7,231	+241%
Total, Wind Energy	**114,000**	**132,000**	**385,000**	**+253,000**	**+192%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $3,317,594; STTR: $460,432
- FY 2023 Enacted: SBIR: $3,704,000; STTR: $521,000
- FY 2024 Request: SBIR: $9,001,000; STTR: $1,266,000

Wind Energy Explanation of Major Changes ($K)	FY 2024 Request vs FY 2023 Enacted
Wind Energy	
Offshore Wind: Increased OSW funding in FY 2024 will be focused on two initiatives: the Near-term Offshore Wind (NOW) initiative, and the Floating Offshore Wind Accelerated Research and Development (FORWARD) program, WETO's primary body of work support the Floating Offshore Wind EarthShot. FORWARD is focused on critical R&D pathways to realizing floating OSW's potential as a resource for grid and economy-wide decarbonization. Additional expanded investments in FY 2024 will support atmospheric science to inform array optimization and advance extreme weather survivability; design and manufacturing of turbine platforms and blades; quieter foundation and installation techniques; expansion of research on environmental and social impacts of floating OSW development; new apprentice and pre-apprentice workforce development programs; and a new supply chain ambassadorship program.	**+152,787**
Land-Based Wind: Increased funding for land-based wind in FY 2024 will prioritize Environmental and Siting R&D and STEM and Workforce Development activities to address the most critical barriers to rapid acceleration of land-based wind deployment. Increased funding will also support a new fellowship and internship program to promote a wind energy education and training ecosystem to drive a robust and diverse workforce.	**+47,849**
Distributed Wind: Increased funding in FY 2024 will expand upon promising R&D pathways to drive innovations that will reduce overall systems cost and accelerate distributed wind deployment. The subprogram will prioritize the advancement of small- and medium-scale wind turbine technologies and development of community-based zero-carbon power plans and utility business and regulatory models that enable markets to incentivize zero-carbon distributed energy resource aggregation.	**+5,161**
Systems Integration: Increased funding in FY 2024 will support the DOE Floating Offshore Wind EarthShot through R&D on cost-effective and reliable offshore transmission access in broad coastal regions, including research to advance subsea cables and improve offshore delivery system protection. Increased funding will also enable wind hydrogen demonstration for both land-based and OSW and advanced grid operators' tools that ensure a reliable and resilient grid operation with substantial wind penetration.	**+39,972**
Data, Modeling, and Analysis: Increased funding for this subprogram will emphasize cross-sectoral analysis in collaboration with other EERE and DOE offices; further development of wind turbine, plant-level, and supply chain modeling capabilities; and increased outreach and engagement with stakeholders to increase adoption and impact of analysis tools and products.	**+7,231**
Total, Wind Energy	**+253,000**

Wind Energy
Offshore Wind

Description
Offshore wind (OSW) development in the U.S. is underway, driven by the attraction of robust OSW resources, falling OSW wind turbine costs, technological advances, accelerated Federal OSW lease auctions, and complementary state policies and commitments. Several challenges have slowed OSW development in U.S. waters, however, including its comparatively high cost; an assortment of unique weather, wildlife, environmental, radar and other siting challenges; and no clear path yet for integrating vast amounts of new power onto an existing shore-based grid. Fixed-bottom technology, as developed abroad, can be adapted to U.S. waters, but the technology for floating OSW is a "new frontier."

In March 2021, DOE announced a joint-agency goal to deploy 30 GW of OSW by 2030, which, if realized, could unlock a pathway to 110 GW or more by 2050. Achieving these OSW goals requires a concerted effort on behalf of the Federal government, including critical R&D efforts by WETO in multiple areas with an increased emphasis on floating OSW technologies. In Fall of 2022, DOE, in partnership with other agencies, announced the Floating Offshore Wind EarthShot to drive U.S. leadership in floating OSW development, with associated targets of reaching a levelized cost of electricity (LCOE) of 4.5c/kWh and deploying 15 GW by 2035.

The OSW subprogram supports two main areas of focus, both of which support progress toward the OSW EarthShot. The first is R&D to accelerate Near-term deployment of OSW (NOW) by lowering costs (from $.08/kWh in 2019 to $.05/kWh by 2030 without subsidies), addressing barriers to siting and permitting, and addressing OSW transmission. The cost-reduction approach will analyze the current OSW turbine cost structure and identify the greatest cost reduction opportunities that can be addressed with R&D. The subprogram will also seek to address the most impactful barriers to OSW deployment through a portfolio of activities designed to ensure sustainable OSW development, promote co-use of ocean space, derive benefits to coastal communities, and result in a thriving domestic supply chain supported by a diverse, domestic workforce. NOW will largely build on the experience gained in Europe, however, the R&D needs for floating OSW are at an early stage.

The second OSW subprogram area of focus is referred to as the Floating Offshore Wind Accelerated Research and Development (FORWARD) initiative. FORWARD is a major body of R&D aimed at unlocking the roughly 66 percent of the Nation's OSW resource accessible only through the development and commercialization of affordable floating OSW technologies (mainly the West Coast and Gulf of Maine). Significant development of floating OSW in the U.S. will require a reduction in costs from the current LCOE of $.135/kWh for floating turbines. The goal requires investments in sustainable and community-compatible development; further refinement of supply chain and workforce development requirements; and advancements in transmission planning and HVDC cable technology. FORWARD will be comprised of a body of expanded and new integrated research to significantly reduce wind turbine, floating platform, and electrical connection costs, while advancing technological readiness across an array of associated systems.

<u>Science and Technology Innovation</u>: This activity seeks to reduce costs and risks to OSW development through advances in OSW technology and scientific understanding in three primary areas of focus: resource characterization, technology innovation, and research to reduce operations and maintenance (O&M) costs. The first of these focus areas, resource characterization, is vital to OSW resource predictability, which helps inform siting and supports whole wind plant optimization. This activity also seeks to develop technology innovations to unlock OSW in 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.

Lastly, this activity supports R&D to improve wind technology reliability by decreasing unplanned maintenance, extending the lifetime of components, and optimizing operations, thus improving overall system performance and decreasing O&M costs.

Manufacturing and Materials R&D: This activity aims to develop and build domestic capabilities for cost-effectively manufacturing, installing, and maintaining OSW plants in the U.S. to support the creation of a robust domestic manufacturing sector. 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. R&D will ease the technical challenges of installation by reducing turbine weight, finding turbine installation methods, and using advanced materials and manufacturing technologies to reduce the fabrication costs of floating offshore turbine foundations.

Environmental and Siting R&D: To support and facilitate sustainable deployment of OSW, this activity supports R&D into environmental impact assessment, minimization, and mitigation solutions for novel issues that pose unique challenges to OSW, such as the need to develop automated wildlife monitoring systems and continued innovation of tools to minimize impacts of construction noise on protected marine species. This activity also addresses siting challenges related to OSW interference to critical radar 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 OSW development, such as long-range air surveillance radars, and on work focused on systems where OSW is likely to have a greater effect, such as coastal high-frequency systems for ocean wave and current measurement, and marine navigation radars. This activity also supports social science and socioeconomic research to understand impacts of OSW on communities and ocean co-users and provide technical assistance to communities considering OSW development.

STEM and Workforce Development: Growth of the American OSW industry has the potential to provide tens of thousands of well paying, union-eligible job opportunities by 2030. Ensuring there is a well-trained and ready workforce available to meet those jobs requires new training and education programs to prepare workers with applicable skills and knowledge. Workforce education and training needs will be linked to the growth of the industry. WETO will support OSW STEM and workforce development activities, including national-scale analyses to systematically identify future workforce needs, university engagement and other programming to catalyze solutions to those needs, and efforts to convene industry and educational institutions to develop workforce development solutions. WETO will increase support for the development of OSW curriculum, fellowships, and internships at universities and colleges, with a strong emphasis on ensuring the diversity of the future OSW workforce.

Offshore Wind

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Offshore Wind $73,200,000	**$225,987,000**	**+$152,787,000**
Science & Technology Innovation $49,765,000	$103,227,000	+$53,462,000
• No significant efforts	• Advanced planning for an OSW atmospheric sciences validation campaign on the Pacific coast.	• New effort to understand Pacific Coast wind behaviors and prediction tools.
•	• Conduct supply chain analysis and coordination efforts for ports needed for OSW development.	• New analyses of supply chain scenarios, gap identification, and mitigations.
• Develop Operations & Maintenance roadmap to inform technology development needs.	• Begin Operations & Maintenance Research to increase the technological maturity of advanced inspection, maintenance, and repair techniques.	• Increased efforts on application of automation techniques and technologies for OSW.
• Advanced planning, needs and feasibility assessments, and design for expansion of existing test facilities to handle 20MW+ OSW turbine components and hybrid offshore systems.	• Development or expansion of test facilities to handle 20MW+ class turbines and for other offshore test facilities (such as hybrid OSW/hydrogen, offshore research, and offshore structures).	• Increased funding for a competitive solicitation to support continued development and/or expansion of test facility(ies)
•	• Advancement of low-TRL Floating Platform Innovation. Develop high-risk innovative scale prototype designs that offer step changes in platform cost and production capability.	• New competitive solicitation focused on low-TRL innovative designs.
•	• Extreme Weather atmospheric science & turbine design efforts to enable OSW deployments in Gulf of Mexico and Southeast U.S.	• New activity builds on BIL funded efforts.
• Support for OSW energy technology demonstration projects to advance OSW development by demonstrating innovative technologies not previously commercially used in the U.S. for OSW.	• Continued support for OSW energy technology demonstration projects to advance OSW development by demonstrating innovative technologies not previously commercially used in the U.S. for OSW with emphasis on new component demonstrations.	• No significant changes
• The Enacted includes funding for National Laboratory work that will leverage existing core capabilities and facilities available through the National Laboratory network. Targeted research	• The Request includes funding for National Laboratory work that will leverage existing core capabilities and facilities available through the National Laboratory network. Targeted research	• No significant changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
areas include OSW resource characterization and forecasting.	areas include OSW resource characterization and forecasting.	
• Deploy a buoy off the coast of Hawaii in conjunction with the Bureau of Ocean Energy Management to characterize the wind energy resource and inform potential future leases.	• Continue buoy deployments to support metocean research and in conjunction with the Bureau of Ocean Energy Management to characterize the wind energy resource and inform potential future leases. Continue to develop new buoy sensor systems to enhance resource assessments.	• No significant changes
• Advance fully coupled turbine/foundation engineering design tools for fixed-bottom and floating foundations.	• Advance high-fidelity models for fully coupled turbine/foundation design and analysis.	• No significant changes
• Technology development of low-noise installation techniques for fixed foundation OSW applications.	• Technology development of low-noise installation techniques for fixed foundation OSW applications.	• No significant changes
• Continue existing Offshore Integrated Systems Engineering efforts to develop analysis and research capability to improve system-level performance and achieve system-level cost reductions.	• Continue existing Offshore Integrated Systems Engineering efforts to develop analysis and research capability to improve system-level performance and achieve system-level cost reductions.	• No significant changes
• Continue efforts to develop OSW full-farm controller using consensus control methodology. Also continues to support floating platform controls and hydro/aerodynamics with focus on advanced flow measurement, increased degrees of freedom, and high-Reynolds number aerodynamics for performance and load predictions.	• Continue efforts to develop OSW full-farm and turbine controls which optimize power output and lifecycle considerations. This effort will also support continuation of floating platform controls.	• No significant change
• Establishment of an Anchoring & Mooring Development effort to demonstrate new concepts applicable to deep-water locations at scale.	• No funding requested	• Deferred to FY 2025.
	•	•
Manufacturing and Materials R&D $5,018,000	$66,500,000	+$61,482,000
• Research effort to analyze existing available infrastructure and needs for application to OSW	• Continue research to analyze existing available infrastructure for application to OSW	• No significant change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
manufacturing, assembly, logistics and port facilities.	manufacturing, assembly, logistics and port facilities.	
• Emphasized advanced materials and manufacturing R&D to reduce full lifecycle costs and accelerate blade/tower/nacelle factory throughput. Develop new manufacturing methodologies.	• Advanced design, materials, and manufacturing R&D to reduce full lifecycle costs and accelerate blade/tower/nacelle factory throughput. Develop new manufacturing methodologies and research efforts to understand the aerodynamics of extremely long blades required in new generation of ultra-large turbines.	• Significantly increased efforts for partial and full-scale demonstration of advanced manufacturing techniques for blades and nacelles. Increased scope will also include aerodynamics R&D associated with ultra-large turbine blades.
	• Floating Platform Industrialization development, testing, and demonstration of high-TRL concepts.	• Moved from Science & Technology Innovation to Materials & Manufacturing R&D.
• Manufacturing and additive design of electric machines enabled by three-dimensional printing (MADE3D) project to additively manufacture every part of the generator.	• No funding requested	• Project completed in FY 2023.
• Manufacture and test full scale 3D printed blade cores for static structural strength.	• No funding requested.	• Project completed in FY 2023.
Environmental and Siting R&D $13,145,000	$38,260,000	+$25,115,000
	• Research on environmental impacts of floating and fixed bottom OSW projects.	• Increase will support new research to understand before (baseline) and after (impacts) to environmental targets of concern for floating OSW development, as well as to refine our understanding of fixed impacts in the Atlantic.
	• Development and validation of environmental monitoring and mitigation tools including integrated autonomous monitoring technologies to lower costs and provide more accurate data regarding species presence and effects.	• New activity.
• Continue international research sharing and dissemination through the International Energy Agency (IEA) Wind Energy Task 34 (WREN) and the Tethys database.	• Continue international and domestic research sharing and dissemination through IEA Wind Energy Task 34 (WREN), the Synthesis of Environmental Effects Research (SEER) effort and Tethys database.	• No significant change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Address wind/radar challenges associated with radar systems of mutual interest to land-based and OSW, while continuing to build understanding of impacts unique to OSW. Continue to facilitate the definition of next-generation radar requirements. Key partnerships with DOD, DHS, DOT, DOI and DOC.	• Address wind/radar challenges associated with radar systems of mutual interest to land-based and OSW, with an increased focus on validation of higher-readiness mitigation technologies. Continue to facilitate the definition of next-generation radar requirements. Key partnerships with DOD, DHS, DOT, DOI and DOC.	• Increased focus on validation and implementation of high-TRL mitigation measures.
• Maintain WINDExchange, to ensure use of the best available science-based technical, economic, and development information to support wind energy policy and deployment decisions.	• Maintain WINDExchange, to ensure use of the best available science-based technical, economic, and development information to support wind energy policy and deployment decisions	• No significant change.
• Provide local and regional technical assistance and knowledge sharing to coastal communities. Expand collaboration with NOAA National Sea Grant Program and other community organizations to support regional or state-level engagement with ocean users.	• Provide local and regional technical assistance and knowledge sharing to coastal communities. Expand collaboration with NOAA National Sea Grant Program and other community organizations to support regional or state-level engagement with ocean users.	• Funding increase to allow for technical assistance and meaningful engagement beyond Atlantic coast, including Pacific, Gulf of Mexico, and the Great Lakes.
	• Support research on social and socioeconomic impacts of wind energy.	• Increase supports new research that builds off of prior years' social science research.
• Continue support for the National Wind Turbine Database.	• Continue support for the National Wind Turbine Database.	• No significant change.
STEM and Workforce Development $5,272,000	$18,000,000	+$12,728,000
• Support the Collegiate Wind Competition (CWC), an annual event that challenges teams of undergraduate students to develop solutions to complex wind energy projects, as well as other OSW STEM educational opportunities.	• Continue support for the Collegiate Wind Competition (CWC), an annual event that challenges teams of undergraduate students to develop solutions to complex wind energy projects.	• No significant change.
	• Initiate programs to increase OSW curriculum, fellowships, and internships at universities and colleges, including an emphasis on ensuring diversity of the future OSW workforce.	• New activity in FY 2024.
• Initiate national-scale analyses to systematically identify future workforce needs.	• Continue to support workforce analysis on an as-needed basis to address.	• Focus will shift from national level to regional and sector specific analysis to refine understanding of workforce needs.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support the National OSW Workforce Development Roadmap and Network	• Continue support for the National OSW Workforce Development Network to meet OSW workforce needs	• Roadmapping efforts will be completed in FY 2023; FY 2024 funding will focus on continuation of Network coordination.
	• Launch initiative to provide competitive funding for pre-apprenticeship and apprenticeship programs for OSW, with an emphasis on increasing diversity in the OSW workforce and providing opportunities in underserved coastal communities.	• New activity in FY 2024.
	• Launch ambassadorship program to increase opportunities for women and minority owned businesses to enter the OSW supply chain.	• New activity in FY 2024.

Wind Energy
Land-Based Wind

Description
The Land-Based Wind subprogram emphasizes efforts to reduce the cost of wind energy to enable nationwide cost-competitiveness and to develop siting and environmental solutions to accelerate land-based wind energy development, comprising most of the country's wind resource. Rotor blade innovation in support of "Tall Wind" turbine technology is 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 greater heights above the ground. Key opportunities include taller towers with larger generators, longer blades, and larger rotor diameters, which all lead to greater energy capture and lower cost per unit of energy output and 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 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 cost-competitive nationwide.

Science and Technology 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 executing field experiments to validate the physics knowledge and design tools developed under the Atmosphere to Electrons (A2e) project.

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. The activity will also advance materials science by developing technology to mitigate bearing and gear failures through advanced lubricants, composite materials, and metallic coatings that are resistant to damage in operating conditions that benefit both land-based and OSW applications. It will also focus on research to recover critical minerals from wind turbine components.

Environmental and Siting: This activity focuses on the development of solutions, impact mitigation, and enabling the efficient siting and operation of land-based wind facilities. It will focus on developing solutions for environmental impacts of land-based wind by supporting research that informs siting decisions. Characterization of impacts will be used in the development of mitigation tools and technologies, and further research will focus on evaluating and addressing impacts on wildlife, including bats, eagles, and grouse species.

This activity also supports 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, field testing, and evaluation to characterize wind turbine interference to develop and deploy high-TRL mitigation technologies that will increase the resilience of existing radar systems to wind turbines.

Finally, this activity will support social science and socioeconomic research to understand impacts of wind energy on communities and enable innovation for siting and participatory outcomes that reduce impacts and promote equitable outcomes for land-based wind energy 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. New education programs, such as university fellowships, to prepare workers with applicable skills and knowledge require a well-trained and ready workforce available to meet these jobs. This activity will support 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, inclusion, equity, and accessibility of the future land-based wind workforce.

Land-Based Wind

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Land-Based Wind $31,800,000	**$79,649,000**	**+$47,849,000**
Science & Technology Innovation $14,434,000	$19,208,000	+$4,774,000
• Maintain mission readiness and operational expertise of DOE's specialized research facilities and capabilities. Initiated the procurement of a modern turbine for the NREL National Wind Technology Center (NWTC).	• Maintain mission readiness and operational expertise of DOE's specialized research facilities and capabilities for the NWTC at Flatirons and Sandia Scaled Wind Farm Technology (SWiFT) facility.	• No significant change.
• Conclude the AWAKEN field campaign and demobilize instrumentation.	• The AWAKEN project will continue data analysis and model validation studies. The project will release international benchmarks, publish both field campaign observations and international model validation studies.	• The collection of field observations concludes in FY 2023 and analysis of the gathered data continues in FY 2024.
• The Rotor Aerodynamics Aeroelastics, and Wake (RAAW) experiment will conclude. Validation of high- and mid-fidelity numerical aerodynamic and wake models will be completed using the data gathered.	• No funding requested.	• The RAAW experiment concludes in FY 2023. Analysis of the gathered data will be undertaken by other projects.
• Initiate the Wind Forecasting for Tall Turbines project.	• Continue the Wind Forecasting for Tall Turbines project. Improvements to model physics for weather forecast models developed under the Weather Forecast Improvement Project 2 (WFIP2) will be tested in other regions to provide more robust model performance statistics.	• Increased funding to include mesoscale simulations with and without improvements identified from the WFIP2.
• Initiate the Fully Coupled Wind-based Hybrid Energy Systems project to accelerate the nationwide understanding, development, and deployment of wind-based hybrid plants through a nationwide, end-to-end approach.	• Continue the Fully Coupled Wind-Based Hybrid Energy Systems project. Accelerate the nationwide understanding, development, and deployment of wind-based hybrid plants.	• Increased funding for design optimization of fully coupled systems with different objectives, such as reliability, resilience, etc.
Manufacturing and Materials R&D $3,858,000	$6,500,000	+$2,642,000
• Continue to investigate the effects of stray electrical currents on white etching cracks failures in bearings and gears, and initiate new research	Continue Drivetrain Reliability research focused on the tribological materials associated with the	• Increased funding for studies on material response to system and environmental conditions

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
focused on material characterization of main bearing and pitch bearing failures. • Continue Big Adaptive Rotor (BAR) program support. Field experiments to demonstrate the design concepts and collect validation data for the new suite of advanced non-linear engineering design tools.	predominant and unaccounted failure modes in pitch, main, and gearbox bearings. • Continue Phase II of the Big Adaptive Rotor (BAR) Program. BAR Phase II will address the science and engineering challenges of the most promising technologies identified in Phase I research.	known to be present during premature component failures. • Increased funding to explore promising research pathways initiated in Phase II of the BAR program.
	• Advanced manufacturing of large iron and steel castings and forgings for wind turbine components.	• New effort in FY 2024 to develop innovative manufacturing technology to enable competitive, domestic manufacturing of large metallic wind turbine components.
Environmental and Siting R&D $10,181,000	$43,941,000	+$33,760,000
	• Advance monitoring technologies (e.g., GPS tags, camera technology, etc.) and expand behavioral studies to better understand drivers of bat risk (e.g., time of night, weather conditions, insect prevalence, etc.).	• Increase supports a new activity that builds off prior year research.
	• Advance large scale field research to advance broader commercial deployment of deterrent and curtailment technologies across a range of geographies and bat species.	• Increase supports a new activity that builds off prior year research.
	• Research impacts and evaluating impact mitigation options related to prairie grouse species. Grouse represent a growing deployment barrier as there is significant uncertainty about the nature and scope of grouse impacts from wind facilities.	• Increase supports a new activity that builds off prior year research.
• Continue international research sharing and dissemination through IEA Wind Energy Task 34 (WREN) and the Tethys database.	• Continue international and domestic research sharing, collaboration, and dissemination through the IEA technology collaboration program.	• No significant change.
• Develop and deploy wind turbine radar interference mitigation for both land based and OSW in partnership with DOD, DHS, DOT, DOI and DOC.	• Continue development and deployment of wind turbine radar interference mitigation for both land based and OSW in partnership with DOD, DHS, DOT, DOI and DOC. Test and validate one or more mitigation measures at a radar site where	• Expanded effort to validate high TRL mitigation options.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	the mission is currently impacted by wind turbine interference.	
• Maintain WINDExchange to ensure use of the best available science based technical, economic, and development information to support wind energy policy and deployment decisions.	• Maintain WINDExchange to ensure use of the best available science based technical, economic, and development information to support wind energy policy and deployment decisions.	• No significant change
• Technical assistance and support to help communities overcome barriers to siting wind and other renewable energy. Provide funding and technical assistance to States interested in developing state and local government programs to understand, share experiences, and manage renewable energy siting in their communities.	• Technical assistance and support to help communities overcome barriers to siting wind and other renewable energy. Provide funding and technical assistance to States interested in developing state and local government programs to understand, share experiences, and manage renewable energy siting in their communities.	• Expand technical assistance funding to States to help reduce barriers to permitting at both the state and local level.
• Expand wind plant development impacts research for wind plant neighbors, with an emphasis on understanding equity and benefits for disadvantaged communities.	• Continue wind plant development impacts research for wind communities with an emphasis on understanding equity and benefits for disadvantaged communities.	• No significant change.
STEM and Information Resources $3,327,000	$10,000,000	+$6,673,000
• Support the Collegiate Wind Competition (CWC) and other STEM educational opportunities.	• Support the Collegiate Wind Competition (CWC), and other STEM educational opportunities.	• No significant change.
• Identify future workforce needs, programming solutions for those needs, and opportunities to convene industry and educational institutions to develop workforce development solutions.	• Continue analysis to Identify future workforce needs and convene stakeholders to collaborate to develop and implement workforce development solutions.	• No significant change.
	• Support wind energy fellowships and internships, with an emphasis on promoting diversity in the future wind workforce.	• New activity in FY 2024.

Wind Energy
Distributed Wind

Description
The Distributed Wind subprogram focuses on achieving breakthroughs in reducing the 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 the cost of permitting and interconnection, increase system power production, enhance grid integration improve decision support tools for distributed wind projects 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, will provide targeted technical assistance to support rural, disadvantaged, and isolated communities with planning and evaluating the opportunities and 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, market, and site assessment tools for standalone and hybrid distributed wind systems. Current tools are too costly, uncertain, and inaccurate to support the third-party financing, grid integration, and energy transition planning at scale.

Testing and Reliability: This activity supports U.S. small and medium wind turbine technology manufacturers through a competitive solicitation to reduce turbine costs, increase system performance, enhance grid support capabilities, and test and certify turbine designs and components to national standards. Efforts will also include aeroelastic modeling tool development, refinement of test processes, and stakeholder engagement to further develop harmonize national and international wind turbine performance and safety standards to ease export market access.

Balance of Systems: This activity will focus support on reducing capital costs through standardization of project assessment, permitting, interconnection, system design, and installation of distributed wind systems. Efforts under this activity will continue to include crosscutting EERE energy transition planning and technical assistance programs for rural and disadvantaged communities. The activity will also continue to fund systems integration R&D that enhances the capabilities of wind technology, as distributed energy resource, to provide valued grid support services. Efforts will also focus on accurately representing the capabilities of wind as a DER in decision-support tools used to by utilities, communities, and industries transitioning to carbon free energy sources.

Distributed Wind

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Distributed Wind $13,000,000	**$18,161,000**	**+$5,161,000**
Science and Technology Innovation $2,551,000	$4,411,000	+$1,860,000
• Refine and integrate validated wind resource models and datasets with lab based and commercially available assessment and decision support tools.	• Continue refining and integrating validated wind resource models and datasets with lab based and commercially available opportunity assessment and decision support tools.	• No significant change.
• Conduct techno-economic and deployment analysis to resolve promising high-impact opportunities for cost reduction and deployment acceleration in support tools used by state energy offices, communities, utilities, financiers, project developers, and other stakeholders.	• Continue techno-economic, deployment scenario, and market data analysis to resolve promising high impact opportunities for cost reduction and deployment acceleration.	• Increased funding for stakeholder engagement and technical assistance.
Testing & Reliability $5,537,000	$6,750,000	+$1,213,000
• Continue Competitiveness Improvement Project with 2023 enacted for proposals to reduce distributed scale wind turbine costs, improve turbine performance and grid support capabilities, and test designs to national safety and performance standards.	• Continue competitive solicitation to reduce small and medium scale wind turbine costs, improve turbine performance and grid support capabilities, and test designs to national safety and performance standards.	• Increased funding in FY 2024 will support expansion of Competitiveness Improvement Project (CIP).
• Continue strategic and technical engagement activities in inform distributed wind R&D, increase the economic and technical viability of distributed wind energy systems, and increase understanding for equitably and justly accelerating deployment.	• Continue stakeholder engagement to inform small and medium wind turbine design, testing, and standards R&D.	• No significant change.
Balance of System R&D $4,912,000	$7,000,000	+$2,088,000
• Support development and demonstration of advanced power electronics, controls, and monitoring for wind hybrid plants and microgrids applications.	• Continue systems integration work to develop and demonstrate advanced power electronics, controls, and monitoring for wind hybrid plants and microgrids applications.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support the development of permitting and interconnection best practices for wind and wind hybrid projects.	• Continue to support the development of permitting and interconnection best practices for wind and wind hybrid projects and reduce barriers to wind deployment in rural communities.	• Increased funding for stakeholder engagement.
• Support the expansion and inclusion of wind in the EERE-funded Energy Transitions Initiative Partnership Project (ETIPP).	• Continue to partner in ETIPP.	• No significant change.
• Participate in EERE cross-cutting project providing communities and electric utilities with technical assistance for development and implementation of 100 percent clean power plans.	• Continue to participate in EERE cross-cutting projects providing communities and electric utilities with technical assistance.	• Expanded engagement and technical assistance to state, local, and tribal entities.

Wind Energy
Systems Integration

Description
The Systems Integration subprogram invests in R&D to ensure cost-effective, reliable, cybersecure, and resilient operation of the power grid with increasing levels of wind energy. Efforts will focus on strategic opportunities to ensure cost-effective and reliable transmission access for wind energy deployment at scale, maintain and increase grid reliability and resilience through the provision of grid services from wind and wind-hybrid systems, address wind-specific cybersecurity needs, and improve the understanding of electricity market operation with high penetrations of wind energy.

Considerations for wind energy systems integration include:

- Demand for Transmission Adequacy and Flexibility: wind deployment at scale requires cost-effective transmission access to deliver the wind energy to the end users. Facilitating collaborative, long-term transmission planning and accelerating generation interconnection can increase the certainty and pace of wind deployment. Advancing transmission technologies, in particular for OSW, enables cost effective wind energy integration.
- Growing Demand for Increased System Flexibility, Reliability, and Resiliency: The future generation mix is anticipated to have higher shares of variable generation sources, including wind. The combined variability and uncertainties from both generation and load require wind and wind hybrid systems to be designed to provide more system flexibility. Wind power and many energy storage options are connected to the grid through inverters. These inverter-based resources respond differently to grid balancing requirements and disturbances than conventional synchronous generators and interact rapidly with other renewable generation systems' power electronics.
- Cybersecurity: Virtually all modern sources of power depend on integrated control systems, data, monitoring, communications, and related technologies, whose security has become increasingly important. Wind energy cybersecurity will need to be strengthened to ensure a cybersecure energy system today and in the future.

The subprogram supports two OSW initiatives CONNECT and TRANSFORM that address challenges to achieving the Administration's OSW deployment goals of 30 GW by 2030 and 110 GW by 2050. CONNECT mitigates transmission constraints, including both land-based interconnections and transmission and offshore transmission. It also improves system security, reliability, and resiliency with OSW. TRANSFORM conducts RD&D to increase OSW's value to a decarbonized economy through OSW hybrid with energy storage technologies and hydrogen and renewable fuel co-generation.

The subprogram aligns with grid activities across multiple DOE initiatives such as the Grid Modernization Initiative that are necessary to enable a just transition to a grid that supports a decarbonized power system by 2035 and a net-zero-emission economy by 2050 while maintaining the reliability, affordability, security, and resilience of the energy system.

Grid integration activities aim to enable cost-effective, cybersecure, reliable, and resilient operation of the energy system with increasing levels of wind in all regions. Progress in these areas will mitigate barriers to transmission access for offshore and land-based wind. With progress, advanced technologies will enable cost-effective wind hardware and controls that will be secure, enhanced, and transformed to provide a full range of grid services for reliable and resilient grid operation.

Systems Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Integration $11,000,000	**$50,972,000**	**+$39,972,000**
• Conduct a series of OSW transmission research and development to enable cost effective transmission access for OSW while maintaining reliable and resilient grid operation with large amounts of OSW.	• Research and development in subsea cable technologies and the protection of OSW delivery systems.	• Increased funding will allow expanded R&D in OSW transmission technologies with focuses on subsea cables and offshore HVDC system protection in FY 2024.
• Provide local governments, utilities, and other stakeholders with technical assistance on wind interconnections.	• Continue support the Interconnection Innovation Exchange (i2X) program to enable improved interconnection of wind and other clean energy technologies to the grid (with SETO).	• No significant change.
• Research and development to increase dispatchability of wind energy and improve wind power forecast for grid services.	• Research and development in wind controls, data, modeling, and tools that ensure reliable grid operation with increasing levels of wind.	• Increased funding will enable system operational tool development and demonstration for a reliable and resilient grid.
• Launch Wind Cybersecurity Lab Call to systematically identify solutions that effectively address wind cybersecurity challenges and increase wind energy system's cybersecurity awareness, preparedness, and responsiveness.	• Continue the National lab led Wind cybersecurity research, development, demonstration, training, and technical assistance.	• No significant change.
• Co-fund Grid Enhancing Technologies (GETs) development demonstration in partnership with industry to accelerate industry adoption of GETs and unlock transmission capacity.	• No funding requested. Continue demonstration projects using prior year funds.	• No funding requested in FY 2024.
• The Wind hybrid program will support OSW co-generation use case analyses, nationwide technoeconomic analysis of wind hydrogen production, and modular component design and control.	• Wind hybrid system demonstration will focus on wind producing hydrogen for storage or for direct industrial applications.	• Increased funding will enable wind hydrogen production demonstration for both land-based wind and OSW.

Wind Energy
Data, Modeling, and Analysis

Description
The Data, Modeling, and Analysis subprogram provides objective analysis to evaluate and prioritize wind energy technology innovation opportunities for offshore, land-based, and distributed applications, based on a solid understanding of techno-economic conditions as well as state-of-the art systems engineering, cost and deployment models, and tools. Subprogram activities of data collection, modeling, and tools development, and analysis guide Wind Program investment in R&D and highlight wind's current and potential future contributions in the U.S. energy sector for stakeholders.

Specific FY 2024 priorities include:
- Continued and expanded collection and dissemination of data on wind technology cost and performance trends to support GPRA reporting, Energy Act of 2020 reporting, and other analytical efforts to inform stakeholders.
- Continued development of capabilities to evaluate the impacts of innovations in land-based, distributed, and OSW technologies, with a focus on supporting capabilities to assess wind-hybrid applications, and the impacts of innovation in wind technologies at a high degree of spatial resolution.
- In collaboration with other EERE and DOE offices, expanded development of linkages between electricity system models and models of other energy production and use sectors.
- In collaboration with other EERE and DOE offices, expanded scenario analysis focusing on potential future wind contributions for deep decarbonization pathways across sectors and assessment of related impacts, including on land and ocean space use, impacts to wildlife, radar and communities, and the sensitivity of wind's contributions to decarbonization to different wind technology evolution pathways.

Data, Modeling and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $3,000,000	**$10,231,000**	**+$7,231,000**
Data, Modeling, and Analysis $3,000,000	$10,231,000	+$7,231,000
• Market data collection, analysis, and reporting including establishing technology baselines and industry benchmarks, tracking progress to goals, and evaluating return on investment.	• Market data collection, analysis, and reporting including establishing technology baselines and industry benchmarks, tracking progress to goals, and evaluating return on investment.	• No significant change.
• Conduct techno-economic analysis including impact evaluations of wind innovations, spatial and temporal supply curve analysis, decarbonization impacts analysis, and cost and performance analysis. Emphasis on assessing the impact of infrastructure investments and innovative operations and maintenance strategies in OSW and expanding land-based wind supply chain analysis.	• Conduct techno-economic analysis including impact evaluations of wind innovations, spatial and temporal supply curve analysis, decarbonization impacts analysis, and cost and performance analysis.	• No significant change.
• Strategic wind energy futures analysis including electric sector modeling, wind value to the grid for energy and grid services, and capacity expansion model development. Emphasis on developing linkages between electricity and other energy sector models to capture interactions between sectors in deep decarbonization scenarios, further developing spatial analysis capabilities to evaluate the impact of siting and land use constraints on wind's role in the electricity sector.	• Strategic wind energy futures analysis, including electric sector modeling, wind value to the grid for energy and grid services, and capacity expansion model development.	• Increase reflects increased emphasis on cross-sectoral analysis, in collaboration with other EERE and DOE offices.

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 (FFRDC). 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. NREL supports the DOE Energy Planning Guide (EPG) Goal1: Drive U.S. energy innovation and deployment on a path to net-zero emissions by 2050.

The objectives of the F&I Program are to:

- 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.

- Ensure continuity of essential lab operations by:
  - Providing the laboratory with a safe, secure work environment for the protection of personnel, partners, and the public and acquiring new mission-critical science and technology capabilities when warranted.
  - Providing NREL with secure information networks with strong cybersecurity protocols.
  - Maintaining and upgrading 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.
  - Providing direct funding for operational activities of major facilities and infrastructure and site-wide investments.

Highlights of the FY 2024 Request

To posture NREL's capabilities to support emerging technologies and future requirements, the FY 2024 F&I Budget Request focuses on sustaining NREL's world-class R&D environment by maintaining and upgrading its capabilities, equipment, and facilities. This request also leverages the Investment Reduction Act (IRA) infrastructure funds, allowing NREL to prioritize Capital Investment Needs to accelerate by 3+ years the Administration's R&D and Infrastructure Priorities. This Request supports key efforts that contribute to achieving its high-level goals:

- Fund the second segment of the construction phase of the Energy Materials and Processing at Scale (EMAPS). The project addresses the full lifecycle of our products, materials, and energy economy to enable partnerships with U.S. and industry to incentivize waste reduction, reuse, and reduced persistence in the environment, accelerates innovations to market viability, which will enable critical research activities for a more rapid transition to a circular economy for energy-relevant and energy-intensive materials and processes. The plan is to projected to achieve CD-2, and *Approve Performance Baseline,* is expected in the third quarter FY 2024.
- Fund the operations, maintenance, equipment, and a refresh/upgrade of the High-Performance Computer (HPC) at the ESIF. The HPC will enable large-scale numerical models for studying and simulating material properties, processes, and fully integrated energy systems. It will also reduce expenses, risks, and uncertainty that are often barriers to industry-adopting new and innovative technologies.
- Support the Advanced Research on Integrated Energy Systems (ARIES) to address the challenges of designing and constructing future energy systems, by operating large-scale hybrid energy systems that interconnect multiple generation, storage, and end-use technologies. Research focus areas include energy storage, power electronics, hybrid energy systems, future energy infrastructure, and cybersecurity.
- Fund investments in Diversity, Equity, Inclusion and Accessibility (DEIA) by prioritizing infrastructure and information technology projects to serve a Historically Black College/University (HBCUs) or Minority-Serving Institution (MSIs).
- Invest $35 million to conduct extensive planning for future construction of the 18th National Laboratory facility. DOE will apply the proposed funding to scale up an existing research facility at a Historically Black College/University (HBCU) or Minority Serving Institution (MSI) or towards construction of an entirely new research facility at an HBCU or MSI, or consortium of such institutions, creating a pathway to National Laboratory designation.

Facilities and Infrastructure
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Facilities and Infrastructure					
Operations and Maintenance	93,590	102,370	118,865	+16,495	+16%
Facility Management	46,410	57,630	66,526	+8,896	+15%
Establish DOE 18th National Laboratory	0	0	35,000	+35,000	+100%
Construction					
21-EE-001, Energy Materials Processing at Scale (EMAPS)	8,000	45,000	57,000	+12,000	+27%
Total, Facilities and Infrastructure	**148,000**	**205,000**	**277,391**	**+72,391**	**+35%**

Facilities and Infrastructure
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Facilities and Infrastructure	
Operations and Maintenance: The Request prioritizes an increase for ARIES investments as well as investments to support the expansion of the NREL campuses.	+16,495
Facility Management: The Request prioritizes an increase in ESIF infrastructure and equipment investments, which are slightly offset by the de-commissioning of the Eagle High Performance Computer (HPC).	+8,896
Establish DOE 18th National Laboratory: The increase is to conduct planning for future construction of the 18th National Laboratory facility. DOE will apply the proposed funding to assess options including scaling up an existing research facility at an HBCU or MSI or constructing an entirely new research facility at an HBCU, MSI, or consortium of such institutions, creating a pathway to National Laboratory designation.	+35,000
Construction: The Request prioritizes a funding increase for second segment of construction of EMAPS.	+12,000
Total, Facilities and Infrastructure	**+72,391**

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)

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 (<$25 million) projects to accommodate new research capabilities.

Major GPP activities:

- ARIES investments that work toward getting the most value from the millions of new devices—such as electric vehicles, renewable generation, hydrogen, energy storage, and grid-interactive efficient buildings—that are being connected to the grid daily.
- Investments in the laboratory campus necessary to ensure continuity of operations, such as South Table Mountain (STM) Substation and Distributed Energy Grid investments.

GPE investments acquire and maintain shared science and support equipment to meet research mission needs, replace outdated technology, and provide for emergent research opportunities.

Major GPE activity:

- The Request provides funding for equipment in support of the Digital Real Time Simulation (DRTS) integration.
- The Request also supports additional high-priority ARIES research platform GPE investments that support the energy storage, power electronics, hybrid energy systems, future energy infrastructure, and cybersecurity research areas.

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 2024 Request ensures NREL will 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.

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.

Operations and Maintenance

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Operations and Maintenance $102,370,000	**$118,865,000**	**+$16,495,000**
• The Request prioritizes continued support GPE ARIES investments in the five research areas of the initiative: Cybersecurity, Future Energy Infrastructure, Energy Storage, Hybrid Energy Systems, and Power Electronics. Includes final funding for the RAIL, the Waste Handling Facility, and Solar Energy Research Facility (SERF)/ Science and Technology Facility (S&TF) Ventilation projects.	• Continued support for GPE ARIES investments in the five research areas of the initiative: Cybersecurity, Future Energy Infrastructure, Energy Storage, Hybrid Energy Systems, and Power Electronics.	• Reprioritized funding in support of STM Substation and STM Distributed Energy Grid investments.
• M&R funding enables continuation of the DOE control standard of two to four percent of RPV, with increased investments in M&R.	• Maintains M&R investments and includes investment in the South Table Energy Park (STEP) campus.	• The increase supports M&R for the STEP campus, deferring other GPP/GPE investments.
• Maintains operational readiness for S&S activities.	• Maintains operational readiness for S&S activities.	• No significant change.
• Maintained 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 three-campuses build-out to ensure the level of services necessary to keep the Laboratory running safely, securely, and effectively.	• 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 three-campuses build-out to ensure the level of services necessary to keep the Laboratory running safely, securely, and effectively.	• Increases 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 2024 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 ARIES' 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 2024 Request provides funding that supports operations, maintenance, equipment, and a refresh/upgrade of the ESIF HPC.

The FY 2024 Request emphasizes investments in ARIES equipment and infrastructure within ESIF.

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

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Facility Management $57,630,000	**$66,526,000**	**+$8,896,000**
• Provides for a refresh/upgrade cycle of the Kestrel High Performance Computer.	• Continues the Kestrel High Performance Computer as year 3 of a planned 4-year refresh/upgrade.	• Increase reflects full operations of the Kestrel High Performance Computer.
• Provides 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. Increases funding in ESIF equipment.	• Increases funding in ESIF equipment investments.
• Increases ARIES equipment and infrastructure investments.	• Continues 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.
• Continues charging prorated share of site operating costs and utilities to indirect funding.	• Continues charging prorated share of site operating costs and utilities to indirect funding.	• No significant change.

Facilities and Infrastructure
Establish DOE 18th National Laboratory

Description
This Request will provide $35 million to conduct extensive planning for future construction of the 18th National Laboratory facility. The goal would be to stand up a new laboratory to serve as the nation's premier research organization focused on modeling, observations, analysis, and multidisciplinary synthesis that are necessary to evaluate heterogeneous regions down to community scales.

For generations, the nation's Historically Black Colleges and Universities (HBCUs) have anchored Black communities by broadening educational opportunities and creating pathways for economic mobility, while minority serving institutions (MSIs) have provided similar opportunities to a diverse range of Americans. There are a number of multidisciplinary analyses to be conducted and assessed, including both opportunities and impacts, that will fall disproportionately on communities of color and low-income Americans.

Because the interdisciplinary social sciences are so well studied by multiple departmental elements, such as the Office of Science's (SC) Office of Biological and Environmental Research (BER) and the Office of Economic Impact and Diversity (ED), and because EERE is primarily an energy technology research office, these decisions and selections will be made in deep consultation with SC/BER, ED, the HBCUs and MSIs seeking this funding, and relevant community partners.

Facilities and Infrastructure
Construction

Description

This subprogram supports line-item construction projects associated with EERE's mission. The Request provides funding for the second segment of the construction phase 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. Construction segment 1 provided sitework, water and sewer taps, foundations, and construction of core and shell dried-in building. Segment 2 will provide completed interior and exterior finishes plus purchase and installation of long-lead equipment. Segment 3 will provide completion of hardscape/landscape, lab fit-out, test and balance, and building commissioning that will lead to Beneficial Occupancy and Certification of Final Completion.

The most recent DOE Order 413.3B Critical Decision (CD) is CD-0, Approve Mission Need, was approved on December 20, 2019. The preliminary estimate for CD-1, Approve Alternative Selection and Cost Range, is anticipated in the fourth quarter of FY 2023. This project is pre-CD-1; therefore, schedule estimates are preliminary and subject to change. The current preliminary Total Estimated Cost (TEC) range for this project is $130,000,000 to $160,000,000 and the preliminary Total Project Cost (TPC) range is $135,000,000 to $165,000,000. These cost ranges encompass the most feasible preliminary current alternatives.

Construction

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Construction $45,000,000	**$57,000,000**	**+$12,000,000**
• Provides funding for the first segment of the construction phase for the EMAPS line-item construction project.	• Provides funding for the second segment of the construction phase for the EMAPS line-item construction project.	• The increase funds the second segment of construction phase for EMAPS.

Facilities and Infrastructure
Capital Summary ($K)

	Total[1]	Prior Years	FY 2022 Enacted	FY 2022 Actuals	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Capital Summary (including Major Items of Equipment (MIE))							
Capital Equipment > $5M (including MIE)	-	0	12,360	12,360	7,220	19,612	+12,392
Minor Construction	-	41,310	25,110	25,110	29,544	63,000	+33,516
Major Construction	-	4,000	8,000	8,000	45,000	57,000	+12,000
Total, Capital Summary	**-**	**45,310**	**45,470**	**45,470**	**81,764**	**139,672**	**+57,908**
Capital Equipment > $5M (including MIE)							
Total Non-MIE Capital Equipment (< $5M)	-	0	12,360	12,360	7,220	19,612	12,392
Total, Capital Equipment (including MIE)	**-**	**0**	**12,360**	**12,360**	**7,220**	**19,612**	**12,392**
Minor Construction Projects							
Total Direct Funded Minor Construction Projects (TEC <$5M)	-	-	5,690	5,690	14,144	55,060	+40,916
Research and Innovation Laboratory (DF)	24,910	19,910	3,000	3,000	2,000	0	-2,000
ARIES 34.5kV Infrastructure Upgrade (DF)	8,000	1,600	6,400	6,400	0	0	0
Waste Handling Facility (DF)	13,350	0	10,350	10,350	3,000	0	-3,000
CFE - Distributed Energy Grid East STM Campus (DF)	19,500	0	0	0	0	3,000	+3,000
SERF/S&TF Ventilation (DF)	14,700	9,300	0	0	5,400	0	-5,400
Flatirons Control Center (DF)	15,500	10,500	0	0	5,000	0	-5,000
STM Substation (DF)	24,900	0	0	0	0	5,000	5,000
Total, Minor Construction Projects	**120,860**	**41,310**	**25,440**	**25,440**	**29,544**	**63,060**	**+33,516**
21-EE-001, Energy Materials and Processing at Scale, TEC[2],[3]	160,000	4,000	8,000	8,000	45,000	57,000	+12,000
Total, Construction	**280,860**	**45,310**	**33,110**	**33,110**	**74,544**	**120,060**	**+12,000**
Total, Capital Summary	**285,860**	**45,310**	**45,470**	**45,470**	**81,764**	**139,672**	**+57,908**

[1] Dashes (-) in the Total column indicates a broad category where totaling would not be applicable as it would be for an individual investment.
[2] This project has not received CD-2 approval; therefore, preliminary estimates are shown for TEC.
[3] Indicates a project where the cost of the Conceptual Design Report is estimated to exceed $3 million.

Outyears ($K)

	FY 2025 Estimate	FY 2026 Estimate	FY 2027 Estimate	FY 2028 Estimate
Capital Summary (including Major Items of Equipment (MIE))				
Capital Equipment > $5M (including MIE)	38,753	50,200	54,305	30,800
Minor Construction	61,213	111,743	132,072	211,871
Major Construction	46,000	0	0	0
Total, Capital Summary	**145,966**	**161,943**	**186,377**	**242,671**
Capital Equipment > $5M (including MIE)				
Total Non-MIE Capital Equipment (< $5M)	31,253	42,700	48,705	30,800
EMAPS Equipment (DF)	7,500	7,500		
Large-Format Stationary Battery Cycling Units (DF)	0	0	5,600	0
Total, Capital Equipment (including MIE)	**38,753**	**50,200**	**54,305**	**30,800**
Minor Construction Projects				
Total Direct Funded Minor Construction Projects (Total Estimated Cost (TEC) <$5M)	9,313	77,243	70,072	207,371
Total Indirect Funded Minor Construction Projects (Total Estimated Cost (TEC) <$5M)	0	0	0	0
Non-Carbon Wastewater Treatment at Flatirons Campus (DF)	7,000	0	0	0
CFE - Distributed Energy Grid East STM Campus (DF)	16,500	0	0	0
STM Substation (DF)	19,900	0	0	0
Future Tech ready Interconnected Research Platforms (DF)	4,000	4,000	0	0
Flatirons Campus Utility Distribution Duct Work (DF)	4,500	4,500	0	4,500
STM Power Plant Upgrade (DF)	0	15,000	0	0
Flatirons Campus Infrastructure Upgrade (DF)	0	5,000	0	0
Electric Heating for all New Buildings (DF)	0	6,000	0	0
Flatirons Campus (FC) Carbon-free Backup Power Technologies (DF)	0	0	19,500	0
STM Carbon-free Backup Power Technologies (DF)	0	0	19,500	0
Onsite Renewable Energy (DF)	0	0	17,000	0
Flatirons Campus (FC) Electrical Distribution Infrastructure (DF)	0	0	6,000	0
Total, Minor Construction Projects	**61,213**	**111,743**	**132,072**	**211,871**
Major Construction Projects				
EE-21-001, Energy Materials Processing at Scale[1] Total Estimated Cost (TEC)	46,000	0	0	0
Total, Construction	**46,000**	**0**	**0**	**0**
Total, Capital Summary	**145,966**	**161,943**	**186,377**	**242,671**

[1] This project has not received CD-2 approval; therefore, preliminary estimates are shown for TEC. Indicates where a project where the cost of the Conceptual Design Report is estimated to exceed $3 million. Other Project Costs (OPC) are funded through laboratory overhead.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name: Project Location/Site:	Research and Innovation Laboratory (RAIL) NREL South Table Mountain Campus:
Type: Total Estimated Cost: Construction Design: Project Start: Design Complete: Construction Complete:	Minor Construction (Direct funded) $24,910 $1,650 FY 2020 FY 2022 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-principle experiments to co-development and initial experimentation at a scale that catalyzes commercial investment. In addition to typical building and site improvements, the project scope accommodates lab equipment fit out, design, procurement and installation for major lab equipment items which requires infrastructure modifications, site improvements and features that will support external collaboration activities, access roadway improvements, and pedestrian scale improvements including walkways, hardscaping, and ramps to enhance ADA accessibility. The project will employ a design-build contract estimated to take nearly 27 months to complete from design through beneficial occupancy. Estimated facility size is approximately 15,000 square feet. Useful segments: Design FY 2021 $1,650; Construction FY 2022 $21,260; Construction FY 2023 $2,000 Extension for added scope for $5,000 budget increase: SC – 6/15/23; FC – 8/15/23
Prior Year Accomplishments:	• Groundbreaking in October 2021 • Building “Topping Out” achieved in March 2022 • Building “Dry-In” achieved in July 2022
Planned Activities:	• Substantial Completion planned to be achieved in June 2023 • Commissioning of Facility and installed equipment planned to be completed in July 2023 • Final Construction Completion (Construction of the project up to final payment as defined in the construction subcontract; construction oversight by NREL) planned to be completed in August 2023 • 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:	A $400,000 budget and scope increase was approved in FY 2021 that directly supports the decarbonization efforts of the NREL STM campus. The change in budget and scope incorporates microgrid infrastructure capabilities, an Emergency Branch Backup Inverter, and provides a service upgrade to enable renewable technology power sources for the RAIL, in lieu of diesel generation, for back-up power. A $5M budget and scope increase was approved in FY 2022 for modifications, site improvements and features that will support external collaboration activities, access roadway improvements, and pedestrian

	scale improvements including walkways, hardscaping, and ramps to enhance ADA accessibility.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name: Location/Site:	ARIES 34.5kV Grid Infrastructure NREL Flatirons Campus
Type: Total Estimated Cost: Construction Design:	Minor Construction (Direct funded) $8,000 $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 2023. Useful segments: • Design FY 2021-2022 $1.60 million; • Construction $3.80 million and switchgear and transformer $2.60 million FY 2023-2024 for a total of $6.40 million.
Prior Year Accomplishments:	• The design has reached the 100% level.
Planned Activities:	• 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 STM Campus
Type	Minor Construction (Direct funded)
Total Estimated Cost	$13,350
Construction Design	$1,000
Project Start	FY 2022
Design Complete	FY 2023
Construction Complete	FY 2024

Project Description:

The lab proposes to construct 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 manage hazardous wastes and support the lab's mission effectively and efficiently. 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 the lab'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.

Supporting Information

The current 1000 sq. ft. Waste Handling Facility is not adequately sized to meet the lab's current or reasonably foreseeable level of activities. The current size and configuration requires waste acceptance to be paused while stored items are packaged and processed for offsite shipment. The lack of sufficient storage and adequate aisle space requires just-in-time procurement of containers and supplies which leads to inefficiencies in removal of wastes from R&D labs. NREL has encountered significant growth throughout the last 8 years with a corresponding increase in research staff and laboratory space generating a variety of hazardous waste streams. To optimize packaging, transportation, and cost-effective disposal, working floorspace which can accommodate physical segregation of cubic yard containers and drums up to 55-gallons in size is necessary to support expanding laboratory R&D operations. The project will utilize a design-build delivery method through the CCCA partner. Award is expected around 3Q of FY 2023. Useful segments: Design FY 2023 $1,000; Construction FY 2024 – FY 2025 $11,349.

Prior Year Accomplishments:	• Preliminary project planning completed in FY 2022 • Finalized technical requirements for a design-build project in FY 2023
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:	Budget increased from $9,350 to $13,350. $1.0 million of the increase is decarbonization efforts for hydrogen fuel cell for backup power and the remainder is due to supply chain delays, and material cost inflation.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Distributed Energy Grid East STM Campus Integrating CFE Resources
Project Location/Site:	NREL STM Campus
Type:	Minor Construction (Direct-funded)
Total Estimated Cost:	$19,500
Construction Design:	$3,000
Project Start:	FY 2024
Design Complete:	FY 2024
Construction Complete:	FY 2026
Project Description:	As NREL expands its facilities at the STM Campuses, it should take advantage of the opportunity to develop distributed renewable energy districts, leveraging NREL's own research expertise on the subject. Alternative thermal energy sources such as ground-source heat pumps, air- source heat pumps, geothermal energy, other electric HVAC technologies, energy storage, and hydrogen fuel cells that reduce emissions will be evaluated for their potential to support buildings that serve simultaneously as research projects and operational assets. This is a shift in the operational behavior and performance from being only consumptive to a Grid-interactive Efficient Building (GEB) with dynamic capability modes of demand management and islanding. Implementing an autonomous (islanded) distributed energy district on an NREL campus is a long-term goal that requires a phased approach to manage risks associated with disconnecting from the electrical grid. At the STM Campus, which is capacity and export constrained, a distributed energy district would investigate behind-the-meter design and control strategies to minimize utility energy costs and maximize flexibility within interconnection constraints. Estimate includes assessment of technologies, project costs and capital installation and infrastructure costs. Technology solutions and processes achieved will additionally benefit DOE program offices for replicable applications. This technology demonstration serves as proof of concept for 5th generation district energy systems and fortifies NREL's role as a living laboratory. This project will be significant for DOE to extend interoperable strategies illustrating deployable operational integration processes and future performance outcomes that can shape industry technologies.
Prior Year Accomplishments:	Initial analysis has been conducted for the STM Campus. NREL researchers are currently finalizing the scope of an assessment for the eastern expansion of the STM Campus to determine the most efficient options for a distributed energy district given NREL's programmatic and infrastructure needs. Modeling will utilize NREL platforms such as Urban Opt and Modelica. NREL will additionally engage industry partners for commercial ready technologies. The aggregation, instrumentation, interoperability, and implementation of an ambient loop for dynamic demand management and resilience is the novelty to demonstrate.
Planned Activities:	• Project scope definition • PMP preparation and approval • Project management • Design • Equipment procurement • Equipment Installation and Commissioning

	• Construction • Equipment Installation and Commissioning • Case study for technology interoperability
Significant Changes from original plan:	N/A

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name: Project Location/Site:	SERF/S&TF Ventilation NREL STM Campus
Type: Total Estimated Cost: Construction Design: Project Start Design Complete Construction Complete	Minor Construction (Direct funded) $14,700 $600 FY 2020 FY 2021 FY 2025
Project Description:	Multi-phased project to upgrade and improve aging and degraded exhaust ventilation infrastructure and fume hoods; phased in a manner that minimizes impact to the ongoing facility work. Work includes: • Adding dedicated exhaust and corrosive etching stations to both the SERF and STF, splitting the SERF center wing exhaust ventilation system and adding additional exhaust capacity to provide redundancy and increased capacity. • Replacing aging fume hoods in SERF center wing, both floors • Replacing aging fume hoods in SERF West wing, both floors
Prior Year Accomplishments:	•
Planned Activities:	• 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:	Budget increased from $9,300 to $14,700 due to delays in project execution of construction phase and construction cost escalation

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	FC Control Center
Project Location/Site:	NREL Flatirons Campus
Type:	Minor Construction (Direct funded)
Total Estimated Cost:	$15,500
Construction Design:	$800
Project Start	FY 2020
Design Complete	FY 2022
Construction Complete	FY 2025
Project Description:	A 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. Useful segments: Design FY 2020 - 2022: $800 Construction FY 2023 – 2025: $14,700
Prior Year Accomplishments:	• The Integrated Project Team (IPT) for NREL has been formed. • The PMP has been reviewed and approved by the IPT. • The design phase is complete. • The Environmental Assessment for the project is complete.
Planned Activities:	• 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:	Construction is delayed due to incoming bids being significantly higher than budget.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name: Project Location/Site:	STM Substation NREL South Table Mountain Campus
Type: Total Estimated Cost: Construction Design: Project Start Design Complete Construction Complete	General Plant Projects (Direct funded) $24,900 $5,000 FY 2024 FY 2025 FY 2026

Project Description:	The STM Substation is planned to be built on the Northeast corner of the STM campus. Interconnection is planned to the existing STM medium voltage loops and feeders with the existing Xcel Energy distribution feed disconnected once the substation is online and operational. Substation initial size to be capable of 30MW to meet the planned needs of the STM Campus. Useful Segments:
	• Design and Xcel Coordination FY 2024 - 2025 $7M
	  ○ Substation Design $5M
	  ○ Xcel Interconnection $2M
	• Construction and Equipment FY 2025 – 2026 $17.9M

Prior Year Accomplishments:	• N/A
Planned Activities:	• RFP • Award of Contract • 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, 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 to include long lead items.)
Significant Changes from original plan:	N/A

21-EE-001, Energy Materials and Processing at Scale, TEC
Project is for Design and Construction

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

Summary: The FY 2024 Budget Request proposes to fund $57,000,000 (of the Total Estimated Cost (TEC)) toward the second segment of the final design and construction phase after the Critical Decision 2/3 Project Baseline using a task order acquisition strategy for a firm fixed price Design/Build project approach under a DOE approved Cooperative Construction Contracting Authority pilot contract for the Energy Materials and Processing at Scale project. The FY2023 funding of $45,000,000 was the first segment to complete the final design, initial sitework, and foundation. This second segment would fund the building core, shell, and associated infrastructure. The current, preliminary Total Estimated Cost (TEC) range is $130,000,000 to $160,000,000 and the preliminary Total Project Cost (TPC) range is $135,000,000 to $165,000,000 per preliminary conceptual Architect/Engineering support estimates. The TEC and TPC estimates are consistent with the DOE Cost Estimating Guide 413.3-21A. The DOE 413.3B Critical Decision 0 (CD-0) approval was obtained on 12/9/19. The preliminary estimate for CD-1, Approve Alternative Selection and Cost Range, is anticipated in the fourth quarter of FY 2023. This project is expected to have approval of CD-1 in 4Q 2023 therefore, schedule estimates are preliminary and subject to change. The FPD for this project is PMCDP certified level 2 working toward level 3 of the Golden Field Office. The Approval of CD-0 in December 2019 target Project Completion range was 2024 to 2026. The currently approved CD-4 date estimate of 2Q 2026 is still on track to the CD-0 Approval letter from Undersecretary of Energy expected CD-4 Project Completion range.

Significant Changes:
The estimated dates for Concept Design completion and CD-1 have slipped a quarter due to the efforts required to integrate the Cooperative Construction Contracting Approach (CCCA) task order agreement procurement strategy with the EMAPS project. There were no cost impacts incurred, only review time for the contracting officer board review approving contract language for the release of the request for proposal.

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	12/16/2019	2Q FY2022	3Q FY2022	3Q FY2023	4Q FY2023	3Q FY2023	NA	2QFY2025
FY 2022	12/16/2019	4Q FY2022	1Q FY2023	4Q FY2023	1Q FY2024	4Q FY2023	NA	3Q FY2025
FY 2023	12/16/2019	2Q FY2023	3Q FY2023	3Q FY2024	4Q FY2024	3Q FY2024	NA	1Q FY2026
FY 2024	12/16/2019	2Q FY2023	4Q FY2023	3Q FY2024	1Q FY2025	3Q FY2024	NA	2Q FY2026

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
FY 2023	12,000	148,000	160,000	5,000	0	5,000	165,000
FY 2024	12,000	148,000	160,000	5,000	0	5,000	165,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 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 becomes increasingly important. The challenge requires much more than end-of-life recycling for complex components, devices, and systems deployed at large scales. Design is required 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 their scalability and durability are established. 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 110,000-125,000 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 was be conducted prior to CD-1 approval and endorsed by the Acting Assistant Secretary of Office of Energy Efficiency and Renewable Energy to proceed with conceptual planning.

With decarbonization efforts, 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 important 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. KPPs may change as the project continues through CD-1. 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. Threshold and Objective KPP descriptions are currently the same (to be later refined). Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
1 – Electrons to Molecules	Laboratory facilities to allow research disciplines to achieve capability to produce multi-disciplinary capabilities that integrate electricity-driven processes with both biotic and abiotic processes that enable net zero fuels and deep CFE 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.	Multi-disciplinary capabilities that integrate electricity-driven processes with both biotic and abiotic processes that enable net zero fuels and deep CFE 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.
2 – Green Process Integration	Laboratory facilities to allow research disciplines to achieve capability to produce 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.
3 – Advanced Electrification	Laboratory facilities to allow research disciplines to achieve capability to produce 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,	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

	and renewable energy generation. Key elements include advanced materials and devices, thermal management, beyond Li-ion battery chemistries, prototype development, characterization, and manufacturing	management, beyond Li-ion battery chemistries, prototype development, characterization, and manufacturing.
4 – Advanced Bio and Chemical Processing	Laboratory facilities to allow research disciplines to achieve capability to develop robust scalable bio and chemical processes that are scalable and demonstrate use of novel systems that apply advanced bioprocessing technologies to produce biofuels, bio-based chemicals, and value added bioproducts from renewable sources. This includes cost effective bio-based chemicals and polymer composites.	Develop robust scalable bio and chemical processes that are scalable and demonstrate use of novel systems that apply advanced bioprocessing technologies to produce biofuels, bio-based chemicals, and value added bioproducts from renewable sources. This includes cost effective bio-based chemicals and polymer composites.
5 – Pilot-Scale Process Integration and Scale-up	High Bay Laboratory facilities to allow research disciplines to achieve 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.	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.

3. Financial Schedule

(Dollars in Thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2021	4,000	0	0
FY 2022	8,000	0	0
FY 2023	0	12,000	8,000
FY 2024	0	0	4,000
FY 2025	0	0	0
Total Design	12,000	12,000	12,000
Construction			
FY 2021	0	0	0
FY 2022	0	0	0
FY 2023	45,000	0	0
FY 2024	57,000	0	92,070
FY 2025	46,000	117,700	55,930
FY2026	0	30,300	
Total Construction	148,000	148,000	148,000
Total Estimated Costs (TEC)			
FY 2021	4,000	0	0
FY 2022	8,000	0	4,730
FY 2023	45,000	57,000	33,640
FY 2024	57,000	57,000	82,330
FY 2025	46,000	31,000	39,300
Total TEC	**160,000**	**160,000**	**160,000**
Other Project Costs (OPC)			
FY 2021	2,000	1,500	750
FY 2022	0	500	750
FY 2023	0	0	500
FY 2024	0	0	0
FY 2025	3,000	3,000	3,000
Total OPC	**5,000**	**5,000**	**5,000**
Total Project Costs (TPC)			
FY 2021	6,000	1,500	750
FY 2022	0	500	750
FY 2023	45,000	8,000	8,500
FY 2024	57,000	121,700	96,070
FY 2025	49,000	33,300	58,930
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 110,000 to 125,000 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)			
Design			
Design	10,000	10,000	N/A
Contingency	2,000	2,000	N/A
Total, Design	12,000	12,000	N/A
Construction			
Site Work	1,250	1,250	N/A
Equipment	15,300	15,300	N/A
Construction	97,450	97,450	N/A
Other, as needed	4,700	4,700	N/A
Contingency	29,300	29,300	N/A
Total, Construction	148,000	148,000	N/A
Other TEC (if any)			
Cold Startup	0	0	N/A
Contingency	0	0	N/A
Total, Other TEC	0	0	N/A
Total Estimated Cost	**160,000**	**160,000**	N/A
Contingency, TEC	*31,300*	*31,300*	N/A
Other Project Cost (OPC)			
OPC except D&D			
R&D	0	0	N/A
Conceptual Planning	1,000	1,000	N/A
Conceptual Design	2,000	2,000	N/A
Other OPC Costs	2,000	2,000	N/A
Contingency	0	0	N/A
Total, OPC	**5,000**	**5,000**	N/A
Contingency, OPC	*0*	*0*	N/A
Total Project Cost	**165,000**	**165,000**	N/A
Total Contingency (TEC+OPC)	**31,300**	**31,300**	N/A

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet.

5. Schedule of Appropriations Requests

(Dollars in Thousands)

Request Year	Type	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	Total
FY 2022	TEC	4,000	8,000	0	151,000	0	159,000
	OPC	2,000	0	0	4,000	0	6,000
	TPC	6,000	8,000	0	151,000	0	165,000
FY 2023	TEC	4,000	8,000	45,000	57,000	46,000	160,000
	OPC	2,000	0	0	0	3,000	5,000
	TPC	6,000	8,000	45,000	57,000	49,000	165,000
FY 2024	TEC	4,000	8,000	45,000	57,000	46,000	160,000
	OPC	2,000	0	0	0	3,000	5,000
	TPC	6,000	8,000	45,000	57,000	49,000	165,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet. FY 2022 was the first-year funding is requested. In FY 2021, Congress appropriated $6,000 for OPC of which only $2,000 is needed for preliminary engineering design. The remaining $4,000 of OPC funds will be used for the testing/acceptance and commissioning of the facility after construction is completed.

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	1QFY2026
Expected Useful Life (number of years)	50
Expected Future Start of D&D of this capital asset (fiscal quarter)	1QFY2076

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	5.4	270	270

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet.

7. D&D Information

If the preferred alternative is a new Federal facility, then this new facility will not replace existing facilities. The applicability of the "one-for-one" offset requirement will be assessed after CD-1 once conceptual design has a square footage footprint.

8. Acquisition Approach

An Acquisition Approach/Plan will be developed post CD-1 approval in accordance with DOE O 413.3B.

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 2022 Actual Cost	FY 2022 Planned Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
National Renewable Energy Laboratory	19,662	18,550	22,129	23,014
Total, Direct-Funded Maintenance and Repair	**19,662**	**18,550**	**22,129**	**23,014**

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

	FY 2022 Actual Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
National Renewable Energy Laboratory	0	0	0
Total, Indirect-Funded Maintenance and Repair	**0**	**0**	**0**

Report on FY 2022 Expenditures for Maintenance and Repair

This report responds to explanatory 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 2022 to the amount planned for FY 2022.

Energy Efficiency and Renewable Energy
Total Costs for Maintenance and Repair ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost
National Renewable Energy Laboratory	19,662	18,550
Total, Maintenance and Repair	**19,662**	**18,550**

Energy Efficiency and Renewable Energy
Safeguards and Security ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Protective Forces	3,470	3,600	3,890	+290	+8.1%
Physical Security Systems	875	925	1,000	+75	+8.1%
Information Security	550	575	620	+45	+7.8%
Cybersecurity	9,200	10,500	11,200	+700	+6.7%
Personnel Security	230	240	260	+20	+8.3%
Material Control and Accountability	0	0	0	0	
Program Management	690	720	780	+60	+8.3%
Security Investigations	185	190	200	+10	+5.3%
Transportation Security	0	0	0	0	
Construction	0	0	0	0	
Total, Safeguards and Security	**15,200**	**16,750**	**17,950**	**+1,200**	**+7.2%**

Geothermal Technologies

Overview

The mission of EERE's Geothermal Technologies Office (GTO) is to drive increased deployment of geothermal energy to enhance exploration and production. The GTO FY 2024 Request supports RDD&D to meet cost targets and make geothermal energy competitive nationwide. GTO's technology portfolio prioritizes investments in three closely related geothermal categories: Enhanced Geothermal Systems (EGS), Hydrothermal Resources, and Low Temperature and Coproduced Resources. This portfolio addresses technology barriers that industry may not have the technical capabilities or institutional knowledge to address.

Geothermal energy is a reliable, secure, clean, firm, and flexible domestic energy source. Geothermal addresses environmental justice 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 communities where geothermal has high technical and economic potential and can reduce dependence on fossil fuels.

The geothermal industry often 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. Built on the analysis from the 2019 DOE study, *GeoVision: Harnessing the Heat Beneath Our Feet* (GeoVision)[1], and presented in the 2022 Geothermal Technologies Office Multi-Year Program Plan[2], GTO has adopted the following Strategic Goals to reach geothermal energy's full potential: Goal 1: Drive toward a carbon-free electricity grid by supplying 60 gigawatts (GW) of EGS and hydrothermal resource deployment by 2050; Goal 2: Decarbonize building heating and cooling loads by capturing the economic potential for 17,500 geothermal district heating (GDH) installations and by installing geothermal heat pumps (GHPs) in 28 million households nationwide by 2050; Goal 3: Deliver economic, environmental, and social justice advancements through increased geothermal technology deployment.

Highlights of the FY 2024 Request

The Geothermal Technologies Program will pursue the following major activities in FY 2024:

- Launched in FY 2022, the Enhanced Geothermal Shot is a whole-of-DOE effort to dramatically reduce the cost of enhanced geothermal systems by 90 percent to $45 per megawatt hour (MWh) by 2035. The Enhanced Geothermal Shot will work toward this goal by aggressively accelerating RD&D focused on EGS, and in technology areas relevant to hydrothermal development as well.
- The EGS Well Construction initiative began in FY 2023 and included the development of a roadmap on technology advancements necessary to reduce costs associated with this capital-intensive aspect of EGS development. In FY 2024, a funding opportunity will be developed on EGS Well Construction that will address the unique barriers that the harsh high-temperature environment of EGS resources pose to cost-effective wellbore completion and production technologies. Significant progress in EGS Well Construction through this funding will enable more rapid commercialization of EGS resources by lowering overall lifecycle well costs.
- The Frontier Observatory for Research in Geothermal Energy (FORGE) 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. In FY 2024, GTO will stimulate a third, long-reach horizontal well, providing an opportunity to further advance stimulation technologies for EGS and enable additional zonal isolation testing.
- The Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE) consortium will continue to prepare solicitations and other activities focused on each GEODE facet, building off the FY 2023 GEODE Roadmap to make immediate progress in modernizing geothermal drilling, deploying O&G technologies to lower geothermal development costs, and standing up workforce development programs that attract, train, and utilize highly skilled workers displaced from the O&G industry.

[1] GeoVision: Harnessing the Heat Beneath Our Feet (energy.gov)
[2] GTO Multi-Year Program Play (FY 2022-2026 (energy.gov)

- The Exploration RD&D program will focus on exploring and characterizing geothermal resource potential in areas that have demonstrated the promise of hydrothermal resources. The need for exploration and test drilling, validation of new technologies, and improving the utilization of new data sets will be addressed through this work.
- GTO will continue to emphasize funding for demonstrations of community heating and cooling systems and direct use heating and cooling, including consideration of agricultural applications, through the Community Geothermal Heating & Cooling initiative. This program will continue to prioritize building local coalitions and developing a vocational workforce to deploy and install geothermal heating systems.
- GTO is involved in several DOE-wide crosscutting initiatives, including the following:
  - Industrial Decarbonization: to support demonstrations of thermal energy storage for manufacturing applications;
  - Energy-Storage to support the assessment of deep, low temperature resources in the U.S. for thermal energy storage as well as continue its Reservoir Thermal Energy Storage (RTES) initiative;
  - Critical Minerals: to support technology and process solutions to our Nation's critical minerals supply through geothermal brine and produced water extraction and processing; and
  - Subsurface Energy Innovation: to support RD&D that focuses on exploration, characterization, reservoir monitoring, and drilling-based verification of advanced technologies and methods.

Geothermal Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Geothermal Technologies					
Enhanced Geothermal Systems	52,143	57,500	129,033	+71,533	+124%
Hydrothermal Resources	22,984	24,000	34,787	+10,787	+45%
Low Temperature and Coproduced Resources	22,234	24,000	34,787	+10,787	+45%
Data, Modeling, and Analysis	12,139	12,500	17,393	+4,893	+39%
Total, Geothermal Technologies	**109,500**	**118,000**	**216,000**	**+98,000**	**+83%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $3,210,510; STTR: $548,990
- FY 2023 Enacted: SBIR: $3,146,000; STTR: $442,000
- FY 2024 Request: SBIR: $8,796,384; STTR: $1,236,992

Geothermal Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Geothermal Technologies	
Enhanced Geothermal Systems: The increase will support the Enhanced Geothermal Shot effort in various technical areas with a focus on learning-by-doing and well construction cost reductions, as well as a new portfolio focused on advanced materials and high temperature components to enable downhole development in EGS environments.	**+71,533**
Hydrothermal Resources: The increase will support Exploration and Characterization R&D for a new initiative focused on exploring and characterizing geothermal resource potential, offset by a slight reduction of funding for critical materials work in Resource Maximization R&D.	**+10,787**
Low Temperature and Coproduced Resources: The increase will support Resource Maximization R&D Activity including a strong focus on assessments for thermal energy storage and direct use systems as well as system deployments through the Community Geothermal Heating and Cooling initiative.	**+10,787**
Data, Modeling, and Analysis: The increase will support cross-EERE analysis and demonstration and increased analysis for streamlining geothermal permitting on Federal lands and improved data ingestion, processing, and dissemination. The Request also provides funding for Geothermal Grid Valuation Technical Assistance and Clean Energy to Communities capacity building.	**+4,893**
Total, Geothermal Technologies	**+98,000**

Geothermal Technologies
Enhanced Geothermal Systems

Description
To ensure the U.S. stays on track for 60 GW deployment of geothermal power by 2050, the FY 2024 Budget Request will support a wide variety of RD&D investments related to nearly every aspect of EGS resource development. The research supported under these activities will reduce costs and advance technologies needed for newly developed enhanced geothermal systems. The focus of the EGS subprogram is to gain an evidence-based understanding of basic and applied 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 RD&D will enable industry to develop a baseload energy resource as shown in the GeoVision report, which will be the major contributor to achieving a potential geothermal power capacity of 60 GW by 2050.

The EGS subprogram is focused on characterizing, accessing, creating, and sustaining EGS reservoirs and is categorized into the following activities: Exploration and Characterization R&D; Subsurface Accessibility R&D; Subsurface Enhancement & Sustainability R&D; Resource Maximization R&D; and Data, Modeling, and Analysis.

In 2022, DOE launched an Enhanced Geothermal Shot, which is a whole-of-DOE effort to dramatically reduce the cost of EGS by 90 percent to $45 per megawatt hour (MWh) by 2035. Capturing even a small fraction of the U.S.' five Terawatts of available heat resource via widescale commercial deployment could affordably power over 40 million American homes and businesses, exponentially increasing deployment of conventional geothermal and geothermal heating and cooling solutions nationwide. All FY 2024 EGS RD&D will seek to make progress towards this EGS Shot target.

Exploration and Characterization R&D: Subsurface characterization technologies seek to track and understand the conditions in the subsurface such that we can design and develop optimized EGS reservoirs to maximize heat extraction, thereby reducing risks and costs of EGS development and the levelized cost of energy (LCOE) of produced energy. Ultimately, success in this space includes remote assessment capabilities and characterization technologies incorporated in real-time into fully coupled 3D reservoir models. In FY 2024, as part of the Enhanced Geothermal Shot, GTO will launch new R&D efforts in hardened materials, electronics, and components to enable subsurface characterization and operation in high temperature, corrosive environments.

Subsurface Accessibility R&D: Guided by a roadmap created in FY 2023, GTO will develop an EGS Well Construction funding opportunity in FY 2024 that will address technical challenges in cost-effective well construction to enable faster commercialization of EGS resources. Opportunities exist for the reduction of well construction costs across a wide range of areas that are not directly related to the drilling of EGS wells, including casing, cement-like materials, new well designs, wellbore integrity monitoring tools, etc.

Subsurface Enhancement & Sustainability R&D: EGS reservoir enhancement and sustainability funds will be directed to early career researchers to foster new ideas in the field of EGS. GTO will conduct this effort in collaboration with the National Science Foundation (NSF) and will focus on attracting new researchers from academia to the field of geothermal energy to expand the collective brain power focused on increasing geothermal energy deployment.

Frontier Observatory for Research in Geothermal Energy (FORGE): FORGE enables scientists and engineers to conduct transformative and high-risk science and engineering, moving EGS toward commercial viability. FORGE technical successes have positively influenced countless start-up designs and geothermal industry practices in the last five years, directly facilitating increased deployment. FORGE was extended via language in the Energy Act of 2020, and FY 2024 funding will support the stimulation of an additional well and a third competitive solicitation.

Data, Modeling, and Analysis for EGS: Data best practices, techno-economic modeling, and strategic analysis underpin RD&D conducted across all GTO Subprogram Research Areas. Ongoing analysis and work in each of these areas is critical to ensure program-wide progress toward meeting EGS specific metrics and goals.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Enhanced Geothermal Systems $57,500,000	**$129,033,000**	**+$71,533,000**
Frontier Observatory for Research in Geothermal Energy (FORGE) $22,952,000	$ 40,000,000	+$17,048,000
• FORGE: R&D focused on developing alternative completion techniques, adopting relevant unconventional O&G stimulation methods, and identifying links between completion techniques and reservoir development and operation. A portion of these funds will enable the drilling of an additional highly deviated well.	• FORGE authorization was extended via language in the Energy Act of 2020, and FY 2024 funding will support the stimulation of an additional well and a third competitive solicitation.	• The increase will fund the commercial scale stimulation of a third highly deviated well, which will advance EGS technology toward commercialization in support of GTO goals for widespread firm, flexible, geothermal power deployment.
Subsurface Enhancement & Sustainability R&D $34,548,000	$30,000,000	-$4,548,000
• EGS STEM Early Career Awards: Issue small seedling grants that allow participants to develop and pursue geothermal-relevant ideas. This will increase awareness of geothermal benefits and resources and attract researchers and other interested parties to the geothermal field.	• Continuing a successful effort started in FY 2022 in collaboration with NSF, GTO will continue to fund seedling grants that allow participants to develop and pursue geothermal-relevant ideas. This will increase awareness of geothermal benefits and resources and attract researchers and other interested parties to the field.	• Funding for EGS STEM Early Career Awards will remain at the same level as FY 2023.
• EGS Greenfield Demonstration: EGS Greenfield Demonstration will target shallow to mid-depth, geothermal temperature anomalies for clean, renewable, geothermal power production. Projects will build on the zonal isolation and stimulation learnings of previous GTO initiatives such as Wells of Opportunity (WOO) and FORGE.	• No funding requested.	• Deferral of funding request in FY 2024 for EGS Greenfield Demonstrations will allow time for IIJA demonstrations to develop so that those projects can inform optimal target for an EGS Greenfield Demonstrations funding opportunity in FY 2025.
• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): Select GEODE Team and prepare solicitations to modernize geothermal drilling, deploy O&G technologies to lower geothermal development costs, and stand-up workforce development	• Funds year 3 of the GEODE consortia, including solicitations that will further the research, development, and demonstration of how oil and gas assets, technologies, and workforce can help solve geothermal's toughest challenges.	• Funding for GEODE remains at the same level as FY 2023.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
programs to attract, train, and utilize highly skilled workers displaced from O&G.		
• EGS Well Construction: Research, develop, and demonstrate well construction technologies that will accelerate commercialization of EGS resources by lowering lifecycle development costs.	• The Request will allow GTO to research, develop and demonstrate well construction techniques and tools to enable more cost-effective development of EGS resources.	• Increased support combined with funds from FY 2023 will be used to develop a funding opportunity on EGS well construction RD&D based a roadmap developed in collaboration with National Laboratory partners.
Subsurface Accessibility R&D $0	$30,000,000	+$30,000,000
• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): Select GEODE Team and prepare solicitations to modernize geothermal drilling, deploy O&G technologies to lower geothermal development costs and stand-up workforce development programs to attract, train, and utilize highly skilled workers displaced from O&G.	• Funds year 3 of the GEODE consortia, including solicitations that will further the research, development, and demonstration of how oil and gas assets, technologies, and workforce can help solve geothermal's toughest challenges.	• Beginning in FY 2024, the GEODE initiative was added to the Subsurface Accessibility R&D category because it is a wide-ranging initiative that spans multiple categories. Funding for GEODE was previously provided through the Subsurface Enhancement & Sustainability R&D activity and the overall funding for GEODE remains at the same level as FY 2023.
• EGS Well Construction: Research, develop and demonstrate well construction technologies that will accelerate commercialization of EGS resources by lowering lifecycle development costs.	• We will seek to research, develop and demonstrate well construction techniques and tools to enable more cost-effective development of EGS resources.	• Increased support combined with funds from FY 2023 will be used to develop a funding opportunity on EGS well construction RD&D based a roadmap developed in collaboration with National Laboratory partners. The EGS Well Construction initiative was added to the Subsurface Accessibility R&D category because it is a wide-ranging initiative that spans multiple categories.
Exploration and Characterization R&D $0	$27,000,000	+$27,000,000
• EGS Near-Field Monitoring & Characterization R&D: Support new near-field EGS demonstrations through the WOO effort.	• Support EGS pilot demonstrations and other EGS activities. • Launch new R&D efforts in collaboration with other DOE partners focused on hardened materials and components to enable subsurface characterization and operation in high temperature, corrosive environments.	• Additional funding will support required monitoring of induced seismicity associated with any pilot stimulation demonstrations. • Increased funding for materials and component focused work that was a major part of Enhanced Geothermal Shot RD&D proposals and underpins all EGS RD&D.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $0	$2,033,000	+$2,033,000
	• EGS-Focused Techno-Economic Tools & Data: Conduct critical power sector analysis and modeling relevant to EGS.	• This represents a new activity in FY 2024, dedicated to analysis and modeling specifically focused on Enhanced Geothermal EarthShot targets.

Geothermal Technologies
Hydrothermal Resources

Description
The FY 2024 Request supports RD&D that can lower cost and risk throughout the lifecycle of a hydrothermal project to bring more hydrothermal power online, from exploration and resource confirmation, to drilling and field development, to reservoir management over multi-decadal timescales. The subprogram also supports R&D for extracting critical materials or other strategic minerals from geothermal brines to maximize the ancillary benefits of geothermal resources.

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 GW of geothermal power capacity by 2050. Hydrothermal resources can also support the nearer-term Administration goal of a carbon pollution-free electricity sector by 2035.

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. 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. Novel exploration technologies can reduce project risk by greatly reducing the number of unsuccessful wells that are drilled. 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. Other paths to improved 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.

Research in the Hydrothermal Resources subprogram is categorized into the following activities: Exploration and Characterization R&D, Subsurface Accessibility R&D, and Resource Maximization R&D.

<u>Exploration and Characterization R&D</u>: This activity 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 the levelized cost of electricity (LCOE) primarily by lowering the capital cost of a geothermal project. 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.

<u>Subsurface Accessibility R&D</u>: The activity focuses on developing capability to access the subsurface effectively and 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. Newly developed drilling techniques deployed in a hydrothermal setting can have spillover benefits to the development of less commercialized EGS and low-temperature systems.

<u>Resource Maximization R&D</u>: This activity focuses on how R&D can help overcome the challenges of proving extraction technologies and scaling them up to commercial levels. R&D can improve tools and techniques for characterizing provenance and sustainability of these types of mineral resources. 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.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydrothermal Resources $24,000,000	**$34,787,000**	**+$10,787,000**
Subsurface Accessibility R&D $11,369,000	$12,000,000	+$631,000
• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): Select GEODE Team and prepare solicitations to modernize geothermal drilling, deploy O&G technologies to lower geothermal development costs, and stand up workforce development programs to attract, train, and utilize highly skilled workers displaced from O&G.	• Funds year 3 of the GEODE consortia, including solicitations that will further the research, development, and demonstration of how oil and gas assets, technologies, and workforce can help solve geothermal's toughest challenges.	• Provides year 3 of funding for a 5-year initiative.
Exploration and Characterization R&D $8,676,000	$20,000,000	+$11,324,000
• FedGeo Power: Conduct feasibility studies and site characterization for geothermal power generation opportunities at Federal and military installations with a large electricity demand and/or strong energy security and resiliency mandates.	• No funding requested.	• No additional funding is needed for FedGeo Power in FY 2024.
	• Exploration RD&D: Building on a decade of R&D from Play Fairway Analyses and Hidden Systems initiatives, this program will focus on exploring and characterizing the geothermal resource potential in areas that have demonstrated the promise of hydrothermal resources. This work will address the need for exploration and test drilling, validation of new technologies, identifying new survey areas, and improving the utilization of new data sets.	• The increase will support a new initiative that will directly enable identification of geothermal systems that will lead to deployment of carbon-free geothermal power production, contributing 30 additional GW by 2050, and aiding the U.S. transition to 100 percent clean energy economy.
• Machine Learning for Geothermal: Identify hidden geothermal resources in the U.S. using machine learning in conjunction with data gathered through geophysical surveys in partnership with USGS (GeoDAWN; GeoFlight).	• No funding requested.	• Partnerships with USGS in this space continue to provide critical data on hydrothermal resources; Needs for additional survey(s) are expected to be incorporated in the Exploration RD&D initiative (above) for FY 2024.

Geothermal Technologies
Hydrothermal Resources

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Resource Maximization R&D $3,955,000	$2,787,000	-$1,168,000
• Critical Materials: Scale up technical solutions for geothermal brine and produced water extraction and processing. Demonstrate technologies in the Salton Sea area of California.	• Initiative to scale-up technologies related to lithium extraction from geothermal brines and identification of additional resources and geographies with high potential for mineral extraction from geothermal brines or waters.	• Funding will be used for R&D for mineral extraction technologies and analyses to serve the administration priorities in critical minerals.

Geothermal Technologies
Low Temperature and Coproduced Resources

Description
The FY 2024 Request supports targeted RDD&D for technologies applicable to geothermal resources below a temperature of 300°F (150°C) as well as geothermal resources, including hybrid energy designs, that can be co-developed with other clean energy technologies. The subprogram also supports R&D on the direct use of thermal resources for process and space heating applications, geothermal heat pumps, district-scale geothermal heating and cooling systems, and deep direct use geothermal resource development. These technologies have the potential to provide cost-effective, renewable thermal energy in large portions of the U.S.

A U.S. Geological Survey (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 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. The U.S. has an opportunity to leverage existing HVAC and piping infrastructure for low-temperature resources, 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, such as storing thermal energy in underground reservoirs, can facilitate near-term development of innovative geothermal technologies in geographically diverse areas of the U.S.

Resource Maximization R&D: This activity supports research that enables maximization of low temperature geothermal resources to develop effective and affordable direct-use systems. This research includes understanding temperature gradients at varying depths and in varying environments (urban/rural, residential/industrial, etc.) and will help the geothermal industry better understand where these low-temperature resources can most effectively be harnessed.

The activity also supports crosscutting efforts in energy storage and industrial decarbonization through standalone funding opportunities for large-scale resource assessment and feasibility research across a diverse group of institutions pursuing geothermal system installation with a goal to develop the ubiquitous thermal energy storage available in the Earth for a variety of direct-use and grid applications. This 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.

The activity also supports district- and community-scale geothermal heating and cooling systems and geothermal heat pumps (also known as “ground-source heat pumps”) that make use of near-constant year-round temperatures in the shallow subsurface to heat communities and infrastructure in the winter and cool them in the summer. Geothermal resources can provide a range of benefits, including grid stability, reliability, resiliency, and partnership with other energy resources for even greater return.

[1] https://www.usgs.gov/programs/energy-resources-program/science/geothermal#overview.

Low Temperature and Coproduced Resources

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Low Temperature and Coproduced Resources $24,000,000	**$34,787,000**	**+$10,787,000**
Resource Maximization R&D $24,000,000	$34,787,000	+$10,787,000
• Energy Storage Grand Challenge: Develop pilots and demonstrations of Reservoir Thermal Energy Storage to demonstrate technical feasibility, grid integration, and opportunities for systems that leverage more than one type of renewable energy or energy storage.	• Thermal Energy Storage Assessments: Develop a partnership to assess deep, low temperature resources in the U.S. for thermal energy storage and industrial direct use systems.	• The increase will support resource assessments to identify promising areas for thermal energy storage deployment.
• Community Geothermal Heating & Cooling Technical Assistance & Deployment: Build on FY 2022 initiative to demonstrate geothermal heating and cooling for communities in a variety of living environments. Build state and local partnerships to develop a vocational workforce to deploy and install geothermal heating systems.	• Community Geothermal Heating & Cooling: Funding for demonstrations of community heating and cooling system and direct use heating and cooling, including agricultural applications. This program will prioritize building local coalitions and developing a vocational workforce to deploy and install geothermal heating systems.	• Increase will expand the community geothermal initiative to additional high-value application spaces and seeks to double the over 3,000 TJ/year of direct-use geothermal energy that is already used in the U.S. agricultural sector for fish farms, greenhouses, and animal farming while also creating net-zero agricultural heating systems and increase deployment of community geothermal systems.
	• New program seeks to develop and fund local and regional outreach-focused partnerships to increase local stakeholder engagement and education related to geothermal heat pumps and community-scale geothermal heating and cooling systems. Regional partnerships will provide tailored information on technologies and opportunities to different regions of the U.S., resulting in increased deployment of geothermal heating and cooling systems.	• Regional deployment partnerships are key to meeting the administration's goal of 28 million geothermal heat pumps in the U.S. by 2050.

Geothermal Technologies
Data, Modeling, and Analysis

Description
FY 2024 activities in the Data, Modeling, and Analysis (DMA) subprogram provide a critical supporting and enabling function toward advancing the entire GTO research portfolio. DMA takes a holistic analytical approach across the GTO's technology portfolio with the aim of improving the state of the art of complex geothermal technologies and to enable further deployment of geothermal resources. The goal of the DMA subprogram is to identify and address barriers to geothermal adoption in the U.S. and validate and assess technical progress across the geothermal sector to inform the direction and prioritization of GTO RDD&D.

DMA conducts analyses in the following areas: resource assessments; assessments of the economic, environmental, system-level, and grid integration impacts and value of geothermal technologies; the policy and regulatory barriers to geothermal development; and techno-economic modeling and validation of geothermal technology cost and performance. DMA supports the collection and dissemination of data for stakeholder use to spur geothermal development. DMA also leverages these data and analyses to support programmatic strategic planning and to either validate or refine the program's overall RDD&D. DMA conducts these activities in partnership with the DOE National Laboratories, Federal agencies, academic institutions, and industry stakeholders to maximize interagency coordination to compound and amplify impact.

In FY 2019, DMA 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, the program published a GTO Multi-Year Program Plan in FY 2022. The GTO Multi-Year Program Plan provides additional RDD&D objectives and associated performance goals through FY 2026 for accelerating towards the outcomes identified in the GeoVision analysis.

Data, Modeling, and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $12,500,000	**$17,393,000**	**+$4,893,000**
Data, Modeling, and Analysis $12,500,000	$17,393,000	+$4,893,000
Techno-Economic Tools & Data: Critical analysis, modeling, and storage of project data. Funding for the second year of development of major analytic capacity building for geothermal at NREL and other laboratories to expand geothermal modeling capacity and representation, power sector analysis on hybridizing geothermal power with other renewables, and heating and cooling sector impact analysis.	• Build on FY 2023 successes by funding the third year of development of major analytic capacity building for geothermal at NREL and other laboratories in FY 2024, focused on representing geothermal technologies in key modeling platforms and leveraging those models to conduct value and impact analyses of geothermal power generation and heating and cooling technologies.	• No significant change.
• Cross-EERE Analysis, Technical Assistance, and Demonstration: Data, tools, analysis to support integrating renewables to the power system. Includes partnering with EERE Offices and the Office of Electricity to expand technical assistance for decision makers, including field demonstration of hybrid geothermal technology applications, designing deployment programs, evaluating electrification and decarbonization pathways, developing market and policy solutions, and planning transmission and distribution upgrades.	• Build upon the FY 2023 successes of projects funded by the FY 2022 lab call "Evaluation of Geothermal Hybrids for Near-Term Commercial Deployment" to implement commercialization pathways for hybrid opportunities. Build on FY 2023 cross-EERE analysis of grid impacts and value of geothermal heating and cooling through continued analysis and stakeholder and utility engagement to expand geothermal heating and cooling adoption. Work with Federal partners to improve leasing, permitting, and siting of geothermal technologies on public lands.	• The increase will support expanded stakeholder outreach and integration with cross-EERE initiatives and to provide geothermal subject matter expertise to interagency partners in geothermal siting, leasing, and permitting.
• Clean Energy to Communities (C2C): Over 170 cities have committed to 100 percent clean energy. GTO will contribute to C2C to provide support mechanisms including analysis of decarbonization strategies, lab demonstrations of technologies and best practices, measurement and verification processes, workforce development pipelines, and disseminating outcomes and lessons learned.	• Increased support to the C2C to provide technical assistance supporting energy assessment, planning, and operations to achieve energy-resilient communities while fostering cross-technology collaboration, planning and solutions.	• The increase will expand cohorts.

Energy Efficiency and Renewable Energy
Safeguards and Security ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Protective Forces	3,470	3,600	3,890	+290	+8.1%
Physical Security Systems	875	925	1,000	+75	+8.1%
Information Security	550	575	620	+45	+7.8%
Cybersecurity	9,200	10,500	11,200	+700	+6.7%
Personnel Security	230	240	260	+20	+8.3%
Material Control and Accountability	0	0	0	0	
Program Management	690	720	780	+60	+8.3%
Security Investigations	185	190	200	+10	+5.3%
Transportation Security	0	0	0	0	
Construction	0	0	0	0	
Total, Safeguards and Security	**15,200**	**16,750**	**17,950**	**+1,200**	**+7.2%**