DOE/CF-0205
Volume 4

Department of Energy
FY 2025 Congressional Justification

Energy Efficiency and Renewable Energy
Electricity
Nuclear Energy
Fossil Energy and Carbon Management
Critical and Emerging Technologies

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FY 2025 Congressional Budget Justification

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DEPARTMENT OF ENERGY
Appropriation Summary
FY 2025
(Dollars in Thousands)

	FY 2023 Enacted (1),(2),(3)	FY 2024 Annualized CR	FY 2025 President's Budget (4)	FY 2025 President's Budget vs. FY 2023 Enacted $	%
Department of Energy Budget by Appropriation					
Energy Efficiency and Renewable Energy	3,460,000	3,460,000	3,118,000	-342,000	-9.9%
Electricity	350,000	350,000	293,000	-57,000	-16.3%
Cybersecurity, Energy Security and Emergency Response (270)	200,000	200,000	200,000	0	0.0%
Strategic Petroleum Reserve	207,175	207,175	241,169	+33,994	+16.4%
Naval Petroleum and Oil Shale Reserves	13,004	13,004	13,010	+6	+0.0%
SPR Petroleum Account	100	100	100	0	0.0%
Northeast Home Heating Oil Reserve	7,000	7,000	7,150	+150	+2.1%
Office of Petroleum Reserves	**227,279**	**227,279**	**261,429**	**+34,150**	**+15.0%**
Nuclear Energy (270)	1,623,000	1,623,000	1,440,660	-182,340	-11.2%
Fossil Energy and Carbon Management	890,000	890,000	900,000	+10,000	+1.1%
Uranium Enrichment Decontamination and Decommissioning (UED&D)	879,052	879,052	854,182	-24,870	-2.8%
Energy Information Administration	135,000	135,000	141,653	+6,653	+4.9%
Non-Defense Environmental Cleanup	358,583	358,583	314,636	-43,947	-12.3%
Science	8,100,000	8,100,000	8,583,000	+483,000	+6.0%
Office of Technology Transitions	22,098	22,098	27,098	+5,000	+22.6%
Office of Clean Energy Demonstrations	89,000	89,000	180,000	+91,000	+102.2%
Federal Energy Management Program	0	0	64,000	+64,000	N/A
Grid Deployment Office	0	0	101,870	+101,870	N/A
Office of Manufacturing & Energy Supply Chains	0	0	113,350	+113,350	N/A
Office of State and Community Programs	0	0	574,000	+574,000	N/A
Advanced Research Projects Agency - Energy	470,000	470,000	450,000	-20,000	-4.3%
Nuclear Waste Disposal Fund	10,205	10,205	12,040	+1,835	+18.0%
Departmental Administration	283,000	283,000	334,671	+51,671	+18.3%
Indian Energy Policy and Programs	75,000	75,000	95,000	+20,000	+26.7%
Inspector General	86,000	86,000	149,000	+63,000	+73.3%
Title 17 Innovative Technology Loan Guarantee Program	-136,018	-71,362	-184,558	-48,540	+35.7%
Advanced Technology Vehicles Manufacturing Loan Program	9,800	9,800	27,508	+17,708	+180.7%
Tribal Energy Loan Guarantee Program	4,000	4,000	6,300	+2,300	+57.5%
Total, Credit Programs	**-122,218**	**-57,562**	**-150,750**	**-28,532**	**+23.3%**
Energy Projects	221,969	221,969	0	-221,969	-100.0%
Critical and Emerging Technologies	0	0	5,000	+5,000	N/A
Total, Energy Programs	**17,357,968**	**17,422,624**	**18,061,839**	**+703,871**	**+4.1%**
Weapons Activities	17,116,119	17,116,119	19,848,644	+2,732,525	+16.0%
Defense Nuclear Nonproliferation	2,490,000	2,490,000	2,465,108	-24,892	-1.0%
Naval Reactors	2,081,445	2,081,445	2,118,773	+37,328	+1.8%
Federal Salaries and Expenses	475,000	475,000	564,475	+89,475	+18.8%
Total, National Nuclear Security Administration	**22,162,564**	**22,162,564**	**24,997,000**	**+2,834,436**	**+12.8%**
Defense Environmental Cleanup	7,025,000	7,025,000	7,059,695	+34,695	+0.5%
Other Defense Activities	1,035,000	1,035,000	1,140,023	+105,023	+10.1%
Defense Uranium Enrichment D&D	586,035	586,035	384,957	-201,078	-34.3%
Total, Environmental and Other Defense Activities	**8,646,035**	**8,646,035**	**8,584,675**	**-61,360**	**-0.7%**
Nuclear Energy (050)	150,000	150,000	150,000	0	0.0%
Total, Atomic Energy Defense Activities	**30,958,599**	**30,958,599**	**33,731,675**	**+2,773,076**	**+9.0%**
Southeastern Power Administration	0	0	0	0	N/A
Southwestern Power Administration	10,608	10,608	11,440	+832	+7.8%
Western Area Power Administration	98,732	98,732	100,855	+2,123	+2.2%
Falcon and Amistad Operating and Maintenance Fund	228	228	228	0	0.0%
Colorado River Basins Power Marketing Fund	0	0	0	0	N/A
Total, Power Marketing Administrations	**109,568**	**109,568**	**112,523**	**+2,955**	**+2.7%**
Federal Energy Regulatory Commission	0	0	0	0	N/A
Total, Energy and Water Development and Related Agencies	**48,426,135**	**48,490,791**	**51,906,037**	**+3,479,902**	**+7.2%**
Sale of the Gas Reserves	0	0	-95,000	-95,000	N/A
Excess Fees and Recoveries, FERC	-9,000	-9,000	-9,000	0	0.0%
Title XVII Loan Guar. Prog Section 1703 Negative Credit Subsidy Receipt	-14,000	-14,000	-2,051	+11,949	-85.4%
UED&D Fund Offset	-586,035	-586,035	-384,957	+201,078	-34.3%
Discretionary Funding by Appropriation	**47,817,100**	**47,881,756**	**51,415,029**	**+3,597,929**	**+7.5%**
DOE Budget Function	**47,817,100**	**47,881,756**	**51,415,029**	**+3,597,929**	**+7.5%**
NNSA Defense (050) Total	22,162,564	22,162,564	24,997,000	+2,834,436	+12.8%
Non-NNSA Defense (050) Total	8,796,035	8,796,035	8,734,675	-61,360	-0.7%
Defense (050)	*30,958,599*	*30,958,599*	*33,731,675*	+2,773,076	+9.0%
Science (250)	8,100,000	8,100,000	8,583,000	+483,000	+6.0%
Energy (270)	8,758,501	8,823,157	9,100,354	+341,853	+3.9%
Non-Defense (Non-050)	*16,858,501*	*16,923,157*	*17,683,354*	+824,853	+4.9%

(1) Funding does not reflect the mandated transfer of $99.75 million in FY 2023 from Naval Reactors to the Office of Nuclear Energy and the inclusion of the mandated transfer in the calculation of the rate of operations for FY 2024 for operation of the Advanced Test Reactor.

(2) Funding does not reflect the transfer of $20 million from the Office of Nuclear Energy to the Office of Science for Nuclear Facilities Oak Ridge National Laboratory Operations and Maintenance.

(3) FY 2023 Enacted levels for base funding includes $300 million for the Office of Nuclear Energy that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

(4) FY 2025 levels include the reallocation of $173 million in funding from Defense Environmental Cleanup to Weapons Activities to support the transition of oversight of the Savannah River Site to NNSA.

Energy Efficiency and Renewable Energy

Energy Efficiency and Renewable Energy

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, $3,118,000,000 to remain available until expended: Provided, That of such amount, $194,792,000 shall be available until September 30, [2025]*2026*, for program direction.

Energy Efficiency and Renewable Energy
($K)

FY 2023 Enacted[1]	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
2,891,000	2,891,000	3,118,000	+227,000

Mission
EERE's mission is to accelerate the research, development, demonstration, and deployment of technologies and solutions to equitably transition America to net-zero greenhouse gas emissions economy-wide by no later than 2050, and ensure 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. Our work aligns with and supports the Department's Equity Action Plan and is driven by four crosscutting principles:

- Building the clean energy economy in a way that benefits all Americans. We must address environmental injustices that disproportionately affect communities of color, low-income communities, and indigenous communities.
- Fostering a diverse STEM workforce. We need to 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 in a unified and coordinated way with state and local governments to accelerate an equitable transition to clean energy economies that benefit everyone.

Overview
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.

As the largest investor in clean energy technology development in the Federal Government, EERE's FY 2025 strategy continues its focus on funding five core programmatic priority areas for lowering the U.S. greenhouse gas (GHG) profile:

- <u>Decarbonizing the electricity sector</u>: 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.

[1] Exclude investment for State and Community Energy Programs (SCEP), Manufacturing and Energy Supply Chains (MESC), and Federal Energy Management Program (FEMP).

- 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.

The FY 2025 request highlights DOE and EERE mission critical investments:

- Drives innovation towards the Energy EarthShot targets (hydrogen, wind, geothermal, industrial heat, chemicals and fuels, affordable housing).
- Expands and coordinates support to utilities and regulators to integrate renewables, newly-electrified loads, and grid-edge technologies reliably and affordably.
- Increases supply chain security through new battery chemistries and improvements in the separation and processing of critical materials.
- Makes clean energy technologies and their benefits more accessible to Americans of all income levels and in all locations.

FY 2023 Accomplishments

Sustainable Transportation & Fuels

- Vehicle Technologies Office (VTO) invested in Clean Cities coalitions that improved transportation energy efficiency and advanced affordable, efficient, and clean transportation fuels and technologies. Combined efforts have yielded impressive results, which include the following:
  - Saved the equivalent of 13 billion gallons of gasoline through diverse transportation projects.
  - Eliminated more than 67 million tons of carbon dioxide emissions through projects that use alternative fuels and fuel-efficient technologies.
  - Placed more than 1.3 million alternative fuel vehicles on the road.
  - Grew from six Clean Cities coalitions in 1993 to more than 75 today, with coalitions in nearly every state.
  - Convened more than 20,000 public and private stakeholders to participate in local coalitions.
- Bioenergy Technologies Office (BETO) worked with several partners to help enable the National Renewable Energy Laboratory (NREL), D3MAX LLC, Southwest Airlines, LanzaJet, Novozymes, and other industry partners to develop technologies to produce sustainable aviation fuel that is less expensive than petroleum-based jet fuel and can reduce carbon emissions by over 80%, boosting ethanol yields by 14% and lowering costs by 33 cents per gallon.
- Hydrogen Fuel Cell Technologies Office (HFTO) investments have enabled the uptake of hydrogen fuel cells for forklifts and backup power applications. For example, years ago, HFTO cost-shared with industry the deployment of approximately 700 forklifts, and today there are more than 60,000 fuel cell forklifts in operation at major warehouses.

Renewable Energy

- Solar Energy Technologies Office (SETO) investments have put the U.S. on a path to drive the average levelized cost of utility-scale Solar Photovoltaic generation down to 3 cents /kWh by 2025 (without subsidies) and 2 cents/kWh by 2030. Also, SETO invested in several programs to reduce the soft costs – siting and permitting, labor, installation, maintenance – of deploying solar energy, especially for low- to moderate-income, or LMI, households and communities.

- Wind Energy Technologies Office (WETO) supported the development of a novel lightning protection coating to reduce damage to wind turbines caused by lightning, for which a technology licensing agreement was recently signed. Wind turbine damage from lightning is a major expense for wind plant operators, both due to loss of production from downtime and costs for repairs. This innovative protective coating helps address these challenges by enhancing the integrated lightning protection system and preventing blade punctures from lightning strikes. More broadly, WETO investments helped drive average U.S. wind capacity additions of 11.2 GW annually between 2018-2022, bringing cumulative domestic wind capacity to more than 144 GW by the end of 2022. Modeled forecasts expect average capacity additions of 11.3 GW per year for the next three years, which would result in cumulative installed capacity exceeding 175 GW at the end of 2025.
- Water Power Technologies Office (WPTO) supported the development of new marine energy hydrofoil (or blade) designs that use composite materials to reduce costs and increase energy capture by up to 24%.
- The Geothermal Technologies Office (GTO) investment enabling Fervo Energy (a geothermal company) to successfully conduct a 30-day well test and break ground on a new greenfield site for an enhanced geothermal system installation. This funding has helped accelerate progress on EGS demonstration and deployment to fully commercialize the next generation of geothermal systems.

Buildings & Industry

- Advanced Materials and Manufacturing Technologies Office (AMMTO) investments in the Critical Materials Institute (CMI) have resulted in development of a process to recover rare earth elements more easily, like neodymium, from magnets and other components in e-waste. This technique, called acid-free dissolution recycling (ADR), is responsive to expected increases in demand for rare earth elements. The technique and its byproducts reduce environmental impacts while ensuring increased recovery of the critical elements and diverting them from landfills. The company working on this technique, TdVib LLC, has recently helped produce new magnets from the recycled metal.
- Industrial Efficiency and Decarbonization Office (IEDO) invested in nine organizations—eight regional and one national—which established a network of Technical Assistance Partnerships (TAPs) to help industrial facilities and other large energy users increase the adoption of onsite energy technologies. The organizations received up to $23 million in federal funding for multi-year technical assistance activities to accelerate the integration and deployment of clean energy technologies to drive U.S. industrial decarbonization, productivity, and competitiveness.
- Building Technologies Office (BTO) funding supported an accelerator program to propel innovations to market. Three 2023 winners of this accelerator program have achieved important project milestones.
    - ThermoVerse, which is combining state-of-the-art thermal energy storage (TES) with ultralow power temperature and humidity sensing and Peltier heating and cooling to create a one-of-a-kind smart wallpaper™, was selected for LEEP's Innovation Crossroads node.
    - EarthEn, also selected for Innovation Crossroads, is developing Energy Pod, an energy storage solution that uses CO_2 and allows the storage of excess energy from solar and wind for long and short durations.
    - Westwood Aerogel was selected for Activate Berkeley for their development ZeroTherm, a scalable breakthrough aerogel insulation engineered to meet the growing demand for high-performance insulation materials.

Corporate Support Programs

Program Direction

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. EERE's commitment to efficient use of Program Direction (PD) resources led to the consolidation of staff into the Forrestal headquarters building and the elimination of program direction costs for leased space. PD's focus on human capital resources garnered 139 new federal employees onboarded. 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.

Energy Efficiency and Renewable Energy
($K)

	FY 2023 Enacted[1]	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023 Enacted	
				$	%
Sustainable Transportation & Fuels					
Vehicle Technologies	455,000	455,000	501,790	46,790	10%
Bioenergy Technologies	280,000	280,000	280,000	0	0%
Hydrogen and Fuel Cell Technologies	170,000	170,000	170,000	0	0%
Renewable Energy					
Renewable Energy Grid Integration	45,000	45,000	65,000	20,000	44%
Solar Energy	318,000	318,000	318,000	0	0%
Wind Energy	132,000	132,000	199,000	67,000	51%
Water Power	179,000	179,000	160,000	-19,000	-11%
Geothermal Technologies	118,000	118,000	156,191	38,191	32%
Buildings & Industry					
Advanced Manufacturing	450,000	450,000	0	-450,000	-100%
Advanced Materials & Manufacturing Technologies	0	0	220,000	220,000	0%
Industrial Efficiency & Decarbonization	0	0	287,227	287,227	0%
Building Technologies	332,000	332,000	340,000	8,000	2%
Corporate Support					
Program Direction	186,000	186,000	194,792	8,792	5%
Strategic Programs	21,000	21,000	21,000	0	0%
Facilities and Infrastructure	205,000	205,000	205,000	0	0%
Operations and Maintenance	*102,370*	*102,370*	*91,570*	*-10,800*	*-11%*
Facility Management	*57,630*	*57,630*	*59,430*	*1,800*	*3%*
Establish DOE 18th National Laboratory	*0*	*0*	*0*	*0*	*0%*
21-EE-001-Energy Materials and Processing at Scale (EMAPS)	*45,000*	*45,000*	*54,000*	*9,000*	*20%*
Total, EERE Organization	**2,891,000**	**2,891,000**	**3,118,000**	**227,000**	**8%**
Undersecretary for Infrastructure (EERE Appropriated funding)					
State and Community Energy Programs Total	493,000				
Manufacturing and Energy Supply Chains Total	19,000				
Federal Energy Management Program Total	57,000				
Grand Total, EERE Appropriation	**3,460,000**				

[1] FY 2023 Enacted comparable to show Advanced Manufacturing Office (AMO) Budget which comprises of the two organizational offices (AMMTO and IEDO) established in FY 2023

SBIR/STTR:

- FY 2023 Enacted: SBIR: $62,406,623; STTR $8,775,933
- FY 2024 Annualized CR: SBIR: $62,406,623; STTR $8,775,933
- FY 2025 Request: SBIR: $68,979,000; STTR: $9,700,000

Future Years Energy Program (FYEP)

($K)

	FY 2025 Request	FY 2026	FY 2027	FY 2028	FY 2029
Energy Efficiency and Renewable Energy	3,118,000	3,190,000	3,263,000	3,338,000	3,415,000

Outyear Priorities and Assumptions

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2026 - FY 2029. The outyear funding levels use the growth rates in outyear account totals published in the FY 2025 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Energy Efficiency & Renewable Energy priorities in the outyears include the following:

- EERE's outyear priorities maintains the Administration's strong commitment to Research and Development (R&D).
- Complying with the Executive Order on Tackling the Climate Crisis at Home and Abroad (including the Justice40 initiative).
- Promoting racial and economic equity across the Federal Government pursuant to Executive Order 13985 (Advancing Racial Equity and Support for Underserved Communities Through the Federal Government).
- Building Clean Energy Projects and Workforce Initiative.
- Decarbonizing the electricity sector.
- Decarbonizing transportation across all modes: air, sea, rail, and road.
- Decarbonizing the energy-intensive industries.
- Reducing the carbon footprint of buildings.
- Decarbonizing the agriculture sector, specifically focused on the nexus between energy and water.

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	FY 2025 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	$40,000,000	EERE
Clean Hydrogen Manufacturing Recycling Research, Development, and Demonstration Program	$100,000,000	$100,000,000	$100,000,000	$100,000,000	EERE
Clean Hydrogen Electrolysis Program	$200,000,000	$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	$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

Appropriated Funding Organization	FY 2022 IIJA Funding	FY 2023 IIJA Funding	FY 2024 IIJA Funding	FY 2025 IIJA Funding	Managing Organization
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**	**$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
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	$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	$600,000,000	MESC
Battery Material Processing Grants	$600,000,000	$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	$80,000,000	MESC
Industrial Research and Assessment Centers	$30,000,000	$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

Appropriated Funding Organization	FY 2022 IIJA Funding	FY 2023 IIJA Funding	FY 2024 IIJA Funding	FY 2025 IIJA Funding	Managing Organization
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	$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**	**$1,560,000,000**	**S3**
Total, EERE IIJA Coordination	**$8,207,200,000**	**$2,221,800,000**	**$1,945,000,000**	**$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**	
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**	

Energy Efficiency and Renewable Energy Crosscut Funding
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
Carbon Dioxide Removal	23,300	20,850	13,300	-7,550
CET - Artificial Intelligence and Machine Learning	52,056	61,000	76,000	+23,944
CET- Biotechnology and Biomanufacturing	96,514	96,514	103,750	+7,236
CET- Microelectronics	15,500	15,500	24,500	+9,000
Clean Energy Technology Manufacturing	321,143	313,258	370,250	+56,992
Clean Fuels and Products	339,500	359,500	353,890	-5,610
Critical Minerals and Materials	157,900	139,948	192,172	+52,224
Energy Storage	352,241	338,511	415,300	+76,789
Energy-Water	34,435	36,250	31,750	-4,500
Grid Modernization	162,440	171,100	247,990	+76,890
Hydrogen	216,160	203,560	210,100	+6,540
Industrial Decarbonization	612,788	572,538	603,927	+31,389
Subsurface Energy Innovations	118,000	81,750	90,250	+8,500
Infrastructure	103,893	103,893	144,595	+40,702
Pensions	38,249	38,249	53,847	+7,656
Research and Development	1,444,291	1,444,291	1,658,964	+214,673
Safeguards & Security	16,750	16,750	17,850	+1,100
Place-Based Initiatives	102,288	102,288	95,950	-6,338

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. The benefits and costs of transportation systems in the U.S. have historically been unequally distributed[7]. American transportation systems have disproportionally impacted underserved or overburdened communities. VTO will continue implementing strategies to ensure the benefits of federal investments flow to disadvantaged communities as described in the Justice40 Initiative.

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.

The 2025 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. In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

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[1] Bureau of Transportation Statistics, DOT, Transportation Statistics Annual Report 2020, Table 4-1. https://www.bts.gov/tsar.

[2] Transportation Energy Data Book 39th Edition, ORNL, 2021. Table 3.8 Shares of Highway Vehicle-Miles Traveled by Vehicle Type, 1970-2018.

[3] 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

[7] The U.S. National Blueprint For Transportation Decarbonization, 2023, https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

Vehicle Technologies
Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Vehicle Technologies					
Battery and Electrification Technologies	211,500		255,500	+44,000	+21%
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies	35,000		35,000	0	0%
Materials Technology	42,500		37,500	-5,000	-12%
Energy Efficient Mobility Systems	54,000		45,000	-9,000	-17%
Technology Integration & Deployment	106,000		122,790	+16,790	+16%
Data, Modeling, and Analysis	6,000		6,000	0	0%
Total, Vehicle Technologies	**455,000**	**455,000**	**501,790**	**46,790**	**10%**

SBIR/STTR:
- FY 2023 Enacted: SBIR: $12,809,000; STTR: $1,801,000
- FY 2024 Annualized CR: SBIR: $12,809,000; STTR: $1,801,000
- FY 2025 Request: SBIR: $15,001,000; STTR: $2,110,000

Vehicle Technologies
Explanation of Major Changes
($K)

	FY 2025 Request vs FY 2023 Enacted
Vehicle Technologies	
Battery and Electrification Technologies: The Request will increase 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. It will also support vehicle grid integration, including development of optimized charge management technologies and collaborative work with stakeholders.	**+44,000**
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies: No significant change.	**0**
Materials Technology: The decrease in funding will refocus on early-stage research on materials development and materials joining technologies to improve the sustainability and reduce the lifecycle greenhouse gas emissions from vehicle manufacturing. Research will target material solutions that can enable overall efficiency improvements while reducing demand for critical materials in battery electric vehicles.	**-5,000**
Energy Efficient Mobility Systems (EEMS): The decrease in funding will de-scope research and deployment efforts in breakthrough modeling, simulation, and the development of new transportation-system technologies, which have the potential to improve energy productivity through new mobility. Despite these reductions, the program will continue to support its core capabilities in modeling tools, extending these tools to demonstrations with key stakeholders, and researching new potentially disruptive transportation technologies to the broader transportation system. One area of focus is systems planning for freight and delivery which supports a broader theme of safe and secure domestic supply chains.	**-9,000**
Technology Integration & Deployment: Increase in funding will support a broad demonstration of vehicle/grid integration technologies to demonstrate management of electrical grid loads to enable large numbers of light-, medium-, and heavy-duty electric vehicle deployments	**+16,790**
Data, Modeling, and Analysis: 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 2025, projects will continue to support analytical capabilities and tools unique to DOE's National Laboratories.	**0**
Total, Vehicle Technologies	**+46,790**

Vehicle Technologies
Battery and Electrification Technologies

Description
The Battery and Electrification Technologies subprogram supports the decarbonization of transportation across all modes and supports the domestic 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 which aim to assure sustainability and domestic supplies of key battery materials and minerals.

The Battery R&D subprogram goals are:
- Reducing the cost of battery packs to less than $75/kWh while maintaining a vehicle range of at least 300 miles and decreasing charge time to less than 15 minutes by 2030.
- Achieve a battery cell manufactured cost of $60/kWh by 2030.

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.

The Electric Drive R&D subprogram goal is:
- By 2030, reduce the cost of 530 kW Electric Traction Drive Systems by 20% while increasing volumetric power density by 20%, compared to 2020 baseline, and enabling 1 million miles/25,000 hours operation in a class 8 truck without failure.

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.

The Electrification R&D subprogram goal is:
- Facilitate development and harmonization of a robust, interoperable, economically vibrant, resilient, cybersecure EV charging infrastructure that is integrated with a decarbonized modern grid.

Battery and Electrification Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Battery and Electrification Technologies $211,500,000	**$255,500,000**	**+$44,000,000**
Battery R&D $146,500,000	$200,500,000	+$54,000,000
• 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 battery active materials that diversify the lithium ion supply chain and focus on domestic supply chain security. Specifically, the increase will: 1. Support a significant expansion of fundamental work on sodium ion batteries while also starting to investigate full cell sodium ion electrochemical couples; 2. Advance the state-of-the-art in next generation phosphate based cathode materials; 3. Develop and improve processes to make lithium metal foils from domestically available precursors. 4. Investigate the potential and support early stage research of conversion based cathodes. These materials have the potential to deliver 3-5x the capacity of commercialized cathode materials. • Additionally, work will focus on lowering the cost of silane-derived silicon, enabling low-cost micro-silicon, and improving the performance of cobalt free cathodes.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Electric Drive R&D $22,500,000	$7,500,000	-$15,000,000
• 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.	• 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.	• Refocus activities on increasing the power density and efficiency of electric drive systems along with further cost reduction. • Support for SuperTruck projects reallocated to other sub-activities.
Electrification R&D $42,500,000	$47,500,000	+$5,000,000
• 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.	• Continue a laboratory research consortium funded in FY 2023. • Continue projects to develop lower cost and innovative vehicle charging concepts and technologies.	• The increase will address technical challenges of vehicle-grid integration. This will include development and demonstration of optimized charge management technologies, improved cyberposture of interactions within the charging ecosystem, and collaborative work with stakeholders to address interoperability.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• In support of the Cybersecurity crosscut, continue projects to develop secure vehicle-grid 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.	• Work with utility and local partners to address the unique challenges and opportunities 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.	• The increase supports funding for the SuperTruck projects from this sub-activity.

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 to reduce GHG emissions and achieve a net-zero economy by 2050. These technologies include electric and hybrid powertrains as well as high-efficiency engines that can use renewable fuels, such as advanced biofuels, hydrogen, and e-fuels. The subprogram also works on optimization of emission control systems to reduce environmental impact in environmental justice communities.

The Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies subprogram goals relative to a 2020 baseline are:

- Demonstrate a 50 percent reduction in GHG emissions in a locomotive engine by 2030.
- Enable a 25 percent efficiency improvement in an off-road vehicle by 2030.
- Demonstrate a 50 percent reduction in GHG emissions in a marine engine by 2030.
- Reduce Sustainable Aviation Fuel (SAF) certification time by 50 percent and enable use of 100 percent SAF (currently limited to 50 percent) by 2028.

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 unique, experimental, high-performance computing (HPC) and hardware in-the-loop facilities and capabilities at the National Laboratories facilities, to create knowledge, concepts, and research tools that industry can use to improve non-road powertrain efficiency and reduce GHG and criteria emission. The subprogram will coordinate with and use expertise from other agencies, DOE 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies $35,000,000	**$35,000,000**	**+$0**
• 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.	• Some sub-activities in the Heavy-duty Consortium activity are merged into this activity to include research on rail, marine and aviation technologies. No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 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.	• Conduct competitive solicitations with industry and universities to increase efficiency when using renewable fuels, such as advanced biofuels and hydrogen, in medium- and heavy-duty engines used in off-road, rail, marine and aviation while reducing GHG and criteria emissions. Improve potential for electrification/hybridization to further reduce emissions.	• Competitive solicitations to include off-road sector. No significant change.

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, critical 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 account for about 30% of a vehicles Lifecycle GHGs, and the Materials Technology subprogram supports research, development, and deployment to increase recyclability and reduce the overall embodied energy of vehicles, thereby reducing the vehicle's greenhouse emissions footprint. Materials will coordinate closely with the Battery and Electrification Technologies subprogram to support materials research and development to address key challenges in hermetic seal quality of battery enclosures, electrical conductivity, thermal conductivity, magnetic materials, and high temperature operation currently limiting advances in electric powertrains 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.

<u>Lightweight Materials:</u> 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 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.

<u>Powertrain Materials</u>: 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 2025, 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Materials Technology $42,500,000	**$37,500,000**	**-$5,000,000**
Lightweight Materials $35,500,000	$30,500,000	-$5,000,000
• 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. • Support the Carbon Fiber Technology Facility (CFTF) and the Composites Core Program targeting core innovations in applied composites R&D. • Multi-materials joining research will include research on multi-material joining and real time weld quality assessments of hermetic seals for battery enclosures to increase reliability and production rates of battery packs. • Continue the development and demonstration of lightweight materials and advanced material solutions in Medium Duty (MD)/Heavy Duty (HD) vehicles.	• The decrease in funding will result in more focus on early-stage research in materials development and materials joining technologies to improve the sustainability and reduce the lifecycle greenhouse gas emissions embodied in future vehicle systems. • Materials research with include research on multi-material joining and real time weld quality assessments of hermetic seals for battery enclosures. • Competitive awards will be limited to awards under the LightMAT activity within the Materials Technology program.
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 2025 Request	Explanation of Changes FY 2025 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 and 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.

The EEMS subprogram goal is:
- Work with three major metropolitan areas to identify solutions through modeling and simulation that improve travel efficiency by 40% by 2050.

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 to improve the efficiency, increase the convenience, and lower the costs of the overall transportation system. 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 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Energy Efficient Mobility Systems $54,000,000	**$45,000,000**	**-$9,000,000**
Computational Modeling and Simulation $28,000,000	$25,000,000	-$3,000,000
• 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, increased efficiency, increased convenience, and lowering costs 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.	• Shift core investments from modeling and simulation R&D stage to targeted application via demonstration and deployment with stakeholders. Decrease in funding will result in more focus on the highest potential capabilities.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Connectivity and Automation Technologies $26,000,000	$20,000,000	-$6,000,000
• 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 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 transition. • Continue funding selected projects previously awarded under the cross-cutting VTO and HFTO SuperTruck solicitation.	• Prioritize building on previous R&D efforts that have demonstrated the highest potential for efficiency improvements while reducing stakeholder engagement efforts, which are currently underway and in a sustainable place. • Continue SuperTruck efforts including use of heavy-duty dynamometer to support SuperTruck projects and use of new freight modeling capabilities to support scenario analysis.

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 2025, 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 2025, 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 2025, 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.

Vehicle Technologies
Technology Integration & Deployment

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Technology Integration & Deployment $106,000,000	**$122,790,000**	**+$16,790,000**
Technical Assistance $94,000,000	$110,790,000	+$16,790,000
• 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.	• 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 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).	• Increase in funding will support a broad demonstration of vehicle/grid integration technologies to demonstrate management of electrical grid loads to enable large numbers of light-, medium-, and heavy-duty electric vehicle deployments.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Initiate a Smart Charging Vehicle-Grid Integration Project to demonstrate smart charging and business models that improve costs and efficiency for the acquisition and operation of new EV models for local governments, utilities, transit, schools, ports, and goods movement. • 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 SuperTruck III demonstration projects.	• Continue collaboration with Underserved communities to address access to equitable transportation and mobility choices.	
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.	• No significant change.
• In accordance with requirements in the Energy Policy and Conservation Act of 1975, publish and distribute the new model year Fuel Economy Guide, in partnership with the U.S. Environmental Protection Agency, update data and tools (e.g., Find-a-Car, Fuel Cost & Savings Calculator) and fuel economy information on www.fueleconomy.gov	• In accordance with requirements in the Energy Policy and Conservation Act of 1975, publish and distribute the new model year Fuel Economy Guide, in partnership with the U.S. Environmental Protection Agency, update data and tools (e.g., Find-a-Car, Fuel Cost & Savings Calculator) and fuel economy information on www.fueleconomy.gov	• No significant change.
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	• Implement year 4 of the EcoCar EV Challenge.	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
electrification challenges in the future of mobility, advanced powertrain, charging, and thermal systems to use grid electricity intelligently.		

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 2025, 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $6,000,000	**$6,000,000**	**+$0**
• 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.	• Continue 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.

Overview

The Bioenergy Technologies Office (BETO) develops and demonstrates technologies to accelerate greenhouse gas emission (GHG) reductions through the cost-effective, sustainable use of biomass and waste feedstocks across the U.S. economy. BETO's research, development and demonstration (RD&D) activities focus on developing safe and secure domestic supply chains for renewable waste streams and biomass, and to develop cost-effective conversion technologies to produce clean fuels and products. Bioenergy and renewable chemicals and materials (also referred to as bioproducts) are essential to decarbonizing the transportation and industrial sectors and can contribute to decarbonization of adjacent sectors of the economy, such as the agricultural and power sectors. In addition to reducing GHGs across economic sectors, bioenergy and bioproducts support increased economic activity across the entire supply chain—reducing waste streams in our communities, creating new jobs in the farms and forests of rural America, and contributing to growth in the nation's construction and manufacturing industries. Investing in new bioenergy technologies helps secure our national competitive advantage and enables private sector opportunities in the renewable energy field.

The U.S. transportation sector overwhelmingly relies on petroleum, which supplies over 90 percent of its energy needs.[1] Aviation, marine, rail and heavy-duty vehicles account for 39 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 RD&D portfolio to enable the production of biofuels and bioproducts from the entire range of renewable carbon resources to ensure that the economic and environmental benefits of the bioeconomy accrue in all regions of the country.

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. In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

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[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.

Bioenergy Technologies
Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	FY 2025 vs FY 2023
Bioenergy Technologies					
System Development and Integration	92,600		122,500	+29,900	+32%
Renewable Carbon Resources	77,900		68,000	-9,900	-13%
Conversion Technologies	100,000		80,000	-20,000	-20%
Data, Modeling, and Analysis	9,500		9,500	0	0%
Total, Bioenergy Technologies	**280,000**	**280,000**	**280,000**	**0**	**0%**

SBIR/STTR:

- FY 2023 Enacted: SBIR $8,643,000; STTR $1,215,000
- FY 2024 Annualize CR: SBIR $8,643,000; STTR $1,215,000
- FY 2025 Request: SBIR $8,672,000; STTR $1,220,000

Bioenergy Technologies
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Bioenergy Technologies	
Systems Development and Integration: The increase in funding for this subprogram will support pilot- and demonstration-scale biorefineries with a focus on producing sustainable aviation fuel (SAF) which will directly support the Sustainable Aviation Fuel Grand Challenge, 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. The increase will also support the upgrades to the Integrated Biorefinery Process Development Unit at NREL.	**+29,900**
Renewable Carbon Resources: Reduction in funding reflects the use of prior year funds for foundational genomics for algal strains to harness algal diversity to improve productivity and quality. Increased funding for sustainable agriculture R&D and field testing of purpose-grown energy crops, including algae, that are necessary to meet the SAF Grand Challenge volumetric goals.	**-9,900**
Conversion Technologies: The reduction in funds reflects a shift from earlier stage and lower TRL R&D that will be scaled back in favor of supporting pilot and demonstration-scale biorefinery projects and advancing furthering maturing technologies, facilitating their transfer to industry, developing overall process data, and increasing commercial readiness.	**-20,000**
Data, Modeling, and Analysis: No major changes.	**0**
Total, Bioenergy Technologies	**0**

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 will identify opportunities and barriers to the deployment of low-carbon fuels to reduce emissions in hard-to-decarbonize modes of transportation, including aviation, marine shipping, freight rail, medium- and heavy-duty vehicles, and non-road applications. This activity will support analysis related to real world engine testing to verify emission reduction potential and identify favorable fuel characteristics for use in hard-to-decarbonize modes of transportation in partnership with the Vehicle Technologies Office.

Systems Development and Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Systems Development and Integration $92,600,000	**$122,500,000**	**+$29,900,000**
Production Process $92,368,000	$117,500,000	+$25,132,000
• 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.	• Continue 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. Funding would support the construction phase of one demonstration-scale and two pilot-scale integrated biorefineries.	• Continues the emphasis on scale-up of pathways to produce low-carbon fuels from a diverse range of biomass and waste feedstocks with a focus on SAFs. This increase, and the use of prior year funds, will support the construction phase of three pilot- and two demonstration-scale integrated biorefineries under the Program's Multi-Year Scale-up strategy initiated in FY 2021.
• 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.	• No funds requested.	• No funding is requested in favor of providing adequate funds for the construction phase of pilot and demonstration-scale integrated biorefineries under the Program's Multi-Year Scale-up strategy.
• 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.	• Continue to address challenges in processing high impact feedstocks, from the bale yard inside the plant into various types of conversion reactors at relevant engineering scales.	• Increased funding will enable support for the scale-up 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.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Fuels and Co-Products R&D $232,000	$5,000,000	+$4,768,000
• 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, marine, rail and other heavy-duty biofuels, and explore non-CO_2 climate impacts of SAF formulations including the formation of contrails.	• Efforts will expand to assess how SAF blends can reduce the formation of contrails and provide additional funding for Non-CO_2 related work with marine, rail and other heavy-duty applications.
• Funding feasibility analyses to identify potential opportunities and challenges for the production and use of biofuels in the marine and rail sectors.	• Continue feasibility and expand upon analyses for marine and rail sectors, but with additional inclusion of off-road sectors.	• Real world engine testing is required to demonstrate the emission reductions of biofuels in these hard-to-decarbonize modes of transportation and to validate the models and tools that have been developed to further encourage adoption by the marine and rail industries.

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:

<u>Terrestrial and Waste Feedstocks R&D</u>: 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.

<u>Aquatic Feedstocks R&D</u>: 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 and macroalgae. 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Renewable Carbon Resources $77,900,000	**$68,000,000**	**-$9,900,000**
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.	• No funds requested for Billion Ton Study.	• Billion Ton Study completed with prior year funding.
• 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.	• Continue 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 necessary to meet the US SAF Grand Challenge volumetric goals.
• 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.	• Support R&D efforts to apply National Laboratory tools and capabilities to address industry challenges to scaling-up feedstock handling and preprocessing systems.	• Early-stage research is completed with prior year funds. Reduced funding levels will support industrial partnerships to advance technologies on feedstock handling and preprocessing to improve reliability at scale.
• 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 production costs, including developing crop protection strategies to prevent pond crashes.	• 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 in FY 2023.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Continue research on applications of foundational genomics for algae strains to harness algal diversity to improve productivity and quality.	• Research on applications of foundational genomics for algae strains to harness algal diversity to improve productivity and quality will continue using prior year funds.	• No funds requested in order to prioritize increased focus on field testing of regionally-appropriate energy crops.
• 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 initiated in FY24 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.	• Increase focus on field testing of regionally-appropriate energy crops that are critical to reaching the Program’s outyear SAF volumetric targets.

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 to produce 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 to produce 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Conversion Technologies $100,000,000	**$80,000,000**	**-$20,000,000**
Bio-Processing R&D $31,322,000	$26,300,000	-$5,022,000
• 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 focusing on 2 organisms and 2 intermediates each for sustainable aviation fuels and chemicals. 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.	• Reduced funding reflects the prioritization of later stage technologies under the Deconstruction and Synthesis R&D Activity. Agile BioFoundry will prioritize R&D on its high-priority organisms and intermediates for SAFs and chemicals. No funds are requested to support partnerships with industry on the use of novel organisms or intermediates that are not included in the strategic plan.
• 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 continue to investigate carbon negative (or low carbon intensive) products/chemicals through the deconstruction of diverse types of biomass feedstocks into clean sugars and other intermediates and novel approaches such as cell-free processing.	• No significant change.
Catalyst R&D $31,500,000	$20,500,000	-$11,000,000
• 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	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 will focus on enabling fuel pathways that reduce GHG	• Reduced funding reflects the prioritization of later stage technologies under the Deconstruction and Synthesis R&D Activity. Catalytic upgrading pathways will focus on those with the greatest potential for GHG and/or cost reduction including strategies that use existing petroleum refinery equipment to reduce capital costs for biofuel production.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
transportation and industry. Catalyst 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.	emissions up to 70 percent compared to 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.	• Continue applied R&D on key barriers to CO_2 utilization in coordination with the Office of Fossil Energy and Carbon Management and the Office of Science.	• Reduced funding reflects the prioritization of later stage technologies under the Deconstruction and Synthesis R&D Activity. R&D will be reduced to focus on most promising barriers that can be addressed with capabilities unique to BETO as identified in cross-office workshops and discussions.
Deconstruction and Synthesis R&D $37,178,000	$33,200,000	-$3,978,000
• 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 transfer of improvements to pretreatment and hydrolysis to industrial partners and identify and address remaining barriers.	• Limit R&D to remaining barriers.
• 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.	• No funds are requested for lignin products technology development.	• Transfer of lignin products technologies to industry will continue using prior year funds.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 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 are requested for additional feasibility studies.	• Technical assistance efforts will continue due to the high interest and positive feedback from communities. Feasibility studies will continue using prior year funds.
• 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 in partnership with major industrial entities.	• No significant change.
• Funding for research and testing of high-efficiency, low-emission wood stoves.	• No funds are requested.	• Wood stove research and testing will continue with prior year funds.
• Initiate analysis and strategic planning to support later stage conversion technology R&D and process development to accelerate technology commercialization and enable scale-up of new production pathways to biofuels and bioproducts.	• Continue later stage R&D efforts with industrial partners to address technology risks associated with scaling up new conversion processes to produce biofuels and bioproducts.	• Increased funding to support later-stage R&D. This effort will focus on a limited number of the most promising near-term technologies that will enable piloting and demonstration of new pathways to biofuels and bioproducts.
• 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.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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.	• No significant change.

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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $9,500,000	**$9,500,000**	**$0**
• Continue strategic analyses on current case studies of developing and deployed bioenergy 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 case studies on developing and deployed bioenergy 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 from FY 2023 to identify ways to address administration priorities in equity and environmental justice.	• Continue analysis on environmental and social impacts of biorefinery siting and initiate development of a siting tool for new biorefineries.	• 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.

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. As stated in the National Clean Hydrogen Strategy and Roadmap, clean hydrogen has the potential to reduce economy-wide emissions 10% by 2050 and create 100,000 jobs by 2030.

In FY 2025, 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.

In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

Hydrogen and Fuel Cell Technologies
Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Hydrogen and Fuel Cell Technologies					
Fuel Cell Technologies	30,000		25,000	-5,000	-17%
Hydrogen Technologies	67,000		67,000	0	0%
Systems Development & Integration	70,000		75,000	+5,000	+7.1%
Data, Modeling & Analysis	3,000		3,000	0	0%
Total, Hydrogen and Fuel Cell Technologies	**170,000**	**170,000**	**170,000**	**0**	**0%**

SBIR/STTR:

- FY 2023 Enacted: SBIR: $5,024,000; STTR: $706,500
- FY 2024 Annualized CR: SBIR: $5,024,000; STTR: $706,500
- FY2025 Request: SBIR: $5,020,800; STTR: $706,050

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

	FY 2025 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.	**0**
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.	**+5,000**
Data, Modeling & Analysis: No significant changes.	**0**
Total, Hydrogen and Fuel Cell Technologies	**0**

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 domestic supply chain security and technology 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 uses 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 or eliminate 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 balance-of-plant (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 2025 Request	Explanation of Changes FY 2025 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 and expand alternative membrane R&D 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, including R&D to enable high temperature operation to address system thermal management challenges.	• 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 and stationary 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. The subprogram also supports activities to enable standardization of components, reduce dependence on critical materials to support robust domestic supply chains.

<u>Production R&D</u>: 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 Bipartisan Infrastructure Law's (BIL) 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, advance these clean energy technologies and maintain American competitiveness. 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.

<u>Storage R&D</u>: 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 and carrier storage technologies as well as other innovative concepts supported by the multi-laboratory Hydrogen Materials Advanced Research Consortium (HyMARC).

<u>Infrastructure R&D</u>: 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. Emphasis will be on bulk and high-capacity delivery pathways, including pipelines. RD&D investigating and developing hydrogen compatible materials (e.g., metals, polymers) and refueling components for heavy-duty stations will continue in collaboration with the H-Mat consortium. Activities will be coordinated with the Office of Fossil Energy and Carbon Management (FECM).

Hydrogen Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Hydrogen Technologies $67,000,000	**$67,000,000**	**$0**
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 toward component integration and reactor concepts in addition to materials development.	• No significant change.
Storage R&D $22,000,000	$22,000,000	$0
• 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 materials-based carrier systems, carbon fiber composites, and other innovative concepts for hydrogen transport and storage.	• Continue liquid hydrogen activities until data is collected from prior year projects. Prioritize bulk and high-capacity technologies for storage and transport applications in alignment with industry priorities on clean hydrogen in the near-term.
Infrastructure R&D $30,000,000	$30,000,000	$0
• 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 carrier scale up and system development for hydrogen storage and transport, potentially for applications such as export and energy storage.
• 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, monitoring, and fueling component technologies.	• Continue liquid hydrogen fueling component activities. Prioritize high-capacity infrastructure technologies for hydrogen transport applications, including pipelines, and monitoring, in alignment with industry priorities on clean 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 2025 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Systems Development & Integration $70,000,000	**$75,000,000**	**+$5,000,000**
Transportation $29,000,000	$39,000,000	+$10,000,000
• 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	$10,000,000	$0
• 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.	• Maintain 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.	• Includes activities on hydrogen for thermal integration for industrial and chemical applications (e.g., SAFs, methanol, etc.).
Grid Energy Storage and Power Generation $16,000,000	$16,000,000	$0
• 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.	• Emphasize industry-led projects for grid-integration with hydrogen technologies and electrolyzer cycling including hybrid approaches to enhance the stability/resiliency of the power grid and enable production of low cost, clean hydrogen.	• Focuses funding on grid integration with hydrogen technologies such as wind, nuclear, long duration energy storage, and grid services.
• 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 2025 Request	Explanation of Changes FY 2025 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.	• Transitioned 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. • Further develop and share best practices and lessons learned by pursuing education, training, and workforce development activities. • Further develop resources to address regulatory and permitting barriers to hydrogen deployments. • Continue work on sensor development and leak quantification.	• 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. • Continue developing and sharing best practices and lessons learned through education, training, and workforce development activities. • Prioritize addressing regulatory barriers, including tunnels and pipelines. • Focus on sensor technology validation and leak quantification.	• No significant change. • Reduces activities on workforce development to focus on RD&D needs including sensor validation, permitting and codes and standards. • Emphasizes addressing hydrogen vehicle use in tunnels. • 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.

The subprogram continues to emphasize 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 infrastructure rollout scenarios, 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 2025 Request	Explanation of Changes FY 2025 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 and water requirements 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.

Renewable Energy Grid Integration

Overview

Decarbonizing the electricity sector will require unprecedented increases in renewable electricity generation, with the bulk of this new generation likely to come from wind and solar power.[1] In addition, a growing number of states and communities are seeking to tap into our nation's abundant, domestic renewable energy resources. Investments in State and Local partnerships support state and local governments with the necessary resources to pursue their affordable and resilient clean energy goals.

As states pursue clean energy, power system planning and operations must evolve to accommodate variable resources that use power electronics rather than resources physically synchronized with the grid, while ensuring the long-term reliability and resilience of the system. The Renewable Energy Grid Integration (REGI) program takes a holistic approach to integration challenges across many technologies and systems. These challenges include:

- <u>Planning a Decarbonized Grid</u>: 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.
- <u>Developing Tools and Technologies to Operate a Decarbonized Grid</u>: 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.
- <u>Addressing Infrastructure Needs and Interdependencies</u>: This includes improving renewable energy project siting and permitting processes and better understanding how to deploy additional system capacity. We must also increase existing transmission capacity use and account for the interdependencies between electricity, fuels, communication, and other infrastructures.
- <u>Accommodating Diverse State Preferences, Markets, and Business Models</u>: This includes assistance to grid operators in developing market products and tools for facilitating the mutual matching of generation and load, allowing for the optimization of energy storage, and ensuring long-term incentives for power system flexibility and resource adequacy. This also includes meeting state and community decision-makers where they are to support choice-based renewable energy buildout.

Addressing these challenges requires new technologies; improved data, tools, and models; and new analysis that directly supports decision-makers responsible for the planning, operation, and regulation, 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 REGI program supports projects coordinated across the energy sector, leveraging staff and expertise within the wind, solar, geothermal, and water program offices. The REGI program also provides the connective tissue for grid-focused collaborations with EERE's Buildings and Industry pillar and Sustainable Transportation and Fuels pillar, as well as the Office of Electricity. REGI supports coordination on and contribution to the Grid Modernization Initiative, focused specifically on tools and technologies that directly facilitate the integration of variable renewables and capitalize on the value of dispatchable renewables like hydropower and geothermal.

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

Renewable Energy Grid Integration

Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Renewable Energy Grid Integration	45,000		65,000	20,000	44%
Total, Renewable Energy Grid Integration	**45,000**	**45,000**	**65,000**	**20,000**	**44%**

SBIR/STTR:

- FY 2023 Enacted: SBIR: $0; STTR: $0
- FY 2024 Annualized CR: SBIR: $0; STTR: $0
- FY 2025 Request: SBIR: $0; STTR: $0

Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Request
Renewable Energy Grid Integration: Prioritize increase of FY 2025 investments to directly support validated data, tools, technical assistance, and real-world experience that give power system and grid edge decision-makers the confidence to increase renewable generation and decarbonize end uses while maintaining or improving affordability, reliability, and resilience for end users.	**+20,000**
Total, Renewable Energy Grid Integration	**+ 20,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Renewable Energy Grid Integration $45,000,000	**$65,000,000**	**$20,000,000**
• 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.	• Funding will continue at the same level.
• 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.	• Funding will continue at the same level.
• 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 and permitting program; continue to develop TA solutions and disseminate learnings to key energy stakeholders engaged in siting, permitting, and community acceptance.	• Funding will continue at the same level.
• 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.	• Provide validated data, tools, technical assistance, and real-world experience that give power system and grid edge decision-makers the confidence to increase renewable generation and decarbonize end uses while maintaining or improving affordability, reliability, and resilience for end users.	• Increased funding to reflect new cross-cutting initiative supporting decision-makers facing a rapidly changing grid and increasing end-use electrification.
• 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.	• Increased funding to reflect new cross-cutting initiative supporting decision-makers facing a rapidly changing grid and increasing end-use electrification.

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 2025 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, [1] up from 5 percent today.[2] 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. In 2022, only 16 percent of solar photovoltaic (PV) modules deployed in the U.S. were domestically made, and the domestic content of the solar hardware installed was only about 20 percent.[3] However, manufacturing capacity is growing significantly across the full supply chain, which will increase these numbers over the coming years.

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 150 GW_{dc} of solar generating capacity has been deployed across the U.S.,[4] a 70-fold increase since 2010. This increase in deployment has been a source of significant job growth, with the industry employing 346,000 workers in 2022.[5] 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 components must continue to fall to make this broadly affordable. Accordingly, in 2021 DOE 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.[6]

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 challenges related to generation and load forecasting, real time situational awareness, control coordination, system

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

2 IEA/PVPS, "National Survey Report of PV Power Applications in the United States of America, 2022."

[3] Brittany Smith, et al., NREL, June 2023, based on 2021 data for direct costs as defined by 26 CFR 1.263A-1(e)(2)(i).

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

[5] "US Energy Employment Report," Department of Energy. USEER 2023 National Report (energy.gov).

[6] DOE/SETO, "2030 Solar Cost Targets," August 2021, http://www.energy.gov/eere/solar/articles/2030-solar-targets.

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.

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.

In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

Solar Energy
Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Solar Energy					
Concentrating Solar Power Technologies	60,000		50,000	-10,000	-17%
Photovoltaic Technologies	77,000		65,000	-12,000	-16%
Systems Integration	55,000		73,000	+18,000	+33%
Balance of Systems Soft Cost Reduction	56,000		65,000	+9,000	+16%
Manufacturing and Competitiveness	70,000		65,000	-5,000	-7%
Total, Solar Energy	**318,000**	**318,000**	**318,000**	**+0**	**+0%**

SBIR/STTR:

- FY 2023 Enacted: SBIR: $8,092,000; STTR: $1,138,000
- FY 2024 Annualized CR: SBIR: $8,092,000; STTR: $1,138,000
- FY 2025 Request: SBIR: $8,544,000; STTR: $1,202,000

Solar Energy
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Concentrating Solar Power Technologies: Funding for Generation 3 CSP thermal systems and solar thermal industrial applications can be decreased while projects funded in prior years yield results. This decrease is partly offset by an increase in funding to study power cycle reliability. The request maintains an emphasis on advancing solar collectors to drive overall decreases in CSP costs.	**-10,000**
Photovoltaic Technologies: Funding for advanced photovoltaic thin film technologies can be decreased while major investments made in FY24 and prior years yield results. This decrease is partly offset by a new focus on developing a better understanding of PV inverter reliability, which is the largest reliability issue for PV systems.	**-12,000**
Systems Integration: Funding for solar systems integration technology and tool development would be expanded so that work can focus on demonstration projects and collaboration with industry. Increased funding would also enable an expansion of activities in cybersecurity R&D, support for enhancing community resilience with PV and other distributed energy resources, as well as research into the reliability of PV inverters (in collaboration with the PV subprogram).	**+18,000**
Balance of Systems Soft Cost Reduction: Increased funding would support research and technical assistance to address siting, permitting, and interconnection barriers to solar deployment, as well as increased support for the National Community Solar Partnership Community Power Accelerator.	**+9,000**
Manufacturing and Competitiveness: A moderate reduction in funding will focus efforts on technologies most likely to support domestic manufacturing growth.	**-5,000**
Total, Solar Energy	**+0**

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 to produce 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.

<u>Thermal Systems R&D</u>: 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.

<u>Power Cycles R&D</u>: 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.

<u>Solar Collector R&D</u>: 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.

<u>Industrial Applications R&D</u>: 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Concentrating Solar Power Technologies $60,000,000	**$50,000,000**	**-$10,000,000**
Thermal Systems R&D $20,851,000	$15,000,000	-$5,851,000
• 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 for new FY 2025-27 projects for National Laboratory research programs and other lab projects related to Gen3 CSP thermal systems and long duration thermal storage.	• No significant changes expected with new lab call research.
• 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. Support to the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories (SNL).	• Maximize learnings from the Generation 3 Particle Pilot Plant at SNL through collaborative research. A competitive solicitation topic to improve the reliability and performance of commercial high-temperature components and systems.	• Reduced funding focuses on commercial CSP reliability while prior year funded topics continue to conclusion.
• 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 2025 competitive solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in thermal systems are eligible.	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Power Cycles R&D $4,794,000	$8,000,000	+$3,206,000
• 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 for new FY 2025-27 projects for National Laboratory research programs and other projects. Work focuses on developing primary heat exchangers for advanced CO_2 power cycles.	• No significant changes expected with new lab call research.
	• A competitive solicitation will focus on continued innovation, maturation, or commercialization of CO_2 power cycles for CSP as well as reliability of existing commercial power cycles.	• Increased funding to further advance overall power cycle innovation and reliability.
• 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 2025 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in power cycles are eligible.	• No significant change.
Solar Collector R&D $15,299,000	$15,000,000	-$299,000
• 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 for new FY 2025-27 projects for National Laboratory research programs and other projects. This work will focus on developing optical components and improved optical characterization methods for CSP collector fields.	• No significant changes expected with new lab call research.
• Continue funding of a National Laboratory consortium test facility on heliostat development and validation.	• Continue funding of a National Laboratory consortium on heliostat development and validation.	• Planned decrease in funding to accommodate an increased focus on collector reliability.
	• A competitive solicitation to characterize the performance and reliability of trough and heliostat fields.	• Increased funding to address important topic of collector reliability.
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP	• Funding for FY 2025 broad solicitation on 1-year innovative seedling R&D projects for CSP	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
research. All topics in solar collectors are eligible.	research. All topics in solar collectors are eligible.	
Industrial Applications R&D $19,056,000	$12,000,000	-$7,056,000
• 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 to progress towards decarbonization of the chemical industry.	• Funding for new FY 2025-27 projects for National Laboratory research programs and other projects. Work focuses on researching novel pathways for the solar thermal production of ammonia and hydrogen to progress towards decarbonization of the chemical industry as well as direct integration of solar thermal process heat with a range of industries.	• Increased emphasis on industrial applications in FY 2025-2027 National Laboratory research.
• Continue development of solar-thermal-driven industrial processes for decarbonizing the industrial sector. FY 2023 efforts will emphasize more mature demonstrations to accelerate deployment.	• Based on learnings from DOE's Energy Earthshots and recent SETO FOA topics, a focused competitive solicitation to prove the best opportunities for solar thermal heat production for industrial decarbonization.	• Significant decrease in funding while learning is derived from projects supported in prior years.
• 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 2025 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in industrial applications are eligible.	

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.

<u>Conversion Efficiency R&D</u>: 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.

<u>Durability R&D</u>: 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.

<u>Materials Availability R&D</u>: This activity supports R&D to better understand how the availability and environmental impacts of key materials used in PV systems could constrain the supply chain for 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Photovoltaic Technologies $77,000,000	**$65,000,000**	**-$12,000,000**
Conversion Efficiency R&D $42,020,000	$27,000,000	-$15,020,000
• 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 core National Laboratory research programs with new scope for FY 2025-27 to advance PV cell and module performance.	• No significant changes expected with new lab call research.
• Funding for 1-year innovative seedling R&D projects focused on material constraints and reducing PV system waste at end of life.	• A competitive solicitation on 1-year innovative projects for PV research.	• No significant change.
• Funding for competitive solicitation on thin film PV to increase performance.	• No funding requested.	• Decrease in funding because projects funded in FY23 are still active.
• 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	$36,000,000	+$4,806,000
• 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 core National Laboratory research programs with new scope for FY 2025-27 to advance PV system durability and resilience.	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 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 joint competitive solicitation with Systems Integration subprogram on PV system durability including inverters and PV balance of system components.	• Increased funding to address gap in SETO portfolio related to inverter and system durability.
• 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.	• Funding for additional competitive projects to augment the CdTe accelerator consortium.	• No significant change.
Materials Availability R&D $3,786,000	$2,000,000	-$1,786,000
• 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.	• National Laboratory work to support international collaborations on PV end of life and recycling, and augment PV End of Life Collaborative launched FY24 with BIL funding.	• No competitive funding topic in FY25, as prior year work is still underway.

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. Solar PV technologies can present challenges for power system planning and operation due to their variable nature, fast-responding power electronics, and their deployment on both the bulk power and distribution systems. Additional challenges arise from the rapid deployment of digital sensors and communication networks that produce a vast volume of operational and control data. Today PV systems produce 5% of U.S. electricity, with over 4 million systems connected to the distribution system. As deployment of these technologies further increases, it is critical that their grid support capabilities be demonstrated in real world situations at a large scale to help grid planners and operators make better decisions for grid reliability, resilience, and security.

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 as cyberattacks, hurricanes, floods, wildfires, and hardware failure. 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.

Systems Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Systems Integration $55,000,000	**$73,000,000**	**+$18,000,000**
Planning and Modeling R&D $11,514,000	$20,000,000	+$8,486,000
• 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 new FY 2025- 2027 lab call projects. Work will focus on dynamic models for PV and power systems, high resolution measurement data, solar resource forecast and integration, reliability standards, data, studies, and testing and validation. Also supports a new prize competition for solar and power system data and model validation.	• Modest increase in funding for the new prize competition for solar and power system data and model validation.
• 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 Office of Electricity (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.	• Funding increase will expand planning tools development with stronger focus on demonstration and collaboration with industry.
Operation and Control R&D $38,505,000	$39,000,000	+$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. This includes demonstration of the interoperability and co-optimized operation of multiple DER and DER aggregation technologies including solar PV, electric vehicle, grid-interactive building, long	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	duration energy storage to improve clean energy deployment, grid reliability, and economic efficiency. This is an EERE and OE collaboration.	
Resilience and Security R&D $4,981,000	$14,000,000	+$9,019,000
• 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 new FY25-FY27 lab call projects. Work will focus on addressing community resilience and cybersecurity challenges with solar, energy storage, and DER-based solutions. These may include the development of solar and DER cybersecurity standard, equipment testing and validation, vulnerability assessment tools and methods, and information sharing mechanism. For resilience, support activities in solar microgrid demonstration, measurement and verification, and cost/benefits analysis. This is an EERE and CESER collaboration. • Funding for competitive solicitation to address inverter reliability and advanced inverters utilizing wide bandgap semiconductors.	• Increase in funding to focus on cybersecurity and resilience. • Increasing efforts on durability of existing commercial PV inverters as well as research on the durability of PV inverters using wide band gap semiconductors.

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 346,000 jobs in 2022. 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Balance of Systems Soft Cost Reduction $56,000,000	**$65,000,000**	**+$9,000,000**
Data, Modeling, and Analysis $10,887,000	$13,000,000	+$2,113,000
• Maintain National Laboratory FY 2022-24 projects to advance data, modeling, and analysis for the reduction of solar soft costs.	• Funding to support FY25-27 national lab projects to advance data, modeling, and analysis for the reduction of solar soft costs.	• Increase for new lab data analysis projects.
• Support EERE and cross-DOE data, tools, and analysis projects to facilitate the widespread integration of renewables in a resilient, reliable power system.	• Continue to support EERE and cross-DOE data, tools, and analysis projects.	• No significant change.
Technical Assistance and Stakeholder Tools $37,313,000	$43,000,000	+$5,687,000
• 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 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.	• No significant change.
• 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.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Support additional multi-stakeholder team participation in the Solar Energy Innovation Network and the replication of solutions developed in previous rounds of the program.	• Support additional multi-stakeholder team participation in the Solar Energy Innovation Network and the replication of solutions developed in previous rounds of the program.	• No significant change.
• Provide local governments, utilities, and other stakeholders with technical assistance on solar grid interconnection via the Interconnection Innovation Exchange (i2x) and on permitting via SolarAPP+.	• Provide local governments, host communities, utilities, and other stakeholders with technical assistance on solar siting, permitting, and interconnection of solar energy, including supporting technical assistance to enable local jurisdictions to adopt the SolarAPP+.	• Increased emphasis on siting, permitting, and interconnection barriers to solar deployment.
STEM & Workforce Development $7,800,000	$9,000,000	+$1,200,000
• Fund competitive awards to advance workforce goals related to curriculum development and dissemination.	• Expand a national workforce technical assistance program to enable replication and scale up of successful training models and programs across the country.	• Additional funding to expand workforce program and replicate successful models.
• 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.	• Continue support for the Clean Energy Innovator Fellowship program.	• 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, 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 20th 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Manufacturing and Competitiveness $70,000,000	**$65,000,000**	**-$5,000,000**
American-Made Challenges $6,500,000	$7,000,000	+$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—now in its 8th year—to support innovators in launching new products that advance the solar industry and support the development of the associated workforce.	• Small increase in funding to include support for workforce development.
• 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	$58,000,000	-$5,500,000
• 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 equipment and other PV module and system components.	• 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 components.	• Reduction in funding will focus efforts on technologies most likely to support domestic manufacturing growth.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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.	• No significant change.

Wind Energy

Overview

The Wind Energy Technologies Office (WETO) invests in a diversified portfolio of wind energy research, development, demonstration, and deployment activities 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. WETO also supports the Floating Offshore Wind Shot to strengthen U.S. leadership in floating offshore wind design, development, and manufacturing. The Floating Offshore Wind Shot seeks to reduce the cost of floating offshore wind energy by more than 70%, to $45 per megawatt-hour by 2035 for deep water sites far from shore.

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.

In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated Energy Efficiency and Renewable Energy (EERE) approach is more efficient than individual technology office efforts.

Wind Energy
Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Wind Energy					
Offshore Wind (OSW)	73,200		113,500	+40,300	+55%
Land-Based Wind	31,800		40,000	+8,200	+26%
Distributed Wind	13,000		15,000	+2,000	+15%
Systems Integration	11,000		23,500	+12,500	+114%
Data, Modeling, and Analysis	3,000		7,000	+4,000	+133%
Total, Wind Energy	**132,000**	**132,000**	**199,000**	**+67,000**	**+51%**

SBIR/STTR:

- FY 2023 Enacted: SBIR: $3,704,000; STTR: $521,000
- FY 2024 Annualized CR: SBIR: $3,704,000; STTR: $521,000
- FY 2025 Request: SBIR: $5,371,000; STTR: $755,685

Wind Energy
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Offshore Wind: Increased OSW funding in FY 2025 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 supporting the Floating Offshore Wind Shot. Support for FORWARD will focus on critical R&D pathways to realize floating OSW's potential as a resource for grid and economy-wide decarbonization. Expanded investments in FY 2025 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 OSW development; new apprentice and pre-apprentice workforce development programs; and a new supply chain minority-owned business ambassadorship program in advance of both NOW and FORWARD.	**+40,300**
Land-Based Wind: Increased funding for land-based wind in FY 2025 will prioritize greater investments in 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.	**+8,200**
Distributed Wind: Funding in FY 2025 will prioritize overcoming challenges to distributed wind deployment such as permitting and site assessment, with a particular focus on community wind, improving integration of distributed wind with other distributed energy resources, and validation and certification of promising small and medium-scale wind turbines.	**+2,000**
Systems Integration: Increased funding in FY 2025 will support the DOE Floating Offshore Wind Shot through R&D on cost-effective and reliable offshore transmission access in broad coastal regions. Increased funding will support the accelerated research on high voltage dynamic cable that are unique for floating offshore wind, as well as improving subsea cable monitoring techniques. Increased funding will also enable wind hydrogen demonstration for both land-based and OSW and explore new offshore wind co-generation opportunities.	**+12,500**
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.	**+4,000**
Total, Wind Energy	**+67,000**

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" where the U.S. has an opportunity to lead on landmark technology developments and maximize the economic potential of our world class offshore wind resource.

The OSW subprogram supports two main areas of focus. The first is R&D to accelerate Near-term deployment of OSW (NOW) by lowering costs from $0.09/kWh in 2019 to $0.05/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 R&D can address. The subprogram will also seek to overcome the most challenging 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.

The second OSW subprogram area of focus is referred to as the Floating Offshore Wind Accelerated Research and Development (FORWARD) initiative, which outlines DOE's contributions to the Floating Offshore Wind Shot. 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. Significant development of floating OSW in the U.S. will require a reduction in costs from the current levelized cost of electricity (LCOE) of $0.132/kWh for floating turbines. The goal requires investments in technology innovation, sustainable and community-compatible development, and further refinement of supply chain and workforce development requirements. 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.

Science and Technology Innovation: This activity seeks to reduce costs and risks to OSW development through advances in OSW technology and scientific understanding in two primary areas of focus: resource characterization and technology innovation. Resource characterization is vital to OSW resource predictability, which helps inform siting and supports whole wind plant optimization. Technology innovations will 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.

Manufacturing and Materials R&D: This activity aims to develop and build robust domestic capabilities for cost-effectively manufacturing, installing, and maintaining OSW plants in the U.S. 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. This activity will support R&D to reduce costs, address the technical challenges of turbine installation through lightweighting and improved installation methods, and reduce the fabrication costs of floating offshore turbine foundations in support of the Floating Offshore Wind Shot.

Environmental and Siting R&D: This activity supports R&D into environmental impact assessment, minimization, and mitigation options for environmental 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, such as interference with critical radar systems, which are less understood than the impacts to 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. This activity will support that objective through 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Offshore Wind $73,200,000	**$113,500,000**	**+$40,300,000**
Science & Technology Innovation $49,765,000	$56,500,000	+$6,735,000
	• Conduct supply chain analysis and coordination efforts for OSW development, in partnership with States.	• New analyses of supply chain scenarios, gap identification, and mitigations. Expanded coordination efforts.
• Develop Operations & Maintenance roadmap to inform technology development needs.	• Begin a new operations & maintenance research campaign to increase the technological maturity of advanced inspection, maintenance, and repair techniques to drive down a key component of offshore wind costs.	• A new research campaign on advancing and testing automation techniques and technologies for OSW prognostic health monitoring and other advancements in O&M that will reduce costs, wind turbine downtime, and increase safety for offshore workers.
• Advanced planning, needs and feasibility assessments, and design for expansion of existing test facilities to handle 20MW+ OSW turbine components and hybrid offshore systems.	• No funds requested.	• Deferred to future years.
	• Advancement of low-Technology Readiness Level (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.
• 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.	• Focus on demonstration of turbine system components rather than full systems.
• The Enacted includes funding for National Laboratory work that will leverage existing core capabilities and facilities available through the National Laboratory network. Targeted research areas include OSW resource characterization and forecasting.	• The Request includes funding for OSW atmospheric science, including resource characterization and forecasting, fundamental physics understanding and validation, and support for at-sea campaigns.	• Expansion of existing activity to include extreme weather efforts and planning for an OSW atmospheric sciences validation campaign on the Pacific coast while completing the Atlantic validation campaign.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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.	• No funding requested.	• Incorporated in advanced modeling and systems engineering line item below.
• Technology development of low-noise installation techniques for fixed foundation OSW applications.	• Technology development of improved installation techniques for fixed foundation OSW applications.	• Focus narrowed on installation techniques that can lower cost as well as lower noise.
• 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 development of high-fidelity models employing artificial intelligence/machine learning and Offshore Integrated Systems Engineering efforts to develop analysis and research capability to improve system-level performance and achieve system-level cost reductions. This includes R&D of individual turbines, floating turbines, and full farm controls.	• Incorporated high-fidelity modeling and controls efforts. Initiate planning for an offshore wind farm performance validation campaign.
• 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.	• No funding requested.	• Incorporated in HFM and systems engineering line item above.
• Establishment of an Anchoring & Mooring Development effort to demonstrate new concepts applicable to deep-water locations at scale.	• No funding requested.	• Deferred to FY 2026.
Manufacturing and Materials R&D $5,018,000	$26,000,000	+$20,982,000
• Research effort to analyze existing available infrastructure and needs for application to OSW manufacturing, assembly, logistics and port facilities.	• Continue research to analyze existing available infrastructure for application to OSW manufacturing, assembly, logistics and port facilities.	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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, minimize environmental impact, increase reliability, and accelerate blade/tower/nacelle factory throughput.	• 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.
	• A new initiative focused on floating platform industrialization with a focus on R&D, testing, and demonstration to advance serial manufacturing of floating platforms.	• New effort to lower floating platform fabrication costs through manufacturing and design innovations.
• 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	$23,000,000	+$9,855,000
	• 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 to better understand and minimize the risk of offshore wind to migratory birds, whales, and other marine species.	• New activity critical to helping address concerns regarding environmental impacts of offshore wind and facilitating permitting.
• 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 2025 Request	Explanation of Changes FY 2025 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. Increased emphasis on resources for tribes to engage in offshore wind development processes.
	• Establish a new program that provides resources for offshore wind engagement to enable tribal communities to participate in offshore wind planning and permitting processes.	• A new effort in FY25 to support tribal engagement in offshore wind siting, permitting, and development.
	• Support research on social and socioeconomic impacts of wind energy.	• Increase supports new research that builds off 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	$8,000,000	+$2,728,000
• 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.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Initiate national-scale analyses to systematically identify future workforce needs.	• Continue to support workforce analysis on an as-needed basis to address current and future workforce needs.	• Focus will shift from national level to regional and sector specific analysis to refine understanding of workforce needs.
• Support the National OSW Workforce Development Roadmap and Network.	• Continue support for the National OSW Workforce Development Network to meet OSW workforce needs.	• 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.
	• Launch ambassadorship program to increase opportunities for women and minority owned businesses to enter the OSW supply chain.	• New activity.

Wind Energy
Land-Based Wind

Description

The Land-Based Wind subprogram emphasizes nationwide cost-competitiveness and efforts to develop siting and environmental solutions to accelerate land-based wind energy deployment. Key opportunities include taller towers and longer blades, which lead to greater energy capture and lower cost per unit of energy output and represent significant opportunities for cost reduction and improved value for energy consumers. WETO's investments in land-based wind also seek to improve America's international competitiveness in a time of fast-growing global interest and support vast growth potential for domestic manufacturing with opportunities for good-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 $0.06/kWh to $0.02/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.

<u>Science and Technology Innovation</u>: This activity seeks to advance land-based wind technology innovation and scientific understanding to decrease cost and improve the performance, reliability, and value of next-generation wind plants and turbine technology. The activity will use data collected from ongoing WETO field experiments to validate the physics knowledge, resource assessment, and design tools developed under the Atmosphere to Electrons (A2e) program. The activity will also pursue innovations in wind-based hybrid power plants that leverage the strengths of various clean technologies to form a more dispatchable energy resource.

<u>Manufacturing and Materials</u>: 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 also strives to onshore and grow domestic production of wind blades by decreasing production costs through improving initial quality, enabling automated fabrication and repair, and scaling factory throughput to support sizeable wind deployment goals. New initiatives will tackle the "grand challenge" of characterizing large, dynamic, and highly flexible wind turbine blades, and improve our understanding and treatment of lost energy production in the field. A key driver for the research is enabling a circular economy that recovers materials from wind turbine components.

<u>Environmental and Siting</u>: This activity focuses on impact mitigation and enabling the efficient siting and operation of land-based wind facilities. Characterizing environmental impacts will allow us to develop 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 social science and socioeconomic research to understand impacts of wind energy on communities and explore innovation for siting and participatory outcomes that reduce impacts and promote equitable outcomes for land-based wind energy development.

Finally, this activity 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 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.

<u>STEM and Workforce Development</u>: Wind energy provides significant domestic job opportunities, and the rapid development of substantial new wind energy integral to achieving our goals will provide even more. New education programs will prepare workers with the applicable skills and knowledge required of a well-trained and ready workforce. 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 create 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Land-Based Wind $31,800,000	**$40,000,000**	**+$8,200,000**
Science & Technology Innovation $14,434,000	$14,500,000	+$66,000
• Conclude the American Wake Experiment (AWAKEN) field campaign, which has been measuring interactions between and within wind farms in northern Oklahoma and demobilize instrumentation.	• The AWAKEN project will focus on 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 an initial analysis of the gathered data continues through FY 2024. A new FY 2025 project will generate and disseminate additional learnings with our industrial and academic partners.
• 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.	• Additional learnings and analysis from the DOE-sponsored RAAW dataset will address the grand challenges associated with turbine modeling and inform intelligent design and execution of future campaigns.	• The RAAW experiment concluded in FY 2023 followed by initial data reduction and analysis in 2024. Further analysis of the gathered data will be undertaken by a new project.
• Initiate the Wind Forecasting for Tall Turbines project.	• Continue the Wind Forecasting for Tall Turbines project.	• Expand focus of measurement campaigns to areas of complex terrain and canopies. Begin development of mobile atmospheric measurement capabilities for future campaigns.
• 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.	• Increased funding (in FY 2024 and 2025) for design and control optimization of fully coupled systems with various objectives, such as reliability, resilience, dispatchability, 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 focused on material characterization of main bearing and pitch bearing failures.	Continue Drivetrain Reliability research focused on the tribological materials associated with the predominant and unaccounted failure modes in pitch, main, and gearbox bearings.	• No significant changes.
• 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.	• No funding requested.	• Project to be completed in FY 2024.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	• Wind Turbine Availability: foundational research enhancing our understanding and treatment of lost energy production in the field. • Predict and design for the dynamics of ever larger and more flexible turbines, a “grand challenge” of wind energy research. • Advanced design, materials, and manufacturing R&D to reduce full lifecycle costs and accelerate blade/tower/nacelle factory throughput while increasing reliability.	• New initiative in FY 2025. • New research effort, leveraging results from the BAR and Blade Durability programs that will close in FY 2024. • New initiative in LBW, expanding an effort within OSW, to enable domestic production of high quality and affordable wind blades.
Environmental and Siting R&D $10,181,000	$14,000,000	+$3,819,000
	• 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.
• 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 the mission is currently impacted by wind turbine interference.	• Expanded effort to validate high-TRL mitigation options.
• 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.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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 wind plant development impacts research for wind plant neighbors, with an emphasis on understanding equity and benefits for disadvantaged 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. • Continue wind plant development impacts research for wind communities with an emphasis on understanding equity and benefits for disadvantaged communities.	• No significant change. • No significant change.
STEM and Information Resources $3,327,000	$5,000,000	+$1,673,000
• Support the Collegiate Wind Competition (CWC) and other STEM educational opportunities. • Identify future workforce needs, programming solutions for those needs, and opportunities to convene industry and educational institutions to develop workforce development solutions.	• Support the Collegiate Wind Competition (CWC), and other STEM educational opportunities. • Continue analysis to Identify future workforce needs and convene stakeholders to collaborate to develop and implement workforce development solutions. • Support wind energy fellowships and internships, with an emphasis on promoting diversity in the future wind workforce.	• No significant change. • No significant change. • New activity in FY 2025.

Wind Energy
Distributed Wind

Description
The Distributed Wind subprogram focuses on achieving breakthroughs in reducing the LCOE from $0.09/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, hybrid plants, and microgrids. The subprogram invests in activities to reduce the cost of permitting and interconnection, increase system power production, enhance grid support from distributed wind projects, and test next generation turbines to national standards to verify performance and safety. Activities to overcome deployment challenges, such as permitting and interconnection, focus on targeted support and development of tools for rural communities to utilize distributed wind as a means of community-based energy transition.

Science and Technology Innovation: This activity will continue work to improve wind resource and site assessment tools for standalone and hybrid distributed wind systems. Current tools are too costly, uncertain, and inaccurate to support 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, improve 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 focuses on reducing costs associated with installation, permitting, and interconnection, particularly for community wind. The activity will continue to fund R&D that enhances the capabilities of distributed wind technology to provide grid support services in both onsite and distribution grid-level applications.

Distributed Wind

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Distributed Wind $13,000,000	**$15,000,000**	**$2,000,000**
Science and Technology Innovation $2,551,000	$2,000,000	-$551,000
• Refine and integrate validated wind resource models and datasets with lab based and commercially available assessment and decision support tools. • 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 refining and integrating validated wind resource models and datasets with lab based and commercially available opportunity assessment and decision support tools. • Continue techno-economic, deployment scenario, and market data analysis to resolve promising high impact opportunities for cost reduction and deployment acceleration.	• Reduced funding reflects shift in focus towards balance of systems R&D. • No significant change.
Testing & Reliability $5,537,000	$4,000,000	-$1,537,000
• 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 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 competitive solicitation to reduce turbine costs, improve performance and grid support capabilities, and test designs to national safety and performance standards. • Continue stakeholder engagement to inform small and medium wind turbine design, testing, and standards R&D.	• Reduction reflects shift in focus toward balance of systems R&D • No significant change.
Balance of System R&D $4,912,000	$9,000,000	+$4,088,000
• 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Support the development of permitting and interconnection best practices for wind and wind hybrid projects.	• New Funding Opportunity Announcement (FOA) topic to support new models for and overcome barriers to development of community wind development, building off lessons learned from community solar over the past decade.	• Increased funding supports FOA topic to advance community wind development.

Description
The Systems Integration subprogram invests in research, development, and demonstration to enable efficient and timely interconnection of wind to the nation's power grid and to ensure reliable, cybersecure, cost-effective, and resilient grid operation with increasing levels of wind energy.

Considerations for wind energy systems integration include:
- 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 to support a robust domestic wind industry. Advancing transmission technologies, in particular for OSW, enables cost effective wind energy integration.
- 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.
- Wind 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.
- Wind Hybrid Systems: Wind, together with other clean energy and storage technologies, can play a major role to decarbonize hard-to-decarbonize industry. This can be achieved through the conversion of wind electricity to hydrogen or other forms of energy.

This subprogram supports two OSW initiatives, CONNECT and TRANSFORM, that address challenges to support the OSW deployment goals of 30 GW by 2030 and 110 GW by 2050. CONNECT mitigates transmission constraints, including both land-based and offshore interconnections and 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 hybrids with energy storage technologies and hydrogen and renewable fuel co-generation.

Systems Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Systems Integration $11,000,000	**$23,500,000**	**+$12,500,000**
• Conduct a series of OSW transmission research and development projects to enable cost effective transmission access for OSW while maintaining reliable and resilient grid operation with large amounts of OSW.	• Initiate research and development campaign designed to address deepwater floating offshore wind transmission challenges by focusing on subsea cable technologies aiming for increased dynamic cable voltage levels, enhanced cable monitoring, and advancements in floating substation design.	• Increased funding in FY25 will allow expanded R&D in OSW transmission technologies with a new initiative on dynamic subsea cable and floating substation design for floating offshore wind in FY25.
• 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 and stable grid operation with increasing levels of wind both onshore and offshore.	• No significant change.
• 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 2025.
• 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 and new offshore wind co-generation opportunities.	• Increased funding will support the exploration of wind co-generation opportunities and enable wind hydrogen production demonstration for land-based wind and/or 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 priorities include:

- Continued and expanded collection and dissemination of data on wind technology cost and performance trends to support GPRA 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $3,000,000	**$7,000,000**	**+$4,000,000**
• 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.	• Increase reflects new model development to address supply chain, lifecycle assessment, and other factors not traditionally captured in techno-economic analysis, and targeted analyses of how these issues interact with wind development.
• 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.	• Cross-sectoral energy futures analysis in collaboration with other EERE and DOE offices, including electric sector modeling, wind value to the grid for energy and grid services, and capacity expansion model development.	• No significant change.

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 domestic marine energy and hydropower resources, and there is enormous potential to enhance domestic energy resiliency through modifications to the existing hydropower fleet; expansion into new markets and applications for hydropower; capturing the power of the oceans to deliver energy and electricity along the U.S. coastlines; increasing generation and flexibility across the Nation's sizable hydropower and pumped storage fleet; as well as growing and strengthening U.S. supply chains in both hydropower and marine energy. WPTO focuses on key areas of opportunity, including enhancing hydropower planning, forecasting, and operations; working with communities on site assessments for powering non-powered dams to cost-effectively increase generation and flexibility; enhancing the cybersecurity research for hydropower; 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 for these water systems. WPTO is continuing efforts to quantify hydrologic and climate change impacts and improve interagency coordination on response and adaptation to climate extremes like drought, working with local communities demonstrating and deploying advanced hydrologic sensors in watersheds across the U.S. to better characterize climate change variations and improve ecological resilience and energy-water security. WPTO is also exploring the potential for how oceans can be an environmentally appropriate sink for carbon, pathways to decarbonization through the maritime sector, and how marine energy can power emerging markets like kelp farming.

Community-centric development is critical to advance water power systems, particularly in remote, underserved, rural, tribal, and/or isolated communities. In support of both community-centric development and field validation of energy-water system technologies, as well as development of new approaches to address regional and local-scale energy-water system needs in a changing climate, in FY 2024 WPTO proposed a new subprogram - Regional Energy-Water Testing and Validation. This subprogram would demonstrate technologies to scale water and energy management solutions in specific watershed regions. This subprogram would also address gaps between systems-level energy-water research and field deployment that require regional, integrated modeling assessments and coordination between EERE and other DOE offices to integrate and scale existing technologies. This would include support for advancing nationwide 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 harness the broader innovation ecosystem in support of commercialization of near-term and early-stage technologies. WPTO supports incubators and accelerators in the private sector to support commercialization of a broad range of technologies and entrepreneurs; builds on National Laboratory-focused commercialization opportunities; and continue 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 in 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, WPTO supports collegiate competitions to attract new students to the sectors, fund evaluation of mechanisms used to support workforce development, and funds fellowships to develop emerging student leaders in water power.

In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

**Water Power
Funding ($K)
(Comparable)**

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Water Power					
Hydropower Technologies	59,000		48,000	-11,000	-19%
Marine Energy Technologies	120,000		112,000	-8,000	-7%
Total, Water Power	**179,000**	**179,000**	**160,000**	**-19,000**	**-11%**

SBIR/STTR:

- FY 2023 Enacted: SBIR $5,147,000; STTR $724,000
- FY 2024 Annualized CR: SBIR $5,147,000; STTR $724,000
- FY 2025 Request: SBIR $4,646,000; STTR $653,000

Water Power
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Water Power	
Hydropower Technologies: The FY 2025 Request funds technology development to increase hydropower flexibility for the grid, environmental fish passage, and for technologies to support retrofitting of nonpowered dams. The subprogram will conduct technical assistance for new, low-impact hydropower to power nonpowered dams or infrastructure, analyze hydrologic and climate change impacts to hydropower, launch an interagency effort on drought and climate resiliency, as well as invest in the environmental and dam safety systems to modernize the existing hydropower fleet.	**-11,000**
Marine Energy Technologies: The FY 2025 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 support at a reduced level for controls and advancements in materials and manufacturing. The subprogram will increase its focus and funding for 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.	**-8,000**
Total, Water Power	**-19,000**

[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

Hydropower serves as critical firm, flexible, baseload power that has helped power the nation for the last century. In 2022, hydroelectricity accounted for about 6.2 percent of U.S. utility-scale electricity generation, and the U.S. had 22 GW of pumped storage hydropower (PSH) installed capacity, or roughly 70 percent of all utility storage capacity dispatched in the United States. Hydropower also has a strong domestic supply chain and nationwide workforce, and provides critical resiliency for the grid, particularly at a time when the grid is accommodating more intermittent renewables. But to continue serving as a critical resource and to grow domestically, RDD&D is needed to enhance and quantify the role of resiliency and reliability of hydropower, advance more environmentally compatible technologies to both retrofit and deploy new hydro and PSH, and better prepare the federal and private domestic fleet for a changing climate environment. The Hydropower Technologies subprogram works with the U.S. hydropower and PSH industry to support RDD&D to responsibly develop new low-impact hydropower; enhance and maintain hydropower's critical contributions to grid reliability and the integration of other energy resources; modernize and safely maintain the existing hydropower fleet; promote and enhance environmental sustainability and performance of the existing and future fleet; and support energy-water systems resilience.

<u>New Low-Impact Hydropower</u>: 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 decrease costs and increase the value of powering non-powered dams, developing new stream reaches, modernizing irrigation systems and partnering with irrigation districts to inform development of digital planning tools and demonstration sites, and providing technical assistance for the hydropower community and developers to identify sites best suited for retrofits. Scientific advances associated with these technologies can allow developers and operators to more effectively identify and mitigate environmental impacts, ultimately allowing for more effective utilization of existing hydropower and reduced regulatory costs. 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.

<u>Grid Integration</u>: Both hydropower and PSH can adjust their output quickly and on demand, providing a highly flexible generation source for 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. Through its HydroWIRES Initiative, the subprogram is expanding its efforts to develop new strategies and technologies that can enhance hydropower's role on the grid, understand and quantify the economic value of these services and capture the additional costs or technical requirements of operating hydropower systems to provide these services for a changing grid. This includes improving how hydropower is represented and understood in energy modeling, enhancing flow forecasting, and improving generation models for the existing fleet. HydroWIRES supports technical assistance to capture the full range of values hydropower and PSH provides to power grids, river basins, and communities.

<u>Existing Hydropower</u>: 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 ensure the continued availability of this safe and secure abundant domestic resource. To support the existing fleet, this activity also assesses and addresses climate change impacts, environmental sustainability, and relicensing. WPTO's work on existing hydropower reservoir management by analyzing infrastructure design and water

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

management creates opportunities to advance climate resilience and adaptation for remote communities. This activity supports work with local communities on energy and water data needs, including identifying sites for deploying advanced hydrologic sensors and sensor networks, to advance a framework for understanding climate change. Lastly, WPTO works to improve the environmental performance and sustainability of hydropower facilities by supporting fundamental research into novel monitoring and mitigation technologies, particularly related to fish passage.

Data, Modeling, and Analysis: To advance the state of the hydropower industry, a robust innovation ecosystem must exist to support developers in commercialization, develop a strong workforce, advance engagement among a broad set of stakeholders, and improve access to 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 incubators and accelerators that mentor promising startups and technology developers in hydropower.

Hydropower Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Hydropower Technologies $59,000,000	**$48,000,000**	**-$11,000,000**
New Low Impact Hydropower $11,000,000	$11,000,000	$0
• 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.	• Develop a funding solicitation to target highest rated advanced materials and manufacturing opportunities and continue collaboration with the Manufacturing Demonstration Facility.	• No change from FY 2023.
• 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.	• Perform more site level analyses to better understand the feasibility of NPD retrofits.	• No change from FY 2023.
• 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.	• Continue scoping for building and maintaining a hydropower test facility by advancing conceptual designs of a full-scale hydraulic hydropower test facility at an existing federal dam.	• 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	$15,000,000	-$7,000,000
• Provide funding to support research into new component-level technology advancements to increase hydropower flexibility.	• No funding requested.	• Work was funded in FY 2023 to support technologies for flexibility enhancement, no further funding requested.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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.	• No funding requested.	• Work initiated in FY 2023 and will not require future funding.
• Not funded in FY 2023 Enacted.	• Fund a new effort to support model vendors in accurately incorporating hydropower and PSH into their software to improve industry-standard modeling products with state-of-the-art hydropower representations, enhancing operational timescale models, and inflow forecasting models to directly target tools used by hydropower operators.	• Building off previous efforts to increase representation in modeling of hydropower's role on the grid, this new effort will create new tools, technologies, and methods to allow for better operational improvements for hydropower generation and dispatch.
• 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 2025.	• Funding through the Bipartisan Infrastructure Law supported three-year efforts for PSH technology advancement.
• 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.	• Continue to expand the Valuation Guidebook and provide technical assistance to PSH developers to support advancing their projects to deployment.	• Reduced funding for technical assistance versus FY 2023 Enacted.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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.	• Reduced funding level for technical assistance versus FY 2023 Enacted.
Existing Hydropower $14,000,000	$13,000,000	-$1,000,000
• 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.	• No change from FY 2023.
• Launch demonstrations, like self-powered Fish Tag lab project and eDNA Demo for FERC relicensing lab project.	• No funding requested in FY 2025.	• 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 to refine the concept and further develop industry confidence in the technology benefit and value.	• No funding requested in FY 2025.	• Funding from prior years 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.	• No change from FY 2023.
• 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.	• Continue development & validation of novel fish and environmental monitoring tools with hydropower partners with an emphasis on technology transfer and commercialization.	• Reduced funding will limit the number of demonstrations planned for FY 2025.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Not funded in FY 2023 Enacted.	• Support work on advanced sensors and artificial intelligence for improved dam safety and dam inspections processes.	• This effort will support National Laboratory R&D into AI tools and sensors to improve dam safety and inspection processes for adoption by the hydropower industry.
Data, Modeling, and Analysis $10,000,000	$9,000,000	-$1,000,000
• 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.	• Update the Reimagined Hydropower Vision Roadmap based on industry perception of progress towards goals outlined.	• Continued at a reduced level versus 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.	• No change from FY 2023.
• Develop analysis and programs to commercialize promising hydropower technologies, including supporting National Laboratory research and private sector industry technologies.	• Continuing to support commercialization efforts with the labs, along with expanded collaboration with the private sector through a water power focused incubator network.	• No funding change, but activities will focus specifically on commercialization both at the National Laboratories and private sector partners.
• Continue to expand and improve HydroSource. Support, a publicly available database to support improved decision-making and basin-wide management of river resources.	• Update datasets and perform maintenance to existing tools. Support existing maintenance of platform and conduct stakeholder engagement to increase usage.	• Increased funding level in FY 2025 will expand the number of data sets and updates of climate data as well as the number of anticipated users.
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 across the U.S. 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] 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 seeking to reduce reliance on imported fuel. 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.[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 makes investments 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 R&D to tackle these challenges to rapidly improve and reduce costs. Advanced controls are a major programmatic focus, as improvements in advanced controls can provide significant increases in energy capture. Foundational research will continue at universities and national labs to support advancements in controls, materials, components, operations, maintenance, and resource characterization.

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 have the potential to serve existing or emerging ocean-based technologies that can advance the Nation's military, commercial, and scientific capabilities. These include power for remote coastal communities and Department of Defense installations with high electricity costs, charging for ocean-based sensors and underwater vehicles, and non-electric end-uses like desalination.

Support for the PBE initiative will continue 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. This activity will also demonstrate and deploy grid-scale marine energy projects to validate performance toward a fully decarbonized electric grid.

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[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

Testing & Reliability: To accelerate deployment, this activity will make strategic investments in infrastructure access at marine energy test sites 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.

Data, Modeling, and Analysis: To accelerate the development of marine energy, this activity will 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Marine Energy Technologies $120,000,000	**$112,000,000**	**-$8,000,000**
Materials and Components R&D $23,000,000	$17,420,000	-$5,580,000
• Continued 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.	• Continued R&D into controls and power take-offs to dramatically reduce costs and/or increase energy capture for marine energy devices.	• Continued at a reduced level versus FY 2023. Significant progress has been made that can be incorporated into technology designs so shift has been focused to System Integration & Validation.
• 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.	• Continued at a reduced level versus FY 2023. This builds on a Materials Strategy, but there have been critical advancements in modeling tools that will shift to modeling devices to be tested in the open water.
• 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 national wave classification metrics and further investigate site-specific marine energy characterization.	• Continued at a reduced level versus FY 2023. New characterization approach developed in FY 2023, maintain some funding for site-specific work.
Systems Integration & Validation $32,000,000	$49,830,000	+$17,830,000
• 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 to expand the number of 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 and development as well as continued WaveSparc work to develop novel concepts.	• Completion of the InDEEP Prize to validate and demonstrate novel concepts and inform continued support in this area.	• Continued at a reduced level versus FY 2023 Enacted. The prize has been primarily funded in FY2023. This funding will provide follow-on support for prize competitors.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Research advanced systems aligned with the Powering the Blue Economy initiative and 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. 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. Research continuing the strategy and roadmap development of supporting blue economy applications.	• Continue efforts to understand the role of marine energy in powering marine carbon dioxide removal (mCDR) and continue support for research into advanced 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. Continue to quantify opportunities and value geographically for remote/community/grid scale marine energy solutions.	• Increased funding to support in-water testing and expand the breadth and depth of grid studies as well as target high-priority and common pain points across industry to advance marine energy components and systems across all sizes and resource types.
Testing & Reliability $49,000,000	$23,230,000	-$25,770,000
• As directed by FY 2023 Enacted Appropriations, fund the costs of construction of the PacWave Open Water Test Facility.	• No funding requested in FY 2025.	• FY 2023 Enacted funding should be sufficient to complete construction of the facility.
• Continue support of TEAMER, a rolling test campaign supported in collaboration with U.S. universities and National Laboratories for early-stage marine energy systems.	• Continue to expand the TEAMER program facility network through additional network organizations and capabilities upgrades, as well as increasing and diversifying the applicant pool.	• No change from FY 2023.
• 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.	• Continued at a reduced level versus FY 2023 Enacted.
• Continue support for upgrades to test infrastructure at marine energy technology	• Support for maintaining, operating and upgrading test infrastructure at marine energy	• Continued at a reduced level versus FY 2023 Enacted.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
testing sites based on the testing needs roadmap.	technology testing sites based on a testing needs roadmap.	
Data, Modeling, and Analysis $16,000,000	$21,520,000	+$5,520,000
• Begin support of commercialization assistance through development of a network of incubators 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.	• Build on initial investments made in prior years to advance commercialization assistance through marine energy and blue economy incubator networks and accelerators, national lab technology transfer; and support disadvantaged students and universities.	• Increase in funding will support expansion of commercialization assistance.
• 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 change from FY 2023.
• 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).	• Increase in funding will support expansion of R&D activities.
• Make program-funded research and testing results widely accessible through databases and tools such as Portal and Repository for Information on Marine Renewable Energy (PRIMRE).	• Make program-funded research and testing results widely accessible through databases and tools such as PRIMRE.	• Increase in funding to maintain and improve public databases to maximize accessibility and usability.

Geothermal Technologies

Overview

America has abundant natural geothermal resources that, if developed for various beneficial uses, can lower energy costs, reduce dependencies on foreign materials and energy sources, and make our energy systems more reliable. Geothermal is a single-source solution that will help decarbonize the electricity grid, create U.S. jobs, support states and communities in meeting their energy goals, and contribute to an energy economy that serves everyone. Geothermal energy is a reliable, secure, clean, firm, and flexible energy source that offers opportunities as both a high-capacity-factor, small footprint power resource as well as a carbon-free heating and cooling solution. Widespread deployment of geothermal applications and associated mineral extraction have the potential to build and support local economies across urban centers, rural areas, and remote communities while accelerating U.S. leadership in these mutually beneficial and rapidly growing technology spaces.

The mission of EERE's Geothermal Technologies Office (GTO) is to enable an energy future where all Americans benefit from geothermal's clean, local energy solutions. GTO strives to increase deployment of geothermal energy while enabling the creation of a workforce that leverages the unique skills and abilities of our strong domestic oil and gas workforce for the geothermal jobs of the future. The GTO FY 2025 Request supports RDD&D to make geothermal energy competitive nationwide. GTO's technology portfolio prioritizes investments in three closely related technology 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. The Office's Data Modeling, and Analysis portfolio of work assesses future opportunities across geothermal use cases through robust grid analysis, environmental assessment and reduction of non-technical barriers including permitting, and lack of awareness of the myriad benefits of this technology.

GTO supports DOE's 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. GTO has adopted three strategic goals to reach geothermal energy's full potential. First, we are driving toward a carbon-free electricity grid by supplying 90 gigawatts (GW) of EGS and hydrothermal resource deployment by 2050. Second, we are aiming to decarbonize building heating and cooling loads saving the U.S. up to 7,400 million metric tons of cumulative CO_2 emissions by 2050 through nationwide-deployment of geothermal heat pumps (GHPs). And finally, we are working to deliver economic, environmental, and social justice advancements through increased geothermal technology deployment.

In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

Geothermal Technologies
Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Geothermal Technologies					
Enhanced Geothermal Systems	57,500		98,091	+40,591	+71%
Hydrothermal Resources	24,000		21,600	-2,400	-10%
Low Temperature and Coproduced Resources	24,000		24,000	0	0%
Data, Modeling, and Analysis	12,500		12,500	0	0%
Total, Geothermal Technologies	**118,000**	**118,000**	**156,191**	**+38,191**	**+32%**

SBIR/STTR:

- FY 2023 Enacted: SBIR: $3,146,000; STTR: $442,000
- FY 2024 Annualized CR: SBIR: $3,146,000; STTR: $442,000
- FY 2025 Request: SBIR: $3,647,000; STTR: $513,000

Geothermal Technologies
Explanation of Major Changes ($K)

	FY 2025 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 through demonstrations and will include a new portfolio focused on advanced materials and high-temperature components to enable downhole development and characterization in harsh EGS environments.	**+40,591**
Hydrothermal Resources: This funding will support Exploration and Characterization R&D focused on exploring and characterizing geothermal resource potential at a reduced level and is partially offset by an increase in funding for critical materials work in Resource Maximization R&D.	**-2,400**
Low Temperature and Coproduced Resources: This funding will support Resource Maximization R&D including a strong focus on assessments for thermal energy storage and system deployments through the Community Geothermal Heating and Cooling initiative.	**0**
Data, Modeling, and Analysis: This funding will support cross-EERE analysis and demonstration; 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.	**0**
Total, Geothermal Technologies	**+38,191**

Geothermal Technologies
Enhanced Geothermal Systems

Description

An enhanced geothermal system is a human-made heat exchanger that use subsurface engineering techniques to harness the Earth's natural ubiquitous heat for direct use and electrical power production applications. To ensure the U.S. stays on track for 90 GW deployment of geothermal power by 2050, this year's Budget Request will support a wide variety of RD&D investments related to nearly every aspect of EGS resource development. Research supported under these activities will reduce costs and advance technologies needed for 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, human-made heat exchangers, including learning by doing through EGS demonstrations. 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.

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 our nation'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 geothermal power and geothermal heating and cooling solutions nationwide. All FY 2025 EGS RD&D will seek to make progress toward this EGS cost target.

<u>Frontier Observatory for Research in Geothermal Energy (FORGE)</u>: 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's authorization was extended via language in the Energy Act of 2020, and FY 2025 funding will support the stimulation of an additional well using a variety of approaches and long-term flow testing to further evaluate the commercial viability of EGS.

<u>Subsurface Enhancement & Sustainability R&D:</u> GTO will support new EGS demonstration projects to continue momentum built by FORGE and EGS pilot demonstrations funded through BIL. This investment will continue to advance EGS toward commercialization for power generation and direct use in settings across the US. GTO will also continue to foster new ideas in EGS through a collaboration with the National Science Foundation (NSF), which aims to attract new researchers from academia to the field of geothermal energy to expand the collective brain power focused on increasing geothermal energy deployment.

<u>Subsurface Accessibility R&D:</u> The Request continues support for the Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE) consortium designed to leverage oil and gas subsurface assets, technologies, and expertise to help solve geothermal energy's toughest challenges while providing clean energy employment opportunities and environmental benefits for communities.

<u>Exploration and Characterization R&D:</u> 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. GTO will launch new R&D efforts in hardened materials, electronics, and components to enable subsurface characterization and operation in high temperature, corrosive environments.

<u>Data, Modeling, and Analysis for EGS:</u> Data best practices, techno-economic modeling, and strategic analysis underpin RD&D conducted across all GTO Subprogram Research Areas, including for the Enhanced Geothermal Shot. Ongoing analysis will ensure program-wide progress toward meeting EGS metrics and goals.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Enhanced Geothermal Systems $57,500,000	**$98,091,000**	**+$40,591,000**
Frontier Observatory for Research in Geothermal Energy (FORGE) $22,930,310	$ 27,500,000	+$4,569,690
• 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 2025 funding will support the stimulation of an additional well and a third competitive solicitation.	• The increase will fund novel stimulation techniques of a third highly deviated well and enable long-term flow testing, which will advance EGS technology toward commercialization in support of GTO goals for widespread firm, flexible, geothermal power deployment.
Subsurface Enhancement & Sustainability R&D $34,569,690	$31,100,000	-$3,469,690
• 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.	• Funding will support additional demonstration projects selected from future rounds of the EGS Demonstrations rolling FOA.	• New EGS demonstration projects will continue momentum built by FORGE and EGS pilot demonstrations funded through BIL. This investment will continue to advance EGS toward commercialization for power generation and direct use in settings across the US.
• 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	• No funds requested for GEODE under this activity.	• Funding for GEODE will focus on the Subsurface Accessibility R&D activity.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 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.	• No funding requested.	• Funding in FY 2023 and FY 2024 was dedicated to a FOA to be released in FY 2024. GTO will evaluate applications and projects in this FOA and consider reprioritization of this initiative in future fiscal years, pending analysis and R&D outcomes.
Subsurface Accessibility R&D $0	$12,500,000	+$12,500,000
• 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. • EGS Well Construction: Research, develop and demonstrate well construction technologies that will accelerate commercialization of EGS resources by lowering lifecycle development costs.	• Funds year 4 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. • No funding requested.	• The GEODE initiative is wide-ranging and spans multiple activities. FY 2024 funding for GEODE was previously provided through the Subsurface Enhancement & Sustainability R&D activity and has been reprioritized to Subsurface Accessibility. The funding for GEODE remains at the same level as FY 2023. • Funding in FY 2023 and FY 2024 was dedicated to a FOA to be released in FY 2024. GTO will evaluate applications and projects in this FOA and consider reprioritization of this initiative in future fiscal years, pending analysis and R&D outcomes.
Exploration and Characterization R&D $0	$26,491,000	$+26,491,000
• 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. • Hardened Materials and Components for Extreme Subsurface Environments: 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 can help adapt new and existing EGS technologies to higher temperatures, which will improve EGS commerciality and enhance deployment opportunities.
Data, Modeling, and Analysis $0	$500,000	$+500,000

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	• EGS-Focused Techno-Economic Tools & Data: Conduct critical power sector analysis and modeling relevant to EGS.	• Continuing activity from FY 2024 dedicated to analysis and modeling specifically focused on Enhanced Geothermal EarthShot targets.

Geothermal Technologies
Hydrothermal Resources

Description

Hydrothermal resources are geothermal reservoirs that include naturally occurring heat, fluid, and permeability at conditions needed to generate geothermal power, and they are currently the primary source of geothermal power and heat worldwide. Recent National Renewable Energy Lab analyses indicate that technology innovation can help unlock additional hydrothermal resources to contribute to the potential 90 GW of geothermal power capacity by 2050.

Hydrothermal Resources supports RD&D that will 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.

Because cost and risk are both concentrated in the early phases of 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 resource identification and drilling success rates. 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 and the application of machine learning and artificial intelligence in field management.

<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 and analysis that is needed to develop an identified resource. These technologies can reduce the levelized cost of electricity (LCOE) 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>: This 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Hydrothermal Resources $24,000,000	**$21,600,000**	**-$2,400,000**
Subsurface Accessibility R&D $11,368,047	$10,000,000	-$1,368,047
• 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 4 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 4 of funding for this multi-year consortium.
Exploration and Characterization R&D $8,676,368	$5,000,000	-$3,676,368
• 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 requested for FedGeo Power in FY 2025.
	• Exploration & Characterization RD&D to identify areas of geothermal resource and technology potential; this initiative will address gaps and challenges identified by FY24 research, monitoring, and assessment work. Initiative also supports RD&D using artificial intelligence and machine learning to improve subsurface analysis, data synthesis, and modeling to identify favorable geothermal resources.	• This funding will directly build on past efforts to enable identification of geothermal systems that will lead to deployment of carbon-free geothermal power production, contributing up to 30 additional GW of hydrothermal resources 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.	• No additional funding requested.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Resource Maximization R&D $3,955,585	$6,600,000	+$2,644,415
• Critical Materials: Scale up technical solutions for geothermal brine and produced water extraction and processing. Demonstrate technologies in the Salton Sea area of California.	• Lithium Extraction Scale-Up: 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.	• Increased funding will be used for RD&D for mineral extraction technologies and analyses to serve the administration priorities in critical minerals.

Geothermal Technologies
Low Temperature and Coproduced Resources

Description

Low Temperature and Coproduced Resources 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 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 fully domestic, cost-effective, renewable thermal energy in large portions of the United States.

A U.S. Geological Survey (USGS) assessment estimates 46,500 MW thermal (MWth) of total beneficial heat that could be extracted from geothermal resources below 90°C in the U.S. using currently available technologies.[1] The GeoVision study estimates that with the adoption of advanced technologies, geothermal district heating could increase to 17,500 installations nationwide, and 28 million U.S. households could realize cost-effective heating and cooling solutions through geothermal heat pumps. 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 country.

Resource Maximization R&D: This activity supports district- and community-scale geothermal heating and cooling systems and geothermal heat pumps (also known as "ground-source heat pumps") that use 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.

The activity also supports crosscutting efforts in energy storage and industrial decarbonization through 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.

This activity also supports research that enables maximization of low-temperature geothermal resources to develop effective and affordable direct-use systems. 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.

[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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Low Temperature and Coproduced Resources $24,000,000	**$24,000,000**	**$0**
Resource Maximization R&D $24,000,000	$24,000,000	$0
• 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.	• Reservoir Thermal Energy Storage (RTES): This initiative will unlock the terawatt-scale thermal energy storage of using the Earth as our battery with pilots and demonstrations that build on prior research to demonstrate technical feasibility, grid integration, and long-term storage opportunities for industrial and manufacturing applications.	• This funding will support additional demonstrations of RTES in the U.S. supporting thermal energy for industrial and manufacturing applications.
• 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.	• Thermal Energy Networks Initiative: This initiative will fund demonstration and deployment of Thermal Energy Networks in a diversity of end uses that leverage novel technologies and demonstrate the value of networking geothermal heat pumps with other building decarbonization technologies.	• This funding will evolve large-scale geothermal heating and cooling systems from geothermal-centered deployments to networked systems working in tandem with other clean energy sources that will increase value to the grid and to consumers.
	• Geothermal Heat Pumps (GHP) Workforce Development: Develop open and inclusive workforce training and credentialing programs for the GHP industry, develop mechanisms to identify trained and qualified designers and installers, and build a pipeline of workers to meet the demand of the growing GHP industry.	• Developing the geothermal heating and cooling workforce is critical to meeting the GTO's Multi-Year Program Plan (MYPP) Strategic Goal goal of 28 million geothermal heat pumps in the U.S. by 2050
	• Geothermal Heat Pump Performance Improvements: Initiative will facilitate collection of relevant data on GHP performance in a variety of GHP end uses as well as catalyze GHP research and innovations for residential applications.	• This new initiative will focus on filling gaps in data curation and research for geothermal heat pumps to better quantify enhanced system performance of these systems and lower costs for consumers.
	• International collaborations: Leverage existing international partnerships to fund projects that will translate successful geothermal heating and cooling deployments in other countries for use in U.S. applications and analyses.	• This funding will build on years of collaborative international partnership and knowledge transfer to the benefit of U.S. geothermal deployments.

Geothermal Technologies
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis (DMA) subprogram provides a critical supporting and enabling function toward advancing the entire GTO research portfolio. DMA takes a holistic analytical approach across 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 GTO'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 toward the outcomes identified in the GeoVision analysis.

Data, Modeling, and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $12,500,000	**$12,500,000**	**$0**
Data, Modeling, and Analysis $12,500,000	$12,500,000	$0
• 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 2025, 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 on FY 2023 successes to expand technical assistance for decision makers to accurately represent geothermal power value in decarbonization pathways planning. Build on FY 2023 analysis of grid impacts and value of geothermal heating and cooling through cross-EERE analysis and stakeholder and utility engagement to expand geothermal heating and cooling adoption. Work with Federal and State partners to implement leasing, permitting, and siting process improvements of geothermal technologies on public lands.	• The increase will support expanded stakeholder outreach and integration with cross-EERE initiatives with valuing geothermal power and heating and cooling technologies 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.	• No additional funding requested in FY 2025.	• No additional C2C funding requested for FY 2025 as EERE has separate funding requested to support C2C.

Industrial Efficiency and Decarbonization

Overview

The Industrial Efficiency and Decarbonization Office (IEDO) invests in research, development, pilot-scale demonstrations, and technical assistance and workforce development to decarbonize America's industrial sector and ensure U.S. competitiveness as the world transitions to a clean energy economy. IEDO supports DOE's Industrial Heat Shot™ and Clean Fuels and Products Shot™, EarthShots which aim, respectively, to develop cost-competitive industrial heat decarbonization technologies with at least 85% lower greenhouse gas (GHG) emissions, and to develop alternative sources of carbon to advance cost-effective technologies with a minimum of 85% lower GHG emissions by 2035.

The U.S. industrial sector makes products that Americans rely on and are energy intensive to manufacture – including iron and steel, chemicals, cement and concrete, glass, and more. As the needs of the U.S. economy evolve, and opportunities emerge in global industrial markets, U.S. industry has an opportunity to innovate, scale, and manufacture these products in a way that reduces, and eventually eliminates, their outsized greenhouse gas (GHG) footprint. IEDO's strategic investments are helping U.S. industry seize this economic opportunity and create more American jobs.

IEDO executes its mission in three subprograms: Energy- and Emissions- Intensive Industries; Cross-Sector Technologies; and Technical Assistance and Workforce Development. Through these subprograms, IEDO pursues high-impact decarbonization strategies identified through careful analysis efforts, such as DOE's Industrial Decarbonization Roadmap, and shaped through on-the-ground stakeholder engagement with manufacturers and communities.

To transform an idea into a commercialized technology, IEDO collaborates with DOE offices working across all stages of the innovation continuum – from fundamental science to applied research and development to demonstrations and deployment. Through the Technologies for Industrial Emissions Reduction Development (TIEReD) program, IEDO works with offices within the Office of the Under Secretary for Science and Innovation to advance research, development, and pilot-scale demonstrations of promising energy efficiency and industrial decarbonization technologies. IEDO also collaborates with offices within the Office of the Under Secretary for Infrastructure to ready our most transformative industrial technologies for at-scale demonstration and deployment on America's factory floors.

IEDO funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

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

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023($)	FY 2025 vs FY 2023(%)
Industrial Efficiency & Decarbonization (IEDO)					
Energy- and Emissions-Intensive Industries	131,000		140,227	+9,227	+7%
Cross-Sector Technologies	90,500		102,000	+11,500	+13%
Technical Assistance and Workforce Development	45,000		45,000	0	0%
Total, Industrial Efficiency & Decarbonization	**266,500**	**266,500**	**287,227**	**+20,727**	**+8%**

Note: The Advanced Manufacturing Office (AMO) budget was split into two control points in the FY24 request to align 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 2023 Enacted: SBIR: $6,139,259; STTR: $901,071
FY 2024 Annualized CR: SBIR: $6,139,259; STTR: $901,071
FY 2025 Request: SBIR: $3,344,000; STTR: $470,000
Note: Please see Advanced Materials and Manufacturing Technologies (AMMTO) for the balance of AMO SBIR/STTR funding in FY23

Industrial Efficiency & Decarbonization

	FY 2025 Request vs FY 2023 Enacted
Energy- and Emissions-Intensive Industries: The request expands RD&D investments aimed at reducing energy use and GHG emissions from essential hard-to-abate industries through transformative technology innovations. The program expands efforts in the chemicals industry, with a focus on increasing the utilization of non-petroleum based sources of carbon through electrochemical utilization of CO_2; supporting a low-carbon cement and concrete consortium to accelerate adoption of innovative materials development, demonstration, and adoption of new low carbon cement and concrete materials through coordination across national labs, innovators, and federal agencies; and continuing to support emerging strategies to reduce emissions from iron and steel, food and beverage, and pulp and paper production, while expanding efforts to include other critical energy- and emissions-intensive industries like glass.	+9,227
Cross-Sector Technologies: The Request continues to prioritize investment in cross-cutting industrial systems with wide applicability across industrial subsectors that are critical for achieving industrial decarbonization. The program is focused on addressing the approximately half of industrial energy usage that is used for process heating and emphasizes electrified heating technologies like heat pumps and development of innovative direct heating technologies, in support of the Industrial Heat Earthshot initiative. The program also continues to support RD&D of emerging efficiency technologies, utilization of alternative fuels, and advanced water and wastewater treatment.	+11,500
Technical Assistance and Workforce Development: The Request continues technical assistance for the accelerated implementation of decarbonization technologies and water efficiency projects and practices with an increased focus on energy-intensive industries. Workforce development activities will focus on scaling successful, existing programs to train the manufacturing workforce of the future.	+0
Total, Industrial Efficiency & Decarbonization	**+20,727**

Industrial Efficiency & Decarbonization
Energy- and Emissions-Intensive Industries

Description
The Energy- and Emissions-Intensive Industries subprogram supports the strategic development of the U.S. industry subsectors with the highest energy consumption and GHG emissions. The subprogram features sector-focused RD&D activities to accelerate the commercial readiness of innovative, cost-effective, net-zero emissions technologies, with a focus on increasing industrial competitiveness while decreasing energy requirements and driving emissions to net-zero by 2050. RD&D challenges and opportunities are identified based on the DOE Industrial Decarbonization Roadmap, stakeholder input, alignment with the program's key activity areas, and future energy, carbon, and economic impacts related to subsequent industrial adoption.

Chemicals, Forest Products, and Related Industries:
This activity addresses energy consumption and GHG emissions from US manufacturing of chemicals, pulp/paper/forest products, and related industries—industries which currently rely heavily on thermally-driven chemical processing and separation processes to produce a wide variety of products. Topic areas focused on in this activity include the development of novel chemical reactor, process, and catalyst designs; increasing the use of alternative low-GHG-footprint feedstocks and electrochemical processes; and advanced drying methods.

To address lifecycle emissions in the manufacturing of carbon-based chemicals, the subprogram supports RD&D on the underlying challenges to effectively use CO_2 as a feedstock in place of fossil resources. Efforts will advance innovative processes like the electrochemical production of ethylene from CO_2, replacing high-temperature incumbent processes. RD&D focuses on the underlying process and materials challenges to enable scale-up (e.g., product selectivity, mass transfer limitations, electrode stability, ion conductivity, catalyst durability, reactor design). Addressing these foundational barriers will enable future electrochemical production of fuels, fertilizers, and commodity chemicals to accelerate decarbonization of the chemicals industry and ensure that the USA expands its leadership in these strategically important areas.

Iron and Steel, and Other Metals Industries:
This activity addresses energy consumption and GHG emissions in the production of iron and steel, an economically critical U.S. industry which currently inherently requires high temperatures and fossil carbon in their manufacturing. Particular emphasis is given to decarbonizing iron production (90% of iron and steel emissions) and steel reheating. RD&D topics include novel iron production routes (i.e., iron ore electrolysis); removal of copper contamination from scrap steel (a critical and growing problem limiting recycling of steel and driving more primary iron production from iron ore); solving key technical challenges in the development of producing hydrogen direct reduced iron (DRI); and novel steel reheat technologies (e.g., electrification and carbon-free fuels). Decarbonization of aluminum production will also be undertaken.

Cement, Food Products, and Other Industries:
This activity addresses energy consumption and GHG emissions for other energy and emissions-intensive industries, with a particular focus on the cement and concrete industry and food and beverage production/processing. An additional, growing focus in this activity is glass manufacturing, a smaller industry with difficult-to-reduce emissions that is expected to grow significantly into the future. In cement and concrete, this activity encompasses a full value chain approach, supporting strategic RD&D investments in novel cement and concrete materials and process development, from raw materials through final products. This activity includes support for a Cement and Concrete Materials Consortium with the goal of safe and rapid adoption and commercialization of novel low-carbon concrete materials by filling a critical gap spanning research, materials evaluation, codes/standards, and validation. RD&D investments in the food and beverage sector will continue to focus on solving the most impactful process related challenges while also considering upstream land use impacts.

Energy- and Emissions-Intensive Industries

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Energy- and Emission-Intensive Industries **$131,000,000**	**$140,227,000**	**+$9,227,000**
Chemicals, Forest Products, and Related Industries $53,000,000	$63,227,000	+$10,227,000
• Fund competitively selected RD&D projects, to rapidly advance technologies focused on decarbonization of the chemicals industry. • Support competitively selected RD&D, to rapidly advance technologies focused on decarbonization of the forest products industries.	• Fund competitively selected RD&D projects focused on decarbonization of the chemicals industries, with a particular focus on commodity chemicals and fuels (e.g., ethylene, methanol, and ammonia) and specialty chemicals that represent early adopters. This includes funding for the RAPID Institute to support the development of an innovation ecosystem centered around chemicals process innovation. • Fund competitively selected RD&D projects focused on decarbonization of forest products, with a focus on pulp and paper production.	• Increased funds will support expanded RD&D to address emissions associated with feedstocks for the chemicals industry, with a particular emphasis on increasing the utilization of non-petroleum based sources of carbon, especially electrochemical utilization of CO_2 .
Iron and Steel, and Other Metals Industries $38,000,000	$36,000,000	-$2,000,000
• Fund competitively selected RD&D projects, to rapidly advance technologies focused on decarbonization of iron and steel manufacturing.	• Fund competitively selected RD&D projects focused on decarbonization of iron and steel manufacturing, with a focus on potentially transformative process for primary iron production and increased scrap in steel making. • Fund RD&D projects in decarbonization of aluminum production and integration with low-carbon electricity resources.	• Decreased funding represents an increase in programmatic focus on decarbonization of chemicals, cement, and food/beverage industries.
Cement, Food Products, and Other Industries $40,000,000	$41,000,000	+$1,000,000
• Fund competitively selected RD&D projects, to rapidly advance technologies focused on decarbonization of cement and concrete manufacturing.	• Fund competitively selected RD&D projects in cement and concrete decarbonization, including the continued operation of a low-carbon cement and concrete consortium focused on accelerating development, demonstration, and adoption of new low carbon cement and concrete materials	• Increase will expand focus to adjacent industrial subsectors, including glass manufacturing.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Fund competitively selected RD&D projects, to rapidly advance technologies focused on decarbonization of food and beverage industries.	through coordination across national labs, innovators, and federal agencies. • Fund competitively selected RD&D projects focused on food processing innovations aiming for deep scope 1, 2, and 3 reductions in emissions. • Fund competitively selected RD&D focused on other energy and emissions-intensive industries, with a particular focus on low-carbon glass production.	• No significant change. • No significant change.

Industrial Efficiency & Decarbonization
Cross-Sector Technologies

Description

The Cross-Sector Technologies subprogram accelerates the readiness of process and equipment technologies that can lower energy usage and reduce emissions across many industrial subsectors. The subprogram focuses on industrial systems with wide applicability and high potential for decarbonization, including advanced thermal processes and systems, enabling technologies for low carbon fuels and feedstocks, and the exploration of emerging efficiency and decarbonization technologies. The subprogram also supports RD&D for energy and emissions reductions from water and wastewater treatment.

<u>Thermal Processes and Systems</u>: This activity addresses opportunities to reduce energy consumption and GHG emissions in process heating operations for the industrial sector. Industrial heating is used to remove moisture, separate chemicals, generate steam, treat metals, melt plastics, and much more. These thermal processes account for about half of all industrial energy usage and are responsible for about 9% of the entire U.S. GHG emissions footprint.

IEDO focus areas within this activity place a high priority on the electrification of thermal operations, including high-temperature industrial heat pumps and other innovative electro-thermal technologies. Additional work covers innovative furnace and process control systems and thermal process intensification, among others. This activity is closely coordinated with the Industrial Heat Earthshot initiative.

<u>Energy & Emissions Reductions from Water and Wastewater Treatment</u>: This activity supports RD&D of water treatment technologies that reduce CO_2, CH_4, and N_2O GHG emissions and recover resources from municipal, industrial, and agricultural wastewater treatment processes and systems, along with efforts to decarbonize energy-intensive water treatment systems that produce freshwater from non-traditional sources. 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, as well as advanced desalination technologies.

<u>Emerging Efficiency and Other Decarbonization Technologies</u>: This activity explores innovative energy efficiency and decarbonization technology concepts to improve industrial production system efficiencies and process yield, recovery of thermal energy, and industrial operational flexibility. Example topic areas include low-thermal budget operations such as membrane-based separation technology, and modeling, digitalization, and software to enable grid interactivity. Additional activities include energy systems analysis and modeling of production systems to identify opportunities for transformative technologies.

<u>Enabling Technologies for Low Carbon Fuels and Feedstock</u>: This activity addresses opportunities to facilitate the use of low carbon solutions in industry and replace existing carbon-based fuels and feedstocks. 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 combustion equipment capable of utilizing bio-derived fuels, hydrogen, or low carbon wastes and byproducts. Efforts also include development of flexible combined heat and power (CHP) systems that rely on low carbon fuels.

Cross-Sector Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Cross-Sector Technologies $90,500,000	**$102,000,000**	+$24,500,000
Thermal Processes and Systems $38,500,000	$50,000,000	+$11,500,000
• Fund competitively selected RD&D projects, to rapidly advance technologies focused on decarbonization of industrial process heating technologies. • Initiate the Electrified Processes for Industry without Carbon (EPIXC) Institute, focused on the development of an innovation ecosystem centered around process heat electrification.	• Fund competitively selected RD&D projects with high cross-sector impact on industrial thermal processing, including furnace and process control technologies, high-temperature industrial heat pumps, and electrification of thermally intensive operations. • Continue support for the EPIXC Institute to increase the number of partner organizations involved in the consortium and support partnered academic-industry-National Lab utilization of test facilities.	• Increase will prioritize the development of electric thermal process technologies by significantly expanding RD&D on industrial heat pumps and innovative electrotechnologies for high-temperature (> 500 °C) applications. • No significant change.
Energy & Emissions Reductions from Water and Wastewater Treatment $20,000,000	$20,000,000	$0
• Fund competitively selected RD&D projects to decarbonize Water Resource Recovery Facilities to reduce emissions from municipal water treatment processes.	• Fund competitively selected RD&D projects focused on decarbonizing wastewater treatment with a focus on industrial and agricultural wet organic waste streams, as well as advanced desalination technologies for secure low-emission water supply.	• No significant change.
Emerging Efficiency and Other Decarbonization Technologies $17,000,000	$17,000,000	$0
• Fund competitively selected RD&D projects to develop emerging cross-cutting industrial decarbonization opportunities.	• Fund competitively selected RD&D projects to develop emerging efficiency and decarbonization technology concepts including technologies for advanced heat management and industrial flexibility, improved flexibility of industrial electric loads and grid integration, advanced low-thermal budget operations; and analysis and modeling of production systems to identify transformative technologies.	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Enabling Technologies for Low Carbon Fuels and Feedstock $15,000,000	$15,000,000	$0
• Fund competitively selected RD&D projects on decarbonized combined heat and power using hydrogen or other renewable fuels.	• Fund competitively selected RD&D projects to enable the use of clean heat, power, and feedstocks sourced from low- or no-carbon fuels and renewable energy sources; with a focus on equipment technology and auxiliary components capable of utilizing bio-derived fuels, hydrogen, or other low carbon wastes and byproducts.	• No significant change.

Industrial Efficiency & Decarbonization
Technical Assistance and Workforce Development

Description

In the industrial sector, significant cost savings are possible through investments in energy efficiency and decarbonization, such as the adoption of energy management practices, onsite energy generation systems, and advanced technologies. These energy and cost savings, and lower carbon footprints, contribute to US manufacturing competitiveness and increase the potentially addressable markets for products. The Technical Assistance and Workforce Development subprogram supports direct assistance and the development of transformational tools to help companies realize these benefits and develop targets for energy efficiency, productivity, carbon reductions, and waste/water use reduction.

Core ongoing programs include the Better Plants Challenge, Better Climate Challenge, Energy Management Program, and the Onsite Energy Program. The subprogram identifies 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 advanced energy and water efficiency technologies and practices across the industrial sector is accelerated by technical assistance that addresses the market and non-market barriers that prevent continued investment. IEDO develops technical assistance resources that include analytical tools, best practice information, project implementation guides, virtual trainings, site-specific assistance, and peer-to-peer learning networks. An emerging area of focus for this portfolio is to supporting initiatives for energy-intensive manufacturers, including peer exchange working groups and training opportunities. The Industrial Technology Validation (ITV) initiative partners with DOE's National Labs to objectively validate performance of emerging technologies in dynamic industrial environments to de-risk implementation. The subprogram is also developing a sustainable, private-sector funding model for the Superior Energy Performance program, which will enable DOE funding to focus on the extension and improvement of existing publicly available state-of-the-art tools for manufacturers to address emerging topics such as smart manufacturing, resiliency, decarbonization planning, and quantification of non-energy benefits. 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 onsite energy generation technology solutions that can reach clean energy targets, replace outdated equipment, and balance resilience requirements. The subprogram's Onsite Energy Technical Assistance Partnerships (TAPs) will provide screenings and resources for a broad range of onsite energy technologies (such as battery storage, bioenergy, combined heat and power, district energy, photovoltaics, solar thermal, geothermal, distributed wind, thermal energy storage, etc.) to assist manufacturers in navigating which energy resources are most cost effective for their specific energy needs. The program will also support grid interactive manufacturing facilities that can use their onsite energy resources and load flexibility to provide services to the local electric grid.

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 implementing and maintaining new efficiency and 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.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Technical Assistance and Workforce Development $45,000,000	**$45,000,000**	**$0**
Technical Assistance and Workforce Development $45,000,000	$45,000,000	$0
• 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 regions 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, Better Plants Challenge, and Onsite Energy program to increase technical assistance opportunities for energy-intensive manufacturers that are pursing cost-effective efficiency solutions. Efforts will target technology validation, peer learning networks, as well as tool and resource development. • Provide validated data, tools, technical assistance, and real-world experience that give power system and grid edge decision-makers the confidence to increase distributed generation and decarbonize end uses while maintaining or improving affordability, reliability, and resilience for industrial end users.	• No significant change.
• 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 augmenting successful reskilling and upskilling programs that train workers to implement and maintain emerging decarbonization technologies and practices.	

Advanced Materials and Manufacturing Technologies

OVERVIEW

The U.S. manufacturing sector and its complex supply chains are vital to our economic and national security. The sector employs nearly 13 million people, represents 11% of the U.S. gross domestic product and accounts for roughly 25% of U.S. exports. The Advanced Materials and Manufacturing Technologies Office (AMMTO) plays a strategic role in building a strong, revitalized domestic manufacturing sector and creating American jobs through investments in research, development, and demonstration (RD&D) activities, as well as technical assistance and workforce training. By advancing next-generation materials and manufacturing technologies, AMMTO secures domestic supply chains, gives U.S. manufacturers a competitive edge in the global marketplace, and grows our nation's workforce.

AMMTO achieves its mission by creating tailored innovation ecosystems that convene the nation's brightest minds – across industry, academia, U.S. national labs, and government at all levels – to solve our most pressing domestic manufacturing challenges. AMMTO's strategic investments are rooted in merit-based selections, informed by stakeholder engagement, evaluated through careful analysis, and proven through peer-reviewed results.

AMMTO executes a three-pillar subprogram structure to meet its goals: Next Generation Materials and Processes; Secure and Sustainable Materials; and Energy Technology Manufacturing and Workforce. Within each subprogram, AMMTO invests in transformative RD&D informed by two-way stakeholder dialogue and guided by strategic roadmaps with direct routes to industry adoption.

To transform an idea into a commercialized technology on the factory floor, AMMTO collaborates with DOE offices working across all stages of the innovation continuum – from fundamental science to applied research and development to demonstrations and deployment. AMMTO works with offices within the Office of the Under Secretary for Science and Innovation to advance research, development, and pilot-scale demonstrations of technologies in areas ranging from energy storage to critical materials to semiconductors and microelectronics. AMMTO also collaborates with offices within the Office of the Under Secretary for Infrastructure to prioritize technology investments to close supply chain gaps and accelerate promising advanced manufacturing research results into commercial technologies.

AMMTO funds will be used to support efforts such as impact evaluations, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated Energy Efficiency and Renewable Energy (EERE) approach is more efficient than individual technology office efforts.

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

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023($)	FY 2025 vs FY 2023(%)
Advanced Materials and Manufacturing Technologies (AMMTO)					
Next-Generation Materials & Processes	90,000		82,000	-8,000	-9%
Secure & Sustainable Materials	40,000		76,000	+36,000	+90%
Energy Technology Manufacturing & Workforce	53,500		62,000	8,500	+16%
Total, Advanced Materials and Manufacturing Technologies	**183,500**	**183,500**	**220,000**	**+36,500**	**+20%**

SBIR/STTR:
FY 2023 Enacted: SBIR: $4,453,741; STTR: $588,929
FY 2024 Annualized CR: SBIR: $4,453,741; STTR: $588,929
FY 2025 Request: SBIR: $10,513,000; STTR: $1,478,000

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

	FY 2025 Request vs FY 2023 Enacted
Next-Generation Materials & Processes: The Request continues support of the development of innovative materials and manufacturing processes for clean energy technologies and reprioritizes investment to support manufacturing digitalization. The reduction in subprogram funding level reduces funding for multiple initiatives including RD&D for processing of advanced composites and nanocellulosic feedstocks for clean energy technologies, as well as management of the Carbon Fiber Technology Facility (CFTF).	**-8,000**
Secure & Sustainable Materials: The Request expands critical materials research investments, with focus on research, development and pilot scale demonstrations aimed at increasing domestic availability of these materials, developing alternatives, and increasing the resiliency of critical materials supply chains for clean energy applications. The Request also expands investment in circular economy initiatives through RD&D activities that 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.	**+36,000**
Energy Technology Manufacturing & Workforce: This Request reduces investments in RD&D to accelerate manufacturability and strengthen supply chains for lithium-ion and flow batteries and expands investments in battery manufacturing testbed platforms to enable a manufacturing continuum for energy storage technologies. Investment in highly efficient microelectronics is also reduced, as the program shifts to inform semiconductor manufacturing investments across the government, based on the Microelectronics Energy Efficiency Scaling over 2 Decades Roadmap.	**+8,500**
Total, Advanced Materials and Manufacturing Technologies	**+36,500**

Advanced Materials and Manufacturing Technologies
Next-Generation Materials & Processes

Description

The Next-Generation Materials & Processes subprogram will focus RD&D to increase U.S. advanced manufacturing competitiveness in clean energy technologies, with an emphasis on advanced materials and innovative manufacturing processes that benefit multiple energy technology applications, strengthen domestic supply chains, and support economy-wide decarbonization. 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. 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.

Advanced Manufacturing Processes and Systems: This activity will support foundational manufacturing processes such as additive manufacturing, automation, digitalization, and cybersecurity. These manufacturing process innovations can help alleviate current U.S. manufacturing capacity constraints, accelerate rapid prototyping, and improve U.S. competitive advantages across a variety of industries important to manufacturing of clean energy technologies and secure vital supply chains. The Manufacturing Demonstration Facility (MDF) works on additive manufacturing coupled with digital twin and related materials and processes for clean energy applications. This activity supports research to advance casting and forging processes particularly for production of 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 accelerate technology developments from small and medium-sized U.S. manufacturers.

High Performance Materials: This activity will support materials with improved performance necessary for decarbonization and clean energy. Specific RD&D will enable advancements in high-conductivity materials systems, 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, high-pressure, corrosive chemicals, neutron irradiation and hydrogen attack service environments required for decarbonized heat, thermal storage and heat exchangers etc., with target to enable industrial decarbonization and clean energy applications.

Next-Generation Materials & Processes

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Next-Generation Materials & Processes **$90,000,000**	**$82,000,000**	**-$8,000,000**
Advanced Manufacturing Processes and Systems $64,500,000	$49,500,000	-$15,000,000
• Continue additive manufacturing and carbon fiber composites research through the MDF.	• Leverage MDF to address cross-cutting manufacturing challenges, drive manufacturing digitalization and enable rapid prototyping and a domestic supply chain for clean energy technologies such as wind and hydropower. Pursue joint funding from other DOE offices (WETO, NE), agencies (DOD, NASA) 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 and supply chain.
• 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.	• Reprioritize funding to focus on manufacturing digitalization. Use the National Smart Manufacturing Strategic Plan[1] and proceedings from Workshop series on Options for a National Plan for Smart Manufacturing to guide funding of RD&D in manufacturing digitalization technology that improves energy efficiency, reduces emissions, and improves supply chain resilience.	• Reprioritize funding to accelerate manufacturing digitalization.
• 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 and scale up, such as quality, yield, and throughput.	• Increased funding to support computational models and analysis for materials design and manufacturing performance and scale up for clean energy technologies in partnership with the national labs and manufacturing firms.

[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

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Fund development of advanced tooling for lightweight automotive components.	• No funding requested.	• Advanced tooling for lightweight automotive components is not in the current scope of AMMTO.
• Near Net Shape Manufacturing, such as castings and forgings, of large components for use in clean energy technologies.	• Fund RD&D that addresses challenges in cross-cutting manufacturing technologies, such as castings and forgings of large, near net shape components, that have the potential for high impact across multiple clean energy technology sectors e.g., offshore wind and hydropower.	• Modest reduction in funding with plan to grow co-funding from other DOE offices and partner agencies.
High Performance Materials $25,500,000	$32,500,000	+$7,000,000
• Fund work on structural composites for clean energy applications, including for offshore wind blades and platforms. Manage the Carbon Fiber Technology Facility (CFTF) in conjunction with this work. • 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. • Fund composite materials R&D in collaboration across EERE and DOE for technologies including wind.	• Manage the Carbon Fiber Technology Facility (CFTF) in conjunction with this work, and accelerate technology scale-up, commercialization and digital transformation. • Increase support for CABLE high conductivity materials activities and industrial materials that operate in harsh service environments to help build an equitable, clean-energy future. Combine additive technology and Artificial Intelligence (AI)/ Machine Learning (ML) to open design space and accelerate materials development. • Fund composite materials R&D through consortia projects.	• Increased funding to CABLE high conductivity materials activities. Increased support for these high conductivity materials to support electrification and transmission deployment goals. Increase in funding for harsh service environment materials. • Reprioritize reduced funding for composite materials R&D through consortia-based projects.

Advanced Materials and Manufacturing Technologies
Secure & Sustainable Materials

Description

The Secure and Sustainable Materials subprogram focuses on materials and processing technologies that strengthen American supply chains and expand domestic manufacturing capacity while positioning the U.S. as the leader in the clean energy economy. This subprogram will support applied RD&D projects and consortia—cost-shared with companies and research organizations—that focus on generating solutions to address challenges in critical materials and circular economy that will reduce our nation's carbon footprint. RD&D in this subprogram will support secure domestic supply chains across multiple industrial sectors, 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: Critical materials are vital to American national and economic security and domestic sources do not meet current or forecast demand across multiple applications. This activity supports a multi-pronged RD&D strategy to increase domestic availability of critical materials as well as identify and mature alternatives. The strategy responds to the authorizations contained in the Energy Policy Act of 2020 through the support of the Critical Materials Collaborative that aligns academia, national labs, and industry to provide technologies 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 prototyping and small-scale demonstrations that verify economics of production and 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 and deployment programs supported by other DOE Offices including the Office of Manufacturing and Energy Supply Chains (MESC) and Fossil Energy and Carbon Management (FECM) funded via annual appropriations, the Bipartisan Infrastructure Law, and the Inflation Reduction Act. As such, AMMTO coordinates continually with these offices on critical materials activities.

Circular Economy Technologies: Materials currently in use across the economy are a valuable domestic source of many important materials classes if they can be retained, recovered, and recycled for use at the end of their present life. 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 supports RD&D that advances the circular economy of materials 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 environmental impacts 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Secure & Sustainable Materials $40,000,000	**$76,000,000**	**+$36,000,000**
Critical Materials $26,000,000	$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 development and maturation of alternative materials.
Circular Economy Technologies $14,000,000	$26,000,000	+$12,000,000
• 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.	• 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[2]. 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[3], 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.

[2] EPA National Recycling Strategy 2023, https://www.epa.gov/recyclingstrategy
[3] 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 invests in RD&D activities to advance manufacturing technologies 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.

Energy Conversion and Storage Manufacturing: This activity invests in manufacturing technologies to meet cost and performance targets of the Department of Energy's (DOE) Long Duration Storage Shot. This activity invests 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. The activity also invests in manufacturing of alternative battery technologies and testbeds for battery manufacturing.

Semiconductors, Electronics, and Other Technology Manufacturing: Cross-cutting technologies enable clean energy technologies to be deployed in multiple industrial sectors. Guided by a Power Electronics R&D Roadmap, this activity will invest in development of lower cost, higher efficiency wide bandgap semiconductors and power electronics that are critical for grid-relevant high voltage transmission and power management of industrial motors and electric vehicle motors. In addition, the activity is supporting data and analysis to inform investment in manufacturing technologies needed to produce high efficiency microelectronics.

Entrepreneurial Ecosystems and Advanced Manufacturing Workforce: Diverse networks of manufacturers in emerging technology areas and/or across supply chains provide the infrastructure to accelerate innovation and manufacturing scale up. This activity will support people and communities to catalyze expertise in information systems, as well as business and entrepreneurial ecosystems. This activity will support 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Energy Technology Manufacturing and Workforce $53,500,000	**$62,000,000**	**+$8,500,000**
Energy Conversion and Storage Manufacturing $20,500,000	$30,000,000	+$9,500,000
• 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.	• RD&D investments to catalyze manufacturing scale up of emerging battery technologies. For flow batteries, the focus will be on addressing manufacturability issues with battery manufacturing scale up. For sodium ion batteries, the focus will be on commercial-scale machines for materials and component manufacturing, cell assembly/finishing, and pack manufacturing. Launch investment in translational testbeds for advancing energy storage technologies and their critical materials supply chains.	• Deepen RD&D investment in testbed platforms for manufacturing scale-up across supply chains and advanced equipment for battery manufacturing. This includes investment in critical materials supply chains and recycling.
Semiconductors, Electronics, and Other Technology Manufacturing $15,500,000	$18,500,000	+$3,000,000
• 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. Data and analysis for high efficiency microelectronics.	• Ramp up support of power electronics manufacturing RD&D guided by the Power Electronics Roadmap currently under development, including addressing gallium supply chains. Reduction of funding in manufacturing RD&D for high efficiency microelectronics; the program will focus on influencing partner agency investments guided by the Microelectronics Energy Efficiency Scaling over 2 Decades (EES2) roadmap.
Entrepreneurial Ecosystems and Advanced Manufacturing Workforce $17,500,000	$13,500,000	-$4,000,000

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• 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 post-doctoral researchers to address fundamental manufacturing decarbonization challenges.	• Train the clean energy innovators of the future leveraging the facilities and scientific expertise of the DOE National Laboratories through the Lab-Embedded Entrepreneurship Program. 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 underserved communities, and integrates activities.	• Reduction in supplements for education and workforce for Manufacturing USA Institutes. Slight reduction in the Lab-Embedded Entrepreneurship Program (LEEP) as the program continues to shift to a cross-office support model.

Building Technologies Office

Overview

The Building Technologies Office's (BTO) FY 2025 Request prioritizes accelerating the most impactful cost and emission reductions from building end uses, placing an additional emphasis on affordable space heating, cooling, and water heating, and increasing the focus on market priming, building quality, and the accelerated adoption of high performing, efficient technologies. This includes prioritization of low-income household impacts, such as projects that reduce costs, improve comfort, and increase accessibility. The U.S. building sector accounts for 75 percent of total U.S. electricity use, 40 percent of all energy use, and 35 percent of energy-related carbon dioxide emissions. BTO's national strategy for buildings is people-centered meaning it strives to deliver economic growth and high-quality jobs, energy justice, climate resilience, improved public health, and reduced energy costs and energy burden, especially in disadvantaged communities (DACs). BTO is focused on reducing energy wasted in buildings (estimated at 30% of $400 billion nation-wide) while also reducing the associated onsite greenhouse gas (GHG) emissions, currently around 13 percent of total U.S. GHG emissions. BTO aims to reduce the cost of building decarbonization, enable decarbonization in disadvantaged communities using a "whole of government" approach, and reduce the need for a larger and more expensive grid by managing demand and developing strategic behind-the-meter investments.

Our work to improve energy performance in buildings increases productivity, reduces costs to occupants and owners, and leverages grid integration to improve energy demand flexibility, helping businesses, consumers, and grid operators to plan effectively while enabling more affordable decarbonization of the power sector and transportation. BTO is working to optimize grid integration to better manage energy loads changed by vehicle charging by integrating onsite generation and other behind the meter resources to reduce utility and consumer costs. Buildings are at the intersection of our most critical investments to improve energy efficiency, reduce current and future costs, and accelerate fair decarbonization helping to avoid trillions of dollars of future electricity system infrastructure upgrades. BTO's work prioritizes affordability, energy security, occupant and community resilience, indoor air quality and comfort, energy equity, and environmental justice. In addition, funds will be used to support efforts such as impact evaluations, technical assistance, workforce development, diversity in STEM, technology-to-market activities, and other crosscutting, mission-critical activities where a coordinated EERE approach is more efficient than individual technology office efforts.

Building Technologies
Funding ($K)
(Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Building Technologies					
Emerging Technologies	117,000		120,000	+3,000	+3%
Commercial Buildings Integration	70,000		78,000	+8,000	+11%
Residential Buildings Integration	70,000		77,000	+7,000	+10%
Appliance and Equipment Standards	60,000		50,000	-10,000	-17%
Building Energy Codes	15,000		15,000	0	0%
Total, Building Technologies	**332,000**	**332,000**	**340,000**	**+8,000**	**+2%**

SBIR/STTR:

- FY 2023 Enacted: SBIR: $5,191,000; STTR: $730,000
- FY 2024 Annualized CR: SBIR: $5,191,000; STTR: $730,000
- FY 2025 Request: SBIR: $5,504,000; STTR: $774,000

Building Technologies
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Emerging Technologies (ET): The increase in this subprogram allows for critical R&D on heat pump technology solutions for multifamily and manufactured housing units, including non-HFC, low-GWP and natural refrigerants that reduce costs and increase customer and building resilience. The increase also enables innovations that overcome long term challenges in building envelope retrofits and prioritizes electrical systems integration in buildings to support EV charging, heat pumps, and demand flexibility. The Request also prioritizes research supporting high temperature heat pumps, cold climate heat pump performance validation, advanced controls, and electric optimization solutions to address control panel upgrades. The Request will also enable the future low carbon grid working in conjunction with other offices including the Office of Electricity.	+3,000
Commercial Buildings Integration (CBI): The increase in this subprogram prioritizes RD&D for energy efficiency and emissions-reduction technologies capable of rapidly scaling retrofits across a variety of building and community types. The Request will expand the number of technology validations and demonstrations for commercial heat pump, energy efficiency, and grid-connected building technologies. The Request will improve and increase the amount of technical assistance provided and teams funded through programs that accelerate market acceptance and uptake such as the Better Buildings Initiative and Buildings Upgrade Prize (Buildings UP).	+8,000
Residential Buildings Integration (RBI): The increase in this subprogram prioritizes activities that focus on improving the effectiveness and affordability of energy efficient retrofit technologies as well as highly efficient new construction for American homes. The Request will increase competitive awards for innovative and affordable building decarbonization technologies that offer a multitude of benefits and will accelerate technology validation and demonstration of low power residential heat pumps, envelope energy efficiency such as panelized retrofits, and grid-connected building technologies, especially for affordable housing.	+7,000
Appliance and Equipment Standards: The Request continues to prioritize DOE's commitment to the appliance and equipment standards program as a fundamental building block to improving efficiency in buildings that contributes to DOE's decarbonization goals. The decrease in this subprogram reflects anticipated decreased number of future standards and test procedure rulemakings.	-10,000
Building Energy Codes: The Request continues activities directed by statute for rulemaking, technical analysis, and technical assistance for the advancement and successful implementation of building energy codes.	0
Total, Building Technologies	**+8,000**

Description

In FY 2025, the Emerging Technology program (ET) will focus on addressing deployment challenges, including affordability, footprint, and grid impacts of the most critical technologies for reducing energy bills and emissions, such as space and water heating, energy demand management, and high-performance envelope technologies. This program will support the breakthrough innovations required to achieve the Affordable Clean Homes Earthshot to reduce the cost of decarbonization existing affordable housing, specifically multifamily and manufactured homes by 50%, reducing energy bills for Low-to-Moderate-Income customers by 20% and extending these innovations to the larger residential and commercial building segments. The Request includes significant new research supporting the Earthshot such as cold climate heat pump performance validation, low-GWP and natural refrigerants, lower cost retrofits for building envelopes, control systems for improving existing buildings, and electric optimization solutions like smart panels to reduce grid impacts. The ET program also supports buildings-and-grid edge integration work in conjunction with offices in Renewable Power, Vehicles, and the Office of Electricity to comprehensively address edge-of-grid challenges. ET's applied RD&D portfolio collaborates with industry and academia and the National Laboratories' researchers, computing capabilities, and other unique facilities to support efforts to significantly reduce emissions from buildings. ET's work invests directly in domestic workforces to accelerate innovation and job creation in a range of key U.S. industries, including building equipment and component manufacturing, distributed energy resources and world class research on novel U.S. technologies.

<u>HVAC, Water Heating, and Refrigeration (HVAC&R) R&D</u>: This activity focuses on improving market uptake of low-emission heating systems through R&D on technical solutions to reduce costs, improve performance, and overcome installation barriers. The portfolio will support innovative technologies to solve thorny challenges such as small form factor heat pump water heaters, rooftop heat pumps for commercial buildings that operate efficiently at temperatures as low as – 15F, compact sustainable air-conditioners that enable climate adaptation and resilience, and thermal systems designed to replace fuel powered boilers in large commercial buildings. It will also enable subsystems such as refrigerant leak detection sensors, advanced variable speed drives, and futuristic cooling technologies. This activity will prioritize critical R&D needs such as: cold climate heat pumps; high temperature heat pumps, heat pumps for affordable housing that address energy use, indoor air quality and comfort issues; Central and 120V heat pump water heaters; and low GWP and natural refrigerants for refrigeration systems, both packaged as well as for large warehouses.

<u>Electrical and Whole Building System R&D:</u> This activity seeks to achieve energy savings and meet building energy standards in new and existing buildings will require significant improvements in design and operation of buildings. This activity puts a focus on energy management in existing buildings through R&D investments in controls hardware and software interoperability. This activity invests in advancing building control systems to enable integration of electric vehicles, energy storage and renewable energy sources in buildings to provide coordinated management of energy uses and to reduce energy costs for consumers. Investments in fundamentals tools for energy modeling enable updated building energy codes and meeting voluntary zero energy standards. Finally, this activity accelerates buildings-and-grid integration R&D with a focus on reducing grid edge investments for decarbonization and enabling virtual power plants by increasing demand flexibility. Lighting R&D will focus on implementation and new applications of solid-state lighting, such as connected lighting, mitigating airborne pathogens, and controlled environment agriculture.

<u>Thermal Systems and Energy Storage R&D:</u> This activity focuses on improving affordability, comfort, and resiliency of our buildings by investing in technologies such as windows, insulation and energy storage to reduce energy use and increase resilience. This activity supports development activities such as development of DIY insulated siding, low-cost vacuum sealed thin triple paned windows, and the Equitable and Affordable Solutions to Electrification (EAS-E) prize that reduces cost of building electrification. Technology investments in this space support efforts to reduce energy bills by 20% and halve the cost of decarbonization by substantially reducing the cost of adding building insulation or replacing windows. Key R&D activities in this space include breakthrough innovations and cost compression in insulative materials, remote retrofitting technologies, aerosol-based envelope sealing, pre-fab panel customization, and aerogel windows to reduce the energy required to heat and cool a building, contribute to improved occupant comfort, building flexibility, and resilience, and reduced costs and installation challenges to enable faster widespread market adoption.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Emerging Technologies **$117,000,000**	**$120,000,000**	**+$3,000,000**
HVAC, Water Heating, and Refrigeration R&D $51,000,000	$53,000,000	+$2,000,000
• Support research to accelerate performance improvement and field validation of cold climate heat pumps, technology advancements to reduce heat pump soft costs, and advanced fault detection and diagnostics that improves heat pump operational performance.	• Advance performance improvement of cold climate and high temperature heat pumps for space and water heating, invest in new HVAC technology architectures to reduce ex-factory gate costs, improve fault detection and diagnostics (FDD), and reduce operational energy waste.	• No significant change.
• Support research to advance heat pump water heaters that can be “ready” replacements for existing water heaters and boilers such as low power (120V) and central heat pump water heaters.	• Advance heat pump technology with a focus on affordable housing (multifamily and manufactured) that incorporate low-GWP, non-HFC refrigerants while reducing physical size and power draw.	• Increased funding for heat pump technology solutions for multifamily and manufactured housing units, as well as for older buildings that may be incompatible with, and whose residents may lack access to modern HVAC equipment.
• Conduct projects that accelerate development and validation of non-HFC low-GWP refrigeration technologies for comfort and product refrigeration to reduce energy use, improve safety and support future regulations.	• Advance technologies for non-HFC, low-GWP and natural refrigerants in buildings, while enhancing operating efficiency and managing safety and serviceability of new refrigerants.	• No significant change.
Thermal Systems and Energy Storage $27,000,000	$27,000,000	+$0
• Advance building energy storage by launching Thermal Energy Storage (TES) National	• Advance optimization of battery and thermal energy storage, accelerating uptake of innovations such as	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Laboratory Consortium and support work to integrate electric storage and thermal energy storage at equipment and building levels.	tunable materials and equipment-integrated storage through the Thermal Energy Storage (TES) National Laboratory Consortium.	
• Support projects to reduce heating and cooling load through advanced envelope retrofit technologies, such as thin triple pane, high efficacy retrofit windows, geospatial identification of thermal leakage, and robotic construction of retrofit facades.	• Advance innovations that overcome long term challenges in building envelope retrofits (including windows, air sealing and high- performance tunable insulation) using cutting edge technologies such as robotics and digitization to reduce need for human intervention and improving worker health and safety.	• No significant change.
Electrical and Whole Building Systems $39,000,000	$40,000,000	+$1,000,000
• Continue development and maintenance of open-source models and analysis to support evaluation of technologies, systems, and strategies and build confidence in building efficiency and flexibility measures among BTO itself, utilities, states, and other organizations.	• Enhance work in building energy modeling and analysis for heat pumps in residential and commercial buildings, quantify cost and emissions impact of energy efficiency and decarbonization measures, and support performance-based measurement and verification (M&V).	• No significant change.
• Support research on controls for whole buildings, as well as connected plug loads, and lighting and how these can enable greater demand flexibility and lower costs for markets that have been left behind.	• Expand and accelerate work to advance integrated energy efficiency and renewable energy elements such as solar, batteries and electric vehicles so that they connect into and support the future low carbon, affordable electric grid.	• The increase sought is to accelerate additional research on customer and building resilience, and analysis of impacts of behind the meter resources such as EV chargers, HVAC, and storage.

Building Technologies
Commercial Buildings Integration

Description
In FY 2025, Commercial Buildings Integration (CBI) will prioritize investments in demonstrations, deployment, and the associated market transformation work needed to support commercial building efficiency, unlock cost reduction opportunities for American businesses, and reduce emissions across a wide array of building types. As part of the Better Buildings Initiative, DOE is working to highlight successful strategies and develop new resources that contribute to lower costs and a cleaner, more resilient, and decarbonized energy system. Through the Better Climate Challenge, CBI is working with more than 100 leaders in the commercial sector to reduce the emissions footprint of their portfolio and highlight the best practices necessary to reduce emissions across the entire commercial building stock. CBI activities will focus on streamlining and scaling adoption through technology demonstrations, procurement best practices, adoption campaigns, and recognition of exemplary practices. CBI will invest in programs to enhance the competitiveness of U.S. businesses through rapid deployment of high performing efficient decarbonization technologies, including through retrofits in commercial buildings and multifamily buildings.

Technology Validation and Demonstration: This activity will accelerate technology adoption for decarbonization in commercial buildings through new initiatives such as the Cold Climate Rooftop Challenge, IMPACT and the Envelope Prize. The Cold Climate Rooftop Challenge will seek to fill a critical industry gap for zero-emissions cold climate rooftop units, while the Envelope prize will reduce cost of retrofits especially windows and insulation, such as curtain wall systems. The IMPACT program works with the national labs and across a broad group of industries to validate, demonstrate and deploy innovative technology solutions that unlock cost savings, attain energy efficiency and decarbonization goals, and enhance occupant comfort in new and existing commercial buildings. Through Connected Communities, CBI will demonstrate community and campus solutions to decarbonization and grid flexible technologies to reduce the emissions footprint of existing commercial buildings. CBI works with third party verifiers to validate technology solutions for low-emission heating and cooling packages that are affordable, efficient, and effective. CBI demonstrates and deploys these solutions via voluntary partnerships under the Better Buildings Initiative and through multi-agency collaboration.

Technology Adoption and Technical Assistance: CBI provides targeted technical assistance to identify and scale best practices through partnerships, including the Better Buildings Initiative. CBI's efforts include resources and support to deploy easy-to-install and use efficiency technologies, building envelope upgrades, renewables integration and demand flexibility technologies in commercial buildings. CBI will highlight the best practices and pathways to strategically overcome technical and structural barriers and to leverage other drivers to accelerate adoption. This effort feeds directly into rapid R&D within BTO and other EERE organizations to help solve critical technical and cost barriers. CBI will continue support for growth in skilled building efficiency and decarbonization jobs through capacity building activities. CBI will continue collaborating with RBI on Buildings UP, which aims to spur new partnerships to develop and implement innovative approaches to rapidly scaling the delivery of building upgrades. In collaboration with the Building Energy Codes Program, CBI will further support the development and implementation of building performance standards through demonstration of decarbonization pathways and technical assistance for local governments.

In FY 2025, CBI will invest in work with utilities to accelerate adoption of energy efficiency, demand flexibility and electrification technologies to lower operational costs and decarbonize the built environment by 2050. CBI leverages utilities' existing efficiency programs and relationship with commercial customers to disseminate information and spur uptake of commercial energy efficiency technologies.

Enabling Tools and Resources: CBI maintains and continuously improves a suite of user-accessible, packaged tools to enable the affordable evaluation of commercial building energy use, emissions reduction, demand flexibility, and performance investments. This work is founded on the physics-based computational simulations supported through the BTO BEM portfolio. CBI's design and decision support tools and resources can evaluate efficiency investments for one building or across a portfolio of buildings at various phases of a building's life cycle–design, operation, renovation, and resale. CBI will also develop software and analysis to support Building Performance Standards.

Commercial Buildings Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Commercial Buildings Integration $70,000,000	**$78,000,000**	**+$8,000,000**
Technology Validation and Demonstration $23,000,000	Technology Validation and Demonstration $27,000,000	+$4,000,000
• Support for the deployment of heat pumps and grid flexible technologies to reduce the carbon footprint of the existing commercial building stock.	• Invest in validation and deployment of technologies such as new envelope and window technologies, new heat pumps for higher temperatures in large commercial buildings and for development and demonstration of the cold climate heat pump rooftop.	• Increased investment in the validation of emerging heat pump technologies for larger commercial buildings, and envelope retrofit solutions (e.g., curtain wall systems) to achieve decarbonization in many commercial building segments.
• Expansion of portfolio of efficiency work with small and medium businesses through demonstration, and deployment of turnkey efficiency and climate-responsive technology packages, scaled in partnership with community-level organizations.	• This effort will also support the Connected Communities effort to demonstrate community and campus solutions to decarbonization and grid flexible technologies to reduce the emissions footprint of existing commercial buildings.	• No significant change.
Technology Adoption and Technical Assistance $37,000,000	Technology Adoption and Technical Assistance $41,000,000	+$4,000,000
• Increase emphasis on decarbonization of commercial buildings including support for implementing decarbonization policies and pathways in multiple commercial use cases.	• Provide technical assistance to partners who are developing innovative building decarbonization approaches that can rapidly scale retrofits across a variety of building and community types.	• No significant change.
	• Provide direct technical assistance to the cohort of teams selected in Buildings UP to enable scaling of building retrofit programs that deliver decarbonization, comfort, improved indoor air quality, energy equity and resilience benefits.	• No significant change.
	• Develop a cross-BTO strategy to work with utilities to accelerate adoption of energy	• Increased analytical support and engagement with PUCs and utilities to accelerate adoption of cost-effective energy efficiency technologies in

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	efficiency, demand flexibility and electrification technologies.	utility programs that mitigate grid-edge impacts and to reduce bill impacts.
Enabling Tools and Resources $10,000,000	Enabling Tools and Resources $10,000,000	$0
• Maintain and continuously improve suite of user-accessible, used, and useful packaged tools, to enable the affordable evaluation of commercial building energy, emissions reduction, demand flexibility, and performance investments.	• Maintain and improve the suite of user-accessible packaged tools to support evaluation of commercial building energy use, emissions reductions, demand flexibility and performance investments.	• No significant change.
• Develop and maintain design and decision support tools and resources that can be used to evaluate efficiency and decarbonization investments for one building or across a portfolio of buildings at various phases of a building's life cycle.	• Develop and maintain decision support tools and resources that can be used across a portfolio of buildings to evaluate efficiency and decarbonization investments.	• No significant change.

Building Technologies
Residential Buildings Integration

Description

In FY 2025, Residential Buildings Integration (RBI) will invest in domestically manufactured residential solutions with the greatest promise for delivering cost, energy, climate, and other benefits at scale. RBI's investments focus on developing low-cost building technologies and approaches that require minimal onsite construction and installation time, appeal to a wide range of consumers and users including renters and occupants of older homes, and can be broadly applied to the multitude of residential building types and climates in the U.S.

Technology Validation and Demonstration: Through its Building America program and other efforts, RBI will build upon its successful track record of working with builders, contractors, manufacturers, program implementers and others to validate, demonstrate, and de-risk new efficiency technologies and integration approaches in real world (non-laboratory) homes, develop solutions to application and integration issues, disseminate resulting "best practice" technical guidance, and provide technical expertise to early adopters. RBI prioritizes demonstration and validation of innovative technologies such as low power and small form factor heat pumps, point mapping and automation for identification of envelope improvements and applying innovations such as robotics and panelization to accelerate retrofits of existing homes. These practices offer a multitude of benefits, including affordability, energy efficiency, emissions reductions, indoor air quality, scalability, simplified installation, and maintenance that reduces inconvenience to tenants and homeowners, and greater reliability.

Technology Adoption and Technical Assistance: RBI works with industry, state and local governments, utilities, residential contractors (including home performance, HVAC, renovation, and other contractors), builders, building owners and operators, and training entities among other key stakeholders to address the barriers hindering widespread uptake of efficiency measures in new and existing single and multifamily homes, including manufactured homes. RBI supports the development, dissemination, and implementation of programs, tools, and resources dedicated to addressing needs beyond technology that are essential to scaling efficiency and meeting decarbonization goals. RBI will leverage technical assistance to encourage partnerships with and between affordable housing entities, cities, utilities, States, and equipment manufacturers and installers to deploy innovative solutions and approaches while driving investment in home energy upgrades. RBI will collaborate with CBI on the Buildings UP Prize, which will spur new partnerships to develop and implement innovative approaches to rapidly scaling the delivery of building upgrades, including streamlining existing incentives, greater leveraging of financing and other value streams, and improved community engagement to make decarbonization upgrades financially beneficial from day one.

In FY 2025, RBI will invest in a cross-BTO strategy to work with utilities to provide validated data, tools, technical assistance, and real-world experience that give power system and grid edge decision-makers the confidence to increase distributed generation and decarbonize end uses while maintaining or improving affordability, reliability, cybersecurity, and resilience for end users. This new effort will accelerate adoption of energy efficiency, demand flexibility and electrification technologies to reduce energy and cost burdens while decarbonizing the built environment by 2050.

Enabling Tools and Resources: Given the complexity and diversity of the U.S. housing stock, as well as the challenges associated with ensuring affordable, comfortable, safe, and decarbonized homes for all Americans, RBI relies on robust analysis and modeling to inform its work. In addition, RBI refines and applies building energy models, data systems, and other tools to assist builders, contractors, homebuyers, utilities, state and local governments, and other decision-makers to consistently and accurately estimate energy use, savings and costs; to inform investment decisions and maximize benefits; to assess the impact of different technologies on demand and on the grid; and, to apply best building science practices as well as the most up-to-date information on new technologies and approaches.

Residential Buildings Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Residential Buildings Integration $70,000,000	**$77,000,000**	**+$7,000,000**
Technology Validation & Demonstration $29,000,000	Technology Validation & Demonstration $32,500,000	+$3,500,000
• Continue investment in development and demonstration of deep energy retrofit solutions for all types of residential buildings, with a priority placed on approaches and technologies that offer additional value add (e.g., non-disruptive installation, greater resiliency) and can be readily scaled. • Expanded field validation of technologies and installation practices, particularly with greater emphasis on testing and improving these innovations in actual existing residential buildings. Select multi-disciplinary teams to address the hard-to-solve technical challenges most common in retrofitting existing residential buildings across various climate zones and building types.	• Continue investment in field validation of scalable retrofit solutions for all types of residential buildings, low power, and smaller form factor heat pumps, new envelope technology that reduce cost and customer impact for achieving energy efficiency and improving indoor environmental quality through better ventilation systems. • Revamp existing initiatives such as the Solar Decathlon Design and Build Challenge, and the Building America retrofit solutions arena with a shifted focus to target innovative technology development and demonstration.	• Increased technology validation of low power residential heat pumps, envelope energy efficiency retrofits, and grid-connected building technologies, especially for affordable housing to support the Earthshot and including installation practices in a wide array of residential building types. • No significant change.
Technology Adoption and Technical Assistance $25,000,000	Technology Adoption and Technical Assistance $28,500,000	+$3,500,000
• Provide technical assistance to public and private organizations, including affordable housing organizations, state and local governments, builders, trades, program implementers, and others to promote best practices in building construction and retrofit, scale heat pump deployment, energy-efficiency measure adoption, and support workforce recruitment and training.	• Deepen and accelerate technical assistance provided to public and private organizations to promote best practices in building construction, retrofit, and workforce, including a focus on scaling heat pump and energy-efficiency upgrades with available incentives.	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Conduct a large-scale competitive prize for communities across the U.S. to spur and support innovative approaches aimed at scaling the use of highly efficient technologies in the residential sector and leverage outside investment.	• Provide technical assistance to a cohort of teams selected in the Buildings UP to enable scaling of building retrofit programs that deliver decarbonization, comfort, improved indoor air quality, energy equity and resilience benefits.	• No significant change.
	• Invest in a cross-BTO strategy to work with utilities to accelerate adoption of energy efficiency, demand flexibility and electrification technologies.	• Expanded assistance to utilities, their regulators and state policymakers to scale adoption of energy efficiency programs and to support grid edge adaptation for building and transport decarbonization.
• Conduct 2023 Solar Decathlon Design Challenge as well as first-of-its-kind all local 2023 Solar Decathlon Build Challenge, to help develop our Nation's next generation of building scientists, architects, engineers, and other experts needed to attain a clean energy economy.	• The Solar Decathlon is moved to Technology Validation and Demonstration.	• The Solar Decathlon is moved to Technology Validation and Demonstration to integrate with related programs.
Enabling Tools & Resources $16,000,000	Enabling Tools & Resources $ 16,000,000	$0
• Continue refinement of analytical tools and models to accurately characterize the U.S. housing stock, to identify promising opportunities for cost compression, and to support utilities and other primary stakeholders in measuring the effectiveness of energy efficiency investments, including nonenergy benefits.	• Continue refinement of analytical tools and models to accurately characterize the U.S. housing stock, to identify promising opportunities for cost compression, and to support stakeholders in measuring the effectiveness of energy efficiency investments, including nonenergy benefits.	• No significant change.
• Apply analytical tools to assist state and local governments, utility programs and other efficiency program implementers in optimizing	• Invest in analytical tools to assist state and local governments, utility programs and other efficiency program implementers in optimizing	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
efficiency packages to meet the needs of their specific housing stock and their policy goals.	efficiency packages to meet the needs of their specific housing stock and their goals.	

Description

Appliance and equipment standards save consumer money on energy bills to lower energy burden and reduce consumer exposure to volatile energy prices, especially in disadvantaged communities (DACs). They deliver co-benefits like improved thermal resilience, comfort, health, and productivity. Appliance and Equipment Standards (AES) develops new or amended energy standards and test procedures, as directed by statute. AES currently sets policy regulations for more than 60 products, representing about 90 percent of home energy use, 60 percent of commercial building energy use, and 30 percent of industrial energy use. AES establishes Federal minimum energy efficiency standards based on DOE's prescribed test procedures to lock in energy savings for consumers. AES develops and updates test procedures to ensure they remain technologically relevant and provide manufacturers with a level playing field and a platform to bring to market new product innovations. AES enforces the energy conservation standards to prevent any manufacturer from undercutting those complying with the rules. AES also supports other Federal initiatives to help consumers make more energy-efficient purchasing decisions, including the ENERGY STAR program and Energy Guide labeling program.

DOE is committed to meeting its legislatively mandated deadlines for covered appliances and equipment. The rulemaking schedule is directed by Congress, and thus the level of program activity is mostly determined by existing statute. DOE will also be completing rulemakings to expand the covered products to lock in additional energy and emissions savings opportunities for consumers. DOE will continue its efforts to support the implementation of negotiated and consensus-based rulemakings, when represented by a cross-section of representative stakeholders.

Energy Conservation Standards: The AES program develops and adopts energy conservation standards for all covered products and equipment in the program under a pre-determined cadence prescribed in statute for the purpose of saving the Nation energy and water. As part of its international engagement on standards, AESP participates in international programs and committees to minimize regulatory burden by ensuring regulatory harmonization to the greatest extent practicable and allowed by law. The request provides for significantly fewer energy conservation standards than in FY2024.

Test Procedures: AES is legally required to review test procedures for covered equipment every seven years and either publish amended test procedures or publish a determination that existing test procedures do not need to be amended. In addition, AES is also required to develop new test procedures where they do not exist for newly covered appliances and equipment for which standards will be proposed. Test procedures are developed to provide additional rigor, consistency, and accuracy during testing, to address testing requirements necessary to support DOE's certification and enforcement activities, and to better address or clarify testing of additional product designs within a given equipment type. This includes the need to respond to products and equipment for which testing waivers have been provided in the past. DOE will continue to prioritize the development of next generation text procedures for priority technologies for efficiency and decarbonization identified by BTO programs. The request provides no support for investigative testing or ENERGY STAR support.

Certification, Compliance, and Enforcement: To ensure the energy savings are realized and a level-playing field is maintained for manufacturers, AES actively enforces the energy conservation standards through certification, outreach, surveillance testing, and enforcement investigations. As part of its verification testing program, AES also supports EPA by working with the Association of Home Appliance Manufacturers on their ENERGY STAR verification program.

Appliance and Equipment Standards

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Appliance and Equipment Standards $60,000,000	**$50,000,000**	**-$10,000,000**
Energy Conservation Standards $38,000,000	$28,000,000	-$10,000,000
• Expand the development of appliance and equipment standards. By establishing national minimum energy efficiency standards, AES's Federal standards preempt product efficiency regulations at the state and local level, reduce regulatory burden for manufacturers and provide them with a larger national marketplace.	• By establishing national minimum energy efficiency standards, the program's Federal standards preempt product efficiency regulations at the state and local level, reduce regulatory burden for manufacturers and provide manufacturers with a consistent national marketplace. Energy savings achieved through new or amended standards will contribute to reducing utility bills and emissions as old appliances are replaced with more efficient products.	• This change represents a projected reduction in the number of DOE standards rulemaking efforts.
Test Procedures $17,500,000	$17,500,000	$0
• Develop and update test procedures to ensure they remain technologically relevant and provide manufacturers with a level playing field and a platform to bring to market new product innovations.	• Continue to develop and update test procedures to ensure they remain technologically relevant and provide manufacturers with a level playing field and a platform to bring to market new product innovations. For consumers, the program's periodic review of test procedures lays the foundation for reliable and comparable operating cost information for the most common household and business appliances. Purchase and test appliances and equipment to explore the energy use.	• No significant change.
Certification, Compliance and Enforcement $4,500,000	$4,500,000	$0
• Ensure products sold in the U.S. meet energy and water conservation standards so that all Americans save money on their utility bills when purchasing new appliances and equipment.	• Continue to ensure products sold in the U.S. meet energy and water conservation standards so that all Americans save money on their utility bills when purchasing new appliances and equipment.	• No significant change.

Building Energy Codes: Building codes ensure a more resilient built environment avoiding a wide range of adverse impacts from extreme weather including injury to building residents, building property damage that can cause loss of housing or business bankruptcy, and other economic losses. Such impacts disproportionately affect low-income and disadvantaged communities. BTO's Building Energy Codes provides rulemaking and technical support for building energy efficiency, emission reductions, and increased resilience and comfort through the advancement and successful implementation of building energy codes. BTO's Building Energy Codes portfolio supports all U.S. states and local governments and also provides foundational support for the rapid and successful deployment of Infrastructure Investment and Jobs Act (IIJA), P.L. 117-58 and Inflation Reduction Act of 2022 P.L. 117-169 (IRA) funds, which will provide awards to only a select number of states and local governments. This Request will continue supporting all the States and local jurisdictions per statute.

DOE is directed by statute to review the technical and economic basis of building energy codes, and participate in processes for their review and modification, including seeking adoption of all technologically feasible and economically justified energy efficiency measures. In addition, DOE is directed to review published editions of the International Energy Conservation Code (IECC) and ANSI/ASHRAE/IES Standard 90.1, and issue Determinations as to whether the updated edition will increase energy efficiency in residential and commercial buildings, respectively, which triggers state building energy code review and update activities. BTO also supports rulemakings as required by statute to advance cost-effective energy codes for Federal facilities, along with the development of a rulemaking to support the statutory directive of reducing and ultimately eliminating fossil fuel use in Federal buildings.

DOE is also directed by statute to provide support for code implementation, including technical analysis to assess energy and environmental impacts and research to support states in evaluating how their codes are applied in practice. BTO will provide education, training, outreach, and tools to help increase compliance in the field and ensure the benefits of building energy codes are realized by American homes and businesses. BTO also will support technical assistance forums that enable the effective exchange of information and successful practices surrounding code implementation. In addition, BTO will provide technical support and guidance for federal, state, and local governments on advanced model codes and stretch codes focused on low-emission, grid-interactivity, advance energy-efficiency, and integrative solutions as well as emerging and innovative concepts, including Building Performance Standards (BPS) to improve energy efficiency in existing buildings. Given the goals for funds appropriated under IIJA and IRA, the BTO Building Energy Codes activities included in the Request are important foundational work needed for ensuring the program can meet the needs of awardees pursuing code updates, code adoption, and code implementation and compliance activities.

Building Energy Codes

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Building Energy Codes $15,000,000	**$15,000,000**	**$0**
Building Energy Codes $15,000,000	$15,000,000	$0
• Continue participation in the industry code processes, including reviewing and modifying national model energy codes. Develop and implement building energy codes for the Federal building fleet, including analysis, rulemakings, and implementation support. • Provide technical assistance and analysis (including REScheck and COMcheck software) to States and localities to support their building codes and building performance standards.	• Continue participation in the industry code processes, including reviewing and modifying national model energy codes. Develop and implement building energy codes for the Federal buildings, including analysis, rulemakings, and implementation support. • Provide technical assistance and analysis (including REScheck and COMcheck software) to States and localities to support their building codes and building performance standards.	• No significant changes. • No significant changes.

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 2025 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.

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.

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.

Program Direction
Funding ($K)

	FY 2023 Enacted[1]	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Program Direction					
Washington Headquarters					
Salaries and Benefits	92,259		104,055	+11,796	13%
Travel	2,917		3,127	+210	7%
Support Services	7,563		8,034	+471	6%
Other Related Expenses	32,873		25,808	-7,065	-21%
Total, Washington Headquarters	**135,612**		**141,024**	**+5,412**	**4%**
Golden Field Office					
Salaries and Benefits	20,931		23,920	+2,989	14%
Travel	625		655	+30	5%
Support Services	5,216		5,463	+246	5%
Other Related Expenses	3,698		2,873	-825	-22%
Total, Golden Field Office	**30,471**		**32,911**	**+2,441**	**8%**
National Energy Technology Laboratory					
Salaries and Benefits	7,245		8,587	+1,342	19%
Travel	208		218	+10	5%
Support Services	5,971		6,253	+282	5%
Other Related Expenses	6,492		5,799	-693	-11%
Total, National Energy Technology Laboratory	**19,917**		**20,857**	**+941**	**5%**
Total Program Direction					
Salaries and Benefits	120,436		136,562	+16,126	13%
Travel	3,750		4,000	+250	7%
Support Services	18,750		19,750	+1,000	5%
Other Related Expenses	43,064		34,480	-8,584	-20%
Total, Program Direction	**186,000**	**186,000**	**194,792**	**+8,792**	**5%**

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Federal FTEs	681	667	667	-14	-2%
Additional Office of Fossil EERE's FTEs at NETL	42	43	43	1	2%
Total EERE-funded FTEs[1]	**723**	**710**	**710**	**-13**	**-2%**
Support Services					
Technical Support	9,649	9,649	10,164	515	5%
Management Support	9,101	9,101	9,586	485	5%
Total, Support Services	**18,750**	**18,750**	**19,750**	**+1,000**	**5%**
Other Related Expenses					
Other Services	23,766	23,766	10,279	-13,487	-57%
Working Capital Fund (WCF)	19,298	19,298	24,201	4,903	-26%
Total, Other Related Expenses	**43,064**	**43,064**	**34,480**	**-8,584**	**-20%**

Program Direction
($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Program Direction $186,000	**$194,792**	**+$8,792**
Salaries and Benefits $120,436	$136,562	+$16,126
• 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 up to 710 FTEs by providing resources for program and project management, administrative support, contract administration, and human capital management.	• The 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	$4,000	+$250
• 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 to perform mandatory project management oversight 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. Additionally, as EERE's project portfolio continues to grow, additional resources will be required for program/project oversight.
Support Services $18,750	$19,750	+$1,000
• 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Other Related Expenses $43,064	$34,480	-$8,584
• 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 decrease reflects adjustments based on streamlining business infrastructure investments.

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 clean energy needs of underserved communities are appropriately addressed.

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

- In FY 2025, EERE will continue to administer Energy Transitions Initiative (ETI) activities and apply the lessons learned from technical assistance provided for selected island and remote communities to a broader set of underserved, disadvantaged, and historically hard to reach communities.
- EERE Strategic Analysis will continue its emphasis on the Decarbonizing Energy through Collaborative Analysis of Routes and Benefits (DECARB) program, which conducts analysis at the intersections between key emissions sectors. Strategic Analysis will also support critical updates to flagship reports and studies (e.g., Annual Technology Baseline and "Future" series studies) that are highly cited and relied on both within and outside of DOE.
- EERE International will focus on technical assistance to strategically important countries and regions with the greatest potential for clean energy deployment and for expanding markets for American clean energy goods and services.
- 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.
- 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 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Strategic Programs					
Technology-to-Market and Communities	5,500		5,500	0	0%
Strategic Analysis	8,500		8,500	0	0%
Communications and Outreach	5,500		6,000	+500	+9%
International	1,500		1,000	-500	-33%
Total, Strategic Programs	**21,000**	**21,000**	**21,000**	**0**	**-0%**

Strategic Programs
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Strategic Programs	
Technology-to-Market and Communities: None.	**0**
Strategic Analysis: None.	**0**
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.	**+500**
International: Refocuses international efforts on priority collaborations and engagements with the greatest impact.	**-500**
Total, Strategic Programs	**0**

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.

Technology-to-Market and Communities

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
$5,500,000	**$5,500,000**	**$0**
• Funding for successful Energy Transitions Initiative and the Energy Transitions Initiative Partnership Project.	• Administer ETI activities and apply the lessons learned from technical assistance provided for selected island and remote communities to an additional set of underserved, disadvantaged, and historically hard to reach communities.	No change.

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 2025, SA will support analyses considering sectoral overlap - 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 technological needs, the potential impact of EERE R&D, and the implications for how the clean energy economy benefits all Americans. 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 2025, 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 develop 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. For example, the Annual Technology Baseline has become the gold standard for clean energy technology cost projections and is widely used across DOE, other agencies including EPA, utilities and state regulatory commissions, and other energy researchers, with over 86,000 unique users. SA will also continue to support analysis used to inform the Energy Storage Grand Challenge and Energy Earthshots.

Additionally, in FY 2025, 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Strategic Analysis $8,500,000	**$8,500,000**	**$0**
• 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.	No change.
• 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.	
• Complete development of analytical tools to enable EERE programs and external stakeholders to maximize U.S. energy job creation and minimize job transitions.	• 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.	
• Continue to provide analytical support for the Energy Storage Grand Challenge in coordination with cross sector analysis examining pathways to decarbonization.		
	• 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	

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	systems.	
	• 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.	• Publish an annual update to the Energy Storage Grand Challenge Cost and Performance Report and support the management and execution of the broader Energy Storage Grand Challenge with the Office of Electricity.	
	• Develop a data set of the potential distributional impacts of economy-wide decarbonization, specifically focused on key energy equity and environmental justice metrics.	
	• Support 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.	

Strategic Programs
Communications and Outreach

Description

The Communications and Outreach subprogram disseminates information on and impacts of key EERE and DOE activities by providing strategic leadership, coordination, and operation support. The subprogram does this by developing and implementing strategic communications plans and messages that reflect EERE's mission, vision, and goals. The goal of the Communications and Outreach subprogram is to engage with a wide variety of audiences to promote critical actions they can take to advance the clean energy transition, including: (1) investing in clean energy; (2) applying for EERE funding opportunities and responding to requests for information; (3) joining the clean energy workforce; (4) planning for the clean energy transition; and (5) championing clean energy through education and promotion of the benefits of EERE's work.

The Communications and Outreach subprogram activities in FY 2025 will focus on developing a suite of outreach materials ranging from print and design work, to website content and social media, to media engagement, and more. The team is focused on sharing the benefits of clean energy and the purpose of EERE's work with all Americans by increasing support for collaboration with tribal communities, disadvantaged and energy burdened communities, minority-serving institutions, and minority professional organizations, all in line with the Justice40 Initiative. These benefits include reliable, secure, and affordable power; safe and secure domestic supply chains; American technological innovation and competitiveness; and improved environmental quality, safety, and health. The subprogram will utilize earned media, the EERE website, and social media to share the work that EERE is doing to transition the Nation to a clean energy economy, fight the climate crisis, and appropriately steward taxpayer dollars.

To ensure EERE advances its mission, the Communications and Outreach subprogram works with the EERE Front Office and Technology Offices to identify priorities, gaps, and opportunities the team can leverage through effective outreach and engagement campaigns. Through events, conferences, workshops, roundtables, and other convenings (both in-person and virtual), the subprogram utilizes the expertise of EERE leadership to help key stakeholders identify their unique roles in the clean energy transition. The subprogram continually works to improve the functionality and effectiveness of EERE's digital, web-based, and social media products, to the benefit of the American people. By effectively reaching audiences of all levels and demonstrating the value that clean energy has on the economy, the subprogram will ensure the continued forward trajectory of the clean energy transition.

Communications and Outreach

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2024 Request
Communications and Outreach $5,500,000	**$6,000,000**	**+$500,000**
• 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.	• Maximize the reach, impact, and longevity of EERE's online presence through evergreen content marketing, search engine optimization (SEO) strategies, cross-promotion between technology offices and web teams, and maintenance of corporate-level and cross-cutting web content. Increasing EERE's placement to top 5 on priority pages in Google searches through SEO strategies. • Demonstrate the benefits of EEREs work through various communications channels and outreach materials—utilizing metrics and analysis to inform future outreach and engagement strategies. • Develop and implement 1 proactive digital communications campaign per month. • Leverage planned DOE/industry events and other EERE announcements to incorporate proof points and amplify content that demonstrates collective EERE impact. Supporting EERE attendance at 50 events and conferences. • Support the development and publication of 50 press releases; 50 weekly JOLT newsletters; 12 Clean Energy in Action Videos; and 100 speeches. • Support external outreach through internal processes and templates to ensure strategic value and best practices, as well as cohesion in branding and messaging across EERE outreach. • Maintain the EERE Communications Standards and Style Guide energy.gov subsite, including	• Increase allows the subprogram to present EERE's funding, prizes, and competition highlights; job opportunities; and key messages in a unified format on energy.gov, offering centralized resources with links to more information. • Increase supports development of 1 internal and 3 external stakeholder toolkits per month to increase reach of EERE messaging.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2024 Request
	staying up-to-date and providing guidance across all EERE offices on plain language, Section 508 Compliance requirements, DOE PA-level process requirements, and federal communication standards.	

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 the U.S. and 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, as well as the Environmental Protection Agency and Offices within the Executive Office of the President to implement expert-driven technical assistance in the areas of sustainable transportation, clean fuels, renewable energy, energy efficiency, and the decarbonization of buildings and industry 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. In addition, the subprogram fosters clean energy cooperation in regions of strategic geopolitical significance to the U.S. (e.g., Eastern and Central Europe).

The International subprogram also facilitates cooperation between experts supporting EERE with experts in strategic partners nations (e.g., the UK, France, Japan, and Germany) to leverage clean energy technology research, development, and innovation and to accelerate deployment of such technologies in the U.S. and worldwide.

International

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
International Coordination $1,500,000	**$1,000,000**	**-$500,000**
• 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 request will allow EERE to implement technical assistance and informational exchanges with international technical and policy experts through sharing research, best practices, and informational resources to address mutual knowledge gaps. For example, the request includes funding to support engagement with partners in Central and Eastern Europe to advance geothermal heating and improved building efficiency to reduce dependence on Russian gas, while opening markets for American technology and service providers.	• The decrease is due to greater demands on EERE's domestic mission. The request reflects a more targeted FY 2025 approach that focuses experts and key resources on a focused set of partner countries and technology collaborations with the greatest potential for clean energy market development, emissions reductions, and improved energy security.

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.
  - Providing NREL with secure information networks with strong cybersecurity protocols.
  - Maintaining, upgrading, and acquiring new mission-critical science and technology capabilities when warranted to support NREL's science infrastructure through regular reinvestments as 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 interest throughout all of government and industry.
  - Providing direct funding for operational activities of major facilities and infrastructure and site-wide investments.

Facilities and Infrastructure
Funding ($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023, $	FY 2025 vs FY 2023, %
Facilities and Infrastructure					
Operations and Maintenance	102,370		91,570	-10,800	-11%
Facility Management	57,630		59,430	+1,800	+3%
Establish DOE 18th National Laboratory	0		0	0	0%
Construction					
21-EE-001, Energy Materials Processing at Scale (EMAPS)	45,000		54,000	+9,000	+20%
Total, Facilities and Infrastructure	**205,000**	**205,000**	**205,000**	**0**	**+0%**

Facilities and Infrastructure
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Facilities and Infrastructure	
Operations and Maintenance: The Request prioritizes construction of the STM substation as well as investments to support the maintenance, repair, safety, and security of the NREL campuses. The request does not provide funding for ARIES investments or scientific and technology enhancement investments on the NREL campuses.	-10,800
Facility Management: The Request maintains the ESIF operations and prioritizes the upgrade and operations of the Kestrel High Performance Computer (HPC).	+1,800
Construction: The Request prioritizes a funding increase for the third segment of construction of EMAPS.	+9,000
Total, Facilities and Infrastructure	**0**

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 (<$30 million) projects to accommodate new research capabilities. Minor Construction projects include:

- Investments in the laboratory campus necessary to ensure continuity of operations, such as South Table Mountain (STM) Substation.
- Investments to support the maintenance, repair, safety, and security of the NREL campuses.

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:

- Equipment investments to support the maintenance, repair, safety, and security of the NREL campuses.

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 2025 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 the STM, South Table Mountain Energy Park (STEP), and Flatirons 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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Operations and Maintenance $102,370,000	**$91,570,000**	**-$10,800,000**
• The Request prioritizes continued support of 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 Research and Innovation Laboratory (RAIL), the Waste Handling Facility, and Solar Energy Research Facility (SERF)/ Science and Technology Facility (S&TF) Ventilation projects.	• Investments in ARIES remain a priority and will be supported with additional funding as current funding prioritizes EMAPS, HPC, and the STM Substation.	• Prioritizes funding for support of STM Substation.
• 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 for the NREL campuses.	• No significant change.
• 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.	• No significant change.

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 2025 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 2025 Request provides funding that supports operations, maintenance, equipment, and a refresh/upgrade of the ESIF HPC.

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 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Facility Management $57,630,000	**$59,430,000**	**+$1,800,000**
• Provides for a refresh/upgrade cycle of the Kestrel High Performance Computer.	• Continues the Kestrel High Performance Computer as year 4 of a planned 4-year refresh/upgrade.	• No significant change.
• 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.	• No significant change.
• Increases ARIES equipment and infrastructure investments.	• Does not fund ARIES equipment and infrastructure investments.	• Prioritizes funding to continue ESIF operations and HPC refresh upgrade.
• 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
Construction

Description

This subprogram supports line-item construction projects associated with EERE's mission. The Request provides funding for the third 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. Segment 4 will provide much of the building core, shell, and interiors.

The most recent DOE Order 413.3B Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, was approved on September 20, 2023. The preliminary estimate for CD-2/3, Final Design and Construction, is anticipated in the fourth quarter of FY 2024. The current Total Estimated Cost (TEC) $218,000,000, with the OPC remaining at $6,000,000 for a budget request of $224,000,000 (includes Management Reserve and Contingency). Preliminary design is nearly complete. A firm fixed price task order agreement is in place. An amended task order will be awarded after CD-2/3 is approved to complete Final Design and Construction with estimated completion date of 3rd Quarter FY 2027 to 1st Quarter FY2028.

Construction

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction $45,000,000	**$54,000,000**	**+$9,000,000**
• Provides funding for the first segment of the construction phase for the EMAPS line-item construction project.	• Provides funding for the third segment of the construction phase for the EMAPS line-item construction project.	• The increase funds the third segment of construction phase for EMAPS.

Facilities and Infrastructure
Capital Summary ($K)

	Total[1]	Prior Years	FY 2023 Enacted	FY 2024 Request	FY 2025 Request	FY 2025 vs FY 2023
Capital Summary (including Major Items of Equipment (MIE))						
Capital Equipment > $5M (including MIE)	-	12,360	7,220	19,612	38,753	+31,533
Minor Construction	-	66,420	31,044	63,060	28,973	-2,071
Major Construction	-	12,000	45,000	57,000	54,000	+9,000
Total, Capital Summary	**-**	**90,780**	**83,264**	**139,672**	**121,726**	**+38,462**
Capital Equipment > $5M (including MIE)						
Total Non-MIE Capital Equipment (< $5M)	-	12,360	7,220	19,612	31,253	+24,033
EMAPS Equipment (DF)	-				7,500	+7,500
Total, Capital Equipment (including MIE)	**-**	**12,360**	**7,220**	**19,612**	**38,753**	**31,533**
Minor Construction Projects						
Total Direct Funded Minor Construction Projects (TEC <$5M)	-	5,690	14,144	53,060	9,313	-4,831
Research and Innovation Laboratory (DF)	24,910	22,910	2,000	0	0	-2,000
ARIES 34.5kV Infrastructure Upgrade (DF)	8,000	8,000	0	0	0	0
Waste Handling Facility (DF)	13,350	10,350	3,000	0	0	-3,000
CFE - Distributed Energy Grid East STM Campus (DF)	19,500	0	0	3,000	0	0
SERF/S&TF Ventilation (DF)	14,700	9,300	5,400	0	0	-5,400
Flatirons Control Center (DF)	17,000	10,500	5,500	0	0	-5,500
STM Substation (DF)	29,900	0	0	7,000	19,660	+19,660
Total, Minor Construction Projects	**119,360**	**66,750**	**31,044**	**63,060**	**28,973**	**-2,071**
21-EE-001, Energy Materials and Processing at Scale, TEC[2,3]	160,000	12,000	45,000	57,000	54,000	+9,000
Total, Construction	**278,360**	**78,420**	**76,044**	**120,060**	**82,973**	**+6,929**
Total, Capital Summary	**278,360**	**90,780**	**83,264**	**139,672**	**121,726**	**+38,462**

[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 2026 Estimate	FY 2027 Estimate	FY 2028 Estimate	FY 2029 Estimate
Capital Summary (including Major Items of Equipment (MIE))				
Capital Equipment > $5M (including MIE)	50,200	54,305	30,800	31,447
Minor Construction	111,743	132,072	211,871	216,320
Major Construction	54,000	0	0	0
Total, Capital Summary	**215,943**	**186,377**	**242,671**	**247,767**
Capital Equipment > $5M (including MIE)				
Total Non-MIE Capital Equipment (< $5M)	42,700	48,705	30,800	31,447
EMAPS Equipment (DF)	7,500			
Large-Format Stationary Battery Cycling Units (DF)	0	5,600	0	0
Total, Capital Equipment (including MIE)	**50,200**	**54,305**	**30,800**	**31,447**
Minor Construction Projects				
Total Direct Funded Minor Construction Projects (Total Estimated Cost (TEC) <$5M)	77,243	70,072	207,371	216,320
Total Indirect Funded Minor Construction Projects (Total Estimated Cost (TEC) <$5M)	0	0	0	0
STM Substation (DF)	2,940	300	0	0
Future Tech ready Interconnected Research Platforms (DF)	4,000	0	0	0
Flatirons Campus Utility Distribution Duct Work (DF)	4,500	0	4,500	0
STM Power Plant Upgrade (DF)	15,000	0	0	0
Flatirons Campus Infrastructure Upgrade (DF)	5,000	0	0	0
Electric Heating for all New Buildings (DF)	6,000	0	0	0
Flatirons Campus (FC) Carbon-free Backup Power Technologies (DF)	0	19,500	0	0
STM Carbon-free Backup Power Technologies (DF)	0	19,500	0	0
Onsite Renewable Energy (DF)	0	17,000	0	0
Flatirons Campus (FC) Electrical Distribution Infrastructure (DF)	0	6,000	0	0
Limited Access Facility (DF)	3,000	26,900	0	0
Total, Minor Construction Projects	**111,743**	**132,072**	**211,871**	**216,320**
Major Construction Projects				
EE-21-001, Energy Materials Processing at Scale[1] Total Estimated Cost (TEC)	54,000	0	0	0
Total, Construction	**54,000**	**0**	**0**	**0**
Total, Capital Summary	**215,943**	**186,377**	**242,671**	**247,767**

[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:	Research and Innovation Laboratory (RAIL)
Project Location/Site:	NREL South Table Mountain Campus:
Type:	Minor Construction (Direct funded)
Total Estimated Cost:	$24,910 (Design & Construction)
Construction Design:	$1,650
Project Start:	FY 2021
Design Complete:	FY 2021
Construction Complete:	FY 2023
Project Description:	This project provides flexible laboratory space that can accommodate interdisciplinary research that integrates science and applied research disciplines to develop and validate the performance of hybrid energy technologies and processes for producing materials, chemicals, and fuels. The building design and layout encourages and supports active collaboration across multi-disciplines and provides enhanced ventilation to keep researchers safe and to allow diverse experiments to be conducted safely in proximity with one another. Design of the laboratories will enable quick reconfiguration to allow new research opportunities along 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 building and site improvements, the project scope includes lab equipment fit out, design, procurement, and installation, which requires infrastructure modifications. Exterior site improvements will encourage external collaboration activities, provide roadway access, and pedestrian improvements to walkways, hardscapes, and ramps for ADA accessibility. The project will utilize a design-build contract estimated to take nearly 25 months to complete from design through beneficial occupancy. Facility size is approximately 15,000 square feet: Extension for added scope for $5,000 budget increase: SC – 6/26/23; FC – 9/1/23
Prior Year Accomplishments:	• Substantial Completion achieved in June 2023
Planned Activities:	• Project closeout scheduled for October 2024
Significant Changes from original plan:	A $400,000 budget and scope increase were 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:	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 2024
Design Complete	FY 2024
Construction Complete	FY 2026

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 2Q of FY 2024. Useful segments: Design FY 2024 $1,000; Construction FY 2024 – FY 2026 $11,350.

Prior Year Accomplishments:	• Finalized technical requirements for a design-build project in FY 2024
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. Project was delayed as it was determined by NREL that this project should be included in the new Cooperative Construction Contracting Agreement (CCCA) Pilot Program approved by DOE. The new CCCA was supported through an implementation plan that

	required final approval from DOE before the project could initiate procurement activities under this agreement. The final approval of the CCCA and selection of a CCCA Design-Build Contractor was not completed until the end of FY23. This project is scheduled to be completed as shown above with Design commencing in FY 24 and Construction completion in FY26.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name: Project Location/Site:	Distributed Energy Grid East STM Campus Integrating CFE Resources NREL STM Campus
Type: Total Estimated Cost: Construction Design: Project Start: Design Complete: Construction Complete:	Minor Construction (Direct-funded) $19,500 $3,000 FY 2024 FY 2024 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:	Project on hold until funding is provided. Funding can initiate the next step in technical development for implementation. The modeling assessment helped develop the approach to what was technically feasible. 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:	SERF/S&TF Ventilation
Project Location/Site:	NREL STM Campus
Type:	Minor Construction (Direct funded)
Total Estimated Cost:	$14,700
Construction Design:	$600
Project Start	FY 2020
Design Complete	FY 2022
Construction Complete	FY 2026
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:	• Design was completed in the beginning of FY22. • Procurement was initiated for construction in the beginnings of FY22. Construction contract awarded July FY23. Preliminary project planning is currently underway with the contractor.
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:	• Total estimated Cost increased from $9,300 to $14,700 due the procurement occurring during the timeframe of a rapidly escalating construction cost environment including labor shortages for construction labor and materials cost increases due supply chain delays and industry shortages of materials. • Procurement was delayed due to extended NEPA determination review due to complexity of project. In addition, two procurement cycles were required to try and engage small business in the construction of the project by deeming the project as a small business set aside. When no small business contractors were found to be technically responsive to the solicitation, the solicitation was reissued as an open competition and a successful award was completed.

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:	$17,000
Construction Design:	$1,000
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: $1,000 Construction FY 2023 – 2025: $14,000
Prior Year Accomplishments:	• Construction services biding phase and contract is complete (16 months)
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. Budget has been increased from $15,500 to $17,000 because of higher construction costs.

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) $29,900 $3,000 FY 2024 FY 2024 FY 2027

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 and design will include the ability of the substation to be capable of future expansion up to 60MW. Useful Segments:
	
	• Design and Xcel Coordination FY 2024 $7M
	  o Substation Design $3M
	  o Long Lead Equipment Procurement $2M
	  o Xcel Interconnection $2M
	• Construction FY 2025 – 2027 $19.66M
	• Electrical Infrastructure to STM Campus FY2026 - $2.94M
	• Testing, Commissioning and Startup FY2027 $0.3M

Prior Year Accomplishments:	• N/A
Planned Activities:	• Issue RFP to CCCA Contractor • Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project) • Execute an Interconnect Agreement with Xcel Energy to support the STM substation and its connection to the Xcel electrical transmission lines in the vicinity of the substation. • Long Lead Equipment Design and Procurement (prepare plans and specifications to support procurement of the two 15MW electrical transformers • 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)
Significant Changes from original plan:	Budget increased from $24,900,000 to $29,900,000. This increase was driven by the cost escalation and supply chain delays associated with electrical power equipment and materials, additional scope required by the local energy provider, Xcel Energy, to provide a ring bus as part of the substation, increased costs for site improvements associated with increasing the size of the substation to meet Xcel requirements, and increased costs associated with Xcel obtaining ROWs and easements to support extending transmission lines to the substation. Project was delayed as only Conceptual Design funding has been provided to date and NREL is unable to begin the procurement stage of contracting with the proposed Design-

	Build Contractor which is proposed to be executed under NRELs CCCA agreement without appropriate funding in place. Finally, Xcel Energy advised NREL that the current supply chain delays for substation scale transformers is expected to be about 2-1/2 to 3 years in duration which has pushed the project completion into late FY27.

21-EE-001, Energy Materials and Processing at Scale,
National Renewable Energy Laboratory, Golden, Colorado
TEC Project is for Design and Construction

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

<u>**Summary**</u>: The FY 2025 Budget Request proposes to fund $54,000,000 (of the Total Estimated Cost (TEC)) toward the third 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 preliminary design, long lead procurements (CD-3A), 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) is $218,000,000, with the OPC remaining at $6,000,000. The preliminary Total Project Cost (TPC) range is $201,000,000 to $246,000,000 per preliminary conceptual Architect/Engineering support estimates (includes Management Reserve and Contingency). The Office of Energy Efficiency and Renewable Energy put forth the $224,000,000 as the final number after confirmation from the Independent Cost Review proceeding after CD-1 with a firm fixed price task order award October 10, 2023. 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 December 16, 2019. This project achieved approval of CD-1 September 20, 2023 therefore, budget is fixed, but schedule estimates are preliminary and subject to change. The FPD for this project is PMCDP certified level 2 working toward level 3. The target Project Completion range is Q3FY2027 to Q1FY2028, approved at CD-1 by PME on September 20, 2023.

Undersecretary of Science and Innovation has delegated the Project Management Executive to the Golden Field Office Executive Director Derek Passarelli effective August 25, 2023.

<u>**Significant Changes**</u>**:**
The Cooperative Construction Contracting Approach (CCCA) task order agreement procurement strategy with the EMAPS project has been competed and a conceptual design selected for CD-1. The project went through Project Peer Review and Independent Cost Review in June 2023. With the feedback from the review teams, the IPT sought an increase from the original ROM cost range to the range reflected above ($201M-$246M) with our Budget request point estimate at $224M "design to budget", with the size range narrowed to 123,000 – 127,000 square feet. The range is a class 3 estimate +/- 10% as we have a selected vendor bid in hand for a firm fixed price design/build construction award after CD-1 approval for phase 1 preliminary design. The Independent Cost Review confirmed the IPT point estimate and range in their final report. With escalation due to the inflationary environment taken into account the team adjusted the design phase funding to accommodate the costs expected to reach the CD-2/3 milestone in 4th Quarter of FY2024. Final design and construction phase will be awarded upon approval of CD-2/3.

<u>**Critical Milestone History**</u>

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	4/5/2023	4Q FY2023	3Q FY2024	1Q FY2025	3Q FY2024	NA	2Q FY2026
FY 2025	12/16/2019	4/5/2023	9/20/2023	3Q FY2024	1Q FY2025	3Q FY2024	NA	2Q FY2027

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
CD-4 – Approve Start of Operations or Project Closeout

Project Cost History

($K)							
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
FY 2025	18,000	200,000	218,000	6,000	0	6,000	224,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 123,000 to 127,000 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 research facilities that can accommodate scaling R&D project from bench scale to pilot scale. 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 123,000-127,000 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, in part, from a pre-CD-1 draft Analysis of Alternatives (AoA) report. KPPs will evolve as the project continues through CD-2/3 approval. At CD-2 approval, the updated KPPs will be baselined. The Threshold KPPs represent the minimum acceptable scope/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. Objective KPPs, once developed, will represent the desired project scope/performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Threshold	Objective
Provide the unique laboratory spaces in the project program with a cumulative/minimum of 55,000 gsf.	TBD
Accommodate a minimum of 165 staff with touchdown/hotel workspaces and shared collaboration areas.	TBD
Provide a facility that achieves at least 30% better energy reduction than a prototypical building per ASHREA 90.1.	TBD
Achieve a minimum of LEED™ Gold certification.	TBD

3. Financial Schedule

($K)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2021	0	0	0
FY 2022	8,000	0	0
FY 2023	10,000	8,000	0
FY 2024		10,000	18,000
FY 2025	0	0	0
Total Design	**18,000**	**18,000**	**18,000**
Construction			
FY 2021	0	0	0
FY 2022	0	0	0
FY 2023	35,000	0	0
FY 2024	57,000	92,000	20,000
FY 2025	54,000	54,000	95,000
FY2026	54,000	54,000	72,000
FY2027	0	0	13,000
Total Construction	**200,000**	**200,000**	**200,000**
Total Estimated Costs (TEC)			
FY 2021	0	0	0
FY 2022	8,000	0	0
FY 2023	45,000	18,000	0
FY 2024	57,000	92,000	38,000

	Budget Authority (Appropriations)	Obligations	Costs
FY 2025	54,000	54,000	95,000
FY2026	54,000	54,000	72,000
FY2027	0	0	13,000
Total TEC	**218,000**	**218,000**	**218,000**
Other Project Costs (OPC)			
FY 2021	6,000	1,500	300
FY 2022	0	1,500	1,000
FY 2023	0	0	1,700
FY 2024	0	0	0
FY 2025	0	0	0
FY2026	0	0	0
FY2027	0	3,000	3,000
Total OPC	**6,000**	**6,000**	**6,000**
Total Project Costs (TPC)			
FY 2021	6,000	1,500	300
FY 2022	8,000	1,500	1,000
FY 2023	45,000	18,000	1,700
FY 2024	57,000	92,000	59,000
FY 2025	54,000	59,000	79,000
FY 2026	54,000	49,000	67,000
FY 2027	0	3,000	16,000
Grand Total	**224,000**	**224,000**	**224,000**

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 123,000 to 127,000 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	14,500	10,000	N/A
Contingency	3,500	2,000	N/A
Total, Design	18,000	12,000	N/A
Construction			
Site Work	4,550	1,250	N/A
Equipment	30,000	15,300	N/A
Construction	134,500	97,450	N/A

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Other, as needed	9,800	4,700	N/A
Contingency	21,150	29,300	N/A
Total, Construction	200,000	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	**218,000**	**160,000**	N/A
Contingency, TEC	*24,650*	*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	3,000	2,000	N/A
Contingency	0	0	N/A
Total, OPC	**6,000**	**5,000**	N/A
Contingency, OPC	*0*	*0*	N/A
Total Project Cost	**224,000**	**165,000**	N/A
Total Contingency (TEC+OPC)	**24,650**	**31,300**	N/A

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 123,000 to 127,000 square feet.

5. Schedule of Appropriations Requests

($K)

Request Year	Type	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	Total
FY 2022	TEC	0	8,000	0	151,000	0	0	159,000
	OPC	6,000	0	0	0	0	0	6,000
	TPC	6,000	8,000	0	151,000	0	0	165,000
FY 2023	TEC	0	8,000	45,000	57,000	54,000	54,000	218,000
	OPC	6,000	0	0	0	0	0	6,000
	TPC	6,000	8,000	45,000	57,000	54,000	54,000	224,000
FY 2024	TEC	0	8,000	45,000	57,000	54,000	54,000	218,000
	OPC	6,000	0	0	0	0	0	6,000
	TPC	6,000	8,000	45,000	57,000	54,000	54,000	224,000
FY 2025	TEC	0	8,000	45,000	57,000	54,000	54,000	218,000
	OPC	6,000	0	0	0	0	0	6,000
	TPC	6,000	8,000	45,000	57,000	54,000	54,000	224,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 123,000 to 127,000 square feet.

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	2QFY2027
Expected Useful Life (number of years)	50
Expected Future Start of D&D of this capital asset (fiscal quarter)	2QFY2077

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 123,000 to 127,000 square feet.

7. D&D Information

The preferred alternative is a new Federal facility, then this new facility will not replace existing facilities. NREL is at or over capacity in all existing laboratories. This new facility will accommodate the expanded R&D mission for clean energy economy and climate resiliency. The applicability of the "one-for-one" offset requirement will be assessed after CD-2/3 once conceptual design has a square footage footprint. The square footage requirement is noted in FIMS AAIM module and the Preliminary Project Execution Plan.

8. Acquisition Approach

An Acquisition Strategy for a Design Build firm fixed price task order agreement has been developed and approved and will be updated post CD-1 approval in accordance with DOE O 413.3B.

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

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Basic	0	0	0	0
Applied	836,967	836,967	989,793	+152,826
Development	607,327	607,327	669,171	+61,844
Subtotal, R&D	**1,444,291**	**1,444,291**	**1,658,964**	**+214,670**
Equipment	38,775	38,775	38,753	-22
Construction	1,688	1,688	91,952	+90,264
Total, R&D	**1,484,754**	**1,484,754**	**1,789,669**	**+304,912**

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

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Vehicles Technologies				
SBIR	12,809	12,809	15,001	+2,192
STTR	1,801	1,801	2,110	+309
Bioenergy Technologies				
SBIR	8,643	8,643	8,672	+29
STTR	1,215	1,215	1,220	+5
Hydrogen and Fuel Cell Technologies				
SBIR	5,024	5,024	5,021	-3
STTR	707	707	706	-1
Solar Energy				
SBIR	8,092	8,092	8,544	+452
STTR	1,138	1,138	1,202	+64
Wind Energy				
SBIR	3,704	3,704	5,371	+1,667
STTR	521	521	755	+234
Water Power				
SBIR	5,147	5,147	4,646	-501
STTR	724	724	653	-71
Geothermal Technologies				
SBIR	3,146	3,146	3,647	+501
STTR	442	442	513	+71
Industrial Efficiency & Decarbonization				
SBIR	0	0	3,344	+3,344
STTR	0	0	470	+470
Advanced Materials & Manufacturing Technologies				
SBIR	0	0	10,513	+10,513
STTR	0	0	1,478	+1,478
Advanced Manufacturing				
SBIR	10,651	10,651	0	-10,651
STTR	1,498	1,498	0	-1,498
Building Technologies				
SBIR	5,191	5,191	5,504	+313
STTR	730	730	774	+44
Total, SBIR	62,407	62,407	70,263	+7,856
Total, STTR	8,776	8,776	9,881	+1,105

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 2023 Actual Cost	FY 2023 Planned Cost	FY 2024 Planned Cost	FY 2025 Planned Cost
National Renewable Energy Laboratory	19,785	19,523	22,420	22,869
Total, Direct-Funded Maintenance and Repair	**19,785**	**19,523**	**22,420**	**22,869**

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

	FY 2023 Actual Cost	FY 2024 Planned Cost	FY 2025 Planned Cost
National Renewable Energy Laboratory	0	0	0
Total, Indirect-Funded Maintenance and Repair	**0**	**0**	**0**

Report on FY 2023 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 2023 to the amount planned for FY 2023.

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

	FY 2023 Actual Cost	FY 2023 Planned Cost
National Renewable Energy Laboratory	19,785	19,523
Total, Maintenance and Repair	**19,785**	**19,523**

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

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted, $	FY 2025 Request vs FY 2023 Enacted, %
Protective Forces	3,600	3,600	3,910	+310	+8.6%
Physical Security Systems	925	925	950	+25	+2.7%
Information Security	575	575	600	+25	+4.35%
Cybersecurity	10,500	10,500	11,190	+690	+6.57%
Personnel Security	240	240	250	+10	+4.17%
Material Control and Accountability	0	0	0	0	
Program Management	720	720	750	+30	+4.17%
Security Investigations	190	190	200	+10	+5.26%
Transportation Security	0	0	0	0	
Construction	0	0	0	0	
Total, Safeguards and Security	**16,750**	**16,750**	**17,850**	**+1,100**	**+6.57%**

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Ames Laboratory			
Vehicle Technologies	1,600	1,600	1,765
Hydrogen and Fuel Cells Technologies	200	200	0
Sustainable Transportation and Fuels	1,800	1,800	1,765
Advanced Materials & Manufacturing Technologies Office	28,730	28,730	10,000
Buildings & Industry (formerly Energy Efficiency)	28,730	28,730	10,000
Total Ames Laboratory	**30,530**	**30,530**	**11,765**
Argonne National Laboratory			
Vehicle Technologies	64,000	64,000	70,580
Bioenergy Technologies	11,000	11,000	9,050
Hydrogen and Fuel Cells Technologies	7,300	7,300	7,100
Sustainable Transportation and Fuels	82,300	82,300	86,730
Renewable Energy Integration	2,000	2,000	3,520
Solar Energy Technologies	1,000	1,000	1,000
Wind Energy Technologies	1,622	1,622	1,758
Water Power Technologies	1,529	1,529	1,500
Geothermal Technologies	30	30	30
Renewable Energy	6,181	6,181	7,808
Advanced Materials & Manufacturing Technologies Office	15,000	15,000	3,000
Building Technologies	1,300	1,300	1,500
Buildings & Industry (formerly Energy Efficiency)	16,300	16,300	4,500
Strategic Programs	713	713	700
Corporate Support	713	713	700
Facility and Workforce Assistance (MESC)	0	750	0
Total Argonne National Laboratory	**105,494**	**106,244**	**99,738**
Brookhaven National Laboratory			
Vehicle Technologies	3,175	3,175	3,502
Hydrogen and Fuel Cells Technologies	200	200	400
Sustainable Transportation and Fuels	3,375	3,375	3,902
Geothermal Technologies	230	230	500
Renewable Energy	230	230	500
Building Technologies	57	57	150
Buildings & Industry (formerly Energy Efficiency)	57	57	150
Total Brookhaven National Laboratory	**3,662**	**3,662**	**4,552**
Golden Field Office			
Bioenergy Technologies	155,350	155,350	138,500
Hydrogen and Fuel Cells Technologies	85,700	85,700	80,000
Sustainable Transportation and Fuels	241,050	241,050	218,500
Solar Energy Technologies	178,500	178,500	146,000
Wind Energy Technologies	32,822	32,822	75,859
Water Power Technologies	66,022	66,022	38,000
Geothermal Technologies	66,464	66,464	89,071
Renewable Energy	343,808	343,808	348,930
Industrial Efficiency & Decarbonization Office	184,900	184,900	198,727
Advanced Materials & Manufacturing Technologies Office	92,313	92,313	113,500
Building Technologies	50,000	50,000	65,000
Buildings & Industry (formerly Energy Efficiency)	327,213	327,213	377,227
Program Direction - Energy Efficiency and Renewable Energy	30,471	30,471	32,911
Total Program Direction (EERE)	30,471	30,471	32,911
Corporate Support	30,471	30,471	32,911
FEEF/AFFECT (FEMP)	14,000	14,000	0
Facility and Workforce Assistance (MESC)	14,987	12,000	0
Training and Technical Assistance (SCEP)	2,200	1,700	0

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Local Government Energy Program (SCEP)	12,000	12,000	0
Energy Future Grants (SCEP)	22,000	27,000	0
State Energy Program Grants (SCEP)	1,220	1,325	0
Program Direction - SCEP	900	1,000	0
Total Golden Field Office	**1,009,849**	**1,011,567**	**977,568**
Idaho National Laboratory			
Vehicle Technologies	10,500	10,500	11,580
Bioenergy Technologies	12,500	12,500	9,000
Hydrogen and Fuel Cells Technologies	8,100	8,100	3,300
Sustainable Transportation and Fuels	31,100	31,100	23,880
Renewable Energy Integration	100	100	100
Solar Energy Technologies	1,000	1,000	1,000
Wind Energy Technologies	1,140	1,140	2,688
Water Power Technologies	4,593	4,593	5,000
Geothermal Technologies	30	30	30
Renewable Energy	6,863	6,863	8,818
Advanced Materials & Manufacturing Technologies Office	0	0	500
Building Technologies	35	35	300
Buildings & Industry (formerly Energy Efficiency)	35	35	800
Federal Energy Management Program (FEMP)	650	334	0
Analysis and Strategic Investment (MESC)	400	400	0
Total Idaho National Laboratory	**39,048**	**38,732**	**33,498**
Lawrence Berkeley National Laboratory			
Vehicle Technologies	18,200	18,200	20,072
Bioenergy Technologies	6,500	6,500	6,000
Hydrogen and Fuel Cells Technologies	4,800	4,800	4,400
Sustainable Transportation and Fuels	29,500	29,500	30,472
Renewable Energy Integration	4,000	4,000	9,050
Solar Energy Technologies	2,500	2,500	2,500
Wind Energy Technologies	3,010	3,010	3,711
Geothermal Technologies	1,930	1,930	2,000
Renewable Energy	11,440	11,440	17,261
Industrial Efficiency & Decarbonization Office	9,900	9,900	9,500
Advanced Materials & Manufacturing Technologies Office	0	0	1,000
Building Technologies	38,800	38,800	41,000
Buildings & Industry (formerly Energy Efficiency)	48,700	48,700	51,500
Strategic Programs	1,890	1,890	1,500
Corporate Support	1,890	1,890	1,500
Federal Energy Management Program (FEMP)	2,410	3,728	0
Facility and Workforce Assistance (MESC)	775	500	0
Training and Technical Assistance (SCEP)	80	100	0
State Energy Program Grants (SCEP)	300	400	0
Total Lawrence Berkeley National Laboratory	**95,095**	**96,258**	**100,733**
Lawrence Livermore National Laboratory			
Vehicle Technologies	2,600	2,600	2,867
Bioenergy Technologies	725	725	725
Hydrogen and Fuel Cells Technologies	2,000	2,000	1,300
Sustainable Transportation and Fuels	5,325	5,325	4,892
Solar Energy Technologies	1,000	1,000	1,000
Wind Energy Technologies	1,619	1,619	1,763
Geothermal Technologies	30	30	30
Renewable Energy	2,649	2,649	2,793
Industrial Efficiency & Decarbonization Office	5,000	5,000	5,000
Advanced Materials & Manufacturing Technologies Office	0	0	5,000

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Building Technologies	0	0	150
Buildings & Industry (formerly Energy Efficiency)	5,000	5,000	10,150
Total Lawrence Livermore National Laboratory	**12,974**	**12,974**	**17,835**
Los Alamos National Laboratory			
Bioenergy Technologies	3,000	3,000	2,500
Hydrogen and Fuel Cells Technologies	5,000	5,000	3,100
Sustainable Transportation and Fuels	8,000	8,000	5,600
Renewable Energy Integration	50	50	80
Wind Energy Technologies	117	117	126
Geothermal Technologies	30	30	30
Renewable Energy	197	197	236
Total Los Alamos National Laboratory	**8,197**	**8,197**	**5,836**
National Energy Technology Lab			
Vehicle Technologies	213,300	213,300	235,235
Bioenergy Technologies	550	550	250
Hydrogen and Fuel Cells Technologies	16,100	16,100	20,000
Sustainable Transportation and Fuels	229,950	229,950	255,485
Renewable Energy Integration	1,450	1,450	0
Geothermal Technologies	20,928	20,928	27,500
Renewable Energy	22,378	22,378	27,500
Program Direction - Energy Efficiency and Renewable Energy	19,917	19,917	20,857
Total Program Direction (EERE)	19,917	19,917	20,857
Corporate Support	19,917	19,917	20,857
Total National Energy Technology Lab	**272,245**	**272,245**	**303,842**
National Renewable Energy Laboratory			
Vehicle Technologies	38,000	38,000	41,908
Bioenergy Technologies	46,000	46,000	35,000
Hydrogen and Fuel Cells Technologies	21,500	21,500	15,400
Sustainable Transportation and Fuels	105,500	105,500	92,308
Renewable Energy Integration	30,000	30,000	33,650
Solar Energy Technologies	100,000	100,000	95,000
Wind Energy Technologies	45,688	45,688	58,881
Water Power Technologies	27,509	27,509	27,000
Geothermal Technologies	7,983	7,983	20,000
Renewable Energy	211,180	211,180	234,531
Industrial Efficiency & Decarbonization Office	5,000	5,000	5,000
Advanced Materials & Manufacturing Technologies Office	900	900	5,000
Building Technologies	56,661	56,661	60,000
Buildings & Industry (formerly Energy Efficiency)	62,561	62,561	70,000
Facilities and Infrastructure - NREL	205,000	205,000	205,000
Facilities and Infrastructure	205,000	205,000	205,000
Strategic Programs	9,550	9,550	10,440
Corporate Support	214,550	214,550	215,440
Federal Energy Management Program (FEMP)	7,255	9,237	0
Facility and Workforce Assistance (MESC)	30	432	0
Analysis and Strategic Investment (MESC)	1,600	1,600	0
Training and Technical Assistance (SCEP)	4,185	4,200	0
Energy Future Grants (SCEP)	5,000	0	0
State Energy Program Grants (SCEP)	1,460	1,400	0
Total National Renewable Energy Laboratory	**613,321**	**610,660**	**612,279**
Oak Ridge Institute for Science & Education			
Vehicle Technologies	850	850	937
Bioenergy Technologies	500	500	600

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Hydrogen and Fuel Cells Technologies	1,000	1,000	1,900
Sustainable Transportation and Fuels	2,350	2,350	3,437
Renewable Energy Integration	0	0	5,050
Solar Energy Technologies	1,000	1,000	1,500
Wind Energy Technologies	0	0	670
Renewable Energy	1,000	1,000	7,220
Industrial Efficiency & Decarbonization Office	3,000	3,000	2,500
Advanced Materials & Manufacturing Technologies Office	2,900	2,900	6,000
Building Technologies	7,500	7,500	9,000
Buildings & Industry (formerly Energy Efficiency)	13,400	13,400	17,500
Strategic Programs	160	160	160
Corporate Support	160	160	160
Federal Energy Management Program (FEMP)	94	1,875	0
Training and Technical Assistance (SCEP)	250	400	0
State Energy Program Grants (SCEP)	1,300	1,500	0
Total Oak Ridge Institute for Science & Education	**18,554**	**20,685**	**28,317**
Oak Ridge National Laboratory			
Vehicle Technologies	35,500	35,500	39,150
Bioenergy Technologies	10,500	10,500	8,500
Hydrogen and Fuel Cells Technologies	3,600	3,600	2,700
Sustainable Transportation and Fuels	49,600	49,600	50,350
Renewable Energy Integration	2,000	2,000	0
Solar Energy Technologies	1,000	1,000	1,000
Wind Energy Technologies	1,724	1,724	1,961
Water Power Technologies	10,959	10,959	11,000
Geothermal Technologies	2,204	2,204	3,000
Renewable Energy	17,887	17,887	16,961
Industrial Efficiency & Decarbonization Office	18,150	18,150	20,000
Advanced Materials & Manufacturing Technologies Office	0	0	25,000
Building Technologies	33,083	33,083	35,000
Buildings & Industry (formerly Energy Efficiency)	51,233	51,233	80,000
Federal Energy Management Program (FEMP)	1,751	2,217	0
Training and Technical Assistance (SCEP)	360	1,200	0
Total Oak Ridge National Laboratory	**120,831**	**122,137**	**147,311**
Pacific Northwest National Laboratory			
Vehicle Technologies	31,000	31,000	34,188
Bioenergy Technologies	12,000	12,000	11,000
Hydrogen and Fuel Cells Technologies	6,500	6,500	5,500
Sustainable Transportation and Fuels	49,500	49,500	50,688
Renewable Energy Integration	5,000	5,000	7,750
Wind Energy Technologies	7,517	7,517	10,285
Water Power Technologies	20,610	20,610	21,000
Geothermal Technologies	330	330	1,500
Renewable Energy	33,457	33,457	40,535
Industrial Efficiency & Decarbonization Office	1,000	1,000	1,500
Building Technologies	39,724	39,724	50,000
Buildings & Industry (formerly Energy Efficiency)	40,724	40,724	51,500
Strategic Programs	770	770	700
Corporate Support	770	770	700
Federal Energy Management Program (FEMP)	6,785	4,542	0
Facility and Workforce Assistance (MESC)	0	200	0
State Energy Program Grants (SCEP)	100	0	0
Total Pacific Northwest National Laboratory	**131,336**	**129,193**	**143,423**
Sandia National Laboratories			

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Vehicle Technologies	6,700	6,700	7,389
Bioenergy Technologies	4,000	4,000	3,500
Hydrogen and Fuel Cells Technologies	7,300	7,300	8,800
Sustainable Transportation and Fuels	18,000	18,000	19,689
Renewable Energy Integration	400	400	0
Solar Energy Technologies	7,000	7,000	7,000
Wind Energy Technologies	12,264	12,264	16,087
Water Power Technologies	9,618	9,618	9,500
Geothermal Technologies	1,158	1,158	2,500
Renewable Energy	30,440	30,440	35,087
Advanced Materials & Manufacturing Technologies Office	25,000	25,000	0
Building Technologies	150	150	200
Buildings & Industry (formerly Energy Efficiency)	25,150	25,150	200
Strategic Programs	500	500	500
Corporate Support	500	500	500
Total Sandia National Laboratories	**74,090**	**74,090**	**55,476**
Savannah River National Laboratory			
Vehicle Technologies	200	200	221
Hydrogen and Fuel Cells Technologies	200	200	0
Sustainable Transportation and Fuels	400	400	221
Advanced Materials & Manufacturing Technologies Office	2,000	2,000	0
Buildings & Industry (formerly Energy Efficiency)	2,000	2,000	0
Total Savannah River National Laboratory	**2,400**	**2,400**	**221**
SLAC National Accelerator Laboratory			
Vehicle Technologies	7,000	7,000	7,720
Bioenergy Technologies	375	375	375
Hydrogen and Fuel Cells Technologies	500	500	500
Sustainable Transportation and Fuels	7,875	7,875	8,595
Advanced Materials & Manufacturing Technologies Office	5,000	5,000	1,000
Building Technologies	0	0	200
Buildings & Industry (formerly Energy Efficiency)	5,000	5,000	1,200
Total SLAC National Accelerator Laboratory	**12,875**	**12,875**	**9,795**
Undesignated Lab/Plant/Installation			
Program Direction - MESC	1,000	1,000	0
Total Undesignated Lab/Plant/Installation	**1,000**	**1,000**	**0**
Washington Headquarters			
Vehicle Technologies	22,375	22,375	24,676
Bioenergy Technologies	17,000	17,000	55,000
Hydrogen and Fuel Cells Technologies	0	0	15,600
Sustainable Transportation and Fuels	39,375	39,375	95,276
Renewable Energy Integration	0	0	5,800
Solar Energy Technologies	25,000	25,000	62,000
Wind Energy Technologies	24,477	24,477	25,211
Water Power Technologies	38,160	38,160	47,000
Geothermal Technologies	16,653	16,653	10,000
Renewable Energy	104,290	104,290	150,011
Industrial Efficiency & Decarbonization Office	39,550	39,550	45,000
Advanced Materials & Manufacturing Technologies Office	11,657	11,657	50,000
Building Technologies	104,690	104,690	77,500
Buildings & Industry (formerly Energy Efficiency)	155,897	155,897	172,500
Program Direction - Energy Efficiency and Renewable Energy	135,612	135,612	141,024
Total Program Direction (EERE)	135,612	135,612	141,024
Strategic Programs	7,417	7,417	7,000

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Corporate Support	143,029	143,029	148,024
Federal Energy Management Program (FEMP)	10,056	7,067	0
Program Direction - FEMP	14,000	14,000	0
Facility and Workforce Assistance (MESC)	208	2,118	0
Training and Technical Assistance (SCEP)	1,925	1,600	0
State Energy Program Grants (SCEP)	1,620	1,375	0
Program Direction - SCEP	21,100	21,000	0
Total Washington Headquarters	**491,501**	**489,751**	**565,811**
Grants			
Weatherization Assistance Program (SCEP)	298,920	320,000	0
State Energy Program Grants (SCEP)	60,000	60,000	0
Weatherization Readiness Fund (SCEP)	30,000	30,000	0
Total Grants	**388,920**	**410,000**	**0**
Undesignated LPI			
Weatherization Assistance Program (SCEP)	27,080	6,000	0
Training and Technical Assistance (SCEP)	1,000	800	0
Total Undesignated LPI	**28,080**	**6,800**	**0**
Total Funding by Site for TAS_0321 - Energy Efficiency and Renewable Energy	**3,460,000**	**3,460,000**	**3,118,000**

Electricity

Electricity

Electricity / Office of Electricity

($K)

FY 2023 Enacted[a]	FY 2024 Annualized CR[b]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
285,293	285,293	293,000	+7,707

Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for electricity activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, $293,000,000, to remain available until expended: *Provided*, That of such amount, $19,700,000 shall be available until September 30, 2026, for program direction: *Provided further*, That funds under this heading allocated for the purposes of section 9 of the Small Business Act, as amended (15 U.S.C. 638), including for Small Business Innovation Research and Small Business Technology Transfer activities, or for the purposes of section 1001 of the Energy Policy Act of 2005, as amended (42 U.S.C. 16391(a)), for Technology Commercialization Fund activities, may be reprogrammed without being subject to the restrictions in section 301 of this Act.

Mission

A reliable, resilient, and secure power grid is vital to our national security, economic security, and the services Americans rely upon. Working closely with its private and public partners, the Office of Electricity (OE) leads the Department's research, development, and demonstration programs to strengthen and modernize our Nation's power grid. These efforts will reinforce, transform, and improve energy infrastructure so every American home and business has reliable access to affordable energy and the U.S. sustains its global leadership in the clean energy transformation.

Overview

America's energy security, economy, and sustained global leadership is anchored in a robust power grid. Through a mix of physical science, social science, and risk science solutions and in partnership with the private and public sectors, OE harnesses innovation to drive a more resilient, reliable, affordable, and secure North American energy system while maintaining energy independence.

The ability to move abundant clean electricity from where it is produced to where and when it is needed is the cornerstone of a reliable electric grid. The electricity delivery system must adapt to all generation resource and load types, and ensure reliable, resilient grid operations under increasingly extreme conditions. OE leads the Department's efforts in developing new technologies to strengthen, transform, and improve electricity delivery infrastructure so new generation and loads can be fully integrated into the energy ecosystem and consumers have access to resilient, reliable, secure, and clean sources of electricity.

A dramatic structural transformation of the electricity delivery system is underway to ensure that reliability is maintained during the rapid integration of renewable generation and customer-based technologies, including distributed generation and the electrification of transportation and building infrastructures. America's grid is transforming into a more dynamic and structurally complex system, with bidirectional power flows. Managing this transition will require significant reengineering and advancements in grid technology and system architectures.

OE's team of experts share their technical, analytical, and policy expertise with offices throughout DOE and with energy transition stakeholders across the country. OE made progress building a strong team in FY 2023 and FY 2024 by addressing skill gaps and supporting succession planning. Continued program direction support in FY 2025 is crucial to grow and sustain

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[a] The FY 2023 appropriation for the Electricity account provided funding for OE and the Grid Deployment Office (GDO). The amount shown here reflects the OE portion. An additional $64,707,000 was appropriated for GDO in FY 2023 for a total of $350,000,000.

[b] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

a talented workforce to support our Nation's initiatives to provide a reliable, resilient, secure, and affordable 21st century power grid for the American people.

FY 2023 Key Accomplishments

- **Validated Microgrid Building Block (MBB) Capabilities to Support Microgrid Deployment:** Validated MBB virtual prototype performance for communications, control, and integration. Use case results showed MBB algorithms can adapt to different DER penetration levels with different control and communication capabilities, facilitating broad microgrid deployment with reduced customized engineering time and effort.
- **Managed Wildfire Risk Using Dynamically Formed Microgrids:** Developed use cases for dynamic formation and operation of networked microgrids (DynaGrids) during normal operations and grid disruptions. Wildfire risk use case testing showed dynamically formed microgrids can serve over 43% of the total load compared to static microgrids, which serve can about 35%.
- **Provided Guidance to Industry on Secure, Redundant Grid Timing:** Developed and published best practices for deploying a terrestrial backup timing system for grid synchronization. This helps electric utilities reduce dependence on satellite timing systems and increases grid reliability and resilience.
- **Identified Storage Shot Technology Pathways:** Held 10 listening sessions between January and April 2023 with storage innovators to identify R&D barriers. The sessions informed the publication of Storage Shot Technology Strategy Assessments, which identified that, with appropriate RD&D support, many technologies have viable pathways to approaching, achieving, or exceeding the Long Duration Storage Energy Earthshot goal.
- **Demonstrated Storage Cost Reductions:** Through lab prototyping and modeling, OE showed that sodium-based utility-scale long duration storage systems can be made for approximately $133/kWh, demonstrating continued cost reductions from the 2020 $200/kWh lithium-ion baseline. Lab-validated improvements include increased energy retention and cycle life for prototype pouch cells.
- **Provided Disadvantaged Community Technical Assistance (ES4SE):** Provided 14 communities with capacity-building support to model the ability of energy storage and related technologies to enhance the energy security, affordability, and resilience of their facilities. OE announced additional support for 4 of these communities to proceed to project development and deployment.
- **R&D 100 Award for Microgrid Innovation**: OE's Resilient Operation of Networked Microgrids (RONM) work at the Los Alamos National Laboratory was honored with a 2023 R&D 100 award for the PowerModelsONM: Optimizing Operations of Networked Microgrids for Resilience software, which uniquely leverages microgrid technologies, particularly microgrid networking, to improve resilience to extreme events on power grids.

Summary Funding Table

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Grid Controls and Communications					
Transmission Reliability and Resilience	34,000	34,000	39,000	+5,000	+14.7%
Energy Delivery Grid Operations Technology	31,000	31,000	31,000	…	…
Resilient Distribution Systems	55,000	55,000	49,000	-6,000	-10.9%
Cyber Resilient and Secure Utility Communications Networks (SecureNet)	15,000	15,000	15,000	…	…
Total, Grid Controls and Communications	135,000	135,000	134,000	-1,000	-0.7%
Grid Hardware, Components, and Systems					
Energy Storage	95,000	95,000	94,800	-200	-0.2%
Transformer Resilience and Advanced Components	27,500	27,500	32,500	+5,000	+18.2%
Applied Grid Transformation Solutions	10,000	10,000	12,000	+2,000	+20.0%
Total, Grid Hardware, Components, and Systems	132,500	132,500	139,300	+6,800	+5.1%

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Program Direction (PD)	17,793	17,793	19,700	+1,907	+10.7%
Total, Office of Electricity	**285,293**	**285,293**	**293,000**	**+7,707**	**+2.7%**

Future Years Energy Program

($K)	FY 2025 Request	FY 2026	FY 2027	FY 2028	FY 2029
Electricity	293,000	300,000	307,000	314,000	321,000

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2026–2029. The outyear funding reflects the amounts published in the FY 2025 President’s Budget. Actual future budget request levels will be determined as part of the annual budget process.

Office of Electricity priorities in the outyears include the following activities aimed at maintaining the reliability, resilience, security, and affordability of America's electricity delivery system:

- Developing data and analytical tools necessary to assess the reliability and performance of the electricity system
- Accelerating development of modular and flexible next-generation technologies, such as HVDC, solid state power substations (SSPS), power electronics, advanced transformers, and advanced conductors, to enable advanced grid capabilities and more fully unlock the value of storage and renewables
- Developing long duration energy storage technologies consistent with the 2030 Long Duration Storage Shot goal of $0.05/kwh Levelized Cost of Storage for 10+ hour systems
- Architecting next-generation grid-communications systems that are built from inception to mitigate communication failures and automatically detect, reject, and withstand cyber incidents
- Conducting research on electricity market designs and distribution planning processes that increase the reliability, social equity, and efficiency of the electricity delivery system

Crosscut Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Energy Storage	95,000	95,000	94,800	-200	-0.2%
Grid Modernization	267,500	267,500	273,300	+5,800	+2.2%
Energy Sector Cybersecurity	15,000	15,000	15,000	…	…
Safeguards and Security	50	25	28	-22	-44.0%
Small Business Innovation Research	5,753	5,753	6,762	+1,009	+17.5%
Research & Development	166,431	166,431	190,000	+23,569	+14.2%

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

Transmission Reliability and Resilience

Overview

The Transmission Reliability and Resilience (TRR) program collaborates with the electric industry to research, develop, and demonstrate system monitoring and diagnostics, advanced data analytics, and robust control technologies that are critically needed to assess and enhance the reliability and performance of the electricity system, mitigate large-scale blackouts, prepare for and respond to the impacts of natural disasters, and adapt to evolving system needs, emerging risks, and interdependencies. This program is critical to realize the full potential of investments in generation technologies and electrification, which are dependent on the transmission grid evolving. TRR focuses on:

- Ensuring the reliability and resilience of the U.S. electric grid through research, development, and demonstration (RD&D) of system observability and control capabilities
- Developing and validating models, approaches, and frameworks to characterize evolving system needs and the emerging operational landscape
- Developing and demonstrating operational tools for grid enhancing technologies (GETs), such as dynamic line ratings and power flow control, to better utilize existing transmission infrastructure
- Identifying pathways for achieving an equitable and risk-informed transition towards decarbonization and electrification
- Addressing ongoing industry challenges related to relay misoperations and identification and isolation of faults
- Mitigating risks across integrated energy systems through comprehensive data acquisition, augmentation, and synthesis at various scales and development of uncertainty-informed decision support systems that consider human factors

TRR brings together energy stakeholders from government, industry, academia, and national laboratories to generate novel ideas and develop transformative solutions to address the Nation's energy infrastructure challenges, including stakeholder landscape and architecture changes as well as natural and man-made hazards.

Transmission Reliability and Renewable Integration (TRRI) develops transmission system operational planning and control tools to inform decisions on maintaining and improving system reliability. A key focus is operational integration of new technologies, such as solar, wind, and electric vehicle chargers, that are driven by power electronics. Advanced analytics and data visualization enables better inference of complex underlying dynamics and diagnosis of system behavior and anomalies, which in turn unlocks the full value of grid-connected assets. Visibility into transmission system conditions allows operators to make risk-informed and equitable decisions. TRRI develops tools that help system operators understand and respond to reliability events, such as wildfires, heat waves, cold snaps, storms, and hurricanes, while adapting to decarbonization, distributed energy resource integration, increased electrification, interdependence with other critical infrastructure systems, and evolving electricity demand. TRRI works to modernize transmission system tools through human factor and cognitive science research for reliable system operations and develops training simulators for more effective operator workforce development. RD&D will improve the speed, accuracy, and precision of power system state determinations required to manage the increasing complexity and uncertainty of grid operations and to monitor and manage the interconnected and interdependent effects among the Nation's critical infrastructures.

Advanced Grid Modeling (AGM) supports building electricity sector capacity and capability to analyze the electricity delivery system using Big Data, advanced mathematical theory, and high-performance computing to assess the current state of the grid, mitigate reliability risks, and understand future needs. In FY 2025, AGM expands to include protective relaying, which identifies and isolates faults so the remaining system will continue to operate under normal conditions and reduces equipment damage and potential injuries to utility personnel and the public. AGM leads research activities to better understand issues affecting the current and future electric power grid and develop robust model-based solutions, resulting in new software and analytical toolsets for operators and planners. Successful research enables grid operators and planners to optimize decision-making, giving the electric industry sophisticated tools, capabilities, and understanding to dramatically improve electric delivery system efficiency, reliability, resilience, security, and affordability.

Building and maintaining effective public-private partnerships is a key TRR strategy; TRR engages with energy stakeholders, decision makers, and practitioners to encourage researcher and practitioner partnerships to accelerate grid modernization by disseminating research results and promoting innovation and risk-informed energy system decisions.

TRR also fosters strategic university-based power system research, helping ensure an enduring strategic national capability for innovation in this essential area.

TRR's university partnerships focus on developing state-of-the-art tools and analytic methods, while simultaneously providing important opportunities for the next generation of scientists and researchers in power systems. These partnerships facilitate RD&D innovations to enable industry and, ultimately, consumers to capitalize on the outcomes. TRRI continues work to develop research datasets and data platforms that facilitate tool development with real data and reduce the burden of data requests on utilities This sets the groundwork for catalyzing artificial intelligence and machine learning (AI/ML) in the transmission system. Advancing analytics that fully capture and understand new system dynamics associated with the integration of renewable energy, inverter-based technologies, and advanced transmission control schemes, such as dynamic line rating and transmission topology control, may further develop the electricity system as a resource. AGM collaborates with the National Science Foundation's (NSF) Division of Mathematical Sciences on Algorithms for Modern Power Systems (AMPS) to build a community of university-level mathematicians and statisticians to solve some of the hardest power-system-related challenges.

Highlights of the FY 2025 Budget Request

TRR investigates and develops technologies that make the present and future grid resilient, reliable, efficient, affordable, and secure. In FY 2025, TRR will concentrate on:

- Advancing the application of cognitive science and human factors to identify and develop tools needed for robust decision making and training for system operators
- Advancing protective relaying methods to improve the functional integrity and effectiveness of corrective actions to prevent mis-operations and mitigate power outages
- Continuing research on changes to grid system dynamics with a focus on updating models to accommodate renewable deployments and electrification
- Supporting the development of industry standards and collaboration for wide-area situational awareness and control technologies on the transmission system
- Developing strategies for improving operations and operational planning across regions
- Identifying operational strategies for maintaining and improving system stability to allow the integration of inverter-based resources (IBRs) associated with electrification, such as solar and batteries
- Developing models and tools to help the electric industry meet decarbonization and electrification targets while maintaining reliability
- Continuing the partnership with NSF on AMPS, targeting university-based research
- Developing risk-based, measurement-model approaches to enable the operation of degraded or damaged electricity systems while sustaining critical functionality by improving detection, mitigation, recovery, and restoration from system issues
- Advancing transmission system tools that anticipate the evolution of distribution systems' operation and energy resources
- Developing and demonstrating tools with utility partners that identify, locate, and inform actions that mitigate reliability and security issues
- Developing training tools for operators for knowledge transfer of existing skills, and developing new skills needed for grid operations

Technology, tools, and applications developed under TRR will be evaluated for and hardened against physical and cyber security risks. Testing and evaluation will be conducted in coordination with OE's SecureNet program to ensure that security is built into these technologies and to guard against new security risks to the electric delivery sector.

The FY 2025 Request will continue to support RD&D activities through the Grid Modernization Initiative, including the Grid Modernization Laboratory Consortium (GMLC).

Centers

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

Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Transmission Reliability and Resilience					
Transmission Reliability and Renewable Integration	9,200	9,200	14,000	+4,800	+52.2%
Advanced Grid Modeling	20,800	20,800	25,000	+4,200	+20.2%
Protective Relaying	4,000	4,000	...	-4,000	-100.0%
Total, Transmission Reliability and Resilience	**34,000**	**34,000**	**39,000**	**+5,000**	**+14.7%**
SBIR [non-add]	*[1,127]*	*[1,127]*	*[1,306]*	*[+179]*	*[+15.9%]*

Explanation of Major Changes

($K)	FY 2025 Request vs FY 2023 Enacted
Transmission Reliability and Renewable Integration: Increases research, development, and demonstration of operational and control tools to modernize the transmission system • Increases development and demonstrations with industry for human-factor-informed operational dashboards and decision processes for reliability events, including technical support for industry. • Develops operational frameworks for incorporating grid edge resource contingencies into transmission system operations and planning to improve system reliability • Supports research on power stability issue identification and demonstration of tools needed for decision making and operator training	+4,800
Advanced Grid Modeling: Supports RD&D to develop new models to increase the net power flowing through transmission lines, develop analytical methods to manage the impact of uncertainty associated with increased renewable sources on the bulk power system to maintain the reliability of the grid, help the electric industry understand and maintain reliability as supply and load change to meet decarbonization and electrification targets, and increase the level of understanding and industry awareness related to energy justice • Subprogram name has been updated from Advanced Modeling Grid Research • Starting in FY 2025, AGM includes Protective Relaying work for better understanding and management of relay misoperations while advancing state-of-the-art technology related to bi-directional power flow, faster response times, and enhanced detection methods	+4,200
Protective Relaying: Activities will be merged into AGM in FY 2025	-4,000
Total, Transmission Reliability and Resilience	**+5,000**

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Transmission Reliability and Resilience $34,000,000	**$39,000,000**	**+$5,000,000**
Transmission Reliability and Renewable Integration $9,200,000	*$14,000,000*	*+$4,800,000*
• Advance cognitive science and human factors research to catalyze development and adoption of new tools for workforce training and development, control room application improvements, and robust decision making • Develop and demonstrate management tools for GETs like dynamic line rating and power flow control to facilitate integration of renewable energy and better utilize existing transmission infrastructure to facilitate integration of renewable energy and better utilize existing transmission infrastructure • Develop transmission system data modernization for wide-area situational awareness, to prevent cascading power outages, through prizes, data set creation, and AI/ML research • Continue technical support for transmission wide-area situational awareness by conducting competitions, information sharing and joint problem solving among utilities, vendors, universities, and the Federal Government	• Advance cognitive science and human factors research to improve operator alarming and cueing, modernize control room applications, and structure robust decision making under uncertainty • Continue RD&D operational strategies to increase transmission infrastructure utilization and reliability and utilize GETs such as power flow control and topology control strategies • Support operating strategies, decision analysis, contingency analysis, and control approaches that recognize and incorporate the control capabilities and attributes of wind and solar generation • Continue RD&D of transmission system data modernization methods and advanced tools for wide-area situational awareness to prevent cascading power outages • Develop operational frameworks for incorporating grid-edge resource contingencies into transmission system operations and planning to improve system reliability • Research power quality issue identification and demonstrate tools needed for decision making and operator training	• Increases development and demonstrations with industry for human factors informed operational dashboards and decision processes for reliability events • Provides technical support for utilities and energy management system vendors to modernize operational dashboards • Develops operational frameworks for incorporating grid edge resource contingencies into transmission system operations and planning to improve system reliability • Researches power quality issue identification and demonstrates tools needed for decision making and operator training

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Advanced Grid Modeling $20,800,000	*$25,000,000*	*+$4,200,000*
• Continue mathematical and computational research to manage uncertainty associated with data, modeling, and model validation • Continue development of next-generation mathematical and statistical algorithms to improve the security, reliability, and resilience of the electric power system with joint funding from NSF's AMPS program • Continue studying the impact of grid changes to accommodate deployment of renewables to facilitate decarbonization • Increase the level of understanding and awareness in National Laboratories related to energy justice while exploring a limited level of mitigation through RD&D • Identify grid risk to accommodate increasing levels of renewables and explore a limited level of mitigation to facilitate decarbonization while ensuring grid reliability, resiliency, security, and efficiency	• Identify and mitigate risk from changes in supply and demand and integration of large number of IBRs across the integrated energy system • Advance tools for transmission and distribution systems operations and control to rapidly mitigate reliability events • Develop new models and tools that can help the electric industry understand and maintain reliability by managing the system as supply and load change to meet decarbonization and electrification targets • Continue mathematical and computational research to manage uncertainty associated with data, modeling, and model validation • Continue development of next-generation mathematical and statistical algorithms to improve the security, reliability, and resilience of the electric power system with joint funding from NSF's AMPS program • Continue exploring alternative methods for transmission planning to increase the amount of energy delivered using existing rights of way • Continue exploring the impact of changes in the grid with a concentration on transmission planning to accommodate large deployment of renewables to facilitate decarbonization • Identify and mitigate grid risk to accommodate increasing levels of renewables to facilitate decarbonization while ensuring grid reliability, resiliency, security, and efficiency	• Increases the level of stakeholder engagement on IBRs to better understand issues and explore mitigating actions, as the integration of more renewables may impact the reliability of the system • Continue characterizing changes in the grid as renewable resource generation increases and develop mitigating actions to ensure the continued reliable operation of the grid • Incorporates work from the Protective Relaying subprogram aimed at avoiding cascading outages and system blackouts by advancing relay protection

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	• Advance protective relaying for a faster response time and enhanced detection methods for relay operation to reduce misoperations at both transmission and distribution levels to mitigate and prevent power outages	
Protective Relaying $4,000,000	*$0*	*-$4,000,000*
• Develop mitigations that reduce misoperations at transmission levels • Develop testing solutions to distinguish between momentary and permanent faults for distribution level reclosers • Develop cybersecurity solutions for protective relaying at the transmission levels • Continue research on adaptive relay settings that address bi-directional power flow • Address best practices and toolsets that will support the protective relaying workforce in an evolving grid environment		• Activities merged into AGM in FY 2025

Resilient Distribution Systems

Overview

Much of the electrical distribution system—infrastructure delivering power from the transmission system to individual businesses and homes—was designed and built for operational conditions established over 100 years ago. The operational conditions of the grid have fundamentally changed. Historically, the distribution system passed electricity from the transmission system through to consumers. Distributed energy resources (DERs) and microgrids are upending this paradigm with two-way flows of electricity across the distribution system. Accelerated electrification of both heat and transportation are connecting distribution to new sectors of the economy. The devices and resources connected to the distribution grid continue to evolve, and it is necessary to respond with appropriate tools and technologies.

The Resilient Distribution Systems (RDS) program focuses on research, development, and demonstration (RD&D) of technologies, tools, and techniques required by the distribution grid to maintain and improve reliability and resilience. The growing convergence of transmission and distribution (T&D) systems requires new architectural, control, and operational approaches alongside a more sophisticated approach to data as a collective resource. As the complexity of the electricity distribution system increases, new technologies are needed to address operational uncertainty and challenges. Utilities require new tools and capabilities to enhance observability, control, and dynamic protection across all distribution system assets.

Many distribution utilities do not have bandwidth to create detailed system models of their service territories without new tools that rely on sensors to validate and update their models. Better modeling of distribution systems, and the attached DERs and other grid-edge devices, is critical for effective utilization of these assets for power stability and mitigating power outages. RDS activities assist in increasing electrification of the economy and strategically integrating multiple grid edge resources to improve the reliability and resilience of the system. RDS pursues tactical investments in innovative technologies and practices that improve reliability, increase resilience, support vehicle electrification, integrate clean DERs, and provide consumers with more choices for managing their energy consumption.

Microgrid Research and Development (R&D) focuses on developing and validating new microgrid technologies and methods to improve grid reliability and resilience under both normal and disruptive conditions while enabling optimized integration of all types of generation sources, loads, storage, and other DERs, enhancing consumer participation and choice, and driving grid technology innovation. Microgrid investments have enhanced electricity service reliability, resilience, security, and affordability, particularly at the community level—enabling remote and island communities to navigate and implement their options for transitioning to sustainable, affordable, and resilient energy systems—and these investments continue to be a strategic RDS focus area. Increased resilience during power outages through the networking of microgrids can be particularly beneficial for large remote and island communities (over 1,000 people) for ensuring critical infrastructure remains operational and enabling mitigation solutions to other community energy risks. As microgrid technology evolves to improve grid performance, microgrids are envisioned to be essential building blocks of the future electric grid and active participants in future power market transactions.

Dynamic Controls RD&D investigates new approaches and technologies to enhance the electric distribution grid's ability to harness flexibility across all distribution and customer assets. Operating an electric grid supporting full electrification of the U.S. economy would require control and balancing capabilities beyond the capabilities of single owner-operators, requiring coordination and incentivization to attract willing and capable customer-owned resources. A new data-rich environment is emerging, with data originating both within and outside traditional utility boundaries. This new environment needs expanded sensor research to increase situational awareness at the distribution level, supporting both normal operations and the ability to withstand and recover from disruptions caused by extreme weather and man-made events. Dynamic Controls also explores implications of transportation electrification and other transformative grid edge influences.

Sensor Data Analytics (SDA), formerly the Sensors subprogram, supports the development and demonstration of systems and data analytics for an increasingly advanced, robust, and diverse mix of information-gathering devices for situational awareness and decision making. SDA focuses on developing data analytics that help inform decision making through advances in standards, platforms, and decision science. The electricity utility has traditionally been the owner and operator of all the sensors and data sources used for operations; however, behind-the-meter devices, electric vehicles, smart thermostats, and other sensors outside of the utility's ownership have become important sources of information for the operation of the grid. Data needs to be shared between the transmission system and the distribution system to leverage grid-edge resources to avoid or mitigate reliability events. SDA works to develop tools to give utilities visibility into the systems they operate, including gaining visibility into impacts of behind-the-meter DERs, for reliable operation of the grid during both normal and extreme-event conditions.

Electricity Delivery Systems (EDS) works closely with State officials and the utility industry to advance practices leading to the formulation of grid investment and DER utilization strategies that address community, State, and Federal policies, and serve utilities and their customers. The program examines technological and institutional issues and applies grid architecture principles and decision-making processes for addressing them. Toward this end, the EDS program is advancing integrated planning practices, developing guidelines to enable coordinated operations between grid operators and DER service providers, and producing distribution system reference designs to address emerging structural complexity at the grid edge. These activities are meant to establish a common understanding among utilities, regulators, and their stakeholders of grid investments needed to enable the utilization of an increasingly diversified set of resources while maintaining reliability, resilience, and affordability.

RDS research results enable the industry to strengthen electrical infrastructure reliability and resilience and support the ongoing evolution of the electric grid. RDS is developing a U.S. Electric Sector Data Strategy to establish a framework to allow sector participants to contextualize information created and used throughout the system, enable new uses for existing and emerging data resources, and extend data sharing capabilities without sacrificing privacy or security.

Highlights of the FY 2025 Budget Request

Microgrids

Microgrid R&D focuses on developing and validating new microgrid technologies and methods to improve grid reliability and resilience. FY 2025 activities are supported in the following areas:

- Microgrid Building Blocks (MBBs): Continued MBB development is a fundamental base to reduce microgrid deployment costs and time. Going beyond current microgrid functionalities, such as supporting local resilience and integrating distributed generation, the virtual MBB prototype designs developed in FY 2023 feature functions for a wide range of microgrids and provide modular and standard interfaces to generation, load, control facilities, and the utility system. Modeling and simulation activities will validate the performance of the virtual MBB prototype performance designs.
- Networked Microgrids: Developing modeling and simulation capabilities for optimal system design and operations of networked microgrids will continue in FY 2025. Networking two or more microgrids that share loads and complementary power resources can increase their combined resilience during power outages, while lowering capital and operational costs for normal operations. Activities in FY 2025 will apply advanced modeling and simulation capabilities developed in FY 2023 in the use case to support a range of resiliency and decarbonization operations at U.S. ports. Networked microgrid R&D will focus on enabling DynaGrid, a concept to enable dynamic formation of microgrid boundaries for optimized operations under both normal and emergency conditions, laying the foundation for a future fractal grid composed of dynamically formed microgrids in a repetitive pattern. Realistic use cases developed in FY 2023 will be evaluated and demonstrated through FY 2025. This activity is expected to accommodate larger-scale DER integration and electrification envisioned for the future grid.
- Development of dynamic real-time protection, monitoring, and control schemes for microgrids with high penetration of inverter-based resources (IBRs) and development of new microgrid fault location algorithms using real-time sensor data and analytics will continue for both singular and networked microgrids. Protection research for secondary networks involving DERs and microgrids will also continue.
- Net-Zero Microgrids (NZMs): NZM activity follows its Technical Studies Guidance report published in 2021.[a] Work will continue to model and simulate a microgrid design with integrated small modular reactors (SMRs) as part of the

[a] Small Reactors in Microgrids: Technical Studies Guidance: https://www.osti.gov/biblio/1829672.

generation mix to investigate power system engineering issues involving microgrid operations and integrated operations to provide grid services.

Dynamic Controls

Dynamic Controls RD&D activities require additional investment to deliver on the priorities of grid resilience and dynamically sourced grid support services to transform distribution grid infrastructure. FY 2025 activities are conducted in the following areas:

- Transactive Controls: Under widespread electrification and power sector decarbonization, enabling and incentivizing DER participation in maintaining system reliability and resilience becomes increasingly important to mitigate expensive T&D upgrades. This requires additional research to compare the economic impacts of achieving widespread electrification with status quo upgrades or with reliance on flexible resources, and assessing when and to what extent these strategies should be leveraged. The FY 2025 request also supports research on the optimal use of direct utility control of DERs and of economically incentivized third-party control of DERs (such as through demand response, aggregators, and virtual power plants). The growth of customer-owned devices at the grid edge at scale requires methods for assuring that grid-edge supplied services match the level of certainty for response that utility operators had come to expect from traditional centralized single-owner control systems.
- Grid Data Science: R&D on highly resilient distribution designs accommodating evolving electricity supply and adapting to extreme events and disruptions will continue in FY 2025. Data flow across ownership boundaries creates the need for new data integrity methods, data sharing agreements, and coordination frameworks. Research continues on secure distributed computational environments to address data transport costs and create effective data architectures within the utility environment.
- Transport Electrification: The increased linkage between the electric and transportation sectors creates interdependencies that can have both positive and negative effects. Sector coupling analysis looks at structural and architectural aspects, seeking to establish a converged perspective on reliability, sustainability, and resilience across both transportation and electricity. In FY 2025, OE will increase dialogues and coordination activities with the Department of Transportation to develop sector coupling analysis for this combined infrastructure. In parallel, a linkage with Dynamic Controls activities will develop control and coordination approaches that address vehicle–grid integration issues through both nodal and network solution paths, encompassing all grid and DER assets and their incentive mechanisms.

Sensor Data Analytics

Sensor Data Analytics supports the development and demonstration of systems and data analytics for an increasingly advanced, robust, and diverse mix of information-gathering devices for situational awareness and decision making. FY 2025 activities are conducted in the following areas:

Enhanced Distribution System Resilience and Visibility:

- Building tools and methods to combine data from connected resources, including Advanced Metering Infrastructure (AMI) data and other utility-owned sensors, for use in operations and planning decision making
- Performing data analytics RD&D utilizing grid-edge resources during power outages to improve grid stability
- Preparing advanced contingency analyses and improved simulations of dynamic behavior, such as those related to IBRs in the distribution system, heatwaves, cold snaps, and electrification

Data Integration and Event Detection:

- Developing research data sets, tools, and procedures to facilitate better two-way power flow from the grid edge across the T&D system
- Developing analytics, platforms, frameworks, and tools to visualize the grid for electric power operations and delivery—from the grid edge to the distribution system and all the way up to the transmission system

Sensor Valuation, Validation and Standards:

- Developing data sharing procedures to enable utilities to know where these resources are on their system
- Developing and demonstrating tools for sensor management and data analytics so utilities can better forecast and react to changes in generation from DERs and load to maintain reliability and reduce costs

Electricity Delivery Systems

The subprogram examines technological and institutional issues and applies grid architecture principles and decision-making processes for addressing them. FY 2025 activities are conducted in the following areas:

- Advancing practices associated with integrated distribution system planning to enable the formulation of holistic and staged grid investment strategies that address community and state policies and priorities, including those associated with resilience, equity, and decarbonization, and ensure the effective integration, orchestration, and utilization of DERs, including evolving market and business models
- Establishing rules to enable coordinated operations between DER service providers and grid operators across the T&D system domains, including developing guidelines and sharing best practices to mature and standardize institutional, business, and technical processes governing the interfaces between them
- Developing functional requirements and reference designs for the distribution system that can accommodate many forms of DERs, ownership models, and market structures, and ensuring an effective transfer of expertise to the industry, including regulators
- Working collaboratively with the National Association of Regulatory Utility Commissioners (NARUC), National Association of State Energy Officials (NASEO), National Rural Electric Cooperative Association (NRECA), American Public Power Association (APPA), National Governors Association (NGA), National Conference of State Legislatures (NCSL), and National Association of State Utility Consumer Advocates (NASUCA) through formal arrangements to engage their respective stakeholders through working groups and education and training programs to advance grid modernization decision-making and coordinated planning and operations across community, state, and regional jurisdictions

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

Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Resilient Distribution Systems					
Microgrids	6,000	6,000	15,500	+9,500	+158.3%
Dynamic Controls	9,000	9,000	20,000	+11,000	+122.2%
Sensor Data Analytics	…	…	6,000	+6,000	N/A
Electricity Delivery Systems	5,000	5,000	7,500	+2,500	+50.0%
Modeling Distributed Energy Resources	5,000	5,000	…	-5,000	-100.0%
Sensors Demonstration	15,000	15,000	…	-15,000	-100.0%
COMMANDER National Testbed Laboratory	5,000	5,000	…	-5,000	-100.0%
Underserved & Indigenous Community Microgrids	10,000	10,000	…	-10,000	-100.0%
Total, Resilient Distribution Systems	**55,000**	**55,000**	**49,000**	**-6,000**	**-10.9%**
SBIR [non-add]	*[961]*	*[961]*	*[1,216]*	*[+255]*	*[+26.5%]*

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

Explanation of Major Changes

($K)	FY 2025 Request vs FY 2023 Enacted
Microgrids: Supports MBB development, advancing the performance of the virtual prototype designs	+9,500
Dynamic Controls: The combination of electrification and decarbonization requires transformative control approaches ensure affordable, reliable, and resilient electricity • Expands data science approaches in the rapidly expanding grid-edge, collaborative control frontier, strengthening coordination capabilities and enabling decarbonized and resilient systems • Anticipates the substantial impact of transportation electrification through increased research on interdependency, adaptation of distribution systems, and coordination of optimizations across new and legacy participants in the electric system	+11,000
Sensor Data Analytics: • Supports R&D to assist and work with industry on data standards required for advanced analytics and software interoperability • Supports R&D on advanced data analytics for system operations through improving visibility and strategies for data quality and validity safeguards • Incorporates sensor demonstration activities in line with congressional direction in prior years • No activities were funded in this subprogram in FY 2023	+6,000
Electricity Delivery Systems: • Supports more robust stakeholder engagement to vet and share guidelines, as well as deliver best practices, around integrated distribution system planning (IDSP), operational coordination, and distribution system reference designs • Begins to advance more comprehensive grid planning practices to address regional and multi-jurisdictional issues, such as coordinated efforts to ensure reliability given high levels of variability and uncertainty	+2,500
Modeling Distributed Energy Resources: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023	-5,000
Sensors Demonstration: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023	-15,000
COMMANDER National Testbed Laboratory: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023	-5,000
Underserved & Indigenous Community Microgrids: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023	-10,000
Total, Resilient Distribution Systems	**-6,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Resilient Distribution Systems **$55,000,000**	**$49,000,000**	**-$6,000,000**
Microgrids $6,000,000	*$15,500,000*	*+$9,500,000*
• Conduct R&D on the DynaGrid concept to enable dynamic formation of microgrid boundaries for optimized operations of networked microgrids, building on the Resilient Operations of Networked Microgrids (RONM) capabilities developed for static-boundary applications • Develop modeling and simulation capabilities for optimal system design and operation of networked microgrids for critical infrastructure decarbonization and resilience with a focus of the use case on ports • Complete the design of virtual MBB prototypes for microgrid communications and control • Develop modeling and simulation of an SMR-integrated microgrid design to examine power system engineering issues and operational challenges of providing grid services • Develop protection schemes for microgrids (singular and networked) with high penetration of IBRs and for secondary networks with DERs and microgrids	• Conduct R&D on the DynaGrid concept to enable dynamic formation of microgrid boundaries for optimized operations of networked microgrids, building on the RONM capabilities developed for static-boundary applications • Apply modeling and simulation capabilities for optimal system design and operations of networked microgrids for critical infrastructure decarbonization and resilience in a use case on ports • Conduct modeling and simulation to validate the performance of the virtual MBB designs • Develop modeling and simulation of a small-modular-reactor-integrated microgrid design to examine power system engineering issues and operational challenges for providing grid services • Develop protection schemes for microgrids (singular and networked) with high penetration of IBRs and for secondary networks with DERs and microgrids	• Increases support for MBB development across multiple national laboratories to advance the performance of the virtual prototype designs
Dynamic Controls $9,000,000	*$20,000,000*	*+$11,000,000*
• Develop a data efficient operations approach with increased reliance on combinations of distributed control and incentivization of flexible DER	• Publish a data efficient operations methodology with increased reliance on combinations of distributed control and incentivization of flexible DER • Overcome value stacking barriers associated with current T&D operational and market structures to maximize utilization of grid edge resources	• Expands a transportation and electric sector coupling analysis to look at structural and architectural aspects as well as control and coordination approaches addressing vehicle–grid integration issues through both nodal and network solution paths encompassing all grid and DER assets and their incentive mechanisms

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Develop a broad framework for data sharing across ownership and responsibility boundaries that assures data security, integrity, and privacy while ensuring attainment of stakeholders’ operational objectives • Extend sector coupling analysis to the transportation and electricity sectors including structural and architectural aspects, seeking to establish a converged perspective on reliability, sustainability, and resilience • Develop control and coordination approaches that address vehicle grid integration issues through nodal and network solution paths, encompassing all grid and DER assets and their incentive mechanisms	• Engage industry on complex data sharing challenges across ownership and responsibility boundaries that assures data security, integrity, and privacy while ensuring attainment of stakeholders’ operational objectives • Apply the sector coupling analysis to the transportation and electricity sectors to propose new reliability index targets for existing metrics and construct new metrics where required • Develop coordinated control options that reduce distributions system upgrade capital requirements by 25%, utilizing grid and DER asset combinations and their incentive mechanisms • Engage digital ledger technology (DLT) industry in generating testable pilots applying DLT to operational challenges	• Supports transformational research on data flow across ownership boundaries, addressing the need for new data integrity methods, data sharing agreements, and coordination frameworks • Expands emphasis on standards interfaces with buildings, vehicles, vehicle charging infrastructure and consumers themselves to ensure interoperability of information flows within the distribution utility and with grid edge participants • Increasing R&D on standardization and usability or power outage data through the Outage Data Initiative Nationwide (ODIN) and Green Button™ to ensure consumer empowerment is intrinsic to grid modernization • Increases GridAPPS-D support to allow utilities to utilize hybrid centralized and decentralized controls in tandem, and constructively engage DERs, EVs, smart buildings, distributed storage, and other grid edge resources
Sensor Data Analytics $0	*$6,000,000*	*+$6,000,000*
	• Develop and integrate advanced data analytics into the electricity delivery system utilizing high-fidelity, fast-acting sensor technologies • Develop and demonstrate data analytics utilizing AMI data and other distribution sensors to inform utilities’ operational planning and decision making	• This program was not funded in FY 2023 due the Sensors Demonstration congressionally directed activities • Program incorporates Sensors Demonstration activities in line with congressionally directed activities • Supports R&D on advanced data analytics to support system operations through improving visibility • Develops research data sets and methods for data quality and validity safeguards

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	• Support the Grid Event Signature Library to facilitate access to research sensor data sets from power systems for advanced analytics[a] • Support data standard development and implementation at utilities to improve data analytics and facilitate T&D information sharing • Develop approaches, analytics, and tools that will accurately detect, characterize, and forecast DER behavior and impacts on electric power distribution systems • Develop a platform for distributed sensing and data visualizations to inform utility operations during regular operations and contingency events like wildfires, heatwaves, and cold snaps • Support a prize program for data analytics tool development utilizing utility data sets, to catalyze independent and academic research into equity and integration of DERs	• Builds data and information standards development activities to support industry collaboration and adoption
Electricity Delivery Systems $5,000,000	*$7,500,000*	*+$2,500,000*
• Advance ISDP practices with regulators and the industry that enable the formulation of holistic technology investment strategies that address multiple objectives (including resilience, energy justice, and decarbonization) and enable the utilization of DERs • Develop guidelines to enable DER coordination to support grid and market operations across the transmission, distribution, and behind-the-meter domains	• Establish a vetted decision framework for an integrated distribution system planning process incorporating roles, responsibilities, and analytical requirements and providing resources to best and emerging practices, including approaches for determining the cost effectiveness of grid investment deployments	• Supports more robust stakeholder engagement to vet and share guidelines and provide education, training, and technical assistance around IDSP, operational coordination, and distribution system reference designs • Initiates efforts to advance more comprehensive grid planning practices to address regional and multi-jurisdictional issues, such as coordinated efforts to ensure system reliability and resource adequacy

[a] The Grid Event Signature Library at https://gsl.ornl.gov/ captures grid characteristics around notable events and allows us the ability to study them to develop more proactive mitigation approaches if these (or similar) events occur in the future.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted

• Apply key grid architecture principles to develop reference designs for a distribution system to address the application of DERs in T&D markets and to support grid operations
  • This begins in FY 2023 and is expected to continue through FY 2025
• Establish formal arrangements with NARUC, NASEO, NRECA, APPA, NGA, and NCSL to vet and disseminate advanced practices and guidelines for integrated distribution system planning and operational coordination as well as provide technical assistance
	• Institute a robust education and training program including targeted technical assistance for State officials to advance integrated distribution system planning practices
	• Develop and initiate a strategy with industry to establish comprehensive multi-State, regional planning approaches to ensure resource adequacy and analysis of grid investment options
	• Establish a compendium of best practices and standards that help the industry mature institutional, regulatory, business, and technical requirements for governing the coordination of operations between DER service providers, microgrid owners, and grid operators
	• Develop a set of functional requirements and reference designs for the distribution system addressing:
	  • coordinated application of DER services in support of grid operations and markets
	  • integration of microgrids and alternative grid structures in grid operations for improving system reliability and resilience
	  • application of technologies to enable dynamic orchestration and optimization of grid assets
	• Continue to work with the national associations to vet and advance this work for practical applications by communities and States	

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Modeling Distributed Energy Resources $5,000,000	*$0*	*-$5,000,000*
• Explore existing DER modeling and develop standardized approaches to facilitate improvements in resilience and reliability metrics for utilities and regulators to inform short- and long-term planning efforts		• Planned activities will be completed with funding provided in FY 2023
Sensors Demonstration $15,000,000	*$0*	*-$15,000,000*
• Demonstrate sensor analytics with industry to allow for better utilization of existing sensors, facilitate data integration from disparate sensors, and inform sensor placement • Demonstrate sensor analytic tools to help accelerate industry utilization of advanced sensor data, improving resilience and operations • Demonstrate grid models and tools to optimize monitoring effectiveness and cost of sensor placements • Continue to fund a prize program for data tool demonstrations in partnership with utilities and their system data sets to catalyze independent academic research into equity and integration of DERs		• Planned activities will be completed with funding provided in FY 2023 • Related work on sensor analytics demonstrations is supported in the Sensor Data Analytics subprogram in FY 2025
COMMANDER National Testbed Laboratory $5,000,000	*$0*	*-$5,000,000*
• Evaluate the current and future role of microgrids and DERs in distribution system operations • Enhance testbed resources, data flows, and exchanges • Understand the impacts of ownership boundaries in coordinated operation, system security, and economic optimization		• Planned activities will be completed with funding provided in FY 2023

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Underserved & Indigenous Community Microgrids Delivery Systems *$10,000,000*	*$0*	*-$10,000,000*
• Release the Underserved and Indigenous Community Microgrids (UICM) funding opportunity announcement (FOA) to seek projects providing replicable microgrid solutions for underserved and Indigenous communities • Award competitively selected projects under the UICM FOA		• Planned activities will be completed with funding provided in FY 2023

Cyber Resilient and Secure Utility Communications Networks (SecureNet)

Overview

Our Nation's energy system is heavily dependent on data communications and cyber-physical controls for operational reliability and resilience. The evolution of the electric grid to rely more on inverter-based resources and distributed assets, such as solar and wind generation and energy storage, increases the volume, velocity, veracity, and variety of information demands on the grid—both for situational awareness under more dynamic conditions and for control and coordination messaging. At the same time, these distributed assets present a broader attack surface for increasingly sophisticated adversaries to exploit. The modernization of communications and control systems to support information security—including integrated cybersecurity—is essential to ensure the efficient, reliable, and resilient operation of the electrical power system in a complex and dynamic risk landscape.

The Cyber Resilient and Secure Utility Communications Networks (SecureNet) program develops solutions to strengthen information security and resilience of the electricity delivery system against cyber-related threats through a security-by-design approach for operational data, communications networks, and control systems, through Secure Communications and Grid Technology Cyber Resilience research, development, and demonstration (RD&D).

Secure Communications Network RD&D supports next-generation grid communications RD&D for systems built from inception to mitigate communication failures and detect, reject, and withstand cyber incidents and other disruptions. This subprogram includes the following lines of effort:

- Grid communications architecture and technology roadmap definition to support secure data communications requirements on the future grid
- Technology RD&D in key gap areas identified by the architecture analysis and roadmap
- Secure Pathways for Resilient Communications (SPARC) testbed development as a resource for labs, utilities, and communications providers to test and evaluate secure communications technologies in realistic grid environments
- Center for Alternate Synchronization and Timing (CAST) testbed operation for terrestrial alternatives to GPS for the electric industry to improve grid security and resilience
- Industry outreach on important grid communications topics to ensure grid stakeholders are aware of and responsive to future grid communications developments
- Grid communications network data collection, representation, and visualization to support grid modeling efforts

Grid Technology Cyber Resilience RD&D makes key investments to ensure next generation grid technology can withstand and recover from incidents that disrupt the ability to rely on system operational data. This subprogram includes:

- Application of a cybersecurity lens to assess relevant OE R&D, ensuring it includes a security-by-design philosophy throughout development and addresses cybersecurity concerns through design modifications or operational changes
- Technology RD&D to enhance the cybersecurity of sensors, network devices, and control systems for the future grid
- Engagement with the Department's cyber-related operational activities, including in the Office of Cybersecurity, Energy Security, and Emergency Response and the Office of Intelligence and Counterintelligence, to ensure OE's R&D activities respond to operational needs, develop a broad base of scientific and technical expertise in grid communications and controls cybersecurity to support the Department's national security mission, and strengthen public-private sector outreach, information sharing, and training in this area

Highlights of the FY 2025 Budget Request

The SecureNet program will continue to develop technical solutions to accelerate and expand efforts to strengthen electricity communications infrastructure against cyber threats. SecureNet will focus on grid communication and information security and resilience, including R&D of enabling technologies and operating a grid communications testbed to validate technology outcomes from these activities to support utility adoption. SecureNet will also be a key element of the Grid Modernization Initiative, including the Grid Modernization Laboratory Consortium (GMLC).

The Request includes the following core activities:

- Secure Communications Network RD&D: The Request supports ongoing updates to an architectural framework and technology roadmap for grid communications infrastructure; secure communications technology RD&D; transition of synchronization and timing R&D previously funded under the Darknet program into the base program; and ongoing development and use of a grid communications testbed to evaluate these technologies. This activity includes information sharing and training with industry, academic, and other public stakeholders to help develop the next generation of secure grid communications specialists.
- Grid Technology Cyber Resilience RD&D: The Request supports new grid cybersecurity tools and technologies focused on the integration of the grid edge and the distribution system, as well as building cybersecurity and cyber-resilience into other OE programs' new grid coordination, operation, and control technologies. Activities may include modeling cyber aspects of future grid scenarios; researching cyber-hardening new grid technologies; and providing cyber design inputs, testing capabilities, and cyber vulnerability assessments to other OE R&D programs. Cyber efforts will be coordinated with cyber activities conducted in other DOE offices.

Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
SecureNet					
Secure Communications Network RD&D	…	…	10,000	+10,000	N/A
Grid Technology Cyber Resilience RD&D	…	…	5,000	+5,000	N/A
Darknet	10,000	10,000	…	-10,000	-100.0%
Distribution Communications & Control Technologies	5,000	5,000	…	-5,000	-100.0%
Total, SecureNet	**15,000**	**15,000**	**15,000**	**…**	**…**
SBIR [non-add]	*[474]*	*[474]*	*[301]*	*[-173]*	*[-36.5%]*

Explanation of Major Changes

($K)	FY 2025 Request vs FY 2023 Enacted
• Secure Communications Network RD&D: Builds on FY 2022 grid communications architecture development, technology R&D, and stakeholder partnership activities	+10,000
• Grid Technology Cyber Resilience RD&D: Supports addressing cybersecurity and resilience considerations in existing OE RD&D programs, with particular focus on communications-enabled, highly distributed components	+5,000
• Darknet: Planned activities for this congressionally directed activity completed with funding provided in FY 2023 with follow-on activities supporting secure communications incorporated into program base funding	-10,000
• Distribution Communications and Control Technologies: Planned activities for this congressionally directed activity completed with funding provided in FY 2023	-5,000
Total, Cyber Resilient and Secure Utility Communications Networks (SecureNet)	**…**

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
SecureNet $15,000,000	**$15,000,000**	**$0**
Secure Communications Network RD&D $0	*$10,000,000*	*+$10,000,000*
	• Update the architectural framework and technology roadmap for grid communications infrastructure • Research, develop, and demonstrate secure communications technologies, including core enabling technologies such as synchronization and timing • Continue development and use of a grid communications testbed to evaluate secure grid communications technologies • Build knowledge and capacity through stakeholder engagement	• Builds on work funded in FY 2022 and through Congressionally directed activities in FY 2023 to reestablish a core program to solidify the RD&D effort in secure grid communications—ensuring the electric grid evolves to an end state in which critical information is secure requires a stable, sustained secure communications RD&D program • Funds secure communication testbed development and use at national laboratories
Grid Technology Cyber Resilience RD&D $0	*$5,000,000*	*+$5,000,000*
	• Support other OE programs in building cybersecurity and cyber-resilience into new technologies for grid coordination, operation, and control • Research, develop, and demonstrate new grid cybersecurity tools and technologies focused on integrating the grid edge into distribution systems	• Builds on work funded in FY 2022 to ensure electricity delivery system cybersecurity is sustained as a key dimension of OE R&D—cybersecurity must be embedded into all grid technologies and cannot be effectively developed separately or after core system development
Darknet $10,000,000	*$0*	*-$10,000,000*
• Continue R&D activities aimed at protecting U.S. electricity infrastructure from disruptive cyber penetration, including expansion of the communications network architecture and development of cutting-edge networking technologies		• Planned activities completed with funding provided in FY 2023 • Darknet R&D project follow-on in areas such as synchronization and timing is integrated into core SecureNet activities

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Distribution Communications and Control Technologies $5,000,000	*$0*	*-$5,000,000*
• Research, evaluate, and commission new distribution communications and control technologies for a secure smart grid		• Planned activities completed with funding provided in FY 2023

Energy Storage

Overview
The Energy Storage program accelerates bi-directional electrical energy storage technologies as a key component of a reliable, resilient, and affordable future-ready grid. Energy storage enables a 100% carbon pollution-free electricity grid; provides new tools to improve grid resiliency, especially in underserved communities; and creates new options for infrastructure planning, from deferral to rapid expansion.

While pumped-storage hydropower and lithium-ion batteries are already common on the grid, new technologies with more flexible siting, added modularity, and lower marginal duration cost attributes will dramatically expand the beneficial deployment of energy storage. OE Energy Storage research, development, demonstration, and deployment (RDD&D) efforts accelerate the development of long-duration grid storage technologies through increasing performance, reducing technology costs, de-risking technologies to ensure safe long-term reliability, developing analytic models to uncover technical and economic benefits, and demonstrating the ability of storage to provide clean and equitable energy access for consumers and communities. The program has four primary focus areas:

- **Cost-Competitive and Long-Duration Technology Development** resolves key cost and performance challenges for storage technologies that rely on earth-abundant, domestically available storage materials, including longer-duration (10+ hour) technologies.
  - In support of the Long Duration Storage Shot™ target, OE is pursuing storage technology improvements that achieve a 5¢/kWh levelized cost of storage for grid-scale 10+ hour duration applications.
  - OE supports a diverse portfolio of energy storage materials and technologies (such as flow batteries; sodium-, zinc-, and lead-based batteries; and thermal energy storage).
  - Additional crosscutting R&D areas include interconnections, power electronics, and power conversion systems.
- **Validated Reliability and Safety** improves the understanding and predictability of energy storage systems and components under realistic grid use cases through research, testing, and guidance.
  - Key stakeholders in this focus area include fire departments, building managers, and other approval authorities.
- **Analytics for an Equitable Regulatory and Social Environment** assists stakeholders in understanding optimal storage sizing, placement, operation, and valuation, as well as quantifying environmental and social impacts.
  - These assistance activities are enabled through the development of new analytical and open-source tools, performance protocols, and advanced control systems.
  - New workforce, entrepreneurial, and education outreach efforts to facilitate storage adoption will build on existing efforts, such as Energy Storage for Social Equity, in this program area.
- **Grid and Field Validation** helps analyze and demonstrate the economic and technical viability of storage to end users through real-world validation of storage systems, tools, and models.
  - The Rapid Operational Validation Initiative (ROVI) will help technology innovators and users understand and forecast long-term performance, cost, and operational reliability of new storage technologies.

Highlights of FY 2025 Budget Request
The Request supports the program's core RD&D focus areas in Cost-Competitive and Long-Duration Technology Development, Validated Reliability and Safety, Analytics for an Equitable Regulatory and Social Environment, and Grid and Field Validation. Highlighted activities in FY 2025, including Opportunities for Alternative Systems and Supply-Chain Innovations and Solutions (OASSIS), Storage Prize for Entrepreneurial Enrichment and Development (SPEED), Blue Sky First Responder Training, and Enhanced Validation of Energy Storage Technologies (EnVEST), provide competitive, collaborative, and nimble mechanisms to nurture a rapidly growing domestic energy storage innovation ecosystem.

OASSIS will incentivize innovations for less mature energy storage technologies (not lithium ion or lead-acid, for example) to address materials, power electronics, and supply chains that limit incumbent technologies. OASSIS will support less mature technologies capable of contributing to reliable, resilient, sustainable, and cost-effective solutions at short-, mid-, and long-duration timescales. Opportunities will be strategically scoped both to advance the target candidate technologies and to share lessons learned from other technologies.

The national Blue Sky First Responder Training program will expand on existing outreach to key deployment stakeholders, including fire safety and codes and standards groups, to help communities evaluate and deploy a rapidly growing number of energy storage installations. By adapting OE's existing fire and safety training into a replicable program, this Blue Sky training will support regionally diverse communities to address safety, emergency response, and security concerns in operating energy storage.

The request increases workforce, entrepreneurial, and education outreach activities to facilitate storage adoption. These activities will leverage collaboration space at the newly constructed Grid Storage Launchpad (GSL) and identify opportunities to boost interest, expand skillsets, and enhance technical capacity. SPEED will support long-duration energy storage (LDES) and grid-scale storage hardware innovators with entrepreneurial training and mentorship tools to help propel their solutions to market. These efforts will work to expand the storage workforce and increase the storage industry's ability to achieve key cost and performance targets.

The Request continues support for Energy Storage for Social Equity (ES4SE) Technical and Project Assistance. Communities across the Nation face significant energy challenges but may not yet be ready to evaluate storage as a solution. The program offers capacity-building to disadvantaged communities for assessments of energy storage feasibility, design, application, operations, and maintenance, followed by physical pilot projects. This Request provides expanded pilot demonstration assistance for communities.

The EnVEST industry voucher program will leverage new GSL testing capabilities. National laboratory test results for new technologies can be major enablers of private sector investment and commercial deployment. In FY 2025, EnVEST will help validate the performance and reliability of emerging storage technologies via competitive opportunities.

ROVI will continue to address gaps for nascent technologies that lack a long-term operational track record. ROVI aims to provide at least a 15-year technology life and performance prediction requiring only 1-year or less of real time testing. These future projections will incorporate and complement the observed testing results from EnVEST and will facilitate development efforts, financial investment, and end user deployment of emerging storage technologies. The Request expands ROVI to complete validation of lithium-ion and flow battery storage technologies.

The Request implements a Critical Facility Energy Resilience (CiFER) effort to validate LDES technologies at critical facilities that provide societal and economic services. LDES technologies must maintain operations during low frequency high impact events that may cause electrical grid outages. In FY 2025, CiFER will validate an innovative LDES technology and demonstrate tangible resiliency benefits to critical loads via competitive opportunities for LDES technologies. The Request also supports continued model standards development through the Transmission-level Inverter Based Resource (TIBeR) activity, providing key decision makers with consensus approaches on operating energy storage effectively as a grid asset. This includes storage as a transmission asset (SATA) and storage as a transmission-only asset (SATOA) classifications for integrated resource planning.

Construction at the Pacific Northwest National Laboratory of GSL, the first national laboratory facility focused on battery materials and battery systems for grid applications, was fully funded through the completion of construction by FY 2022 appropriations. Beneficial occupancy is planned for early 2024 and start of operations (CD-4) in 2025. GSL will:

- Focus on materials development and prototype battery systems (up to 100 kW systems integration and testing) to identify and solve issues before moving to larger-scale systems
- Standardize grid performance testing across the spectrum of battery materials, battery systems, inverters, auxiliary power, and battery management systems under market-aware and grid-specific use-case conditions
- Provide an objective national resource to report battery testing performance under grid conditions and duty cycles
- Integrate and coordinate researchers from universities and national labs to rapidly solve crosscutting science and technology challenges
- Develop new capabilities, including characterization capabilities, to rapidly scale-up new materials for grid scale storage and deliver these capabilities
- Conduct realistic testing of design options in a laboratory environment

The GSL mission directly supports the Energy Storage Grand Challenge (ESGC) , the Long Duration Energy Storage Shot, and ROVI. The Request includes operational support for activities at the GSL across the four energy storage program focus areas as applicable.

The FY 2025 Request will support RD&D activities through the Grid Modernization Initiative (GMI), including the Grid Modernization Laboratory Consortium (GMLC).

Energy Storage Grand Challenge: ESGC is a crosscutting effort managed by DOE's Research and Technology Investment Committee and co-chaired by OE and the Office of Energy Efficiency and Renewable Energy. ESGC coordinates complementary RDD&D across DOE to advance energy storage and technologies that provide similar capabilities. The OE Energy Storage program's request supports grid-related ESGC objectives. Other OE RD&D efforts are also aligned with ESGC goals. DOE is taking a holistic approach to accelerate the development, commercialization, and utilization of next-generation energy storage technologies. ESGC is employing the Department's extensive resources and expertise to address technology development, commercialization, manufacturing, valuation, and workforce challenges. Part of the ESGC vision is to create and sustain global leadership in energy storage utilization and exports, with a secure domestic manufacturing supply chain that is independent of foreign sources of critical materials, by 2030.

Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Energy Storage					
Research					
Cost-Competitive and Long-Duration Technology Development	39,000	39,000	31,650	-7,350	-18.8%
Validated Reliability and Safety	12,500	12,500	17,450	+4,950	+39.6%
Analytics for an Equitable Regulatory and Social Environment	8,500	8,500	24,400	+15,900	+187.1%
Grid and Field Validation	10,000	10,000	21,300	+11,300	+113.0%
Section 3201 Pilot Demonstration Grants	20,000	20,000	...	-20,000	-100.0%
Storage and Microgrid Deployment Assistance	5,000	5,000	...	-5,000	-100.0%
Total, Energy Storage	**95,000**	**95,000**	**94,800**	**-200**	**-0.2%**
SBIR [non-add]	*[2,267]*	*[2,267]*	*[2,918]*	*[+651]*	*[+28.7%]*

Explanation of Major Changes

($K)	FY 2025 Request vs FY 2023 Enacted
• Cost-Competitive and Long-Duration Technology Development: the emerging technology funding opportunity announcement (FOA) is fully funded in FY 2023 and FY 2025 funding is reallocated to support activities in the other subprograms	-7,350
• Validated Reliability and Safety: supports TiBER and increases GSL EnVEST and Blue Sky First Responder Training	+4,950
• Analytics for an Equitable Regulatory and Social Environment: increases workforce, entrepreneurial, and education outreach efforts and technical and project assistance to ES4SE recipients	+15,900
• Grid and Field Validation: expands activities under ROVI and CiFER	+11,300
• Section 3201 Pilot Demonstration Grants: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2022 and 2023	-20,000
• Storage and Microgrid Deployment Assistance: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023	-5,000
Total, Energy Storage	**-200**

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Research $95,000,000	**$94,800,000**	**-$200,000**
Cost-Competitive and Long-Duration Technology Development $39,000,000	*$31,650,000*	*-$7,350,000*
• Initiate new emerging technology FOA focused on ultra-low-cost chemistries consistent with goals of the Long Duration Storage Shot. Multi-year consortium targeting progress toward the 5¢/kWh levelized cost of storage (LCOS) goal with intermediate targets of 30¢/kWh, 20¢/kWh, etc. • Continue focused development programs on other earth-abundant materials systems (sodium, zinc, sulfur, etc.) with potential to meet the 2030 LCOS target • Demonstrate prototype pack architectures with capacities greater than 5 kWh based on 300 Ah zinc-manganese dioxide batteries and projected cell level costs below $50/kWh when produced at scale • Migrate new power electronics and power converter topologies from R&D to scalable prototype formats and demonstrate efficient coupling between batteries and power electronics	• Support innovations for less mature energy storage technologies (not lithium ion or lead acid, for example) to address materials, power electronics components, and supply chain challenges through the OASSIS activity • Continue development on other earth-abundant materials with the potential to meet the 2030 LCOS target • Advance power electronics and power converter designs into prototype systems capable of operating under simulated grid environments	• The emerging technology FOA is fully funded in FY 2023 • FY 2025 funding is reallocated to support activities in other subprograms
Validated Reliability and Safety $12,500,000	*$17,450,000*	*+$4,950,000*
• Expand training and technical assistance to fire officials and safety code officials for energy storage best practices • Continue development and validation of novel control strategies and architectures with industry for distributed control of energy storage for improved grid stability, economic dispatch, and system reliability and safety	• Develop model standards providing key decision makers with consensus approaches on operating energy storage effectively as a grid asset through TIBeR • Validate technologies from early-stage innovators by leveraging the testing and validation capabilities offered by the GSL through EnVEST • Integrate existing fire and safety training into a national Blue Sky First Responder Training program, supporting several regionally diverse communities	• Increases reflect TIBeR, EnVEST, and Blue Sky First Responder Training activities

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Expand reliability testing of new battery chemistries under defined grid use cases and develop comprehensive grid scale storage system reliability metrics with industry for use at GSL	• Continue energy storage testing, data collection, standards development, and outreach, including root cause failure analysis and facilitating safety codes and standards for new technologies	
Analytics for an Equitable Regulatory and Social Environment $8,500,000	*$24,400,000*	*+$15,900,000*
• Continue support for execution of projects selected under the FY 2022 Technology Liftoff FOA • Continue engagement with PUCs and States developing energy storage policy and integrated resource planning • Continue follow-up support for the first ES4SE cohort	• Target SPEED program to advance LDES and grid-scale storage technologies at the entrepreneurial stage • Increase workforce, entrepreneurial, and education outreach efforts to facilitate storage adoption • Support a new cohort of ES4SE recipients in the project assistance phase • Continue outreach to end users, utilities, regulators, the financial industry, and other storage decisionmakers	• Increases support for workforce, entrepreneurial, and education activities, including SPEED • Provides increased project assistance to selected ES4SE recipients
Grid and Field Validations $10,000,000	*$21,300,000*	*+$11,300,000*
• Develop ROVI, to incorporate data and models for one to two additional chemistries or storage technology types • Continue development of higher fidelity software tools and analytical models for optimal value and sizing based on storage location • Add additional functionality to tools to quantify environmental benefits (such as greenhouse gas reduction) and social benefits	• Identify innovative energy storage validation opportunities through CiFER to validate, in real conditions, the ability for LDES to support operation of critical facilities during low-frequency, high-impact events • Expand ROVI to complete the validation phase of lithium-ion and flow battery storage technologies • Continue development of software tools and analytical models for the optimal value, sizing, and location of storage resources, as well as quantifying environmental and social benefits	• Expands ROVI and CiFER
Section 3201 Pilot Demonstration Grants $20,000,000	*$0*	*-$20,000,000*
• New competitive opportunity to accelerate large scale commercial development and deployment of energy storage technologies, including for long-cycle-life lithium grid-scale batteries		• Planned activities completed with funding provided in FY 2022 and 2023

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Storage and Microgrid Deployment Assistance $5,000,000	*$0*	*-$5,000,000*
• Support electric cooperatives and municipal power utilities in the analysis and deployment of energy storage technologies as a critical component of resilient microgrids		• Planned activities completed with funding provided in FY 2023

Construction Projects Summary

($K)	Total Project Cost (TPC)	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	Future Years
20-OE-100 Grid Storage Launchpad							
Total Estimated Cost (TEC)	75,000	75,000	...	...	...	...	...
Other Project Costs (OPC)	2,000[a]	1,000[a]	1,000[a]	...	...	-1,000	...
Total Project Costs	77,000	76,000	1,000	...	...	-1,000	...

[a] OPC is funded through national laboratory overhead.

Transformer Resilience and Advanced Components

Overview

The Transformer Resilience and Advanced Components (TRAC) program identifies and addresses issues facing the electricity delivery system due to the rapid changes challenging the system. As most aspects of daily life increasingly depend on the grid, legacy approaches to power conversion and delivery are no longer sufficient. TRAC develops innovations to carry, control, convert, and condition electricity to ensure the system is future ready and equip this future-ready grid to achieve decarbonization goals while enhancing its reliability and resilience. TRAC principles—to incorporate flexible, modular, and data-driven approaches—will ensure that every component of the grid will be ready to serve the clean energy future.

Flexibility will be a major advantage of new critical grid components. For example, a large power transformer (LPT) failure could disrupt power to a half million homes. Even prior to recent supply chain disruptions, a replacement could take over 12 months to procure, transport, and install, in large part because LPTs are nearly always custom-made. Electrification of the U.S. economy is also adding unprecedented demand for distribution transformers. TRAC supports innovative transformer designs that are more flexible and adaptable, enabling fewer standardized designs to be used in more locations, which decreases manufacturing lead times while increasing the applicability of spare inventory. The program covers full range of electric power transformers from LPTs to distribution service transformers.

Modularity will be an essential part of grid infrastructure planning. Trends such as the increasing adoption of rooftop solar and electric vehicles introduce new uncertainties in load growth projections. Consumer behaviors and technological improvements could require new grid capacity in increasingly unpredictable ways. Legacy grid expansion approaches, with long lead times and large, lumpy installations, are insufficient in this new environment. TRAC supports innovative grid-enhancing technologies (GETs), high voltage direct current (HVDC) technologies, and solid-state power substations (SSPS) to enable faster capacity additions at a smaller, granular scale. In the near term, HVDC technologies and GETs, including dynamic line ratings and power flow controllers, will help unlock more capacity from existing and future infrastructure. In the medium to long term, the SSPS building block concept will allow for nearly on-demand capacity additions or reallocations. These modular and scalable designs enable greater standardization and allow for more cost-effective capacity expansion. Additional benefits include smaller module sizes for ease of transport and lower power ratings to reduce criticality.

Data-driven approaches will be necessary for a resilient and efficient grid. For example, transmission and distribution equipment such as transformers, power lines, and substation equipment are often exposed to the elements and are vulnerable to adverse conditions, which occur increasingly often. Next generation grid hardware technologies will need to anticipate, withstand, and rapidly recover from the impact of extreme events, including terrestrial and space weather events, other electrical disturbances, equipment failures, accidents, deliberate attacks, and other unknowns. Local intelligence with embedded sensors, data processing, and communications will enable real-time health monitoring, reducing maintenance costs and enhancing system reliability. Leveraging results from other OE activities, including phasor measurement units (PMUs) and other sensors, and incorporating emerging technologies, including unmanned aerial vehicles (UAVs), TRAC technologies will proactively respond to a changing threat landscape to enhance the security, affordability, reliability, and resilience of the electric power system.

The TRAC scope encompasses materials research, exploratory concepts, modeling, and analysis to address the range of challenges associated with transformers and other grid components. Specific technologies include transformers, cables and conductors, power flow and voltage controllers, protection equipment and switchgear, and equipment sensors. Program activities, developed in close coordination with industry, aim to fill fundamental research and development (R&D) gaps and encourage the adoption of new technologies and approaches.

Market and System Impact Analysis supports high-fidelity modeling and simulation to help the grid community understand the value and impact of these improved grid component capabilities. Component Design and Development addresses critical GETs and SSPS research needs with an emphasis on embedded intelligence for equipment monitoring, validation of prototype converter building blocks, and medium voltage converter building block development. Applied Material R&D targets the use of advanced materials for improvements in magnetics, conductors, semiconductors, alternative transformer core materials, packaging, and insulation to increase voltage and power capability while withstanding more rigorous environments, including for use in HVDC technologies.

Highlights of the FY 2025 Budget Request

The Request continues materials, component, and system development to enable next-generation transformers and converters. Major technology focus areas include:

- **Market and System Impact Analysis**: The Request supports one distribution-scale pilot demonstration for advanced power electronic systems and the continued market and system impact analyses of various grid hardware components, including HVDC, advanced conductors, advanced transformers, and GETs.
- **Component Design and Development**: The Request supports continued device and operational improvements for SSPS technologies as identified in the 2020 SSPS roadmap.[a] The high-voltage, high-power, and high-reliability requirements of grid applications present unique challenges for SSPS technologies, especially when operating at higher frequencies. Greater utilization of high-voltage power electronic converters within substations, including in hybrid and solid-state transformer applications, can provide power flow control capabilities and reactive power support, limit fault currents, and increase system flexibility, reliability, and resilience. The Request advances modular, scalable, flexible, and solid-state transformers from early concept prototypes systems to larger systems suitable for field validation, enabling standardized designs to increase grid resilience. The Request supports the development of HVDC and medium voltage DC (MVDC) hardware components, controls, testbeds, and advanced concepts to address technical challenges of HVDC deployment. The Request also supports the development of low voltage (LV) grid components and power electronic systems that support grid operations and enhance system resiliency and reliability. The Request also supports the continued development of technologies to improve situational awareness of power grid system, subsystem, and component conditions. This includes developing and applying sensing technologies and utilizing emerging platforms such as robotics, UAVs, advanced transformers, and other component health monitoring.
- **Applied Material R&D**: The Request supports continued improvements in magnetics, semiconductor devices, alternative transformer core materials, conductors, packaging, and insulation, targeting increases in heat dissipation, electrical and thermal conductivity, mechanical strength, voltage limits, and operational durability.

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

The FY 2025 Request continues to support R&D activities through the Grid Modernization Initiative, including the Grid Modernization Laboratory Consortium (GMLC).

Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[b]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Transformer Resilience and Advanced Components					
Market and System Impact Analysis	5,000	5,000	6,000	+1,000	+20.0%
Component Design and Development	15,000	15,000	22,000	+7,000	+46.7%
Applied Material R&D	2,500	2,500	4,500	+2,000	+80.0%
Grid Research Integration and Design Center	5,000	5,000	…	-5,000	-100.0%
Total, TRAC	**27,500**	**27,500**	**32,500**	**+5,000**	**+18.2%**

[a] https://www.energy.gov/sites/prod/files/2020/06/f75/2020%20Solid%20State%20Power%20Substation%20 Technology%20Roadmap.pdf

[b] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

($K)	FY 2023 Enacted	FY 2024 Annualized CR[b]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
SBIR [non-add]	*[640]*	*[640]*	*[746]*	*[+106]*	*[+16.6%]*

Explanation of Major Changes

($K)	FY 2025 Request vs FY 2023 Enacted
• **Market and System Impact Analysis**: increases market and system analyses for different grid hardware components, while market and system analyses of Smart Universal Power Electronics Regulators (SUPER) and SSPS development taper off	+1,000
• **Component Design and Development**: accelerates addressing HVDC hardware technical challenges, performs a field demonstration exercise of MV advanced power electronic systems at distribution scale, and expands advanced transformer development, including solid-state, flexible, and modular transformers	+7,000
• **Applied Material R&D**: expands R&D on conductors, alternative materials for transformer cores, magnetics, semiconductor devices, and embedded intelligence for equipment monitoring, including advanced health monitoring for transformers	+2,000
• **Grid Research Integration and Design Center**: completes planned activities for this congressionally directed activity with funding provided in FY 2023	-5,000
Total, TRAC	**+5,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Transformer Resilience and Advanced Components $27,500,000	**$32,500,000**	**+$5,000,000**
Market and System Impact Analysis $5,000,000	*$6,000,000*	*+$1,000,000*
• Develop the SUPER library, the SSPS controller for the consumer end node and validate the use case • Develop characterization methods and tools to evaluate reliability, transient stability, and economics of large-scale DC architectures in AC grids	• Develop a framework and analysis to evaluate the future architecture impact of advanced power flow controllers and distribution scale components, including solid-state transformers • Initiate a distribution-scale architecture pilot demonstration for advanced power electronic systems	• Performs solid-state transformer system impact analysis • Tapers off market and system analysis phase of SUPER and SSPS development
Component Design and Development $15,000,000	*$22,000,000*	*+$7,000,000*
• Develop reliable medium voltage power stages with advanced features for SSPS	• Perform a field demonstration exercise of MV advanced power electronic systems at distribution scale	• Accelerates addressing HVDC hardware technical challenges

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
• Develop advanced medium voltage to high voltage semiconductor modules • Develop advanced gate driver technologies to support advanced semiconductor switches • Develop high voltage auxiliary power supply stages • Develop subsystems to support electromagnetic interference mitigation and thermal limitations • Develop advanced features for diagnostics and prognostics of future grid interfaces • Test and validate GETs by conducting a full scale, multi-faceted field exercise	• Continue developing HVDC and MVDC hardware components, controls, testbeds, and advanced concepts to address technical challenges of HVDC deployment • Develop and expand modular, scalable, and flexible transformers from early-concept prototypes systems to larger systems suitable for field validation • Develop power electronics augmented distribution transformers to increase grid flexibility • Develop advanced transformer health monitoring solutions to enhance equipment reliability	• Performs a field validation of MV advanced power electronic systems • Further expands the development of modular, flexible, solid-state, and scalable transformers
Applied Material R&D $2,500,000	*$4,500,000*	*+$2,000,000*
• Develop magnetics and passives to advance basic insulation level and high-frequency requirements for power electronic systems and future grid infrastructure • Develop high voltage and high current interconnects to support the integration of subsystems for large-scale power electronic systems • Research to address critical needs in packaging for the high voltage, high current, and high-temperature environments associated with power electronic systems, transmission, distribution • Address insulation issues associated with transmission, sub-transmission, and distribution voltage grid systems • Fund a prize program to demonstrate Power Electronic Systems (PES) developed using recycled/refurbished parts	• Develop soft magnetics to fill a gap in commercially available core materials for power conversion applications—improvements in core materials are needed to achieve the efficiencies, power densities, and reliabilities required for emerging power conversion applications • Continue the development of advanced conductor materials with improved performance for overhead transmission cables and transformer winding applications • Develop packaging solutions to enable high voltage, high power wide bandgap modules • Research and develop material alternatives for transformer cores	• Addresses LPT seismic vulnerabilities and further develops packaging solutions

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Grid Research Integration and Demo Center $5,000,000	*$0*	*-$5,000,000*
• Validate a 480 V SSPS 1.0 node which aggregates multiple downstream SUPERs connected to assets/loads • Develop and demonstrate the SSPS controller capable of coordinating the downstream resources (nodes or hubs) using a Controller-Hardware-in-the-Loop (CHIL) test bed in the Grid Research Integration and Deployment Center (GRID-C) • Develop a baseline IPS using 3.3 kV semiconductor devices for MVDC–DC applications, and validate at GRID-C • Continue the development of the GRID-C facility by providing support on the operation, purchase, and maintenance of infrastructure and equipment		• Planned activities will be completed with funding provided in FY 2023

Applied Grid Transformation Solutions

Overview

America's grid is transforming into a more dynamic and structurally complex system. This complexity includes increasing sources of renewable energy, bidirectional power flows, and the electrification of the transportation and building sectors, all while contending with varied threat challenges. Managing this transformation will require significant reengineering and advancements in grid technology and system architectures. Innovative technological advances are needed to accomplish these changes while still meeting the strict performance requirements of a safety- and reliability-focused industry that requires high confidence to consider new solutions. The performance and benefits of these innovative grid technologies, systems, and subsystems must be assessed and validated for their ability to meet evolving demands, their integrability into an increasingly complex legacy system, and their compatibility with diverse operational, institutional, and regulatory contexts.

The Applied Grid Transformation Solutions (AGTS) program addresses the pressing need for rapidly assessing new grid systems and subsystems (including hardware and software systems for transmission, distribution, energy storage, and power control and conversion hardware and associated software) by testing integrated technology suites in controlled pilot environments prior to the hardware and software being deployed by industry in operational environments. These assessments provide utilities and other decision-makers, including state regulators and energy officials, with information they need to quantify and validate functionality, performance, and economic benefits before deploying new technologies. Today, the benefits of new grid technologies are difficult to extrapolate when tested in isolation and difficult to quantify when measuring some socio-economic benefits such as resilience. AGTS pilot integrations will yield the actionable information desired by utilities and regulators to drive new technology adoption, including performance under various conditions and specific validated data on technology costs, uses, and capabilities; investment value and feasibility; cost recovery during changing times; and requirements for integration with other systems. The results of the pilot demonstration will validate the techno-socio-economic performance of the systems and will help to accelerate the adoption of new technologies by the electric power industry.

Advanced testbeds are necessary to safely test new grid hardware and software and can provide industry confidence to enable adoption. AGTS leverages existing national laboratories, industry, and academia testbeds to facilitate advanced grid technology testing that takes advantage of unique capabilities of each facility and provides the industry with a coordinated testing platform to support testing and validation of new technologies in a controlled and safe environment for a variety of use cases.

Highlights of the FY 2025 Budget Request

AGTS will consult stakeholders for each applied pilot demonstration area to ensure the project scope and outputs will be immediately useful to targeted decision makers. AGTS will collaborate with DOE stakeholders and industry to identify the most suitable pilot environments for testing and demonstration. Based on collaboration feedback, Administration goals, and industry needs, AGTS will then select a technology suite to achieve the desired functionality. Example technologies include:

- Advanced conductors
- Advanced transformers, including flexible and modular large power transformers (LPTs), hybrid and solid-state transformers, and distribution transformers
- Dynamic line rating (DLR) and dynamic transformer rating systems
- Power flow controllers (PFCs)
- Sensors and system and equipment condition monitoring solutions
- Energy storage systems
- Advanced alternating current (AC) and direct current (DC) microgrids
- Power-electronics-based systems, such AC/DC and DC/DC interface converter topologies to enable low-voltage (LV) or medium voltage (MV) DC power distribution systems and solutions
- Other hardware and associated software and monitoring, controls, and communications technologies

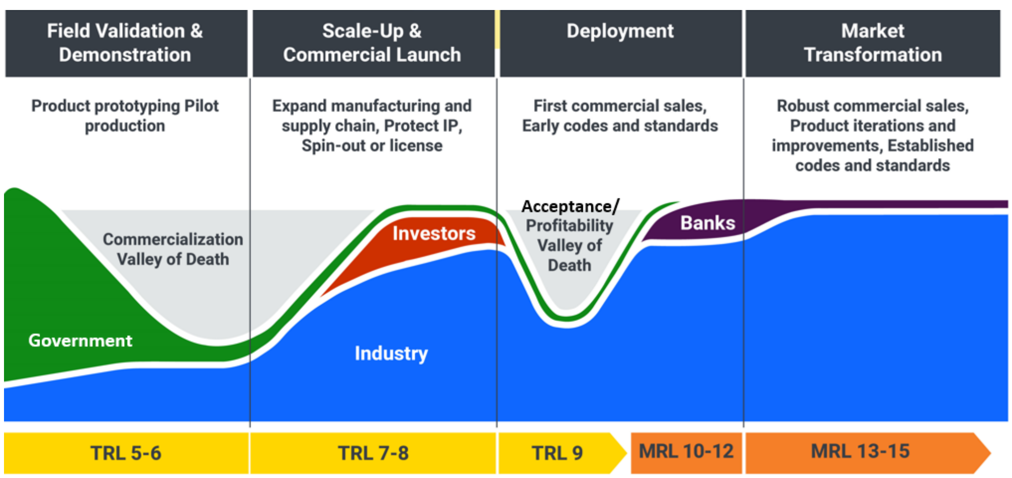
The technologies will be integrated into pilot environments and operated to validate the performance and operational capabilities of new technologies for a variety of use cases. Results from the AGTS hardware-in-the-loop and other types of demonstrations will be shared with broader decision makers, such as planners, operators, manufacturers, investors, regulators, and ratepayers. Coordinating with stakeholders to quantify and disseminate the measured benefits is essential to a successful demonstration, as is understanding the alignment of benefits and incentives as it relates to these new technologies. At the conclusion of the project, decision makers should have sufficient information to evaluate new technical approaches alongside legacy solutions. Project results can also inform manufacturers in addressing new or emerging market opportunities.

In FY 2025, AGTS will:

- Continue supporting at least one workshop for information sharing, education, and supporting innovation
- Continue supporting existing working groups for industry outreach to gather feedback and target new grid technology validation and demonstration needs to show how new technologies enable community, state, and regional goals
- Support at least one new pilot demonstration in a field or laboratory environment to validate technological maturity and show how new technologies achieve desired technical, economic, societal, policy, and market outcomes
- Enhance at least one existing national electrical grid advanced testing capability in collaboration with national laboratories, private industry, and academia

AGTS will support scoping needs to determine the testing requirements, including hardware-in-the-loop set up, demonstration, and enhancing/developing testbeds. Based on the results, AGTS will enhance or build the capability for required demonstration and testing. The results will be shared with the industry through summits, webinars, and workshops for facilitated information sharing.

These activities will help advanced grid technologies get though the commercialization and acceptance/profitability valleys of death (illustrated below), which prevent many technologies from making it to market.



AGTS will include coordination with the GMLC on shared technology development objectives and coordinate with GDO and other DOE offices on demonstration results. FY 2025 integrated pilots will showcase resiliency and renewable integration objectives aligned with the GMI and other DOE crosscutting efforts.

Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Applied Grid Transformation Solutions					
Scoping, Design, and Stakeholder Collaboration	2,000	2,000	1,500	-500	-25.0%
Demonstrations	8,000	8,000	7,000	-1,000	-12.5%
Testbeds	…	…	3,500	+3,500	N/A
Total, AGTS	**10,000**	**10,000**	**12,000**	**+2,000**	**+20.0%**
SBIR [non-add]	*[36]*	*[36]*	*[27]*	*[-9]*	*[-25.0%]*

Explanation of Major Changes

($K)	FY 2025 Request vs FY 2023 Enacted
• Scoping, Design, and Stakeholder Collaboration: limits outreach activities to focus on testbed enhancement	-500
• Demonstrations: limits the demonstration scale and technology data used to validate technology to focus on testbed enhancement	-1,000
• Testbeds: enhances testbeds to support advanced grid component testing	+3,500
Total, Applied Grid Transformation Solutions	**+2,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Applied Grid Transformation Solutions $10,000,000	**$12,000,000**	**+$2,000,000**
Scoping, Design, and Stakeholder Collaboration $2,000,000	*$1,500,000*	*-$500,000*
• Facilitate stakeholder-focused grid transformation working groups • Provide technical assistance to State and local governmental entities, Tribal nations, and others through modeling, analysis, and use case validation	• Continue stakeholder-focused grid transformation working groups • Continue workshops with industry to support information sharing and adoption, each working group will be a case-by-case activity	• Limits outreach activities supporting acceptance and adoption of new grid technologies to focus on testbed enhancement

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Demonstrations $8,000,000	*$7,000,000*	*-$1,000,000*
• Support an advanced conductor/cable pilot for reconducting existing power lines with double capacity conductor/cable, without the need to rebuild existing infrastructure, to increase grid efficiency and allow for more renewable connections to the grid • Support a grid enhancing technology pilot for increased capacity, resiliency, and reliability using existing energy delivery pathways	• Support at least 1 demonstration and validation of a new grid technology in a real-world or laboratory setup	• Limits the demonstration scale and technology data used for validating technology to focus on testbed enhancement
Testbeds $0	*$3,500,000*	*+$3,500,000*
	• Based on the results of FY 2024 testbed scoping, design, and stakeholder collaboration, enhance testbeds in collaboration with national laboratories, academia, and private industry to support advanced grid components	• Enhances existing national laboratory testbed capabilities in collaboration with industry and academia to test future advanced grid technologies

Program Direction

Overview
The Program Direction (PD) program provides for the Federal workforce responsible for the overall direction and administrative support of the Office of Electricity (OE). Headquarters Federal employees provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program, as well as communications, finance, operations, planning, and workforce development functions. PD funding is also provided for time spent by Office of Fossil Energy and Carbon Management (FECM) technical staff at the National Energy Technology Laboratory (NETL) in support of OE financial assistance activities, including procurement, finance, and legal functions.

Contractor support services are utilized for some administrative tasks and special purpose analyses for management, such as technology and market analyses and development of tools to improve overall office efficiency, consolidate organizational knowledge, track performance and inventory data, and facilitate staff use of the information. Other related PD expenses include corporate IT support and equipment through DOE's Energy Information Technology Services (EITS) and common administrative services such as rent for office space leased from the General Services Administration, telecommunications, and corporate business systems through DOE's Working Capital Fund (WCF).

Highlights of the FY 2025 Budget Request
OE's team of experts share their technical, analytical, and policy expertise with offices throughout DOE and with energy transition stakeholders across the country. OE made progress building a strong team in FY 2023 and 2024 by addressing skill gaps and supporting succession planning. Continued program direction support in FY 2025 is crucial to grow and sustain a talented workforce to support our Nation's initiatives to provide a reliable, resilient, secure, and affordable 21st century power grid for the American people.

Funding

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	8,654	8,654	11,585	+2,931	+33.9%
Travel	311	311	350	+39	+12.5%
Support Services	3,185	3,185	1,733	-1,452	-45.6%
Other Related Expenses	3,203	3,203	2,963	-240	-7.5%
Total, Washington Headquarters	**15,353**	**15,353**	**16,631**	**+1,278**	**+8.3%**
National Energy Technology Laboratory					
Salaries and Benefits	1,376	1,376	1,659	+283	+20.6%
Travel	8	8	35	+27	+337.5%
Support Services	360	360	375	+15	+4.2%
Other Related Expenses	696	696	1,000	+304	+43.7%
Total, National Energy Technology Laboratory	**2,440**	**2,440**	**3,069**	**+629**	**+25.8%**
Total Program Direction					
Salaries and Benefits	10,030	10,030	13,244	+3,214	+32.0%
Travel	319	319	385	+66	+20.7%
Support Services	3,545	3,545	2,108	-1,437	-40.5%
Other Related Expenses	3,899	3,899	3,963	+64	+1.6%
Total, Program Direction	**17,793**	**17,793**	**19,700**	**+1,907**	**+10.7%**

[a] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

($K)	FY 2023 Enacted	FY 2024 Annualized CR[a]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
				$	%
Federal FTEs	**39**	**39**	**56**	**+17**	**+43.6%**
Additional FECM FTEs at NETL supporting OE[a]	10	10	11	+1	+10.0%
Total OE-funded FTEs	49	49	67	+18	+36.7%
Support Services and Other Related Expenses					
Support Services					
Technical Support	2,020	2,020	1,280	-740	-36.6%
Management Support	1,525	1,525	828	-697	-45.7%
Total, Support Services	**3,545**	**3,545**	**2,108**	**-1,437**	**-40.5%**
Other Related Expenses					
EITS Desktop Services	446	446	438	-8	-1.8%
WCF	2,692	2,692	2,525	-167	-6.2%
Other Services	761	761	1,000	+239	+31.4%
Total, Other Related Expenses	**3,899**	**3,899**	**3,963**	**+64**	**+1.6%**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Program Direction $17,793,000	**$19,700,000**	**+$1,907,000**
Salaries and Benefits $10,030,000	*$13,244,000*	*+$3,214,000*
• Supports 49 FTEs at Headquarters and NETL, providing executive management, programmatic oversight, and analysis for the effective implementation of the OE program	• Support 67 FTEs at Headquarters and NETL, providing executive management, programmatic oversight, and analysis for the effective implementation of the OE program	• Supports additional FTEs and the Federal pay increase
Travel $319,000	*$385,000*	*+$66,000*
• Funds transportation, subsistence, and incidental expenses allowing OE to effectively facilitate its mission	• Funds transportation, subsistence, and incidental expenses allowing OE to effectively facilitate its mission	• Supports additional laboratory and site visits to oversee OE's research portfolio
Support Services $3,545,000	*$2,108,000*	*-$1,437,000*
• Includes contractor support directed by Federal staff to perform administrative tasks and provide analysis to management • May also include support for post-doctoral fellows and IPA assignments	• Includes contractor support directed by Federal staff to perform administrative tasks and provide analysis to management • May also include support for post-doctoral fellows and IPA assignments	• FY 2023 includes one-time expenses related to transitions between support service contractors, including some overlap for knowledge transfer, while FY 2025 only reflects operations under the new contracts

[a] OE funds FTEs at FECM's NETL that support OE activities. The FTEs are included in FECM's FTE totals and not in the OE FTE totals shown on the "Federal FTEs" line.

FY 2023 Enacted	FY 2025 Request to Congress	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Other Related Expenses $3,899,000	*$3,963,000*	*+$64,000*
• Includes EITS desktop services and equipment upgrades and replacements • WCF expenses include rent, supplies, copying, graphics, mail, printing, and telephones • Supports commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, security clearances, and other needs	• Includes EITS desktop services and equipment upgrades and replacements • WCF expenses include rent, supplies, copying, graphics, mail, printing, and telephones • Supports commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, security clearances, and other needs	• Increases training to support new staff

Office of Electricity

Research and Development (R&D)[a]

($K)	FY 2023 Enacted	FY 2024 Annualized CR[b]	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
Basic	8,915	8,915	12,000	+3,085	+34.6%
Applied	62,553	62,553	74,000	+11,447	+18.3%
Development	94,962	94,962	104,000	+9,038	+9.5%
Total, R&D	166,431	166,431	190,000	+23,569	+14.2%

Small Business Innovative Research (SBIR)

($K)	FY 2023 Transfer	FY 2024 Projected Transfer[b]	FY 2025 Projected Transfer	FY 2025 vs FY 2023	
				$	%
Transmission Reliability and Resilience	1,127	1,127	1,306	+179	+15.9%
Energy Delivery Grid Operations Technology	248	248	248	–	–
Resilient Distribution Systems	961	961	1,216	+255	+26.5%
Cyber Resilient and Secure Utility Communication Networks (SecureNet)	474	474	301	-173	-36.5%
Energy Storage	2,267	2,267	2,918	+651	+28.7%
Transformer Resilience and Advanced Components	640	640	746	+106	+16.6%
Applied Grid Transformation Solutions	36	36	27	-9	-25.0%
Total, SBIR	5,753	5,753	6,762	+1,009	+17.5%

[a] R&D reporting includes a proportional share of program direction funding in addition to direct R&D funding.
[b] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

Office of Electricity

Research and Development (R&D)[a]

($K)	FY 2023 Enacted	FY 2024 Annualized CR[b]	FY 2025 Request	FY 2025 vs FY 2023	
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Applied	62,553	62,553	74,000	+11,447	+18.3%
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Total, R&D	166,431	166,431	190,000	+23,569	+14.2%

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[a] R&D reporting includes a proportional share of program direction funding in addition to direct R&D funding.
[b] FY 2024 amounts shown reflect the P.L. 118-35 continuing resolution (CR) level annualized to a full year.

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Ames Laboratory			
Transformer Resilience and Advanced Components	350	0	0
Grid Hardware, Components, and Systems	350	0	0
Total Ames Laboratory	**350**	**0**	**0**
Argonne National Laboratory			
Transmission Reliability and Resilience	2,730	0	3,080
Energy Delivery Grid Operations Technology	2,297	0	2,300
Resilient Distribution Systems	1,634	0	2,000
Grid Controls and Communications	6,661	0	7,380
Energy Storage R&D	2,733	0	2,850
Energy Storage	2,733	0	2,850
Applied Grid Transformation Solutions	400	0	500
Grid Hardware, Components, and Systems	3,133	0	3,350
Total Argonne National Laboratory	**9,794**	**0**	**10,730**
Brookhaven National Laboratory			
Transmission Reliability and Resilience	1,100	0	1,240
Grid Controls and Communications	1,100	0	1,240
Total Brookhaven National Laboratory	**1,100**	**0**	**1,240**
Idaho National Laboratory			
Transmission Reliability and Resilience	2,361	0	2,670
Energy Delivery Grid Operations Technology	22	0	25
Resilient Distribution Systems	2,038	0	1,500
Cyber Resilient & Secure Utility Communications Network (SecureNet)	0	0	4,500
Grid Controls and Communications	4,421	0	8,695
Energy Storage R&D	1,538	0	1,600
Energy Storage	1,538	0	1,600
Transformer Resilience and Advanced Components	1,008	0	2,500
Applied Grid Transformation Solutions	1,644	0	2,000
Grid Hardware, Components, and Systems	4,190	0	6,100
Total Idaho National Laboratory	**8,611**	**0**	**14,795**
Lawrence Berkeley National Laboratory			
Transmission Reliability and Resilience	1,250	0	1,400
Resilient Distribution Systems	2,230	0	2,700
Grid Controls and Communications	3,480	0	4,100
Applied Grid Transformation Solutions	800	0	1,000
Grid Hardware, Components, and Systems	800	0	1,000
Total Lawrence Berkeley National Laboratory	**4,280**	**0**	**5,100**
Lawrence Livermore National Laboratory			
Transmission Reliability and Resilience	2,204	0	2,490
Energy Delivery Grid Operations Technology	7,771	0	7,770
Resilient Distribution Systems	668	0	850
Cyber Resilient & Secure Utility Communications Network (SecureNet)	0	0	500
Grid Controls and Communications	10,643	0	11,610
Energy Storage R&D	762	0	800
Energy Storage	762	0	800
Grid Hardware, Components, and Systems	762	0	800
Total Lawrence Livermore National Laboratory	**11,405**	**0**	**12,410**

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2025

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Los Alamos National Laboratory			
Transmission Reliability and Resilience	2,125	0	2,400
Energy Delivery Grid Operations Technology	2,289	0	2,290
Resilient Distribution Systems	1,200	0	1,500
Grid Controls and Communications	5,614	0	6,190
Energy Storage R&D	100	0	100
Energy Storage	100	0	100
Grid Hardware, Components, and Systems	100	0	100
Total Los Alamos National Laboratory	**5,714**	**0**	**6,290**
National Energy Technology Lab			
Energy Delivery Grid Operations Technology	208	0	0
Grid Controls and Communications	208	0	0
Program Direction - OE	0	3,135	3,269
Total Program Direction (OE)	0	3,135	3,269
Total National Energy Technology Lab	**208**	**3,135**	**3,269**
National Renewable Energy Laboratory			
Transmission Reliability and Resilience	3,410	0	3,840
Energy Delivery Grid Operations Technology	4,038	0	4,040
Resilient Distribution Systems	9,068	0	11,000
Cyber Resilient & Secure Utility Communications Network (SecureNet)	0	0	1,000
Grid Controls and Communications	16,516	0	19,880
Energy Storage R&D	1,233	0	1,300
Energy Storage	1,233	0	1,300
Transformer Resilience and Advanced Components	250	0	500
Applied Grid Transformation Solutions	239	0	250
Grid Hardware, Components, and Systems	1,722	0	2,050
Total National Renewable Energy Laboratory	**18,238**	**0**	**21,930**
Oak Ridge Institute for Science & Education			
Transmission Reliability and Resilience	201	0	0
Grid Controls and Communications	201	0	0
Total Oak Ridge Institute for Science & Education	**201**	**0**	**0**
Oak Ridge National Laboratory			
Transmission Reliability and Resilience	4,094	0	4,600
Energy Delivery Grid Operations Technology	3,923	0	3,925
Resilient Distribution Systems	6,887	0	8,600
Cyber Resilient & Secure Utility Communications Network (SecureNet)	9,808	0	4,000
Grid Controls and Communications	24,712	0	21,125
Energy Storage R&D	3,783	0	4,000
Energy Storage	3,783	0	4,000
Transformer Resilience and Advanced Components	5,304	0	9,500
Applied Grid Transformation Solutions	1,005	0	1,000
Grid Hardware, Components, and Systems	10,092	0	14,500
Total Oak Ridge National Laboratory	**34,804**	**0**	**35,625**
Pacific Northwest National Laboratory			
Transmission Reliability and Resilience	6,301	0	8,180
Energy Delivery Grid Operations Technology	7,637	0	7,635
Resilient Distribution Systems	10,429	0	12,700

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Cyber Resilient & Secure Utility Communications Network (SecureNet)	0	0	3,500
Grid Controls and Communications	24,367	0	32,015
Energy Storage R&D	24,895	0	30,680
Energy Storage	24,895	0	30,680
Transformer Resilience and Advanced Components	100	0	500
Grid Hardware, Components, and Systems	24,995	0	31,180
Total Pacific Northwest National Laboratory	**49,362**	**0**	**63,195**
Sandia National Laboratories			
Transmission Reliability and Resilience	2,262	0	2,550
Energy Delivery Grid Operations Technology	2,102	0	2,100
Resilient Distribution Systems	1,100	0	2,400
Cyber Resilient & Secure Utility Communications Network (SecureNet)	0	0	1,000
Grid Controls and Communications	5,464	0	8,050
Energy Storage R&D	25,548	0	26,550
Energy Storage	25,548	0	26,550
Transformer Resilience and Advanced Components	1,375	0	3,000
Applied Grid Transformation Solutions	50	0	100
Grid Hardware, Components, and Systems	26,973	0	29,650
Total Sandia National Laboratories	**32,437**	**0**	**37,700**
SLAC National Accelerator Laboratory			
Transmission Reliability and Resilience	2,025	0	2,244
Resilient Distribution Systems	1,078	0	1,300
Grid Controls and Communications	3,103	0	3,544
Energy Storage R&D	277	0	300
Energy Storage	277	0	300
Grid Hardware, Components, and Systems	277	0	300
Total SLAC National Accelerator Laboratory	**3,380**	**0**	**3,844**
Washington Headquarters			
Transmission Reliability and Resilience	122	734	0
Energy Delivery Grid Operations Technology	0	267	0
Resilient Distribution Systems	1,153	1,872	1,000
Cyber Resilient & Secure Utility Communications Network (SecureNet)	0	7	0
Grid Controls and Communications	1,275	2,880	1,000
Energy Storage R&D	80	513	500
Energy Storage	80	513	500
Transformer Resilience and Advanced Components	200	223	200
Applied Grid Transformation Solutions	665	692	600
Grid Hardware, Components, and Systems	945	1,428	1,300
Program Direction - OE	8,609	14,658	16,431
Total Program Direction (OE)	8,609	14,658	16,431
Total Washington Headquarters	**10,829**	**18,966**	**18,731**
Grants			
Transmission Reliability and Resilience	3,786	3,375	4,306
Energy Delivery Grid Operations Technology	297	238	248
Resilient Distribution Systems	17,173	16,454	3,416
Cyber Resilient & Secure Utility Communications Network (SecureNet)	5,188	5,181	301
Grid Controls and Communications	26,444	25,248	8,271
Energy Storage R&D	33,974	33,541	23,118
Energy Storage	33,974	33,541	23,118
Transformer Resilience and Advanced Components	18,622	18,599	15,746

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Applied Grid Transformation Solutions	5,172	5,145	3,027
Grid Hardware, Components, and Systems	57,768	57,285	41,891
Program Direction - OE	9,184	0	0
Total Program Direction (OE)	9,184	0	0
Total Grants	**93,396**	**82,533**	**50,162**
Undesignated LPI			
Transmission Reliability and Resilience	29	29,891	0
Energy Delivery Grid Operations Technology	416	30,495	667
Resilient Distribution Systems	342	36,674	34
Cyber Resilient & Secure Utility Communications Network (SecureNet)	4	9,812	199
Grid Controls and Communications	791	106,872	900
Energy Storage R&D	77	60,946	3,002
Energy Storage	77	60,946	3,002
Transformer Resilience and Advanced Components	291	8,678	554
Applied Grid Transformation Solutions	25	4,163	3,523
Grid Hardware, Components, and Systems	393	73,787	7,079
Total Undesignated LPI	**1,184**	**180,659**	**7,979**
Total Funding by Site for TAS_0318 - Electricity	**285,293**	**285,293**	**293,000**

Nuclear Energy

Nuclear Energy

Nuclear Energy
($K)

FY 2023 Enacted [1,2,3,4]	FY 2024 Annualized CR [1,3]	FY 2025 Request
1,773,000	1,773,000	1,590,660

Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for nuclear 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, $1,590,660, to remain available until expended: Provided, That of such amount, $97,000,000 shall be available until September 30, 2026, for program direction: Provided further, That of the amounts made available under this heading, $300,000,000 is designated by the Congress as being for an emergency requirement pursuant to section 251(b)(2)(A)(i) of the Balanced Budget and Emergency Deficit Control Act of 1985: Provided further, That such amount shall be available only if the President designates such amount as an emergency requirement pursuant to such section 251(b)(2)(A)(i).

Mission

The primary mission of the Office of Nuclear Energy (NE) is to advance nuclear power to meet the nation's energy, environmental and national security needs.

Under the guidance of three research objectives, NE resolves barriers to technical, cost, safety, security, and proliferation resistance through early-stage research, development, and demonstration to:

- Enhance the long-term viability and competitiveness of the existing U.S. reactor fleet.
- Develop an advanced reactor pipeline.
- Implement and maintain national strategic fuel cycle and supply chain infrastructure.

Overview

Nuclear energy underpins the President's plan to put the United States (U.S.) on a path to net-zero emissions by 2050. With 93 operating units in 28 states, the U.S. nuclear reactor fleet provides half of the nation's carbon pollution-free electricity with firm power that complements renewables. Expanded deployment of advanced nuclear power promises to minimize land-use and transmission requirements while offering regional economic benefits, equitable job transitions, and unique capabilities to decarbonize several non-electric applications. U.S. nuclear energy leadership also plays key national security and global strategic roles for the United States, including supporting the highest international standards for safety, security, and nonproliferation while shedding light on anti-competitive behaviors that impede the expedient deployment of nuclear energy.

The United States pioneered the development and peaceful use of civil nuclear power and the nuclear fuel cycle to produce around-the-clock, emissions-free baseload electricity generation. The Office of Nuclear Energy now leads and supports research, development, and demonstration (RD&D) activities enabling (1) continued operation of existing reactors, (2) deployment of new reactors, (3) a secure and sustainable nuclear fuel cycle, and (4) expansion of U.S. international nuclear energy cooperation. NE executes its mission through investments in early-stage RD&D that

[1] Funding does not reflect the transfer of SBIR/STTR to the Office of Science.
[2] Funding does not reflect the FY 2023 mandatory transfer of $99.7M from Naval Reactors for operation of the Advanced Test Reactor.
[3] Funding does not reflect the mandatory transfer of $20M to the Office of Science for ORNL Nuclear Facilities O&M.
[4] Funding reflects $300M appropriated under Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

leverage the tremendous innovation capacity of the United States' national laboratories, universities, and advanced nuclear technology developers to transform the global energy landscape. Through coordination and engagement with the public, regional governments, and Tribes, NE also incorporates crosscutting initiatives to advance diversity in nuclear energy, energy and environmental justice, and jobs and the American workforce. NE is also responsible for ensuring the secure operational availability of Idaho National Laboratory (INL) as a national asset supporting a broad range of civilian and national security research.

The FY 2025 Request helps to advance U.S. leadership in critical technologies, invest in our workforce, and upgrade America's research infrastructure. It supports the diverse civilian nuclear energy programs of the U.S. Government to research and develop nuclear energy technologies, including generation, safety, and security technologies, to assist in unleashing the clean energy transition through strategic, innovative RD&D activities. The NE FY 2025 Request will expand the impact of our RD&D funding through innovative funding mechanisms - such as prizes, competitions, technical assistance, and programs targeted to small businesses.

Additionally, the FY 2025 Request strives to develop and demonstrate the advanced fuel cycle technologies needed to place the United States in a global leadership position of the nuclear industry by addressing gaps in the domestic nuclear fuel supply chain for both existing and advanced nuclear reactors to assure the supply of low enriched uranium (LEU), including high assay low enriched uranium (HALEU), needed by U.S. reactors and those of our allies. The FY 2025 Request also supports spent nuclear fuel management activities, including a consent-based approach to siting interim used nuclear fuel storage which centers energy and environmental justice.

Finally, the FY 2025 Request supports U.S. nuclear energy leadership that enables our bilateral and multilateral civil nuclear energy engagements to promote global decarbonization, achieve energy security, and create synergies for civil nuclear cooperation with like-minded partners across the globe.

FY 2023 Key Accomplishments

- Hosted, in partnership with the International Atomic Energy Agency (IAEA), the 5th IAEA Ministerial Conference on Nuclear Energy in the 21st Century on October 26-28, 2022 in Washington, DC with representatives from over 65 countries.

- In support of the current light water reactor U.S. nuclear power fleet, preconceptual designs of coupled power delivery between a reference light water reactor and 100-500 MWe high temperature steam electrolysis hydrogen production plants were completed. These designs confirm the feasibility of both heat and electrical energy offtake from an operating nuclear plant for industrial processes and supports DOE's Earthshot: Hydrogen initiative to deliver clean hydrogen that powers U.S. industry.

- In support of microreactor and advanced reactor development, testing was initiated on the Primary Coolant Apparatus Test (PCAT), a full scale non-nuclear prototype of the Microreactor Applications Research Validation and Evaluation (MARVEL) test platform. A construction contract was awarded for the Demonstration of Microreactor Operations (DOME).

- After two years in the Calvert Cliffs reactor, the first complete Accident Tolerant Fuel Assembly underwent a detailed visual inspection that revealed excellent fuel performance with no degradation and very low corrosion.

- Awarded first-ever contract for domestic production of high-assay low-enriched uranium (HALEU). More than 1.7 metric tons of HALEU were produced from recycling Experimental Breeder Reactor-II (EBR-II) driver material.

- Transferred all EBR-II spent nuclear fuel from wet to dry storage, accomplishing a major milestone in the Idaho Settlement Agreement.

- Publicly posted a revised Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel, outlining a roadmap for a consent-based approach to siting one or more federal consolidated interim storage facilities. Selected 13 consent-based siting consortia members that will work with communities and organizations interested in learning more about spent nuclear fuel management and DOE's community-centered approach to siting storage facilities for spent nuclear fuel.

- Awarded 43 Nuclear Energy University Program research and development, three Integrated Research Projects, and 18 infrastructure support and grants, providing R&D solutions most directly relevant to the near-term, significant needs of NE R&D programs. NE announced five Distinguished Early Career Program recipients.

Highlights and Major Changes in the FY 2025 Congressional Budget Request

The NE Budget requests $1.59 billion and proposes six new budget lines. The lines will provide enhanced visibility and clarity for ongoing Nuclear Energy activities and the Department's crosscutting R&D efforts.

- **Integrated Energy Systems (Reactor Concepts RD&D)**, previously included in the discontinued Crosscutting Technology Development line, supports R&D to expand the role of nuclear energy by developing technologies that support electrical, thermal, and chemical energy pathways that deliver nuclear energy both on and off the electricity grid.
- **Next Generation Fuels (Fuel Cycle R&D),** previously included in the discontinued TRISO and Graphite Qualification line, supports industry with financial assistance and lab-based research and development to continue to drive fuel innovation over the long term. It lays the groundwork for fuels that significantly outperform today's fuel, focusing on long-term, high-risk, high-reward fuel concepts.
- **Advanced Materials and Manufacturing Technologies (Nuclear Energy Enabling Technologies, NEET),** previously included in the discontinued Crosscutting Technology Development line, focuses on innovative research to accelerate the development, qualification, demonstration, and deployment of advanced materials, manufacturing technologies, and supply chain capacity.
- **Advanced Sensors and Instrumentation (ASI)**, previously included in the discontinued Crosscutting Technology Development line, performs research and development of advanced sensors and instrumentation to expand measurement capabilities to address critical technology gaps.
- **Gateway for Accelerated Innovation in Nuclear (GAIN),** previously funded as a crosscutting activity across multiple NE subprograms, facilitates access for industry to national laboratory knowledge and capabilities to rapidly advance the development and deployment of nuclear energy, and to communities looking to investigate options for deployment of nuclear energy power sources.
- **International Nuclear Energy Cooperation (INEC)**, previously funded within Program Direction, leads NE international engagement through the development, coordination, and implementation of U.S. civil nuclear policy and integrates it with NE's technical programs.

Additionally, three scope elements are realigned within the budget structure:

- R&D to support the cyber security of the commercial nuclear fleet is added to the Advanced Reactor Safeguards and Security line (Advanced Reactor Demonstration Program, ARDP);
- Graphite Qualification efforts are included under Advanced Reactor Technologies (Reactor Concepts RD&D); and
- The Advanced Nuclear Energy Cost-Share Grant Program to help reduce the regulatory risks for advanced reactors and other nuclear energy related technologies is aligned within Regulatory Development (ARDP).

To facilitate review and understanding of the FY 2025 Request, the FY 2023 Enacted and FY 2024 Annualized CR funding levels and activities' descriptions are provided on a comparable basis to the FY 2025 Request, meaning, as if the FY 2023 appropriations had been provided in the proposed FY 2025 budget structure.

A detailed crosswalk of FY 2023 as enacted to FY 2023 as presented in the FY 2025 budget structure is at the end of this Overview.

Nuclear Energy
Funding by Congressional Control ($K)

	FY 2023 Enacted - Comparable[5,7,8]	FY 2024 Annualized CR - Comparable[6,7,8]	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
NEUP, SBIR/STTR and TCF	**130,276**	**130,276**	**143,400**	**+13,124**	**+10%**
Reactor Concepts Research, Development & Demonstration (RD&D)					
Advanced SMR RD&D	164,400	164,400	0	-164,400	-100%
Light Water Reactor Sustainability	44,400	44,400	35,000	-9,400	-21%
Advanced Reactor Technologies	59,072	59,072	43,800	-15,272	-26%
Integrated Energy Systems	12,000	12,000	9,500	-2,500	-21%
Reactor Concepts RD&D	**279,872**	**279,872**	**88,300**	**-191,572**	**-68%**
Fuel Cycle Research and Development					
Mining, Conversion and Transportation	2,000	2,000	2,000	0	0%
Materials Recovery and Waste Form Development	44,500	44,500	38,500	-6,000	-13%
Accident Tolerant Fuels	96,000	96,000	97,900	+1,900	+2%
Fuel Cycle Core R&D	15,000	15,000	15,000	0	0%
Next Generation Fuels	47,400	47,400	43,290	-4,110	-9%
Advanced Nuclear Fuel Availability	100,000	100,000	150,000	+50,000	+50%
Used Nuclear Fuel Disposition R&D	47,000	47,000	47,000	0	-0%
Integrated Waste Management System	53,000	53,000	53,000	0	0%
Fuel Cycle R&D	**404,900**	**404,900**	**446,690**	**+41,790**	**+10%**

[5] Funding includes the funding transfer of SBIR/STTR to the Office of Science.
[6] Funding does not reflect the FY 2023 mandatory transfer of $92.7M from Naval Reactors for operation of the Advanced Test Reactor.
[7] Funding includes the transfer of $20M to the Office of Science for ORNL Nuclear Facilities O&M.
[8] Funding reflects $300M appropriated under Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

Nuclear Energy
($K)

	FY 2023 Enacted - Comparable	FY 2024 Annualize CR - Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Nuclear Energy Enabling Technologies					
Advanced Materials and Manufacturing Technologies	9,610	9,610	23,000	+13,390	+139%
Advanced Sensors and Instrumentation	6,500	6,500	9,000	+2,500	+38%
Nuclear Energy Advanced Modeling and Simulation	27,500	27,500	28,600	+1,100	+4%
Nuclear Science User Facilities	34,750	34,750	34,500	-250	-1%
Gateway for Accelerated Innovation In Nuclear	10,053	10,053	10,000	-53	-1%
Nuclear Energy Enabling Technologies	**88,413**	**88,413**	**105,100**	**+16,687**	**+19%**
Advanced Reactor Demonstration Program					
National Reactor Innovation Center[3]	67,000	67,000	31,000	-36,000	-54%
ARDP Demonstration Reactors	60,000	60,000	0	-60,000	-100%
Risk Reduction for Future Demonstrations	120,000	120,000	142,500	+22,500	+19%
Regulatory Development	12,065	12,065	15,000	+2,935	+24%
Advanced Reactor Safeguards and Security	9,250	9,250	11,000	+1,750	+19%
23-E-200, LOTUS	20,000	20,000	18,748	-1,252	-6%
Subtotal, Advanced Reactors Demonstration Program	**288,315**	**288,315**	**218,248**	**-70,067**	**-24%**
Infrastructure					
INL Facilities Operations & Maintenance	318,924	318,924	333,922	+14,998	+5%
ORNL Infrastructure Facilities O&M	20,000	20,000	0	-20,000	-100%
Construction					
16-E-200, Sample Preparation Laboratory	7,300	7,300	0	-7,300	-100%
Subtotal, Infrastructure	**346,224**	**346,224**	**333,922**	**-12,302**	**-4%**

Nuclear Energy
($K)

	FY 2023 Enacted - Comparable	FY2024 Annualized CR – Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Idaho Sitewide Safeguards and Security	**150,000**	**150,000**	**150,000**	**0**	**0%**
International Nuclear Energy Cooperation	**3,320**	**3,320**	**8,000**	**+4,680**	**+141%**
Program Direction	**81,680**	**81,680**	**97,000**	**+15,320**	**+19%**
Total, Nuclear Energy R&D	**1,773,000**	**1,773,000**	**1,590,660**	**-183,340**	**-10%**
Federal FTEs	277	313	320		

SBIR/STTR:

- FY 2023 Enacted: SBIR $23,385; STTR $3,288
- FY 2024 Annualized CR: SBIR $23,385; STTR $3,288
- FY 2025 Request: SBIR $22,216; STTR $3,124

Future-Years Energy Program

($K)

	FY 2025 Request	FY 2026	FY 2027	FY 2028	FY 2029
Nuclear Energy (Non 050)	1,440,660	1,474,000	1,508,000	1,543,000	1,578,000
Nuclear Energy (050) S&S	150,000	153,000	157,000	158,000	159,000

Outyear Priorities and Assumptions

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2025 - FY 2029. The outyear funding levels use the growth rates from and match the outyear account totals published in the FY 2025 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Nuclear Energy priorities in the outyears include the following:

- Supporting the five Risk Reduction for Future Demonstration awards and the National Reactor Innovation Center under the Advanced Reactor Demonstration Program.
- Providing limited quantities of HALEU for NE research and demonstration requirements.
- Providing for the secure availability of Idaho National Laboratory for NE, DOE and other U.S. government requirements.
- Expanding access to university based nuclear energy science and engineering opportunities.

Bipartisan Infrastructure Law (BIL) Investments

NE was appropriated funds through the Bipartisan Infrastructure Law (BIL) (P.L. 117-58). Not all BIL activities will be managed by the organization to which funds were appropriated. Activities that will be managed by other organizations are discussed below.

($K)

Nuclear Energy	FY 2023 BIL Funding	FY 2024 BIL Funding	FY 2025 BIL Funding	Managing Organization
Civil Nuclear Credit Program	1,200,000	1,200,000	1,200,000	GDO
Total, Nuclear Energy	**1,200,000**	**1,200,000**	**1,200,000**	

- **Civil Nuclear Credit Program:** The goal of this investment is to help preserve the existing U.S. reactor fleet and save thousands of high-paying jobs across the country. Under the new program, owners or operators of commercial U.S. reactors can apply for certification to bid on credits to support their continued operations. An application must demonstrate the reactor is projected to close for economic reasons and that closure will lead to a rise in air pollutants and carbon emissions. The program is available for plants that are certified as safe to continue operations and prioritizes plants that use domestically produced fuel. Although funds were appropriated to NE, the Grid Deployment Office (GDO) will continue to execute the Civil Nuclear Credit Program in FY2025.

Inflation Reduction Act (IRA) Investments

Nuclear Energy was appropriated funds through the Inflation Reduction Act of 2022 (IRA). Not all IRA activities will be managed by the organization to which funds were appropriated. Activities that NE will manage, including those appropriated to other organizations, are itemized below.

($K)

Appropriated Funding Organization	FY 2022 IRA Funding	Managing Organization
Nuclear Energy		
Sec. 50172 National Laboratory Infrastructure (c) Office of Nuclear Energy	150,000	Nuclear Energy
Sec. 50173 Availability of High-Assay Low-Enriched Uranium	700,000	Nuclear Energy
Total, Nuclear Energy	**850,000**	

- **Sec. 50172 National Laboratory Infrastructure:** The goal of this investment is to accelerate infrastructure upgrades at Idaho National Laboratory. FY 2025 activities will see ongoing efforts on general plant projects initiated in FY 2023.
- **Sec. 50173 Availability of High-Assay Low-Enriched Uranium**: The goal of this investment is to accelerate the availability of HALEU to fuel advanced demonstration and commercial reactors. FY 2025 activities will include supporting the U.S. Nuclear Regulatory Commission with criticality benchmark data, assisting industry with transportation package development, and working toward supplying HALEU to industry in coordination with a HALEU Consortium.

Nuclear Energy Crosscut Funding
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Critical and Emerging Technologies (CET) – Artificial Intelligence and Machine Learning	3,820	3,820	4,480	+660
Clean Energy Technology Manufacturing	8,800	8,800	17,000	+8,200
Energy Storage	23,000	23,000	11,500	-11,500
Energy-Water	2,300	2,300	2,000	-300
Grid Modernization	188,000	2,000	2,000	-186,000
Hydrogen	23,000	23,000	6,000	-17,000
Industrial Decarbonization	66,000	66,000	26,100	-39,900
Energy Sector Cybersecurity	4,500	4,500	5,000	+500
Infrastructure	82,113	82,113	184,770	+102,657
Pensions				
Safeguards and Security	150,000	150,000	150,000	0
Small Business Innovation Research / Small Business Technology Transfer	26,673	26,673	25,340	-1,333
Research and Development	1,308,040	1,308,040	1,453,451	145,411

Nuclear Energy
Minor Construction Activities ($K)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)
Minor Construction Projects (Total Project Cost (TPC)<$30M)						
Idaho National Laboratory (Direct Funded)						
Fuel Conditioning Facility Cooling Water System (IFM)	7,000	0	0	0	7,000	+7,000
TRA Storage Pad (IFM)	25,000	-	-	0	5,000	+5,000
HALEU Polishing Capability (IRA)	28,000	0	0	28,000	0	0
MFC Mockup Shop Machining Relocation (IRA)	10,000	0	0	10,000	0	0
FCF Criticality Alarm System (IRA)	5,000	0	0	5,000	0	0
Minor Construction Projects (Total Project Cost (TPC)<$30M)						
Idaho National Laboratory (Indirect Funded)						
MFC East Campus Utility Corridor	20,000	0	0	0	1,000	+1,000
MFC-752 HVAC Upgrades	12,000	0	0	0	1,500	+1,500
MFC Office Building	30,000	0	0	0	1,500	+1,500
Fuel Conditioning Facility Vitrification Melter	6,539	0	700	700	5,139	+4,439
CFA CKTs 41, 42, 43 Underground Relocation	7,500	0	0	0	5,000	+5,000
Scoville Substation Transformer Replacements and Reliability Upgrades	11,000	0	0	0	404	+404
CFA Data Center/Dial Room	18,000	0	0	0	3,000	+3,000
CITRC Multi-Purpose Facility	25,000	0	0	0	5,000	+5,000
CFA Admin Building	25,500	0	0	0	3,000	+3,000

Nuclear Energy
Minor Construction Activities ($K)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)
CFA Craft Shops	15,000	0	0	0	5,000	+5,000
ATR Wellness Center	13,000	0	0	0	3,000	+3,000
NQA-1 Storage Facility	12,000	0	0	0	3,000	+3,000
Bridge Replacements and MFC/TREAT Intersection	8,800	0	0	0	1,500	+1,500
Outer West Loop	29,000	0	0	0	4,231	+4,231
Outdoor Testing Space and Pads at ETPG	7,500	0	0	0	3,000	+3,000
TRA-653/662 Remodel	15,000	0	0	0	3,000	+3,000
New ATR Dial Room	7,000	0	0	0	3,000	+3,000
SMC Guardhouse	11,000	0	0	0	1,000	+1,000
SMC Sewer Lagoon Upgrade	7,500	0	0	0	3,000	+3,000
MFC Stormwater Retention Pond	8,000	0	0	0	8,000	+8,000
CFA Thermal Energy Island	22,100	0	0	0	22,100	+22,100
Total, Minor Construction Projects	**386,439**	**0**	**700**	**43,700**	**97,374**	**+96,674**
Total, Capital Summary	**386,439**	**0**	**700**	**43,700**	**97,374**	**+96,674**

Budget Structure Crosswalk ($)
Nuclear Energy
FY 2023 Enacted to FY 2023 Enacted in FY 2025 Proposed Budget Structure

	FY 2023 Enacted	INEC as Control Line	Realignment - Commercial Cybersecuity to ARDP	Realignment - Graphite Qualification to ART	Realignment - Adv Reactor Licensing to Reg Dev	New - Integrated Energy Systems	New - Next Generation Fuels	NEW - AM&MT	NEW - AS&I	New - GAIN	FY 2023 Enacted in FY 2025 Structure
Reactor Concepts RD&D											
Advanced SMR RD&D	165,000									(600)	164,400
LWR Sustainability	45,000									(600)	44,400
Advanced Reactor Technologies	49,000			13,600				(175)		(3,353)	59,072
Integrated Energy Systems						12,000				-	12,000
Fuel Cycle Research and Development											
Material Recovery and Waste Form Development	45,000									(500)	44,500
Accident Tolerant Fuels	114,000						(15,000)			(3,000)	96,000
Triso Fuel and Graphite Qualification	32,000			(13,600)			(18,400)			-	-
Fuel Cycle Laboratory R&D	29,000						(14,000)			-	15,000
Next Generation Fuels							47,400				47,400
Adv Nuc Fuel Availability	100,000										100,000
Used Nuclear Fuels Disposition R&D	47,000										47,000
Integrated Waste Management System	53,000										53,000
Nuclear Energy Enabling Technologies											
Crosscutting Technology Development	32,000		(4,500)			(12,000)		(9,000)	(6,500)	-	-
Advanced Materials and Manufacturing Technologies								10,360		(750)	9,610
Advanced Sensors and Instrumentation									6,500	-	6,500
Nuclear Energy Advanced Modeling and Simulation	28,500									(1,000)	27,500
Nuclear Science User Facilities	35,000									(250)	34,750
Gateway for Accelerated Innovation in Nuclear										10,053	10,053
Advanced Reactors Demonstration Program											
National Reactor Innovation Center	70,000				(3,000)					-	67,000
Regulatory Development	10,250				3,000			(1,185)			12,065
Advanced Reactor Safeguards and Security	4,750		4,500								9,250
International Nuclear Energy Cooperation	-	3,320									3,320
Program Direction	85,000	(3,320)									81,680
Programs Not Afffected by Comparabilities	828,500										828,500
Total, Nuclear Energy	1,773,000	-	-	-		-	-	-	-	-	1,773,000

University and Competitive Research Programs

Overview

The University and Competitive Research Programs consolidates and focuses support to universities and small businesses in areas relevant to the Office of Nuclear Energy's (NE) mission. This program funds university research, infrastructure support and revitalization, workforce development, and technology commercialization efforts for nuclear energy. Efforts are largely awarded through competitive opportunities for researchers, students, faculty, and small businesses. Additionally, the program provides fuel services, maintenance support, reactor sharing, and safety upgrades of fuel fabrication equipment and facilities for United States (U.S.) university research reactors. This program seeks to advance equal opportunities and benefits for all, while seeking to eliminate barriers to such capabilities for those individuals and communities that have been historically underserved, e.g., students and faculty at minority serving institutions (MSIs), including Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs).

The University and Competitive Research Programs includes three programs: (1) the Nuclear Energy University Program (NEUP), Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs, and the Technology Commercialization Fund (TCF) program, (2) the University Nuclear Leadership Program (UNLP), and (3) the University Fuel Services (UFS).

Highlights of the FY 2025 Budget Request

Under the University Nuclear Leadership Program (UNLP), funding will support a new opportunity that will pair a major nuclear engineering institution with an MSI that is looking to develop nuclear engineering expertise within its current programs. Activities will include a summer school or workshop opportunity for students interested in nuclear science and curriculum/program development. Funding will also support a new opportunity to provide faculty at two-year trade schools and community colleges support for curriculum development to train the next generation of nuclear technicians, operators, and skilled craftspeople.

Under University Fuel Services (UFS), funding will be used to complete the fabrication of 25 new fuel assemblies for the North Carolina State University (NCSU) PULSTAR reactor.

University and Competitive Research Programs
Funding ($K) (Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
University and Competitive Research Program					
NEUP, SBIR/STTR, and TCF	106,276	106,276	106,670	+394	+0.4%
University Nuclear Leadership Program	6,500	6,500	8,500	+2,000	+30.8%
University Fuel Services	17,500	17,500	28,230	+10,730	+61.3%
Total, University and Competitive Research Program	**130,276**	**130,276**	**143,400**	**+13,124**	**+10.1%**

SBIR/STTR:
- FY 2023 Enacted: SBIR $23,385; STTR $3,288
- FY 2024 Annualized CR: SBIR $23,385; STTR $3,288
- FY 2025 Request: SBIR $22,216; STTR $3,124

University and Competitive Research Programs
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
NEUP, SBIR/STTR, and TCF: The increase from $106,276,000 to $106,670,000 supports additional R&D awards and the Innovations in Nuclear Energy Technology R&D Publication Competition for undergraduate and graduate students.	**+394**
University Nuclear Leadership Program: The increase from $6,500,000 to $8,500,000 supports a new funding opportunity for faculty at two-year trade schools and community colleges for curriculum development and a summer school opportunity for students attending minority serving institutions (MSIs) who are interested in nuclear science.	**+2,000**
University Fuel Services: The increase from $17,500,000 to $28,230,000 reflects additional Training, Research, Isotopes, General Atomics (TRIGA) fresh fuel orders needed to support university research reactors. The increased funding will support completion of fabrication of new fuel assemblies in support of the North Carolina State University (NCSU) PULSTAR reactor. The increase will support a TRIGA fuel receipt, inspection, and storage facility needed to store the TRIGA fresh fuel.	**+10,730**
Total, University and Competitive Research Program	**+13,124**

NEUP, SBIR/STTR, and TCF

Description

The NEUP, SBIR/STTR, and TCF subprogram includes competitively awarded opportunities for small businesses, national laboratories, and universities. The university program seeks to support cutting-edge, innovative research at U.S. universities, with the goal to expand participation of minority serving institutions (MSIs), including Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs). Having a single program funding line provides more flexibility to Nuclear Energy's (NE) competitive award process; streamlines program execution; and provides enhanced transparency for small businesses, universities, and other stakeholders.

The principal focus areas for FY 2025 include four elements: (1) Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR); (2) Technology Commercialization Fund (TCF); (3) University-led Research and Development; and (4) University Infrastructure.

1. **SBIR/STTR –** NE supports small business through the Department's SBIR/STTR program. The SBIR/STTR reauthorizing language (Reauthorization Act of 2011 (P.L. 112-81, 125 STAT 1822)) directs the Department to spend not less than 3.2 percent of its extramural research and development (R&D) budget for SBIR and not less than 0.45 percent of its extramural R&D budget for STTR. NE's contribution supports scope relevant to NE's R&D mission, for example technologies for improvements of existing reactors, advanced reactors, and fuel cycle systems.
2. **TCF –** NE supports the transfer of promising nuclear energy technologies developed at the Department's national laboratories to the nuclear industry for commercialization through TCF. The TCF was established under 42 U.S. Code § 16391, which directed the Secretary to "establish an Energy Technology Commercialization Fund, using 0.9 percent of the amount made available to the Department for applied energy research, development, demonstration, and commercial application for each fiscal year based on future planned activities and the amount of the appropriations for the fiscal year, to be used to provide matching funds with private partners to promote promising energy technologies for commercial purposes."
3. **University-led Research and Development –** NE supports the U.S. university community with competitive research and development through yearly competitive solicitations. The program's goal is to support outstanding, cutting-edge, and innovative research at U.S. universities in the areas of nuclear energy science, technology, and social impacts through the following funding opportunities:
    a. **Consolidated Innovative Nuclear Research (CINR):** NE will continue to utilize the CINR funding opportunity to align nuclear energy research being conducted at U.S. colleges and universities with DOE's mission, focusing on strategic, blue-sky research as well as the needs and priorities of key NE programs including fuel cycle, reactor concepts, and spent fuel management research. This effort also includes Integrated Research Projects (IRPs), which are multi-disciplinary and multi-institutional projects that address near-term nuclear energy research challenges, technology innovation needs, or capability gaps. IRPs are intended to integrate across disciplines to achieve solutions to complex research challenges that cannot be addressed by a less comprehensive team.
    b. **Distinguished Early Career Program (DECP):** NE will continue to utilize its most prestigious opportunity for faculty members, DECP. This program will focus on early career faculty conducting transformative research, education, and leadership aligned with the Office of Nuclear Energy's mission. It will enable awardees to develop innovative, cutting-edge research programs in nuclear energy relevant areas, not only recognizing their demonstrated potential as outstanding researchers but also as transformative educators. This opportunity will support the development of the most promising faculty members nationwide as they advance novel nuclear energy research and train the next generation of nuclear energy professionals. DECP aims to recognize distinguished researchers at the pivotal initial stage of their

careers and to support high-impact contributions to nuclear energy research, innovation, discovery, leadership, and dissemination of knowledge.

c. **Phase II Continuation CINR:** NE will continue to utilize the Phase II Continuation CINR FOA to provide opportunities for teams that have performed high quality work through the Nuclear Energy University Program (NEUP) to propose new projects that complement and enhance ongoing NEUP research through a competitive application and review process.

d. **Innovations in Nuclear Energy Research and Development (R&D) Student Competition:** NE will support five competitions under this student opportunity, which recognizes, and awards published graduate and undergraduate students for innovative nuclear energy research.

4. **University Infrastructure –** Nuclear Energy (NE) supports the infrastructure needed at universities to conduct cutting-edge research and to educate and train the next generation nuclear workforce.

   NE provides competitively awarded funding to universities through solicitations that will include the following elements to revitalize the existing university nuclear research infrastructure.

   a. **Scientific Infrastructure Support**

      i. *General Scientific Infrastructure:* to focus on equipment, instrumentation, and associated non-reactor upgrades that significantly improve or expand research, instruction, and training capabilities at individual universities and colleges.

      ii. *Reactor Upgrades:* to improve existing nuclear research and training reactors at individual universities and colleges. It includes the purchase and maintenance of equipment to enhance the safety, security, performance, control, or operational reliability of the research reactor.

   b. **Reactor Sharing:** to provide a competitive opportunity to increase the use of university research reactors through support of expanded partnering and public outreach. The program will improve public understanding of nuclear energy, increase public acceptance of nuclear reactor technologies, and build goodwill with communities that house research reactors while also stimulating undergraduate and graduate enrollment in nuclear energy related fields.

   c. **Infrastructure Revitalization:** to competitively award consortium-led efforts to establish and/or enhance nuclear research infrastructure capabilities at U.S. universities. They may include enhancements to existing reactors and addition of related capabilities such as simulators. This support will help U.S. universities (1) develop a workforce with hands-on experience with commercially relevant advanced reactor concepts, reflective of those being deployed by industry; (2) offer research capabilities that address emerging technical challenges; and (3) ensure that access to the opportunities and benefits of these capabilities are equitably provided, specifically seeking ways to include communities that have historically faced limits in access to such capabilities. These activities are expected to be led by one or more diverse consortia with appropriate expertise to ensure that the new capabilities will support these goals. A goal is to maximize the research and educational value and the broad accessibility of these resources in an equitable and inclusive manner.

NEUP, SBIR/STTR, and TCF
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
SBIR/STTR		
$26,673,000	**$25,340,000**	**-$1,333,000**
• In FY 2023, Nuclear Energy (NE) provided $26,673,000 for Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR). Awards were made in areas such as advanced technologies for nuclear energy and used fuel.	• Support competitively awarded nuclear science and engineering small business and technology awards focusing in the areas of advanced technologies for nuclear energy and used fuel.	• The FY 2025 request reflects the legally directed 3.65% of NE research and development funding.
Technology Commercialization Fund		
$8,602,000	**$6,338,000**	**-$2,264,000**
• In FY 2023, NE provided $8,602,000 for the Technology Commercialization Fund (TCF). Awards were made in areas such as advanced technologies for nuclear energy and used fuel.	• Support competitive laboratory funding opportunity designed to help commercialize promising nuclear energy related technologies developed at the national laboratories.	• The FY 2025 request reflects the legally directed 0.9% of NE research, development and demonstration funding.
University Led Research & Development		
$59,001,000	**$62,992,000**	**+$3,991,000**
• In FY 2023, NE provided $59,001,000 for university led R&D. Awards were made for research in areas such as fuel cycle, reactor concepts, and mission supporting research.	• Support competitively awarded, university-led nuclear energy R&D that supports the NE mission. • Support early career awards focused on faculty conducting transformative research, education, and leadership aligned with the NE mission. • Support Innovations in Nuclear Energy Technology R&D Publication Competition focused on graduate and undergraduate students' research published through journal publications and conference proceedings.	• The increase will support the Innovations in Nuclear Energy Technology R&D Publication Competition for undergraduate and graduate students.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
University Infrastructure **$12,000,000**	**$12,000,000**	**+$0**
• In FY 2023, NE used $5,000,000 for university infrastructure awards to support general scientific infrastructure and reactor upgrades at U.S. universities. • New funding opportunity announcement was created for University Infrastructure Revitalization to improve existing university nuclear research infrastructure. This FOA will be funded using $6,000,000 in FY 2023 carryover for awards made in FY 2024. • New funding opportunity announcement was created for University Reactor Sharing. This FOA will be funded using $1,000,000 in FY 2023 carryover for awards to be made in FY 2024.	• Support general scientific infrastructure, reactor upgrades, reactor sharing, and infrastructure revitalization through competitive solicitations. • Support competitively awarded, consortium-led activities to enhance nuclear research capabilities at U.S. universities, including establishment of new non-reactor capabilities such as simulators and relevant improvements to existing research reactors.	• No change.

University Nuclear Leadership Program

Description

The University Nuclear Leadership Program (UNLP) provides undergraduate scholarships and graduate fellowships to students attending two and four-year institutions of higher education. The subprogram provides important educational support to bolster scientific discovery and innovation in nuclear science and engineering (NS&E) at U.S. universities and colleges, while supporting the next generation of the nuclear energy workforce.

All scholarship and fellowship awards are competitively awarded to students attending U.S. institutions of higher education offering NS&E educational programs, including minority serving institutions (MSIs) such as Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs). Emphasis is placed on increasing the involvement of MSIs, resulting in direct and meaningful investments in the areas of clean energy training and workforce development in support of the administration's goals for equity and inclusion.

The subprogram is intended to attract qualified students to nuclear energy professions by providing single-year undergraduate scholarships and multi-year graduate fellowships.

Scholarships are awarded for undergraduate study at two and four-year institutions leading to a major or minor degree or certificate. Currently, scholarships are offered at $10,000 for one year to students attending four-year institutions and $5,000 to students attending two-year trade schools and community colleges.

Fellowships are awarded for graduate-level work leading to a master's or doctoral degree in the fields or disciplines of NS&E relevant to the NE mission. NS&E disciplines of interest include nuclear engineering, mechanical engineering, electrical engineering, chemistry, health physics, nuclear materials science, radiochemistry, applied nuclear physics, nuclear policy, radiation protection technology, nuclear power technology, nuclear maintenance technology, nuclear engineering technology, cybersecurity, and nuclear safety. Fellowships include an internship at a DOE national laboratory or other designated facility, as well as an opportunity for graduate fellowship students to tour nuclear facilities in the United Kingdom (UK) under the United States (US) / UK bilateral collaboration. The maximum award for a fellowship is $54,000 per year for three years, with an additional one-time $7,000 allotment to fund the minimum 10-week internship.

In FY 2025, UNLP will support a new funding opportunity that will pair a major nuclear engineering institution with an MSI that is looking to develop nuclear engineering expertise within its current programs. Activities will include a summer school or workshop opportunity for students interested in nuclear science and curriculum/program development. Funding will also support a new opportunity to provide faculty at two-year trade schools and community colleges support for curriculum development to train the next generation of nuclear technicians, operators, and skilled craftspeople.

<u>OMNI Internships</u>
OMNI Internships, a DOE Office of the Chief Information Officer-led effort, help to build careers for talented cybersecurity and information technology professionals to strengthen the security of the Department, the national laboratories, and the nuclear industry.

University Nuclear Leadership Program
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
University Nuclear Leadership Program $6,500,000	**$8,500,000**	**+$2,000,000**
• Supported nuclear science and engineering study and research by fully funding approximately 30 or more multi-year student fellowships and 45 or more single-year scholarships in the nuclear energy field of study. • Supported a new scholarship program opportunity that targets two-year applied technical degree programs focused on nuclear energy-related topics, all with an increased emphasis on capacity-building and education at minority serving institutions (MSIs), and institutions in disadvantaged communities. This opportunity focused on workforce development for nuclear relevant technician training, including nuclear operations, mechanical maintenance, electrical maintenance, chemistry, health physics and other nuclear energy-related topics. • Bolstered outreach efforts focused on increasing MSI involvement to include website resources, conference promotion, and university visits. • Supported an OMNI internship program that will help build careers for talented cybersecurity and information technology professionals to strengthen the security of the Department, the national laboratories, and the nuclear industry.	• Support nuclear science and engineering study and research by fully funding approximately 30 multi-year student fellowships and 75 single-year scholarships in the nuclear energy field of study. • Support competitive exchange opportunity for UNLP fellows to tour nuclear facilities under the bilateral collaboration with the UK. • Bolster outreach efforts focused on increasing MSI involvement to include website resources, conference promotion, and university visits. • Support a new funding opportunity for faculty at two-year trade schools and community colleges for curriculum development and offer a summer school opportunity for students attending MSIs who are interested in nuclear science. • Support an OMNI internship program that will help build careers for talented cybersecurity and information technology professionals to strengthen the security of the Department, the national laboratories, and the nuclear industry.	• The increase will support a new funding opportunity that will pair a major nuclear engineering institution with an MSI that is looking to develop nuclear engineering expertise within its current programs. Activities will include a summer school or workshop opportunity for students interested in nuclear science and curriculum/program development. • The increase will also support a new opportunity to provide faculty at two-year trade schools and community colleges support for curriculum development to train the next generation of nuclear technicians, operators, and skilled craftspeople.

University Fuel Services

Description

University Fuel Services (UFS) provides fuel services for U.S. university research reactors.
UFS provides fresh reactor fuel to, and removes used fuel from, 25 operating university research reactors at 24 U.S. universities to support their continued operation. This provides continued research and training reactor capability to U.S. universities to ensure their continued ability to support U.S. nuclear energy initiatives in the areas of research, development, and educational opportunities.

The continued operation of U.S. university research reactors directly supports the successful execution of the nuclear energy research mission and plays an important role in developing future scientists and engineers in the U.S. These research reactors provide irreplaceable training, education, and research support to hundreds of students annually, and many hosting universities expand access to these reactors through partnerships with minority serving institutions in underserved or disadvantaged communities, including innovative online opportunities providing direct access to reactor operating data. UFS support ensures continued reactor operations that directly expand diversity of Science, Technology, Engineering and Math (STEM) opportunities. This subprogram sustains unique capabilities for research and development and educational opportunities supporting U.S. energy initiatives. Used nuclear fuel shipments support U.S. and Department of Energy non-proliferation and national security objectives.

UFS provides project management, technical support, quality engineering and inspection, and nuclear material support. Major program deliverables include procuring new plate fuel elements and shipping them to select universities; transporting used fuels from U.S. universities to a DOE site; procuring High Assay Low Enriched Uranium (HALEU) and shipping it to the Training, Research, Isotopes, General Atomics (TRIGA) Fuel Fabrication Facility (TFFF) in Romans, France, procuring fresh TRIGA fuel elements from the TFFF; and reusing lightly-irradiated TRIGA fuel currently in inventory at Idaho National Laboratory (INL) by retrieving, inspecting and shipping it to universities with the most urgent need.

Commercial fresh TRIGA fuel element production at the TFFF started in FY 2022. In FY 2025, UFS will continue to procure fresh TRIGA fuel elements to meet the increased fresh fuel requests from the 12 TRIGA research reactors located at U.S. universities based on recent assessments. TRIGA fuel needs by universities are anticipated to increase based on emergent and changing R&D missions and priorities. Additionally, UFS may repatriate foreign unused TRIGA fuel for use by university reactors.

Receipt, inspection, and storage of fresh TRIGA fuel elements will be executed at the INL. Universities with TRIGA reactors are unable to store all their needed fuel for their lifespan under Nuclear Regulatory Commission (NRC) possession limits. Fresh TRIGA fuel will be shipped from INL to the universities as needed.

UFS will also continue to ship used plate, TRIGA, and other types of reactor fuel elements from supported universities to DOE used fuel receipt facilities. The Department will continue its policy of reusing lightly irradiated TRIGA fuel in the DOE inventory and will evaluate additional alternative sources.

The existing North Carolina State University PULSTAR reactor fuel is reaching the end of its current core life. In FY 2025, funding will be used to continue fabrication of new fuel assemblies. Work will include fabrication of the fuel pins, manufacturing of fuel assembly zircaloy fuel boxes, and manufacturing of fuel assembly end fittings.

University Fuel Services
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
University Fuel Services **$17,500,000**	**$28,230,000**	**+$10,730,000**
• Procured 40 and delivered 27 plate fuel elements required by University of Missouri (MU) and Massachusetts Institute of Technology (MIT) • Established a contract to procure 90 Training, Research, Isotopes, General Atomics (TRIGA) fuel elements from the TRIGA Fuel Fabrication Facility (TFFF). • Procured and shipped High Assay Low Enriched Uranium (HALEU) metal to the TFFF in Romans, France, for fresh TRIGA fuel elements. • Completed five used fuel shipments to Savannah River Site (SRS). • Initiated fuel design and engineering studies; modeling, design and licensing of a shipment package, and procurement of fuel assembly boxes; and end fittings for the North Carolina State University (NCSU) PULSTAR reactor. • Continued UFS project management, quality assurance, nuclear material accountability, and transportation cask maintenance.	• Procure 40 and deliver between 33 and 36 plate fuel elements required annually by MU and MIT as determined by need and fuel availability. • As needed, ship up to two cask loads of lightly irradiated 8.5 wt% standard TRIGA fuel elements from the Irradiated Fuel Storage Facility at INL to select U.S. university research reactor facilities. • Procure up to 90 TRIGA fuel elements and as needed, procure and ship HALEU metal to the TFFF in Romans, France. • Manage the fresh TRIGA fuel elements receipt, inspection, and storage at the Idaho National Laboratory (INL). • Complete up to five used fuel shipments to SRS and the INL, pending resolution of moratorium on such shipments to the INL. • Procure fuel pins, fuel assembly boxes, and end fittings for the NCSU PULSTAR reactor. • Continue UFS project management, quality assurance, nuclear material accountability, and transportation cask maintenance.	• The increase reflects additional procurement of TRIGA fresh fuel elements to meet the increased requests from the 12 TRIGA research reactors located at U.S. universities based on recent assessments. • The increase provides support to prepare for the disposition of university partially used TRIGA fuel. • The increase supports management of the fresh TRIGA fuel elements receipt, inspection, and storage at INL until it is needed by the university reactors. • The increase provides funding for the fabrication of the fuel pins, fuel assembly boxes, and end fittings for the NCSU PULSTAR reactor.

Reactor Concepts Research, Development, and Demonstration

Overview

The Reactor Concepts Research, Development, and Demonstration (RD&D) program supports conducting RD&D on existing and advanced reactor designs and technologies. This RD&D enables industry to address technical and regulatory challenges associated with maintaining the existing fleet of nuclear reactors; promoting the development of a robust pipeline of advanced reactor designs, technologies, and associated supply chains; and progressing these advanced reactor designs and technologies towards demonstration when appropriate. Program activities are focused on addressing technical, economic, safety, and security enhancement challenges associated with the existing commercial light water reactor fleet and advanced reactor technologies, covering large, small, and micro-sized designs across an array of reactor concepts including those cooled by light water, liquid metal, gas, and molten-salt.

To maximize the benefits of nuclear power, the following challenges must be addressed:

- improving affordability of nuclear energy technologies;
- enhancing safety and reducing technical and regulatory risk;
- minimizing proliferation risks of nuclear materials; and
- improving the economics of new reactor deployment.

Reactor Concepts RD&D is key to enabling the industry to reverse the downward market trajectory of our nation’s nuclear energy sector by regaining a technological and market leadership role. Through cost-shared RD&D activities, related technical assistance, and cross-cutting innovative research and development (R&D), the Department will enable industry to accelerate the timeline for commercialization of new, advanced, and more economic reactor technologies that will help revive and expand domestic nuclear energy deployment while advancing America's leadership role in the global nuclear power sector and meeting our nation’s clean energy goals.

The Reactor Concepts RD&D program continues to support RD&D efforts focused on advanced reactors and the existing fleet in FY 2025. The Light Water Reactor Sustainability (LWRS) subprogram conducts research in support of light water reactor (LWR) technologies so that LWR-based commercial nuclear power plants can continue to provide safe, clean, and reliable energy. The goal is to enable industry to enhance the efficient and economic performance of current nuclear power plants while enabling their extended operation. A critical element of the subprogram is cost-shared, private-public partnerships to help industry resolve its highest priority and highest uncertainty technical issues where U.S. government partnership is appropriate.

The Advanced Reactor Technologies (ART) subprogram conducts targeted R&D on advanced reactor technologies, including molten salt reactors, liquid metal-cooled reactors, high temperature gas-cooled reactors, and microreactors. The subprogram also supports work on cross-cutting R&D that can be applied to multiple advanced reactor concepts, including non-light water reactor SMRs. This subprogram focuses on efforts in the following areas: fundamental technologies and design methods for advanced reactors, interactions of diverse reactor coolants with materials and components, advanced energy conversion, research to enhance safety and reduce regulatory risk, experimental validation of models, advanced materials qualification, and continued international collaborations. The ART subprogram will also support competitively awarded projects to assist the progression of emerging advanced reactor designs and technologies.

With the November 2023 cancellation of the Carbon Free Power Project, no funding is requested to continue the Advanced SMR RD&D subprogram in FY 2025. Domestic supply chain support is requested under the Nuclear Energy Enabling Technology, Advanced Materials and Manufacturing Technologies subprogram.

Highlights of the FY 2025 Budget Request

The ART subprogram will continue to support execution of two of the three Advanced Reactor Concepts 2020 (ARC-20) awards to reduce technical and regulatory risks for innovative advanced reactor designs that can be demonstrated by the mid-2030s or later. The Massachusetts Institute of Technology (MIT) ARC-20 award will be completed in FY 2024.

Reactor Concepts Research, Development, and Demonstration
Funding ($K)

	FY 2023 Enacted Comparable	FY 2024 Annualized CR Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Reactor Concepts Research, Development and Demonstration					
Advanced Small Modular Reactor RD&D	164,400	164,400	0	-164,400	-100.0%
Light Water Reactor Sustainability	44,400	44,400	35,000	-9,400	-21.2%
Advanced Reactor Technologies	59,072	59,072	43,800	-15,272	-25.9%
Integrated Energy Systems	12,000	12,000	9,500	-2,500	-20.8%
Total, Reactor Concepts Research, Development and Demonstration	**279,872**	**279,872**	**88,300**	**-191,572**	**-68.4%**

Reactor Concepts Research, Development and Demonstration
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Advanced Small Modular Reactor RD&D: The decrease from $164,400,000 to $0 reflects the November 2023 termination of the Carbon Free Power Project and the transfer of SMR supply chain efforts into the Nuclear Energy Enabling Technology program.	-164,400
Light Water Reactor Sustainability: The decrease from $44,400,000 to $35,000,000 reflects a reprioritization of competitively selected industry-led projects to directed R&D that will develop technologies to improve the economic competitiveness of the existing fleet.	-9,400
Advanced Reactor Technologies: The decrease from $59,072,000 to $43,800,000 reflects completion of construction of the non-nuclear power conversion test in Microreactor AGile Non-nuclear Experimental Test bed (MAGNET) in FY 2024; and completion of funding of the ARC-20 projects in FY 2023.	-15,272
Integrated Energy Systems: The decrease from $12,000 to $9,500 reflects the completion of core Integrated Energy Systems modeling and simulation capabilities.	-2,500
Total, Reactor Concepts Research, Development & Demonstration	**-191,572**

Reactor Concepts Research, Development and Demonstration
Advanced Small Modular Reactor RD&D

Description
The Advanced Small Modular Reactor (SMR) Research, Development, and Demonstration (RD&D) subprogram provided support to help re-establish U.S. leadership in nuclear energy by maturing SMR concepts toward commercial readiness. A range of significant technological accomplishments were achieved in developing advanced SMR designs.

No funding is requested in the FY 2025 budget for the Advanced SMR RD&D subprogram. In FY 2025, efforts to support the domestic build-out of the SMR supply chain will continue under the Nuclear Energy Enabling Technologies program.

Advanced Small Modular Reactor RD&D

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Advanced Small Modular Reactor RD&D $164,400,000	**$0**	**-$164,400,000**

• Completed federal financial support for the NuScale SMR First-of-a-Kind Nuclear Demonstration Readiness Project, which supports the development of a U.S. SMR technology for deployment in domestic and international markets. Specific project activities include:
  o Completion of a Standard Plant Design, which will support deployments both domestically and abroad.
  o Submission of the Standard Design Approval Application (SDAA) to the Nuclear Regulatory Commission (NRC) for review and approval.
• Continued support for the Carbon Free Power Project, the first domestic demonstration of the NuScale SMR technology, on a timeline to achieve commercial operation of the first module by 2029 and the remaining five modules by 2030. Specific project activities include:
  o Completion of a Class 3 project cost estimate.
  o Collection of site environmental data needed for licensing.
  o Preparation of a Combined License Application (COLA) for submittal to the NRC in January 2024.
  o Initiation of a Class 2 project cost estimate and site-specific preliminary engineering.
	• No funding is requested to continue this program in FY 2025. Domestic supply chain support will continue under the Nuclear Energy Enabling Technology program.	• The decrease reflects the private sector's decision to terminate the Carbon Free Power Project in November 2023. Small modular reactor supply chain efforts transfer into the Nuclear Energy Enabling Technology program.

Description

The Light Water Reactor Sustainability (LWRS) subprogram conducts research and development (R&D) on technologies and other solutions that can improve economics, sustain safety, and maintain the technical reliability of the current domestic fleet of commercial nuclear power plants.

The focus of the subprogram is on conducting R&D that addresses the nuclear industry's economic challenges that have led to premature plant shutdowns. LWRS will continue to collaborate with nuclear power plant owner-operators, vendors, suppliers, industry support organizations, other research organizations, and the Nuclear Regulatory Commission (NRC) to closely coordinate research that both supports industry needs and maximizes taxpayer benefit.

The LWRS subprogram consists of the following R&D areas:

- Plant Modernization: R&D to address nuclear power plant economic viability in current and future energy markets by increasing efficiency through the implementation of digital technologies. The R&D products will enable modernization of plant systems and processes across the industry by enabling a shift from a labor centric to a technology-centric business model that supports improved performance at a lower cost.
- Flexible Plant Operations and Generation: R&D to establish the technical feasibility and economic potential of dispatching thermal and electrical energy to diversify and increase revenue of commercial light water reactors in the U.S. The R&D products, including hydrogen production demonstration activities, will allow the existing fleet of nuclear reactors to readily respond to rapid changes in electricity supply and demand due to the widespread adoption of variable renewable energy resources and demonstrate the ability to repurpose nuclear power reactors into flexible energy sources for low-carbon industrial commodity production.
- Risk-Informed Systems Analysis: R&D to support decision-making related to the economics, reliability, and safety of the existing fleet by providing analysis solutions for integrated plant systems. By applying advanced quantitative methods, these activities support the improvement of plant operational procedures, plant asset management, and operations and maintenance activities. In addition, the R&D products in this area will be used to optimize plant economic performance and safety by incorporating the impacts of physical aging and degradation processes.
- Physical Security Research: R&D that will validate methods and tools which can be used to implement an updated, cost-effective physical security regime. The R&D products are expected to enable companies across the industry to reduce excessive conservatisms in security modeling, leverage automation as force multipliers, optimize security postures, and develop additional means to risk-inform approaches to evaluate security changes.
- Materials Research: R&D to develop the scientific basis for understanding and predicting long-term environmental degradation behavior of materials in nuclear power plants. The R&D products will be used to define operational limits and aging mitigation approaches for materials in nuclear power plant systems, structures, and components (SSC) subject to long-term operating conditions, providing key input to both regulators and industry.

In FY 2025, the LWRS subprogram will continue to leverage cost-shared, private-public partnerships and our national laboratory system to conduct R&D to resolve industry's highest priority and highest uncertainty challenges where U.S. government partnership is appropriate. These high priority areas include providing science and technology-based solutions to improve the current business model and associated practices of the current fleet and develop the scientific bases for managing the aging of SSCs to allow existing nuclear power plants to continue to operate safely and cost-effectively.

Light Water Reactor Sustainability

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Light Water Reactor Sustainability **$44,400,000**	**$35,000,000**	**-$9,400,000**
• Plant Modernization - Completed development of the Integrated Operations for Nuclear business operating model and demonstrate its use with an operating nuclear power plant which will allow utilities to shift their operations from a labor centric to a technology centric business model. Produced an Artificial Intelligence/Machine Learning methodology to achieve a fully automated risk-informed predictive maintenance strategy. • Flexible Plant Operation and Generation - Developed the methods and licensing approach for thermal extraction, thermal energy storage, and distribution. Engineered and simulated operations and control systems for direct use of heat generated from the existing light water reactor fleet. Developed architectural and engineering models, and investor-grade reports to detail the opportunities for providing clean thermal and electrical energy for industrial applications (e.g., hydrogen, ammonia, metals, chemicals, and fuels production). • Risk-Informed Systems Analysis – Enhanced the algorithm used to optimize the reactor core reload process and enable crediting Terry Turbines for extended operation, which will expand the mitigation options available to operators under both normal and emergency conditions. • Physical Security - Delivered guidance to industry on the use and implementation of	• Plant Modernization – Provide guidance to industry on plant-wide nuclear plant modernization to deliver sustainable instrumentation and control technologies for plant operation. Develop and demonstrate artificial intelligence and machine learning technologies to improve and automate monitoring and control of plant systems and tie real-time plant information to automated work activities at operating plants to enhance plant performance during long term operation. • Flexible Plant Operation and Generation – Provide technical assistance to develop nuclear thermal and chemical energy pathways for industrial, commercial, and transportation applications. Continue research to reduce the regulatory risk of nuclear-integrated industrial applications. Study thermal extraction for boiling water reactors at scales over 500 megawatts of thermal power. Design reference plants with detailed cost analysis for LWR-integrated thermal energy storage systems. • Risk-Informed Systems Analysis – Complete demonstration of core-reload analysis software that can be used to minimize the volume of new fuel needed during refueling, reducing the costs for new nuclear fuel and reducing the volume of spent fuel on the back end. • Physical Security – Finalize Remote Operated Weapons System (ROWS) model-based simulator installation and training to improve the efficiency	• The decrease reflects a reprioritization of competitively selected industry-led projects to directed R&D that will develop technologies to improve the economic competitiveness of the existing fleet.

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
dynamic risk analysis tools to support dynamic physical security risk assessments, reducing utility security cost burdens and improving market competitiveness. • Materials Research - Published a methodological guideline on concrete degradation for industry and accompany with the public release of Microstructure Oriented Scientific Analysis of Irradiated Concrete (MOSAIC) for industry use. Completed material harvesting from the reactor pressure vessel at the Palisades Nuclear Generating Station to support validation of materials degradation models.	of the physical security posture at commercial nuclear power plants. Conduct pilot studies of commercial-off-the-shelf water intake detection technologies at various nuclear power plant sites in seawater environments to ensure high reliability of sensing capability with low nuisance and false alarm rates. • Materials Research – Provide guidance on methods for mitigation techniques of stress corrosion cracking in Nickel-based alloys used in many nuclear plant pressure boundaries, as well as methods for plant-wide cable monitoring and inspection technologies and methods. Implement the reactor pressure vessel predictive embrittlement model through American Society for Testing and Materials (ASTM) and American Society of Mechanical Engineers (ASME) for code acceptance and wide industry use.	

Reactor Concepts Research, Development and Demonstration
Advanced Reactor Technologies

Description

The Advanced Reactor Technologies (ART) subprogram conducts essential research and development (R&D) activities to reduce technical risks associated with advanced reactor technologies and systems. The subprogram R&D scope reflects input from advanced reactor stakeholders with a goal of enabling industry to mature and ultimately demonstrate advanced reactor technologies in the 2030s. Innovative advanced reactor concepts have the potential to offer significant benefits versus existing technologies, including possible lower costs, enhanced safety and security, greater resource utilization, and simplified operations. Such advantages could allow nuclear energy to increase its contributions to domestic clean and resilient energy sources and to support the growth of high-quality, high-paying U.S. jobs. The ART subprogram conducts R&D that can help reduce long-term technical barriers for multiple reactor technology concepts. This subprogram will address the full range of high-value R&D to advance technologies that benefit multiple advanced reactor concepts, including microreactor designs, and stimulate new ideas for transformational future concepts. The ART subprogram supports the Microreactor Applications, Research, Validation and Evaluation (MARVEL) project. MARVEL will be a nuclear microreactor test platform to test microreactor technologies and end-use applications.

ART R&D efforts support innovative reactor concepts, including high temperature gas-cooled reactors (HTGR), fast reactors, and molten salt reactors (MSR) using liquid salt coolants and/or fuels. The ART subprogram focuses on industry-informed R&D priorities that would provide widely-applicable benefits across many different advanced reactor concepts including: fundamental technologies and design methods for advanced reactors; interactions of advanced reactor coolants with components; advanced systems and components that can operate in extreme high temperature environments; research to enhance safety; advanced materials codification; cross-cutting areas of support in advanced energy conversion technologies; and research to support microreactors for remote and micro-grid commercial applications. The ART subprogram conducts R&D to enhance the likelihood of future demonstration and commercialization of emergent advanced reactor technologies. The ART subprogram continues support for international collaborations on advanced reactor operations and safety promoting the development of advanced reactors in the United States (U.S.) and supporting deployment of U.S. technologies in the global marketplace. The ART subprogram supports R&D activities to irradiate, characterize and qualify nuclear grades of graphite and to establish design rules to enable use of graphite in high temperature reactors.

Industry-led, cost-shared R&D activities are supported through competitively selected industry awards to reduce technical and regulatory risks associated with advanced reactor designs. Specifically, in FY 2021, DOE announced the selection of three awards to support the development of designs that could have significant impact on the energy market in the mid-2030s or later. These projects continue to meet project milestones. The three concepts selected for award were:

- Development of a conceptual design of a seismically isolated advanced sodium-cooled reactor facility - Advanced Reactor Concepts, LLC;
- Development of a fast modular reactor conceptual design with verifications of key metrics in fuel, safety, and operational performance - General Atomics; and
- Maturing the Modular Integrated Gas-Cooled High Temperature Reactor (MIGHTR) concept from a pre-conceptual stage to a conceptual stage - MIT.

The MIT ARC-20 project is planned to be completed in FY 2024. FY 2025 activities for the ART subprogram will focus on essential research to address the highest priority challenges facing advanced reactor technologies and continued support for innovation through cost-shared partnerships with industry.

Advanced Reactor Technologies

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Advanced Reactor Technologies **$59,072,000**	**$43,800,000**	**-$15,272,000**
• Fast Reactor Technologies – Performed additional testing of the Thermal Hydraulic Experiment Test Article (THETA) in the Mechanisms Engineering Test Loop (METL) to generate data for fast reactor design and safety code validation. Performed model development and experimental validation activities to support development and licensing activities for fast reactors. • Gas Reactor Technologies – Performed modeling and simulation activities to analyze pebble bed reactor core performance and optimize reactor design. Performed experimental validation of design basis and off-normal conditions and supported modeling and simulation activities using the water-based reactor cavity cooling system at the natural convection shutdown heat removal test facility (NSTF) at Argonne National Laboratory (ANL). Supported long term testing to characterize creep behaviors of high temperature alloys. • Molten Salt Reactor (MSR) Technologies – Maintained and expanded the molten salt thermal properties database to aid in the design and licensing of MSRs. Developed and demonstrated online monitoring technologies to meet deployment process control needs with the transition from laboratory scale experiments to the Liquid Salt Test Loop at the Oak Ridge National Laboratory • Microreactor Technologies – Continued qualification and testing of high temperature	• Fast Reactor Technologies – Commission the Gripper Test Article, which simulates the fuel assembly gripper in a compact in-vessel fuel handling mechanism, for sodium testing in METL. Complete quality assurance on software to predict the safety performance of fast reactors. Complete the data package preparation for the initial Alloy 709 ASME code case (100,000 hours) by utilizing the years of data generated by the ART program. • Gas Reactor Technologies – Complete High Temperature Test Facility (HTTF) thermal hydraulic code validation benchmark with industry, academic, and international collaborators. Complete modeling and simulation activities associated with the water-based reactor cavity cooling system experimental campaign at the NSTF at ANL. • Molten Salt Reactor (MSR) Technologies – Continue testing of sensors at the liquid salt test loops at the Oak Ridge National Laboratory (ORNL) to support MSR applications. Further expand the molten salt thermal properties database to aid in the design and licensing of MSRs. • Microreactor Technologies –Complete fabrication of fuel and components for the Microreactor Applications, Research, Validation and Evaluation (MARVEL) test platform and initiate construction to enable demonstration of microreactor technologies and end-use applications. Begin	• The decrease reflects completion of construction of the non-nuclear power conversion test in MAGNET in FY 2024; and completion of funding of the Advanced Reactor Concepts 2020 (ARC-20) projects in FY 2023.

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted

moderator materials that have the broadest potential application for microreactor applications. Completed design of nonnuclear integrated testing and validation capabilities for microreactor systems and operation. Completed 90% final design for the Microreactor Applications, Research, Validation and Evaluation (MARVEL) test platform (nuclear microreactor test platform to demonstrate the integration of commercial end-user applications).
• Graphite - Further irradiated high dose graphite experiment in INL's Advanced Test Reactor (ATR) to subject graphite to doses that more closely reflect what would be experienced in pebble bed type reactors. Performed additional characterization and post-irradiation examination (PIE) of graphite specimens to provide qualification data of various grades of graphite for use in high temperature reactors. Supported additional testing and activities for American Society of Mechanical Engineers (ASME) code qualification of nuclear grade graphite and establish design rules for use in high temperature reactors.
• Industry Awards (ARC-20) – Supported execution of the three ARC-20 projects per established project plans using current and prior year carryover funds. Specific project activities include:
  ○ For the Advanced Reactor Concepts, LLC award: Conducted further pre-application engagement with the NRC. Completed conceptual design report. Continued activities to support design and licensing.
  ○ For the General Atomics award: Conducted further pre-application
	testing first non-nuclear power conversion test in MAGNET to provide valuable data on integrated microreactor system operation. Continue production of high-quality data on performance of microreactor technologies to enhance the viability of microreactor concepts and drive down cost.
	• Graphite - Complete high dose graphite (HDG-1) irradiation, which will improve understanding of graphite behavior with high levels of irradiation damage. Continue to support additional testing and activities to achieve ASME code qualification of nuclear grade graphite and establish design rules for use in high temperature reactors.
	• Industry Awards (ARC-20) – Support execution of the three ARC-20 projects per established project plans and using prior year carryover funds. Specific project activities include:
	  ○ For the Advanced Reactor Concepts, LLC award: Complete preliminary design of the ARC-100 plant. Complete cost report, preliminary constructability review, and final report of 3-D SMARTPLANT model.
	  ○ For the General Atomics award: Complete preliminary cost analysis for the General Atomics fast modular reactor concept. Finalize conceptual design of reactor. Continue fuel irradiation testing in INL's Advanced Test Reactor and complete fuel testing in INL's Transient Reactor Test Facility.	

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
engagement with the NRC. Completed report documenting analysis of reactor passive safety. Initiated and progressed fabrication of fuel rodlets for irradiation in INL's ATR. o For the MIT award: Completed preliminary manufacturing and licensing assessments for the modular integrated gas-cooled high temperature reactor (MIGHTR). Completed conceptual core design and demonstrated adequate performance by the passive decay heat removal system.		

Reactor Concepts Research, Development and Demonstration
Integrated Energy Systems

Description

Integrated Energy Systems (IES) supports R&D to expand the role of nuclear energy by developing technologies that support electrical, thermal, and chemical energy pathways that deliver nuclear energy both on and off the electricity grid. Integrated nuclear systems will allow carbon-free nuclear energy to complement other energy sources and to decarbonize industrial, chemical, and transportation applications.

The goals of the Integrated Energy Systems Program include:

- Expanding nuclear capability in the electricity sector by providing flexible electrical generation capacity to the grid with thermal energy storage systems.
- Serving industrial loads by enabling the deployment of nuclear reactors with thermal distribution and control systems capable of delivering heat directly to major industrial and commercial applications.
- Serving the industrial and transportation sectors by converting nuclear energy into fuels and chemicals for industrial processes and transportation applications (e.g., hydrogen, synthetic liquid fuels)

Integrated Energy Systems focuses on researching energy pathways from nuclear reactors to transportation, industrial, and commercial applications through electrical, thermal, and chemical energy forms. To increase the value of nuclear generated electricity, the IES subprogram focuses on thermal energy storage to provide the flexible capacity needed to balance supply and demand. IES researches several options for very low cost, robust energy storage systems based on the thermal capacity of low-cost storage media such as molten salts, sand, aggregate or concrete, as well as the potential for geothermal energy storage and thermo-chemical systems. IES modeling capabilities are used to understand the value of thermal energy storage for various regions, at hourly to seasonal time scales, for purposes of balancing nuclear energy sources with electrical or process heat demand, or balancing variable renewable generation.

Heat is produced by the reactor at very low cost without the expense or inefficiency of electricity generation and distribution. The IES program will conduct research on utilizing heat for industrial applications in close proximity to the reactors. IES analyzes industrial requirements by developing reference plant designs, determining process heat and temperature requirements, assessing industrial hazards to determine appropriate distance from the plant, and evaluating several options for heat exchangers and thermal transport systems (e.g. steam, molten salts, nitrogen, CO2, oils) for cost, performance, and durability. The program researches turbine engines to optimize the configuration of nuclear plants that cogenerate electricity and industrial process heat, and heat pumps are explored to provide temperature boosting for industrial applications that require temperatures higher than what a reactor can provide.

While chemical energy is more expensive to produce, it is inexpensive to move, store, and dispense. It has unmatched energy density at small scales suitable for the majority of vehicular transportation or equipment. IES focuses on developing nuclear e-fuels that can be made with carbon-neutral carbon sources (e.g. captured CO_2 emissions) and distributed into the existing infrastructure as a gas or a liquid, as well as polymers and chemicals such as ammonia and methanol, that are broadly used in the agriculture and industrial sectors. The IES program focuses on process optimization and trade studies with a variety of options for plant unit operations in order to reduce the cost of nuclear e-fuels and chemicals to competitive levels. Test data for unit processes is essential for model verification and obtained at appropriate scales to capture real-world phenomena. These test data, as well as improved estimates for plant capital costs will ensure that techno-economic analysis can support investment decisions for nuclear e-fuels and chemical energy pathways.

FY 2025 activities for IES include cost analysis for thermal storage technologies to support the electric grid; greater emphasis on research, development, and testing of thermal system components and their integration, including heat exchangers, heat engines, and heat pumps; as well as testing unit processes to validate models for chemical energy pathways that include polymers, chemicals and synthetic fuels production applications.

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Integrated Energy Systems **$12,000,000**	**$9,500,000**	**-$2,500,000**
• Developed integrated energy systems techno-economic assessments; thermal storage and distribution, dynamic controls, and site integration technology for using clean nuclear heat and electricity from advanced reactors to decarbonize distributed industrial applications. • Developed thermal quantity and quality requirements, engineering requirements, and safety basis for industrial applications including refining, combined heat and power, hydrogen and synthetic fuels production, and ammonia production. • Completed modeling tool development for modeling dynamic integrated energy systems.	• Complete reference industrial plant designs for nuclear integration with refineries, fuel and chemical synthesis, and biomass processing. • Begin developing reference plant designs for polymers, chemicals, and metal processing plants, • Develop and test thermal distribution components and systems for a variety of heat transfer fluids as necessary for system modeling and design. • Validate thermally integrated chemical synthesis reactors or process parameters needed for economically feasible nuclear energy pathways.	• The decrease reflects the completion of core Framework for Optimization of Resources and Economics (FORCE) modeling and simulation capabilities.

Fuel Cycle Research and Development

Overview

The Fuel Cycle Research and Development (FCR&D) program conducts applied research and development (R&D) on advanced fuel cycle technologies that have the potential to accelerate progress on managing and disposing of the nation's spent fuel and high-level waste, improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk. Advancements in fuel cycle technologies support the enhanced availability, economics, and security of nuclear-generated electricity in the U.S., further enhancing U.S. energy independence and economic competitiveness. The FCR&D program also contributes to the Department's policies, and programs for ensuring a secure reliable and economic nuclear fuel supply for both existing and future reactors.

The FCR&D program participates in world-class R&D and employs internationally renowned technical experts. FCR&D subprograms leverage their technical expertise by participating in international collaborations through bilateral and multilateral technical agreements. The program also participates in projects sponsored by the International Atomic Energy Agency and the Organization for Economic Cooperation and Development/Nuclear Energy Agency which provides further leverage in key technical areas.

The program supports R&D and evaluation of spent fuel and high-level waste disposition pathways, covering storage, transportation, and disposal technologies. The program also supports R&D on multiple advanced fuel technologies that hold promise for enhanced performance and improved economics or are an important element in the development of the next generation of reactor designs; making available small quantities of High Assay Low Enriched Uranium (HALEU) in the short term and working with industry to build out commercial HALEU production in the long term to support demonstration of advanced reactor technologies.

Fuel Cycle Research and Development
Funding ($K)

	FY 2023 Enacted Comparable	FY 2024 Annualized CR Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Fuel Cycle Research and Development					
Material Recovery and Waste Form Development	44,500	44,500	38,500	-6,000	-13.5%
Mining, Conversion, and Transportation	2,000	2,000	2,000	0	0.0%
Accident Tolerant Fuels	96,000	96,000	97,900	+1,900	+2.0%
Fuel Cycle Laboratory R&D	15,000	15,000	15,000	0	0.0%
Next Generation Fuels	47,400	47,400	43,290	-4,110	-8.7%
Advanced Nuclear Fuel Availability	100,000[1]	100,000	150,000	+50,000	+50.0%
Used Nuclear Fuel Disposition R&D	47,000	47,000	47,000	0	0.0%
Integrated Waste Management System	53,000	53,000	53,000	0	0.0%
Total, Fuel Cycle Research and Development	**404,900**	**404,900**	446,690	**41,790**	**+10.3%**

[1] Funded by Ukraine Supplemental Appropriations Act, 2023 (P.L. 117-180)

Fuel Cycle Research and Development
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Material Recovery and Waste Form Development Funding decrease from $44,500,000 to $38,500,000 reflects a reduced effort on hybrid ZIRCEX demonstration.	**-6,000**
Accident Tolerant Fuels Funding increase from $96,000,000 to $97,900,000 reflects focus on meeting industry's objectives for developing the near-term ATF concepts.	**+1,900**
Next Generation Fuels Funding decrease from $47,400,000 to $43,290,000 reflects ramping down of the TRISO fuel qualification program as it nears completion and high-cost activities such as irradiation experiments are completed.	**-4,110**
Advanced Nuclear Fuel Availability Funding increase from $100,000,000 to $150,000,000 reflects expanding recovery and downblending at Savannah River Site. HALEU production at Piketon increases and shifts from a 50-50 cost share demonstration to a cost-plus incentive fee basis.	**+50,000**
Total, Fuel Cycle R&D	**+41,790**

Fuel Cycle Research and Development
Material Recovery and Waste Form Development

Description

The Material Recovery and Waste Form Development (MRWFD) subprogram conducts applied research and development (R&D) on advanced fuel recycle technologies that have the potential to improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk. The subprogram focuses on developing advanced fuel recycling technologies and addressing fundamental materials separations and recovery challenges that present significant degrees of technical risks and financial uncertainties.

MRWFD provides unique nuclear chemistry expertise and technical capabilities in separation technologies to a broad range of applications by seeking a fundamental understanding of various chemical challenges related to civil nuclear applications. MRWFD stewards the capabilities and knowledge relied upon by policy makers to make informed decisions regarding nuclear fuel cycle options. Such decisions in turn rely on the development of efficient and economical separation methods that can accept the used nuclear fuel containing actinides and fission products to recycle selected actinides, recover valuable by-products, and deliver waste streams that are suitable for disposal. For example, MRWFD supports molten salt chemistry research to support advanced nuclear technologies using molten salts as electrolytes, fuel solvent and coolants. MRWFD funds research on integrated advanced technologies encompassing R&D on off gas capture and immobilization and advanced robust waste form development. The subprogram employs a science-based approach to foster innovative and transformational technology solutions to achieve this objective.

The MRWFD subprogram supports the development and demonstration of various recycling technologies to make available small quantities of high-assay low enriched uranium (HALEU) materials for advanced reactor fuel-fabrication R&D needs. HALEU can be recovered from feedstock that contains highly-enriched uranium (HEU) by using the molten salt and hybrid Zirconium Extraction (ZIRCEX) processes. For example, MRWFD supports the development of simplified salt process and advanced solid cathode technology which improve operations efficiency. The subprogram continues to evaluate the feasibility of recycling federally owned HEU fuels for HALEU production by developing hybrid ZIRCEX technology using a ¼-scale vapor phase demonstration pilot facility at Idaho National Laboratory. In FY 2025, the hybrid ZIRCEX activity will continue supporting R&D in advanced chlorination agents via starting a pilot scale demonstration to improve the economic and efficiency of the process and demonstrating the feasibility of aluminum extraction using unirradiated fuel from the Advanced Test Reactor. The subprogram also continues supporting the accelerated treatment of irradiated Experimental Breeder Reactor-II (EBR-II) fuel to produce HALEU materials for advanced reactor fuels R&D needs. The accelerated EBR-II fuel activity will also support fulfilling a supplemental agreement between DOE and the State of Idaho to complete treatment of all sodium bonded EBR-II driver fuel by December 2028.

Specifically, the MRWFD subprogram will continue to support R&D in the following areas:

- HALEU Material Productions;
- Aqueous Processing & Vapor Phase Technologies;
- Pyro-processing Technologies; and
- Advanced Waste Forms and Off-gas Technologies

Material Recovery and Waste Form Development
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Material Recovery and Waste Form Development **$44,500,000**	**$38,500,000**	**-$6,000,000**
• Continued the acceleration of EBR-II used fuel treatment. • Conducted lab scale demonstration of an innovative aqueous separation technology for simplified uranium recovery. • Determined efficiency of advanced complexants for improved actinide separations. • Initiated a simplified lithium chloride based single salt flowsheet for pyroprocessing technology. • Demonstrated a new salt waste form baseline using iron phosphate technology. • Continued developing innovative sorbent materials for off-gas technologies. • Continued vapor phase extraction and hybrid ZIRCEX technology development.	• Continue accelerated EBR-II Driver Fuel recycle under 24/7 schedule with target annual production of 1,200 Kg in FY 2025 • Initiate new pilot scale demonstration using advanced chlorination agent for potential HALEU production. The pilot scale chlorination demonstration study is anticipated to last for three to five years. • Initiate simplified uranium recovery lab-scale demonstration to target HALEU containing fuels. The demonstration is expected to become fully operational in FY 2025. • Complete Adv Vol-oxidation lab experiments to demonstrate skipping acid dissolution and to improve off-gas management. • Demonstrate new tailored ligands to enhance separation efficiency and minimize irradiation damage. • Demonstrate electrolytic conversion of uranium metal to uranium chloride. • Demonstrate key operations of simplified single-salt pyroprocessing flowsheet for oxide and metallic fuels. • Demonstrate the new iron phosphate for advanced salt waste form. • Initiate iodine off-gas capture and immobilization demonstration.	• Funding decrease reflects a reduced scope in hybrid ZIRCEX technology demonstration.

Fuel Cycle Research and Development
Mining, Conversion, and Transportation

Description

This subprogram supports R&D that enables technological advances in uranium mining, conversion, and transportation capabilities in the United States as well as conducting evaluations and assessments related to these areas. This subprogram supports activities related to the front end of the nuclear fuel cycle and supply chain.

Mining sites are often located in underserved communities and locations with limited water resources. Improvements to mining technology spurred by R&D may enable local economic opportunities and include environmental justice equities while reducing the amount of water used during uranium production.

In FY 2025, this subprogram will continue (1) supporting technical experts at national labs to develop innovative separation technologies to improve in-situ uranium extraction efficiency and resource utilization for mining industry, and (2) demonstration efforts to restore groundwater geochemical conditions in-situ to background levels for uranium recovery operations.

Mining, Conversion, and Transportation
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Mining, Conversion, and Transportation $2,000,000	**$2,000,000**	**$0**
• Continued R&D for uranium mining and processing technologies that reduce water usage and/or improve extraction efficiency and resource utilization for uranium production.	• Continue the demonstration efforts to restore groundwater geochemical conditions in-situ to background levels for uranium recovery operations.	• No funding change.

Fuel Cycle Research and Development
Accident Tolerant Fuels

Description

The subprogram mission is enabling industry's development of one or more light water reactor (LWR) fuel concepts with significantly enhanced accident tolerance through cost shared research and development (R&D).

Following the accident at Fukushima, the Office of Nuclear Energy responding to Congressional guidance initiated a program in collaboration with LWR fuel suppliers, commercial reactor owner/operators, national laboratories, and universities to explore advanced LWR fuel with enhanced accident tolerance, including under severe accidents, to benefit the existing U.S. commercial nuclear power reactor fleet. After five years of feasibility studies, industry interactions, and assessments of potential fuel concepts, the industrial program participants identified promising concepts that have the potential to significantly enhance accident tolerance. To implement the industrial collaboration, competitively-awarded, cost-shared cooperative agreements were established with three fuel vendors and the Department. The program has progressed to testing fuel within operating commercial reactors and in parallel analyzing the performance of vendor-selected test fuels at the national laboratories, primarily to address data needed to support licensing.

The U.S. fuel suppliers are developing accident tolerant fuel concepts that the owner/operators of commercial U.S. reactors expect will provide substantial performance improvements during accidents and under normal operations. The enhanced performance expected of the accident tolerant fuel may also enable the fuel to operate for a longer period of time in the reactor. This would allow reactors to operate for longer times between refueling outages. Many reactors would be able to increase their cycle lengths from 18 to 24 months, and less fuel would be needed to generate the same amount of electricity resulting in substantially reduced spent nuclear fuel storage and disposal requirements. The use of accident tolerant fuel will also enable utilities to consider additional power uprates, a significant potential for improved utility economics.

This subprogram continues to support the industry's objective to initiate installing the first commercial quantities of accident tolerant fuel by the mid-2020s and also qualify the fuel for use at higher burnup levels. The many facets of the program are progressing at different timelines. These include near-term concepts such as coated cladding, doped UO2 fuel pellets, high burnup fuel, and higher enrichment levels. All of this involves cost-shared testing and examination of fuel and cladding material performance to generate data that can be used by industry partners to support their Nuclear Regulatory Commission (NRC) licensing efforts, research and development of pilot fuel pellet and cladding manufacturing equipment, analysis and redesign of fuel fabrication processes, and revising fuel performance codes and methods.

This subprogram is primarily using the experimental and advanced analytical capabilities, only found at the Department of Energy (DOE) National Laboratories, to provide the U.S. nuclear industry with the data needed to qualify the accident tolerant fuel concepts. This includes fuel use at higher burnup levels and demonstrating the performance of the fuel to take advantage of the safety and economic benefits that come with these more robust fuel designs. In FY 2025, this includes continuing the modifications at Idaho National Laboratory to expand its experimental capabilities. This involves: (1) continuing design, fabrication, and testing of experimental capsules to house irradiated fuel samples to simulate loss of coolant accident conditions in the INL transient reactor test facility (TREAT) and (2) completing the design and installation of a new test loop (I-Loop) in the Advanced Test Reactor (ATR). Both provide world-class experimental capabilities that were lost when the Halden test reactor in Norway shut down. These capabilities involve simulating boiling and pressurized water reactor conditions, highly-instrumented test trains, ramp testing, and dry-out testing. In addition, enhancements of the ORNL Severe Accident Test Station (SATS) will continue to provide licensing data. Also, in FY 2025, the partnership with industry to implement the necessary test plans to develop the data needed to qualify the accident tolerant fuel concepts for higher burnup will continue.

One significant change in FY 2025 is that this Accident Tolerant Fuel subprogram will focus solely on the near-term accident tolerant fuel concepts: coated cladding and doped UO2 pellets. These are the concepts that are most advanced and are capable of meeting industry's objective of near-term deployment. The long-term concepts: silicon carbide cladding, iron-chrome-aluminum cladding, and high uranium density fuel, will join other advanced fuel concepts in the new Next Generation Fuels subprogram. These fuel concepts are at lower technology readiness levels and will require more years of research and development.

Accident Tolerant Fuels
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Accident Tolerant Fuels $96,000,000	**$97,900,000**	**+$1,900,000**
• Continued irradiations of fuel rodlets in the central water loop of the ATR. Initiated advanced instrumented tests to expand data generation for real time fuel performance under irradiation. • Continued partnership with industry to support the Fuel Performance and Testing Technical Experts Group for burnup extension. This includes examination of high burnup fuel rods, furnace testing, re-irradiation of test samples in ATR, and loss of coolant tests in TREAT. • Conducted advanced LWR fuel technology research on ceramic fuel and cladding concepts. This includes fabrication technology development, separate effects irradiation tests in High Flux Isotope Reactor (HFIR) and ATR, and advanced characterization of properties and irradiation performance. • Continued to advance the accident tolerant fuel concepts under development by the three fuel vendor teams under cooperative agreements with the Department. This involves cost-shared testing and examination of fuel and cladding material performance, research and development of pilot fuel pellet and cladding manufacturing equipment, analysis and redesign of fuel fabrication processes, and revising fuel performance codes and methods.	• Continue to support the accident tolerant fuel concepts under development by the three fuel vendor teams under cooperative agreements with the Department. This involves cost-shared testing and examination of fuel and cladding material performance, and appropriate research and development support. • Continue irradiation of test rods in commercial reactors and examine them in place or ship them to national labs for detailed examination, as needed. Five reactors have outages scheduled in FY 2025, that will allow for numerous test rods to be removed and examined in place or shipped to a national lab for examination. • Continue irradiations of fuel rodlets in the central water loop of the ATR. • Continue in partnership with industry to support the Fuel Performance and Testing Technical Experts Group for burnup extension. This includes examination of high burnup fuel rods, furnace testing, re-irradiation of test samples in ATR, and loss of coolant tests in TREAT and SATS. • Perform TREAT tests that: investigate fuel fragmentation, relocation, and dispersal phenomena; investigate reactivity insertion accident induced clad burst performance; and demonstrate power ramp testing in a flowing water loop. • Complete I-Loop installation in the ATR and begin commissioning.	• Activities in FY 2025 will continue to focus on meeting industry's objectives for developing the near-term ATF concepts.

Fuel Cycle Research and Development
Fuel Cycle Laboratory R&D

Description

This subprogram supports research activities that advance knowledge of nuclear fuel cycles and provide transformative innovations to accelerate development of civil nuclear technologies, including consideration of fuel cycle impacts from the potential deployment of advanced reactor technologies. It includes activities in Materials Protection, Accounting and Control Technologies (MPACT), Systems Analysis and Integration (SAI), Innovative Nuclear Materials (INM), and Innovative Process Control (IPC). Advanced reactor fuels R&D has joined other long-term fuel concepts in the new Next Generation Fuel subprogram.

MPACT develops innovative technologies, analysis tools, and advanced integration methods to enable U.S. domestic nuclear materials management and safeguards for emerging nuclear fuel cycles. It also includes assessing vulnerabilities in current nuclear systems while minimizing proliferation risks. Addressing U.S. energy security needs requires innovative approaches to material control and accounting to ensure that nuclear material is not misused, diverted, or stolen.

SAI activities include strategic planning and analysis as well as integrated evaluation of Fuel Cycle Research and Development program activities. It provides the critical capability needed to analyze complex fuel cycle system options, assess overall performance under various scenarios, and improve understanding of the interdependencies between various subsystems and associated technologies.

INM activities started in FY 2023 and continue focusing on longer-term cladding and in-core materials discovery and development for advanced nuclear energy systems applications. INM seeks innovative experimental approaches to understand, predict, and ultimately discover functional materials targeted for nuclear fuel and fuel recycle applications. The goals are to develop new tools, techniques, and capabilities at national laboratories to accelerate the pace of new materials discovery, building on recent advances in artificial intelligence, machine learning, theory, modeling, and computing, and advanced characterizations. For example, innovative approaches are needed to develop advanced metallic alloys and composite materials that are optimized to meet new reactor performance targets within the reactor core and fuel cladding. It also includes recycling of zircaloy cladding material, which is the second largest mass in used fuel assemblies. Developing recovery process with sufficient Zr purity to permit re-use will reduce the waste quantity as well as enhance resource utilization. Similar recycling approaches will be developed for other high value nuclear materials.

IPC activities support foundational research to innovate the fuel cycle process and associated control technologies. The goals are to enhance process controllability and to enable predictive modeling capability in advanced fuel cycle systems. For example, a significant fraction of the space in a nuclear fuel recycling plant is occupied by large tanks—used for surge capacity or system redundancy. Implementing advanced process control and modeling technologies into the recycling plant design will reduce the size of such tanks, or even eliminate the need for this tank space. This, in turn, would directly reduce the cost of plant construction and operations.

Fuel Cycle Laboratory Research & Development
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Fuel Cycle Laboratory R&D $15,000,000	**$15,000,000**	**+$0**
• Continued innovative on-line process monitoring capabilities for advanced reactors fuel recycling. • Completed development of nuclear materials accounting and control training curricula that fills gaps identified by industry stakeholders. • Documented state-of-the-science for molten salt purification, sampling and analysis R&D needs. • Demonstrated first-of-a-kind probes for quantitative measurement of molten salt basicity. • Completed initial fabrication and screening test of promising new cladding materials and initiate irradiation studies. • Continued to conduct performance assessments and economic and market analyses of promising advanced nuclear energy systems and their role in achieving a net-zero economy by 2050.	• In Systems Analysis & Integration, develop microreactor capital cost dataset – preliminary estimate through final as-built. Identify barriers to advanced reactor deployment pathways. • In IPC, initiate experiments to demonstrate the performance of alkaline process using surrogate material. • In MPACT, demonstrate salt sampling system to support both process and domestic safeguards development and issue a "Nuclear Material Control" guidance document for technology developers. • In INM, complete a new cladding barrier development and demonstrate its capability to transfer from flat surfaces to tubes.	• No funding change.

Fuel Cycle Research and Development
Next Generation Fuels

Description

Next Generation Fuels supports industry with financial assistance and lab-based research and development to continue to drive innovation over the long term. It lays the groundwork for fuels that significantly outperform today's fuel, focusing on long-term, high-risk, high-reward fuel concepts.

This subprogram combines several small, fragmented fuel development efforts into a single subprogram with a common purpose, focused on the long term:

- Long-term accident tolerant fuel concepts
- Metallic fuel
- Advanced TRISO fuel
- Molten salt fuels

Silicon-carbide cladding, iron-chrome-aluminum cladding, and higher uranium density fuel all have great potential to provide even better performance than the near-term accident tolerant fuel concepts. They will require several more years of research and development to progress to the point where the near-term concepts now reside.

Many advanced reactor developers are interested in the performance benefits that metallic fuel offers. The Department has a long history of metallic fuel development and can assist industry in qualifying the fuel for use in demonstration reactors and to improve metallic fuel in the long term. The Leading Innovation in Fuel Technology (LIFT) Program was designed to assist industry in this way. The program will establish a reference fuel performance using legacy data and modern tools to fill the gaps. Next, it will innovate metallic fuel design using accelerated techniques to maximize their performance.

Tristructural-isotropic (TRISO) particle fuel development and qualification activities support prismatic and pebble-bed high temperature fuel designs. Since the onset of the TRISO Fuel Program in 2002, it has focused on qualification of the fuel design for high temperature gas reactor concepts. However, TRISO fuel also has applications for other reactor concepts such as molten salt-cooled high temperature reactors and microreactors. Irradiation, safety testing, and PIE of TRISO fuel continue to provide data for fuel development and qualification in support of industry efforts to establish a domestic commercial TRISO fuel fabrication capability.

Molten salt fuels are also of interest to advanced reactor developers and require considerable research and development to increase their technology readiness level. Molten salt fuels activities support the development of equipment for salt fuel purification, synthesis, and characterization and capabilities to convert oxide and metal fuels to molten halide salt fuels at national laboratories.

Next Generation Fuels
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Next Generation Fuels $47,400,000	**$43,290,000**	**-$4,110,000**
• Performed further post-irradiation examination (PIE) of the Advanced Gas Reactor (AGR) -3/4 and AGR-5/6/7 TRISO fuel experiments to characterize fission product inventory and fuel performance in response to varying reactor fluence and temperature to support industry TRISO fuel qualification efforts. • Performed additional safety testing of TRISO fuel to characterize performance in elevated temperatures and fission product transport. • Performed facility modifications and air/moisture ingress experiment (AMIX) furnace qualification activities at INL. • Continued accelerated irradiation experiments using the ATR and HFIR using Fission - Accelerated Steady-State Testing (FAST) and Mini-fuel Testing, respectively. Continue U.S./Japan joint transient testing of advanced reactor fuel concepts in TREAT. • Initiated a metallic fuel qualification program that supports advanced reactor developers using metallic fuel. This includes establishing a reference fuel baseline, improving performance modeling capability, and preparing for future transient experiments. • Supported molten salt recycling for salt fuels development capabilities at the national laboratories. • Silicon carbide cladding development continued to	• Issue AGR-3/4 final report that will assess fission product retention and transport in reactor graphite and fuel matrix. • Perform further PIE of the AGR-5/6/7 TRISO fuel experiment to support qualification of TRISO fuel for use in demonstration and commercial high temperature reactors. • Perform testing of TRISO fuel in the AMIX furnace to understand performance in transient scenarios. • For silicon carbide cladding development, continue financial assistance to industry and lab-based research and development to progress from lab-scale irradiation testing and examination to lead test rods in commercial reactors. • For metallic fuel, continue the Leading Innovation in Fuel Technology (LIFT) program. Submit the first topical report on fission product retention and transport. Complete the final design of the first sodium-loop experiments. • For molten salt fuel, continue to develop simplified molten salt oxide-to-chloride. Develop simplified molten salt oxide to chloride conversion process. Install particulate detection/characterization probe in engineering-scale molten salt test equipment. Develop equipment for MSR fuel purification, synthesis, and characterization.	• The TRISO fuel qualification program is ramping down as it nears completion and high-cost activities such as irradiation experiments are completed.

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
progress with irradiation testing, improved fabrication materials and methods, and modelling development.		

Fuel Cycle Research and Development
Advanced Nuclear Fuel Availability

Description

Advanced reactors are being developed for flexible baseload power generation, providing U.S. leadership in nuclear technology, enabling new markets for export, and reducing greenhouse gas emissions. Many of these reactors are expected to require high-assay, low-enriched uranium (HALEU) fuel. HALEU is uranium with the fissionable isotope U-235 enriched to between greater than 5 and less than 20 percent. Current commercial light water reactors use uranium enriched up to 5 percent U-235. There are no commercial suppliers of HALEU in the United States and advanced reactor developers will need small quantities of HALEU in the near term to support the qualification of their fuel and larger quantities for the first demonstration reactors. Much larger quantities of HALEU will be needed when advanced reactors requiring HALEU fuel are commercialized.

This subprogram will work to make available small quantities of HALEU from limited DOE uranium inventories and leverage the HALEU enrichment demonstration capability in the short term, in coordination with the National Nuclear Security Administration (NNSA), and work with the private sector to establish a commercial U.S. HALEU production and supply chain capability for the long term, including associated research and development activities.

Subprogram activities include continuing the recovery and down-blending of limited excess quantities of DOE uranium inventories to HALEU for DOE's use in research, development, and demonstration programs. In coordination with NNSA, NE will recover and downblend highly-enriched uranium from existing inventories located at the Savannah River Site, and NNSA will identify and repurpose unused or scrap material at Y-12 under their Convert subprogram. The NE project initiated in FY 2023 continues in FY 2025, focusing on completing restart preparations for a downblending startup test and meeting regulatory requirements including NEPA compliance. Additionally, equipment will be procured and a plan will be developed for the receipt and processing of HALEU shipped from Savannah River Site beginning in late FY 2025 and FY 2026.

DOE transitioned the HALEU enrichment activities in Piketon, Ohio in November 2022, to a new competitively-awarded, cost-share program to complete the HALEU Enrichment Demonstration and operate the 16-centrifuge cascade to produce a limited quantity of HALEU. Twenty kilograms of HALEU were produced by November 2023, nearly two months ahead of schedule. Production of HALEU will continue at 900 kilograms per year. The limited quantity of HALEU produced under this contract will be used for DOE's research, development, and demonstration programs

This subprogram complements the activities funded under Section 50173 of the Inflation Reduction Act of 2022. Inflation Reduction Act activities include supporting the U.S. Nuclear Regulatory Commission with criticality benchmark data, assisting industry with transportation package development, supplying HALEU to industry in coordination with a HALEU Consortium, and providing other supporting activities.

Advanced Nuclear Fuel Availability
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Adv Nuclear Fuel Availability $100,000,000	**$150,000,000**	**+$50,000,000**
• Initiated the project for recovery and down-blending of limited excess quantities of DOE uranium inventories to HALEU. In coordination with NNSA, NE will recover and downblend highly-enriched uranium from existing inventories located at the Savannah River Site. FY 2023 activities include project planning, regulatory compliance activities, and the beginning of equipment reconstitution and flowsheet development. • Continued activities under a new competitively awarded cost share program to operate the 16-centrifuge cascade in Piketon to produce a limited quantity of HALEU for research, development, and demonstration use for one year, with the option to extend in future years. The private sector partner awarded the contract will operate the facility and produce HALEU for DOE's use. • Developed and begin to execute a strategy to address the National Environmental Policy Act requirements.	• Continue production of HALEU at the Piketon site at an annual rate of at least 900 kg/year. • Continue recovery and downblending at Savannah River to produce up to 2.4 MT of 19.75% HALEU. Complete operational readiness and start-up authorization and begin operations in FY 2025. • Prepare for the processing of the uranyl nitrate produced at Savannah River into an oxide fuel form: facility layout, equipment purchases. • Complete installation of a processing system to remove radiological and chemical contaminants from HALEU produced from EBR-II fuel. Begin operations. This "polishing" system will produce an oxide powder with a high degree of purity for a wide range of advanced reactor concepts.	• Expanding recovery and downblending at Savannah River Site. HALEU production at Piketon increases and shifts from a 50-50 cost share demonstration to a cost-plus incentive fee basis.

Fuel Cycle Research and Development
Used Nuclear Fuel Disposition R&D

Description
The Used Nuclear Fuel Disposition Research and Development (R&D) subprogram conducts scientific research and technology development to enable long term storage, transportation, and disposal of spent nuclear fuel and high-level wastes. The primary focus of this subprogram supports the development of disposition-path-neutral waste management systems and options in the context of the current inventory of spent nuclear fuel and high-level waste.

Research and Development
Full-Scale Storage Cask Demonstration – Although the nuclear power industry has used dry storage for many years, this storage option has been for low-burnup fuel; therefore, there is limited data available on the degradation of more contemporary high-burnup fuels. To address this data gap, the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and nuclear industry are cooperating to investigate extended storage of high-burnup fuels (≥ 45 GWd/MTHM). DOE, in cooperation with the NRC and industry, is conducting a full-scale demonstration of storage for high-burnup fuel that will be beneficial by: 1) benchmarking the predictive models and empirical conclusions developed from short-term laboratory testing, and 2) building confidence in the ability to predict the performance of these systems over extended time periods.

Storage and Transportation R&D – In addition to the Full-Scale Storage Cask project, DOE will continue to support targeted, defined end point testing at the national laboratories and with industry experts that include, field studies, and both numerical and physical modeling R&D related to the storage and transport of high-burnup fuel to include: testing of cladding response with hydride reorientation and embrittlement; the effects of atmospheric corrosion on storage welds; measuring the embrittlement of elastomer seals; determining thermomechanical degradation of bolts, welds, seals and poisons; analyzing thermal profiles of stored fuels; determining the stress profiles of fuels and casks; evaluating cask drying processes; laboratory post-irradiation examination and testing of the fuel from the cask demonstration project at the North Anna Generating Station in Mineral, Virginia; and the development of sensors for internal and external cask monitoring. The targeted R&D will focus on technical knowledge to support long-term storage and eventual transportation of high-burn-up fuels. As industry moves to higher enrichment fuels with burn-ups up to 78 GWd/t, DOE will evaluate the optimum time and tests that should be conducted to ensure that the new higher burn-up fuel can be stored and transported in the future. Current work also indicates that burn-up rates for the spent fuel from some advanced reactors is very different from existing light water reactors. It is imperative that waste confidence is reached ensuring the new fuel types can safely be stored over the short term and managed over the longer term. Working with reactor vendors and potential licensees, DOE will evaluate establishing waste confidence and assess the potential for spent nuclear fuel conditioning to meet waste confidence acceptance. Under this subprogram, collaboration with DOE Environmental Management and Naval Reactors will ensure programs are aligned and leverage the ongoing missions of each program to further the overall mission of spent nuclear fuel and high-level waste management, public outreach, and transportation.

Disposal R&D – Activities continue to further the understanding of long-term performance of disposal systems in three main geologic rock types: clay/shale, salt, and crystalline rock. These activities include existing and new collaborations with international partners to leverage and integrate applicable R&D being conducted by other countries into the U.S. disposal R&D portfolio. Also, evaluations will continue to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository. The disposal performance characteristics of new accident tolerant fuels and any spent fuel and waste forms from new proposed advanced reactors will be evaluated. A pilot program to increase participation of underrepresented groups in research activities related to management and disposal of radioactive wastes will be supported.

Used Nuclear Fuel Disposition Research & Development (R&D)
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Used Nuclear Fuel Disposition Research & Development $47,000,000	**$47,000,000**	**$0**
• Continued ongoing disposal R&D. • Evaluated the storage, transportation, and disposal performance characteristics of new accident tolerant fuels and high-level radioactive waste glass compositions. • Supported pilot program to increase participation of underrepresented groups in research activities related to management and disposal of radioactive wastes. • Consistent with the results of an Independent Technical Review continue evaluations to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository. • Continued destructive testing on sibling rods. • Worked with SONGS to install instrumentation on typical canisters used by the nuclear power plant industry. • Continued work to clear hot cells and prepare for acceptance of new accident tolerant fuels.	• Continue ongoing disposal R&D to further advance process and total system performance models for generic geologic repositories. • Continue to evaluate the storage, transportation, and disposal performance characteristics of spent fuel and waste forms from new proposed advanced reactors. • Work with vendors and potential licensees on characterizing the anticipated waste forms from advanced reactors to assess storage, transportation, and disposal considerations. • Continue to support pilot program to increase participation of underrepresented groups in research activities related to management and disposal of radioactive wastes. • Complete evaluations to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository. • Conclude destructive testing on sibling rods. • Work with SONGS install instrumentation on typical canisters used by the nuclear power plant industry. • Continue research on Stress Corrosion Cracking for the canisters already loaded and future cans. Including collaboration with leading industry laboratories. • Continue work to clear hot cells.	• No funding change.

Fuel Cycle Research and Development
Integrated Waste Management System

Description

The Nuclear Waste Policy Act of 1982 (NWPA) assigns the Department of Energy the responsibility for disposition of U.S. spent nuclear fuel (SNF) and high-level radioactive waste (HLW), and the Department remains committed to fulfilling the Federal Government's legal obligations to properly manage and dispose of that material. The Integrated Waste Management System (IWMS) subprogram supports efforts to develop and implement a Federal interim storage program that uses a consent-based approach to siting as part of an overarching waste management system, as well as storage, transportation, and systems engineering and analysis activities. The activities of this subprogram include implementing a consent-based siting process, executing Stage 1 of DOE's Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel (2023), and preparing for Stage 2 of the process. The first stage focuses on capacity building through broad public outreach and engagement, mutual learning, and supporting a national conversation about what spent nuclear fuel is and how it can be managed on interim and longer timescales. The second stage focuses on seeking volunteers interested in considering hosting a federal facility and conducting site suitability assessments.

The IWMS subprogram's FY 2025 Budget Request funds critical activities required for effective implementation of consolidated Federal interim storage following a consent-based siting process. Consent-based siting focused activities include:

- Working collaboratively with the public, communities, stakeholders, and governments at the Tribal, state, and local levels to inform and refine DOE's Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel (2023);
- Continuing to build public participation into the consent-based siting process;
- Supporting interested groups, communities, states, and Tribes to explore consent-based siting and interim storage;
- Supporting mutual learning through engagement with Consent-Based Siting Consortia funding awardees;
- Reducing barriers to participation in the consent-based siting process for historically underserved groups;
- Continuing development of communications materials and digital tools to support information sharing;
- Continuing to work toward implementing an integrated waste management system, including storage and associated transportation of SNF, that incorporates social equity and environmental justice; and
- Preparing to move to Stage 2 in the Consent-Based Siting Process.

In parallel, the IWMS subprogram will continue technical preparations for design, construction, and operation of a Federal consolidated interim storage facility, including transportation of spent nuclear fuel to the facility. Transportation-focused activities include:

- Beginning a full-scale package performance demonstration of a rail-sized SNF cask to help build public trust and confidence in the safety of SNF transport to Federal storage and disposal facilities;
- Preparing to ship one demonstration cask of SNF to support research on the performance of high burnup fuels, which may be conducted as a pilot shipment for future large-scale SNF transport to federal storage and disposal facilities;
- Develop a plan to build public trust, transportation capability and infrastructure in the period preceding the opening of a DOE owned storage facility;
- Developing guidance documents, operational plans, and procedures for shipping SNF, including shipment security;
- Engaging with State and Tribal government partners to cooperatively plan for SNF transportation activities, including approaches to emergency response training, vehicle safety inspections, and transportation system operations;

- Developing, qualifying, and maintaining purpose-built railcars and security and safety monitoring equipment to support large-scale SNF transport; and
- Evaluating transportation infrastructure at nuclear power plant sites to identify options for removing SNF from each site.

Meanwhile, other technical preparations will include:

- Developing a project management plan and supporting technical documentation to site, design, license, construct, and operate Federal interim storage facilities and an associated SNF transportation system;
- Analyzing regulatory considerations applicable to interim storage facility design options and siting processes;
- Updating and analyzing detailed data on quantities and characteristics of relevant nuclear waste inventories to inform options analyses and transportation planning;
- Initiating a notice of intent to prepare an environmental impact statement for a federal consolidated interim storage facility project; and
- Analyzing mission need for a federal interim storage capability for commercial spent nuclear fuel in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*. NE intends to initiate an Analysis of Alternatives to support consolidated interim storage planning and communications related to consent-based siting after Critical Decision 0, *Approve Mission Need*, has been achieved.

Along with consent-based siting activities, IWMS will continue technical engineering and analysis work to prepare for designing and licensing one or more Federal interim storage facilities which could be constructed and operated in the future along with the associated SNF transportation capabilities. Preparations for large-scale transportation of SNF and HLW include development of purpose-built railcar equipment, design of a safety and security monitoring system for rail shipments, analyzing alternatives for shipment security escort services, assessment of transportation infrastructure and transport options at nuclear power plant sites, employment of state-of-the-science data and software tools to support decision-making and communications, thorough analysis of transportation system operational elements and dependencies, active engagement with State and Tribal government representatives through the Department's National Transportation Stakeholders Forum and associated working groups, and coordination with appropriate Federal agencies on regulatory, safety, and security considerations. These efforts build on successes and lessons learned from previous Departmental radioactive materials transportation programs and campaigns as identified through knowledge management activities.

Integrated Waste Management System
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Integrated Waste Management System $53,000,000	**$53,000,000**	**$0**
• Awarded funding to interested groups, communities, States, or Tribes exploring the consent-based siting process and interim storage. • Developed siting analysis tools to assist interested communities in exploring interim storage. • Continued development of a plan, schedule, and cost estimate for a full-scale package performance test, including input from State and Tribal partners. • Completed multiple-car testing and will deliver one Atlas 12-axle cask-carrying railcar, two buffer railcars, and one rail escort vehicle conditionally approved for operational use. • Began fabrication of one Fortis 8-axle cask-carrying railcar prototype. • Finalized the railcar safety inspection protocol developed in coordination with States and Tribes. • Began work to update DOE's proposed Section 180(c) Policy to provide emergency response training funds and technical assistance to States and Tribes. • Continued existing planning, analysis, and outreach work for large-scale SNF transportation. • Started work on a concept of operations for SNF shipment security escort services. • Applied a systems engineering approach to IWMS planning efforts, factoring in early feedback from consent-based siting activities. • Updated computational analysis tools to support systems engineering analyses for an integrated	• Continue a public outreach and information campaign for consent-based siting. • Continue engaging with consent-based siting consortia and their cohorts to provide programmatic and technical information, develop and build new community and stakeholder engagement capacity. • Continue building equitable community decision-making processes that incorporates social science and other expertise. • Collect and analyze feedback to inform next steps and revisions to DOE's consent-based siting process. • Start preparing for the next stage of consent-based siting, including initial site screening and suitability analysis resources for future volunteer sites, including digital tools for siting analysis. • Initiate cask acquisition and establish a testing plan for a full-scale package performance test of a rail-sized transportation cask, including avenues to engage the public in the project (the package performance testing is expected to be conducted over a subsequent 5-year period). • Prepare to transport a single SNF cask containing high burnup fuel by 2030. • Continue single-car testing of one Fortis 8-axle cask-carrying railcar prototype. • Continue work to update DOE's proposed Section 180(c) Policy to provide emergency response	No funding change.

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
waste management system. • Provided technical information on interim storage and operations to support consent-based siting communications. • Started collecting data on proposed advanced reactor SNF forms and characteristics. • Developed an updated reference concept for a generic Federal consolidated Interim storage facility (CISF), including functions and requirements for facility operations. • Began assembling technical documentation to prepare for Critical Decision 0 - Mission Need for federal consolidated interim storage through the Department's Program and Project Management for the Acquisition of Capital Assets process (Order 413.3B). • Procured a pressure vessel to test inspection procedures for SNF casks. • Began work on a NEPA strategy and analysis approach for interim storage and associated transportation.	training funds and technical assistance to States and Tribes and establish a framework concept of operations that identifies functions, requirements, roles, and responsibilities for SNF shipments. • Continue and expand upon existing planning, analysis, and outreach work for large-scale SNF transportation. • Continue storage and maintenance of all DOE railcars and associated hardware. • Continue working on a concept of operations for SNF shipment security escort services, including possible new agency directives, training requirements, and standard operating procedures. • Coordinate with other Federal agencies and organizations on transportation requirements. • Continue site infrastructure evaluations at nuclear power plants. • Begin working on an environmental impact statement for federal consolidated interim storage. • Analyze mission need for a federal consolidated Interim storage capability for commercial spent nuclear fuel in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.* Commence an Analysis of Alternatives to support consolidated interim storage planning and communications related to consent-based siting after Critical Decision 0, *Approve Mission Need,* has been achieved. • Refine interim storage facility design concepts	

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	based on consent-based siting engagement and other feedback. • Continue work on SNF canister leak check testing process and procedures development.	

Nuclear Energy Enabling Technologies

Overview

The Nuclear Energy Enabling Technologies (NEET) program conducts research and development (R&D) and makes strategic investments in research capabilities to develop innovative and crosscutting technologies that resolve nuclear technology development issues. The Advanced Materials and Manufacturing Technologies (AMMT) subprogram focuses on innovative research to accelerate the development, qualification, demonstration and deployment of advanced materials, manufacturing technologies, and supply chain capacity. The Advanced Sensors and Instrumentation (ASI) subprogram directs and performs research and development of advanced sensors and instrumentation to expand measurement capabilities by enhancing performance of existing technologies or developing novel techniques and systems to address critical technology gaps. Also, NEET invests in modeling and simulation tools for existing and advanced reactors and fuel system technologies via the Nuclear Energy Advanced Modeling and Simulation (NEAMS) subprogram. The NEET program also provides industry, universities, and national laboratories with access to unique nuclear energy research capabilities through the Nuclear Science User Facilities (NSUF) subprogram. By delivering innovative clean energy and advanced manufacturing technologies for nuclear energy systems, NEET-sponsored activities collectively support the Department's priorities to combat the climate crisis, create clean energy jobs with the free and fair chance to join a union and bargain collectively, and promote equity and environmental justice. NEET also makes these technology advancements accessible to the U.S. industry through the Gateway for Accelerated Innovation in Nuclear (GAIN).

Highlights of the FY 2025 Budget Request

- AMMT will optimize materials and manufacturing technologies to improve use for advanced reactors and address gaps needed for qualification of new materials and technical basis for regulatory acceptance. AMMT will also initiate a competitive solicitation to address high priority supply chain needs for the near-term deployment of advanced reactors.
- ASI will accelerate the development of qualification methods for the use of sensors in harsh environments and expand work in the development of advanced control systems and autonomous operations.

Nuclear Energy Enabling Technologies
Funding ($K)

	FY 2023 Enacted Comparable	FY 2024 Annualized CR Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Nuclear Energy Enabling Technologies					
Advanced Materials and Manufacturing Technologies	9,610	9,610	23,000	13,390	139%
Advanced Sensors and Instrumentation	6,500	6,500	9,000	2,500	38%
Nuclear Energy Advanced Modeling and Simulation	27,500	27,500	28,600	1,100	4%
Nuclear Science User Facilities	34,750	34,750	34,500	-250	-1%
Gateway for Advanced Innovation in Nuclear	10,053	10,053	10,000	-53	-1%
Total, Nuclear Energy Enabling Technologies	**88,413**	**88,413**	**105,100**	**16,687**	**19%**

Nuclear Energy Enabling Technologies
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Advanced Materials and Manufacturing Technologies: The increase from $9,610,000 to $23,000,000 reflects additional scope to include advanced materials, such as for high temperature use, whether or not fabricated with additive methods, and associated supply chain; continued qualification efforts including testing, quality assurance and production of parts and components for laser powder bed fusion 316 stainless steel and other materials; and a competitive solicitation to address high priority supply chain needs for the near-term deployment of advanced reactors.	**+13,390**
Advanced Sensors and Instrumentation: The increase from $6,500,000 to $9,000,000 accelerates the development of qualification methods for the use of sensors in harsh environments and increases investments in digital twin development, artificial intelligence, and machine learning applications.	**+2,500**
Nuclear Energy Advanced Modeling and Simulation: The increase from $27,500,000 to $28,600,000 reflects additional funding to support efforts to take better advantage of leadership class high performance computing platforms and other emerging computing hardware.	**+1,100**
Nuclear Science User Facilities: The decrease from $34,750,000 to $34,500,000 reflects reduced program management costs.	**-250**
Gateway for Accelerated Innovation in Nuclear: No significant changes to the funding level.	**-53**
Total, Nuclear Energy Enabling Technologies	**+16,687**

Advanced Materials and Manufacturing Technologies

Description

The Advanced Materials and Manufacturing Technologies (AMMT) subprogram will develop crosscutting technologies in support of current light-water reactors and next-generation advanced nuclear reactor technologies. The vision of the AMMT subprogram is to accelerate the development, qualification, demonstration, and deployment of advanced materials and manufacturing technologies to enable reliable and economical nuclear energy.

Advanced materials and manufacturing can have a broad impact on the nuclear industry. Materials with improved high-temperature performance can support reactors that operate at high temperatures by providing a more efficient and cost effective design. Innovative manufacturing technologies, including additive manufacturing, also offer new ways to produce materials with tailored properties that were impossible with traditional manufacturing methods. Including sensors inside advanced manufactured materials would allow for better monitoring of plant conditions. These new manufacturing and materials technologies could also reduce the cost of reactor components and the complexity of their supply chains.

The major goals of the AMMT subprogram are (1) to develop advanced materials and manufacturing technologies that benefit multiple types of reactors, (2) to establish a comprehensive framework for rapid qualification of conventional and new materials made by advanced manufacturing, (3) to accelerate commercialization of new materials and manufacturing technologies through demonstration and deployment, and (4) enhance supply chain resilience by supporting industry advancements in manufacturing and materials capabilities, including applying $6,000,000 of the proposed increase to supporting the commercial sector in the near-term domestic build-out of supply chain capacity needed to deploy advanced reactors. These goals will be achieved through three major elements:

1) <u>Development, Qualification, and Demonstration</u>
Qualification of advanced materials and components will require identifying and prioritizing their needed characteristics, developing or adapting quality assurance tools, and optimizing materials chemistry and manufacturing processes. Long-term AMMT program objectives include developing advanced materials and manufacturing technologies, establishing a rapid qualification framework, evaluating materials performance in nuclear reactor environments, and demonstrating the use of this technology. The AMMT program is currently developing a rapid qualification framework, which it intends to demonstrate by 2028 using Laser Powder Bed Fusion 316 Stainless Steel as a test case. This material was selected because of the broad industry use of conventionally manufactured 316 stainless steel and potential near-term value of an additively manufactured alternative. This framework will be applied to other materials and manufacturing methods to show multi-material applicability, shortened qualification timelines, and new materials and manufacturing for industrial use. These additional materials will be developed in parallel, rather than awaiting full demonstration of the new framework in 2028. In FY 2025 the program will continue to develop the framework and test case for 316 Stainless steel, will optimize Alloy 709 (a structural steel material) for printability, will select the next material with which to exercise the qualification framework from a set nickel and refractory based materials and manufacturing methods, and will initiate this qualification process.

2) <u>Capability Development and Transformative Research</u>
This element supports the development of capabilities needed for qualification and supports low TRL transformative research that may result in significant advances in materials design, discovery, and processing. This includes developing accelerated testing and high-throughput characterization techniques, supporting modeling capabilities for advanced materials, and conducting research on cutting edge materials concepts and designs. There are several continuing investigations in this area in FY 2025. The program intends to complete advanced creep testing and associated analysis for 316H in FY 2025.

3) <u>Collaborative Research, Development and Demonstration</u>

This element supports collaboration and partnerships with other DOE programs, agencies, industry, and universities. These collaborative activities will investigate a broad range of advanced materials and manufacturing techniques, address reactor-specific issues, and leverage and collaborate on capability and capacity development. In FY 2025, the program will engage with industry partners to identify components for potential demonstration projects. While specific projects have not yet been identified for FY 2025 in this area, the results of these engagements may result in new tasks to demonstrate the manufacturing of selected components using advanced technologies, to benchmark demonstrations against modeling and simulation results, or to support regulatory acceptance of advanced materials or components.

Advanced Materials and Manufacturing Technologies

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
$9,610,000	**$23,000,000**	**+$13,390,000**
• Completed initial builds of specimens on three different laser powder bed systems using three different 316H powder compositions. • Captured microstructural variation (porosity and grain structure) as a function of laser powder bed fusion process variables, enabling future studies on post-build anisotropy. • Initiated larger-scale builds to provide performance metrics (tensile, creep, creep-fatigue) as a function of microstructure and post-process heat treatment. • Initiated ASME Code case development for laser powder bed fusion 316 stainless steel for elevated temperatures. • Collaborated with the MARVEL Project to conduct a feasibility study and prototype fabrication of the 316 SS liner of the intermediate heat exchanger using additive manufacturing techniques.	• Update the AMMT program roadmap, in coordination with industry stakeholders, to prioritize materials and manufacturing technologies R&D. • Down select next materials to begin qualifying using the new framework under development. • Develop methods for high-throughput characterization and advanced testing, completing the techniques for accurate prediction of creep performance of laser powder bed fusion 316 stainless steel. • Optimize fabrication of alloy 709, including soliciting input from industrial manufacturers on the scale up potential and deployment timeline. • Showcase improved design and enhanced functionality of a component through the application of advanced manufacturing techniques potentially with MARVEL or industry partner. • Competitively support the nuclear industry in addressing high priority supply chain needs necessary for the successful near-term deployment of advanced reactors.	• The increase reflects the addition of scope to support availability of advanced materials, such as those for high temperature use, whether fabricated with conventional or advanced methods, and their associated supply chains. • The increase expands qualification efforts for Laser Powder Bed Fusion 316 stainless steel and other materials. • $6,000,000 of the increase supports a competitive solicitation to address high priority supply chain needs for the near-term deployment of advanced reactors.

Advanced Sensors and Instrumentation

Description

The Advanced Sensors and Instrumentation (ASI) subprogram conducts research and development (R&D) of sensors, instrumentation and controls to support the continued operation of the existing reactor fleet, to address critical measurement technology gaps identified by the advanced reactor developer community, and to support nuclear fuel cycle development. By leveraging engagement with the U.S. national laboratories, universities and private industry, the ASI subprogram coordinates R&D to foster technology maturation from initial concept to commercial product. ASI engages directly with other programs in the Office of Nuclear Energy (NE) and with advanced reactor developers to inform its R&D, with its goals and R&D priorities published in the Advanced Sensors and Instrumentation Roadmap, updated annually.

ASI supports the existing U.S. nuclear reactor fleet by performing research to enhance the capabilities of existing sensors and instrumentation. Notable R&D has included radiation hardened video camera systems for high resolution imaging of spent fuel during refueling operations and wireless systems for data transmission in nuclear power plant environments. In FY 2025, ASI will continue work to establish a multi-band wireless architecture, to be qualified for the existing fleet adoption by 2027.

ASI enables the deployment of advanced nuclear reactors by developing a wide variety of sensors, such as for pressure, temperature, and radiation monitoring that can operate in the harsh environments of advanced reactors. Optical fiber-based thermometry and pressure measurement, in-core high-temperature neutron flux monitoring, ultrasonic thermometry and surface acoustic wave transducers for structural health monitoring are just a few examples of advanced sensors that ASI is maturing towards commercialization. ASI compliments the sensor development portfolio by investing in development of advanced control systems and digital twin systems, which are key components of enabling more versatile reactor designs and the implementation of autonomous operational modes.

ASI supports advanced nuclear fuel cycle development by supplying sensors with enhanced capabilities. Many types of advanced fuels such as accident tolerant fuel must be tested and qualified in conditions that far exceed the capabilities of traditional and established measurement systems. ASI is developing novel measurement methods and improvements to the performance of sensors under conditions relevant to nuclear fuels qualification.

ASI is expanding focus and funding towards the development of artificial intelligence (AI) and machine learning (ML) techniques for nuclear industry applications, such as for autonomous control systems, applications of digital twins, and optimization of sensor architectures. As this expanded focus area will be new in FY 2025, specific milestones and project objectives are being developed during FY 2024 and will be added to the ASI R&D roadmap.

In FY25, the ASI program plans to improve the performance of self-powered neutron detectors, fission chambers, distributive sensing optical fibers and ultrasonic thermometers in environments relevant to advanced reactors. The program also plans to have a working digital twin of the MARVEL reactor that will be coupled with the Microreactor Automated Control System (MACS) to test AI-enabled autonomous operation concepts.

Advanced Sensors and Instrumentation

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Advanced Sensors and Instrumentation **$6,500,000**	**$9,000,000**	**+$2,500,000**
• Continued the development of advanced sensors (multi-mode; multi-point/distributed; miniature size and limited or no penetrations) and supporting technology (radiation hardened electronics, wireless communication, power harvesting) for nuclear instrumentation. • Established supply chain for key technologies in support of advanced reactor instrumentation. • Continued development of advanced control technologies for anomaly detection, diagnostics, prognostics, and decision making and integrated them into nuclear digital twins with hardware in the loop simulation for demonstration.	• Continue the capability enhancement of advanced sensors, such as optical fiber, neutron flux, radiation hardened electronics, and acoustic sensors to support fuel cycle development and advanced reactor designs. • Finalize the development of the digital twin advanced control methods testbed, which is critical to establishing autonomous reactor operation modes in support of advanced reactor designs. • Mature in-core reactor power monitoring methods using neutron flux and gamma-ray detectors, to support development of advanced control systems for advanced reactor designs. • Enhance capabilities and accuracy of temperature qualification and radiation qualification devices for in-core and near-core instrumentation, which is needed to accelerate qualifications of sensors for higher temperature and radiation environments relevant to advanced reactor designs.	• The increase expands work in the development of advanced control systems and associated sensors, key enabling technologies for autonomous operations. • The increase will accelerate the application of AI/ML techniques to sensors, instrumentation, and controls applications, enabling faster development and industry adoption. • The increase accelerates the development of qualification methods for the use of sensors in harsh environments, increasing the availability of critical sensors at the demonstration stage of advanced reactors.

Nuclear Energy Advanced Modeling and Simulation

Description

The Nuclear Energy Advanced Modeling and Simulation (NEAMS) subprogram develops and deploys a set of predictive modeling and simulation tools to support Office of Nuclear Energy (NE) mission priority areas: continued operation of the existing fleet of U.S. nuclear reactors; enable deployment of advanced nuclear reactors; develop advanced nuclear fuel cycles; and maintain U.S. leadership in nuclear energy technology. NEAMS engages scientists and engineers in developing state-of-the-art, multi-scale models of physics and chemistry that drive advanced computational methods for simulations of advanced nuclear energy systems. NEAMS empowers researchers and designers to gain fundamental insights that are unattainable through experiment alone, inform experiment selection, drive design, and minimize the cost of research and development.

The NEAMS subprogram has developed a set of analytic modeling and simulation tools that are flexible and able to accommodate different reactor types and designs. NEAMS continually seeks to improve the efficiency, accuracy and usability of its tools, including efforts to take greater advantage of leadership class high performance computing and other emerging computing hardware.

For the existing fleet, NEAMS tools address core performance optimization issues and accelerate development of fuels with enhanced accident tolerance to help assure the long-term availability and market competitiveness of nuclear energy. The Bison fuel performance code, and the lower-length scale work that underpins it, helps to provide fundamental insight into how nuclear fuel behaves under normal and extreme reactor conditions, as well as higher fuel "burnup." When coupled with experimental work performed under the Fuel Cycle Research & Development program, this has the potential to accelerate the design and licensing of new fuel forms that can improve or extend the operation of existing reactors.

For advanced reactor technologies, NEAMS tools help industry accelerate development and meet otherwise cost-prohibitive data needs. These tools also help support Nuclear Regulatory Commission (NRC) efforts to address its confirmatory analysis needs. While many existing industry software tools are designed for specific reactor designs, primarily light-water reactors, NEAMS has developed and continues to add capabilities to a suite of tools for reactor physics, thermal hydraulics, fuel performance, materials, chemistry, and system modeling that flexibly accommodate the range of reactor designs currently being considered by industry. Several of these tools are being used, adopted, and modified by industry, universities, and NRC to meet their needs, consistent with the FY 2023 Congressional direction. NEAMS incorporates feedback and inputs from these stakeholders to ensure proper focus on relevant capabilities.

For fuel cycle technologies, continued modeling and simulation tool development provide capabilities that can support future used nuclear fuel research and development, including development of strategies to burn less fuel, and high-fidelity analysis and prediction of fuel and cladding performance through the storage cycle.

Nuclear Energy Advanced Modeling and Simulation

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Nuclear Energy Advanced Modeling and Simulation **$27,500,000**	**$28,600,000**	**+$1,100,000**
• Enabled and accelerated industry's advanced reactor deployment efforts through advanced multiscale and multi-physics modeling and simulation approaches. ○ Developed fully coupled, full-core simulation of entire microreactor to demonstrated self-regulation and load-following, during transient scenarios. ○ Conducted graphite structural analysis and behavior for gas-cooled reactors during steady-state and transient conditions including swelling and oxidization as well as multiscale structural materials modeling for metallic structures including piping, heat exchangers, and reactor vessel. ○ Developed and assembled molten salt reactor modeling capability and data sufficient to support the development of a mechanistic source term to support data safety and licensing. • Implemented and demonstrated use of mechanistic tools to assess high-burnup fuel pulverization and burst potential for Light Water Reactor fuels to support licensing process associated with extending fuel burnup limits. • Maintained software tools with strong software quality assurance such that the tools can be used by industry and research institutions in research, design, and ultimately commercial deployment.	• Enable and accelerate industry's advanced reactor deployment efforts through advanced multiscale and multi-physics modeling and simulation approaches. ○ Increase the capability of steady-state and transient modeling for fast reactors, including advanced fuel performance models for metal and uranium nitride, thermal striping and enhanced coupled multiphysics simulations of key fast reactor phenomena. ○ Complete initial steady state core simulation capability for a pool type molten salt reactor, coupling reactor physics, thermal hydraulics and evolving chemistry. • Complete implementation of advanced fuel performance models for high priority LWR fuel concepts and demonstrate use in systematic assessment for impact on high-burnup on fuel reliability and accelerated fuel qualification approaches. • Begin adaptations to the MOOSE framework to take greater advantage of leadership class high performance computing and other emerging computing hardware. • Continue to maintain software tools with strong software quality assurance and to provide access to modeling and simulation tools on high-performance computing systems at Idaho National Laboratory through the Nuclear Computational Resource Center.	• This increase supports software updates to allow NEAMS tools to take better advantage of leadership class high performance computing platforms and other emerging computing hardware such as the GPU-accelerated hardware driving exascale computing systems.

Nuclear Science User Facilities

Description

The Nuclear Science User Facilities (NSUF) subprogram is the Nation's designated mechanism to gain access to user facilities for nuclear energy research. As a consortium of partner facilities, the NSUF connects a broad range of nuclear research capabilities, expert mentors, and experimenters. The NSUF represents a "prototype laboratory for the future," promoting the use of unique nuclear research facilities located at multiple sites across the Nation and encouraging active university, industry, and laboratory collaboration in relevant nuclear science research. The NSUF, through competitive solicitations, provides a mechanism for research organizations to collaborate, conduct experiments and post-experiment analysis, and utilize high performance computing at facilities that are often not otherwise accessible to these organizations. On an annual basis, researchers propose projects to be conducted at these unique facilities, with timelines ranging from a few months to several years. When projects are awarded, the NSUF subprogram pays for experiment support and laboratory services at the partner user facilities. In this manner, researchers benefit from the introduction to new techniques, equipment, and personnel. NSUF supports the development of a pipeline of skilled workforce by providing hands-on experience and access to nuclear materials and fuel capabilities at DOE national laboratories for graduate students and post-doctoral associates. In FY 2023, the NSUF subprogram supported 129 researchers from 23 different States and two other countries through awards and over 1250 researchers across 40 States and 13 other countries through access to high performance computing capabilities. Emphasis is placed on increasing the involvement of minority serving institutions, including Historically Black Colleges and Universities and Tribal Colleges and Universities, resulting in direct and meaningful investments through project selection and NSUF partnership agreements.

The principal focus areas in NSUF for FY 2025 include irradiation and post-irradiation examination of fuels and materials, high performance computing, and maintenance of the Nuclear Fuels and Materials Library as follows:

- The NSUF subprogram competitively supports irradiation and post-irradiation examination activities by providing researchers with access to unique nuclear research facilities. Support includes access to research and test reactors such as the Advanced Test Reactor, hot cells, beamline capabilities, irradiation capabilities, and irradiation experiment design and fabrication support, expert technical support, and research community outreach.
- High Performance Computing (HPC) supports scientific computing capabilities to enable advanced modeling and simulation. These resources support a wide range of research activities, including performance of materials in harsh environments (such as the effects of irradiation and high temperatures), performance of existing light water and advanced nuclear reactors, multiscale multi-physics analysis of nuclear fuel performance, and emerging artificial intelligence capabilities. HPC capabilities are available to industry, universities, national laboratories, and federal agencies to support research and development. Four HPC supercomputers are planned to be in operation at the Idaho National Laboratory: Sawtooth, Hoodoo, Bitterroot, and Teton. Teton, the newest technology class flagship supercomputer in the HPC suite, supports significantly larger data analysis and modeling and simulation efforts. HPC also maintains a data repository system to enable long-term storage and equitable access to NSUF user project data.
- The Nuclear Fuels and Materials Library supports the curation of a collection of specialized information and material specimens from past and ongoing irradiation test campaigns, real-world components retrieved from decommissioned power reactors, and donations from other sources. Everything in the Nuclear Fuels and Materials Library is available to the nuclear research community, either through a peer-reviewed proposal process or through direct programmatic request.

Nuclear Science User Facilities

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Nuclear Science User Facilities **$34,750,000**	**$34,500,000**	**-$250,000**
• Competitively solicited and awarded a limited number of new, fully-funded facility access awards. • Awarded more than 70 Rapid Turnaround Experiment projects through three competitive proposal periods. • Continued NSUF partnership agreements with universities, industry, and national laboratories to support ongoing irradiation experiments ranging from neutron, gamma, and ion irradiation to post--irradiation examination and incorporate new irradiation capabilities as needs are identified. • Enhanced the Nuclear Fuels and Materials Library through the addition of irradiated fuels and materials. • Operated three supercomputers totaling more than 120,000 processor cores and 7 Petaflops of computational performance. Support more than 800 users by providing training, user support, and code optimization. Ensure effective cybersecurity, user access controls, and data collection.	• Competitively solicit and award new, fully-funded facility access awards to accelerate the development of fuels and materials for nuclear energy applications. • Award more than 75 Rapid Turnaround Experiment projects through three competitive proposal periods for partner facilities access to support emergent and innovative nuclear science and materials research topics. • Continue NSUF partnership agreements with universities, industry, and national laboratories to support ongoing irradiation experiments ranging from neutron, gamma, and ion irradiation to post--irradiation examination and incorporate new irradiation capabilities as needs are identified. • Enhance the Nuclear Fuels and Materials Library through the addition of irradiated fuels and materials. • Operate four supercomputers totaling more than 560,000 processor cores and 30 Petaflops of computational performance. Support more than 1250 users by providing training, user support, and code optimization. Ensure effective cybersecurity, user access controls, and data collection.	• Decrease reflects reduced program management costs.

Gateway for Accelerated Innovation in Nuclear

Description

The Office of Nuclear Energy maintains a vibrant portfolio of research and development activities in nuclear technologies and facility capabilities in which to perform them. The Gateway for Accelerated Innovation in Nuclear (GAIN) subprogram facilitates access for industry and other stakeholders to those capabilities and knowledge at the national laboratories to rapidly advance the development and deployment of nuclear energy. GAIN accomplishes this in several ways due to an increasingly wide range of stakeholders that are investigating, developing, or moving toward deployment of nuclear energy technologies.

The GAIN subprogram provides competitive opportunities for cost-shared research at the Department's national laboratories to resolve specific technical issues hindering the deployment of nuclear technologies. Traditionally, the effort has been aimed at providing the nuclear industry with access to national laboratory facilities for work that is difficult or prohibitively expensive to do outside the national laboratory complex and access to knowledge that resides primarily or exclusively at the national laboratories. More recently, requests have broadened in scope to also include the use of analysis tools developed at the national laboratories as utilities consider deployment of new technologies or at new locations. GAIN works with other programs and organizations to conduct webinars to increase awareness on nuclear technologies and to better inform the Department's programs. GAIN also has participated in the Department's efforts to examine and improve its contracting mechanisms and terms to more effectively collaborate with industry. In FY 2025, GAIN will maintain and expand a database of projected costs of advanced reactor components to provide a more consistent basis for system cost estimates and market penetration analysis, continuing an effort being initiated in FY 2024.

With the renewed interest in advanced nuclear energy technologies beyond the light-water technologies currently deployed in the United States, there is a wealth of legacy knowledge and documentation from past research programs and projects within the Department and its predecessor agencies. GAIN is working to retrieve historical data from the demonstration reactors and other significant experiments dating back to the 1950s so that they can be reviewed, marked appropriately, and distributed to U.S. companies to ensure the knowledge of those designs and operations are incorporated into the next generation designs. To date, GAIN has released over 20 such documents to industry, with half of those being released to multiple parties. There are currently over 40 additional documents that have been identified and prioritized for review, marking, and eventual distribution. As part of this process, GAIN also ensures that the Department's Office of Scientific and Technical Information (OSTI) receives copies of the documents for archival purposes and further distribution.

In addition to working directly with the nuclear industry, GAIN is increasingly engaging with other stakeholder groups to provide technical assistance and enable them to make informed decisions on whether nuclear energy is an appropriate fit for their energy needs and clean energy objectives. A "new to nuclear" informational packet was developed in response to such requests to provide basic information and links to other sources of information. The Department expects that these activities will increase in importance as more and more states and communities consider clean energy transitions.

Gateway for Accelerated Innovation in Nuclear

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Gateway for Accelerated Innovation in Nuclear **$10,053**	**$10,000**	**-$53**
• Conducted quarterly calls for nuclear energy vouchers to conduct cost-shared research with the national laboratories to utilize their unique capabilities. • Continued to identify critical issues preventing industry deployment and facilitate industry access to information and resources to address them, including through webinars, research products, etc. • Established and communicated a process for industry to request access to legacy documents and data in coordination with the Office of Scientific and Technical Information. • Developed a “New to Nuclear” communication kit for non-nuclear audiences to provide basic resources and information on nuclear energy and links to other industry and government sources.	• Conduct quarterly calls for nuclear energy vouchers to conduct cost-shared research with the national laboratories to utilize their unique capabilities and broaden eligibility beyond nuclear industry developers and supply chain. • Continue to identify critical issues preventing industry deployment and facilitate industry access to information and resources to address them, including through webinars, research products, etc. • Increase engagement with non-nuclear stakeholder groups by providing technical assistance, in the form of documents and briefings, to facilitate their consideration of nuclear energy for their clean energy portfolio.	• No significant changes.

Advanced Reactor Demonstration Program

Overview

The Advanced Reactor Demonstration Program (ARDP) focuses Departmental and non-federal resources on supporting the development of commercially promising advanced reactors that have the potential for near and mid-term demonstration and commercial deployment and addressing challenges hindering their deployment.

In the FY 2020 Further Consolidated Appropriations Act, Congress established ARDP to demonstrate multiple advanced reactor designs. In the Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act, P.L. 117-58), multi-year funding for the reactor demonstration elements of this program was provided under the new Office of Clean Energy Demonstrations (OCED). The ARDP research and development elements leading to demonstration remain with Nuclear Energy and include these four major elements:

- National Reactor Innovation Center (NRIC) – Supports testing, demonstration, and performance assessment to accelerate deployment of advanced reactors through development of advanced nuclear energy technologies by utilizing the unique DOE national laboratory facilities and capabilities;
- Risk Reduction for Future Demonstrations – Supports cost-shared (up to 80% government, not less than 20% industry) partnerships with U.S.-based teams to address technical, operational, and regulatory challenges to enable development of a diverse set of advanced nuclear reactor designs for future demonstration;
- Regulatory Development – Coordinates activities with the Nuclear Regulatory Commission (NRC) and U.S. industry to address and resolve key regulatory framework and licensing technical issues that directly impact the "critical path" to advanced reactor demonstration and deployment; and
- Advanced Reactor Safeguards and Security – Evaluates safeguards and security issues that are unique to advanced reactors to help reduce roadblocks by solving regulatory challenges, reducing safeguards and security costs, and utilizing the latest technologies and approaches for plant monitoring and protection.

In FY 2025, the Department continues to focus on the execution of the Risk Reduction projects selected in FY 2021. For the Risk Reduction projects, funding supports five domestic advanced reactor development partners in resolving technical, operational, and regulatory challenges to enable future demonstration of their concepts. Efforts initiated under the NRIC, Regulatory Development, and Advanced Reactor Safeguards and Security subprograms continue in FY 2025.

The two ongoing ARDP Demonstration projects (managed by the Office of Clean Energy Demonstrations, OCED) and the five Risk Reduction projects (in NE) are working to overcome barriers to future deployments and have the potential to create substantial numbers of new, skilled, good-paying domestic jobs with the free and fair choice to join a union. For example, in the early stages of design, development, and licensing, the reactor demonstration vendors are adding many technical and professional employees to address design, engineering, testing, procurement, and licensing requirements. The construction phase of each reactor is expected to result in hundreds of short-term construction jobs. The eventual operation of these reactors will require the creation of additional long-term operations, maintenance, and security positions. Overall, the deployment and operation of these reactors are expected to yield significant positive, long-term, economic impacts for the communities in which they operate.

Highlights of the FY 2025 Budget Request

A key FY 2025 activity for NRIC includes continuing support for establishing infrastructure for the testing of multiple advanced reactor concepts. FY 2025 marks the final year for capital line-item funding for the Laboratory for Operations and Testing in the United States (LOTUS) Project (23-E-200, LOTUS).

The two advanced reactor demonstrations are supported by multi-year funding provided by the Infrastructure Investment and Jobs Act to the Office of Clean Energy Demonstrations.

Advanced Reactor Demonstration Program
Funding ($K)

	FY 2023 Enacted[1] Comparable	FY 2024 Annualized CR Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Advanced Reactor Demonstration Program					
National Reactor Innovation Center	67,000	67,000	31,000	(36,000)	-54%
ARDP Demonstration Reactors	60,000	60,000	0	(60,000)	-100%
Risk Reduction for Future Demonstrations	120,000	120,000	142,500	22,500	19%
Regulatory Development	12,065	12,065	15,000	2,935	24%
Advanced Reactor Safeguards and Security	9,250	9,250	11,000	1,750	19%
Construction: 23-E-200, LOTUS	20,000	20,000	18,748	(1,252)	-6%
Total, Advanced Reactor Demonstration Program	**288,315**	**288,315**	**218,248**	**-70,067**	**-24%**

[1] FY 2023 Enacted levels for base funding include $20 million for the National Reactor Innovation Center, $120 million for Risk Reduction for Future Demonstrations, and $60 million for ARDP Demonstration Reactors that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

Advanced Reactor Demonstration Program
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
National Reactor Innovation Center: The decrease from $67,000,000 to $31,000,000 reflects completion of Demonstration of Microreactor Experiments (DOME) test bed construction and transition to the operations phase of the project.	**-36,000**
ARDP Demonstration Reactors: No funding is requested for the two ARDP demonstration reactor efforts (Demonstration 1 X-energy and Demonstration 2 TerraPower) within Nuclear Energy. IIJA provided multi-year funding for these demonstrations under the Office of Clean Energy Demonstrations.	**-60,000**
Risk Reduction for Future Demonstration: The increase from $120,000,000 to $142,500,000 reflects a ramp-up in activities to enable long lead procurements and other activities required to maintain the schedules of the five projects and completes funding for three of the five projects at the current baselines.	**+22,500**
Regulatory Development: The increase from $12,065,000 to $15,000,000 reflects an expansion of the Advanced Nuclear Energy Licensing Cost-Share Grant Program to help reduce the regulatory risks for advanced reactors.	**+2,935**
Advanced Reactor Safeguards and Security: The increase from $9,250,000 to $11,000,000 reflects expanded activities across the program and focus on integrated safety, security, and safeguards by design for U.S. advanced reactors.	**+1,750**
Construction: The decrease from $20,000,000 to $18,748,000 reflects continuation of the LOTUS project consistent with the performance baseline.	**-1,252**
Total, Advanced Reactor Demonstration Program	**-70,067**

National Reactor Innovation Center

Description

The National Reactor Innovation Center (NRIC) mission enables and accelerates the testing and demonstration of advanced reactors by utilizing the unique capabilities of U.S. national laboratories. NRIC ensures that the strategic infrastructure and assets of the national laboratories are available to enable physical validation of advanced nuclear reactor concepts, resolve technical uncertainties, and generate data relevant to safety, resilience, security, and functionality of advanced nuclear reactor concepts. NRIC works closely with R&D programs within the Office of Nuclear Energy to avoid duplication. NRIC does not conduct R&D; it ensures the connectivity necessary to enable the demonstration of selected nuclear reactor technologies and designs.

The NRIC subprogram activities include interactions with reactor developers who are considering options for demonstrating their reactor technologies as well as development of national laboratory capabilities for hosting advanced reactor demonstrations and tests. While NRIC is led by Idaho National Laboratory (INL) with significant activities at the INL Site, resources at other national laboratories and potential nuclear reactor demonstration sites will play an important role in achieving NRIC's objectives.

NRIC is expected to help accelerate technology readiness of advanced reactors to meet the energy needs of the future. Key support to be provided by NRIC includes:

- Establishing and maintaining testing capabilities at DOE national laboratories to enable development and future demonstration of advanced reactor technologies;
- Developing complementary technologies, in conjunction with relevant Nuclear Energy R&D programs, such as application of digital engineering philosophies and development and proof of concept of advanced construction technologies, to reduce the cost and schedule risks associated with the deployment of advanced reactors;
- Assisting with National Environmental Policy Act (NEPA) evaluations and DOE authorization related to testing of advanced reactor technologies;
- Developing a resource network of sites, facilities, and capabilities suitable for performing key R&D, experiments, tests, or fabrications, and for hosting advanced reactor demonstrations; and
- Identifying and facilitating resolution of experimental capability gaps which are vital to advanced reactor development and demonstration.

A key FY 2025 activity for NRIC includes support for establishing infrastructure for the testing of multiple advanced reactor concepts. The Demonstration and Operation of Microreactor Experiments (DOME) test bed will be capable of hosting experiments to support testing and development of microreactor technologies. DOME will be located at the former Experimental Breeder Reactor II facility at INL to support this new mission. Several microreactor developers have expressed interest in using DOME to test their technologies and generate data to support design and licensing activities. Construction of the DOME test bed is expected to be completed in FY 2025. Activities to support establishment of the LOTUS test bed are described in the Construction section of the ARDP program. It should be noted that Other Project Costs (OPCs) for the LOTUS project are reflected in the NRIC subprogram, while Total Estimated Costs (TECs) are reflected in line item 23-E-200, LOTUS.

National Reactor Innovation Center

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
National Reactor Innovation Center $67,000,000[2]	**$31,000,000**	**-$36,000,000**
• Continued support for establishment of the Molten Salt Thermophysical Examination Capability (MSTEC) at INL to close a vital experimental gap for molten salt reactors (MSRs). • Continued support for Phase I of the Advanced Construction Initiative (ACT) Initiative to enable development of advanced construction technologies that may reduce the cost and schedule risks associated with advanced reactor construction. • Engaged with key stakeholders such as the Nuclear Regulatory Commission (NRC), advanced reactor developers, and potential end-users. • Continued evaluating capabilities and gaps and working with R&D programs to facilitate. coordinated actions to address critical needs. • Awarded the contract for construction of the DOME test bed to enable development and future demonstration of microreactor technologies. • Continued OPC activities for the LOTUS project per DOE Order 413.3B.	• Initiate operation of MSTEC at INL to close a vital experimental gap for MSRs. • Continue Phase II of the ACT Initiative to support proof of concept of advanced construction technologies. • Complete construction of the DOME test bed to enable development and demonstration of microreactor technologies. • Develop documentation to establish performance baseline and start construction on the LOTUS project. • Enable access to additional Mechanisms Engineering Test Loop (METL) test vessels at Argonne National Laboratory to enable multiple experiments to run simultaneously, including those from several industry users, to advance component technologies that will be used in demonstration and commercial Sodium Fast Reactors	• The decrease reflects completion of DOME test bed construction and transition to DOME operations.

[2] FY 2023 Enacted levels include $20 million for the National Reactor Innovation Center that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

Risk Reduction for Future Demonstrations

Description

The Risk Reduction for Future Demonstrations subprogram supports advanced reactor concepts with the potential for future demonstration through cost-shared (up to 80% government, not less than 20% industry) competitively awarded (through a financial assistance solicitation) projects that are designed to maximize the utility of the results across the nuclear energy industry. The projects are aimed at reducing risk and technical uncertainty for a broad range of advanced reactor designs. Project activities may include R&D to address technical challenges associated with development of technologies and methods to improve the timelines for advanced reactor deployments, the cost and schedule for delivery of nuclear products, services, and capabilities supporting these nuclear technologies, design and engineering processes, and resolution of certification challenges potentially impeding the introduction of these technologies into the marketplace. This subprogram coordinates closely with the Reactor Concepts Research, Development & Demonstration program and other relevant programs to avoid duplication, leverage existing expertise, and maximize synergies.

In FY 2021, DOE announced the selection of five projects to aid advanced reactor developers in resolving technical, operational, and regulatory challenges to enable potential future demonstration of a diverse set of advanced reactor designs. The Risk Reduction projects support the development of safe and affordable advanced reactor technologies that may have the potential to be licensed and deployed by 2035. Industry partners are providing at least 20 percent in matching funds for their cost share of the program.

The five projects are:

- Kairos Power, LLC (Alameda, CA) will work to design, construct, and operate its Hermes reduced-scale test reactor. Hermes is intended to lead to the development of Kairos Power’s commercial-scale fluoride salt-cooled high temperature reactor (FHR), a novel advanced nuclear reactor technology that leverages TRI-structural ISOtropic particle fuel (TRISO) fuel in pebble form combined with a low-pressure fluoride salt coolant;
- Westinghouse Electric Company, LLC (Cranberry Township, PA) will advance the design of a heat pipe-cooled microreactor;
- BWXT Advanced Technologies, LLC (Lynchburg, VA) will mature a commercially viable transportable microreactor conceptual design focused on using TRISO fuel particles to achieve higher uranium loading and an improved core design using a silicon carbide (SiC) matrix;
- Holtec Government Services, LLC (Camden, NJ) will focus on early-stage design, engineering, and licensing activities to accelerate the development of its light water-cooled small modular reactor (SMR); and
- Southern Company Services Inc. (Birmingham, AL) will lead a project to design, construct, and operate the Molten Chloride Reactor Experiment (MCRE), a critical nuclear test bed supporting molten salt reactor systems and components demonstrations.

FY 2025 activities focus on continuing design activities; supporting further interactions with the NRC on high impact regulatory related topics; conducting activities to resolve technical, operational, and regulatory challenges; and developing and executing plans for establishing infrastructure and support capabilities to enable execution of the Risk Reduction projects and future commercialization activities.

Risk Reduction for Future Demonstrations

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Risk Reduction for Future Demonstrations $120,000,000[3]	**$142,500,000**	**$22,500,000**
• Support execution of the Risk Reduction projects per established project plans and using current and prior year carryover funds. Specific project activities include: ○ For the Kairos project: Conducted activities to support the design, licensing, construction, and operation of an FHR test reactor. ○ For the Westinghouse project: Scaled-up and enhanced heat pipe manufacturing and finalized design for irradiation test of moderator material. ○ For the BWXT project: Initiated fabrication of TRISO fuel specimens to support irradiation testing in INL's Advanced Test Reactor (ATR). ○ For the Holtec project: Initiated long lead procurement activities by selecting the Control Rod Drive Mechanism subcontract supplier which will demonstrate the capability of the existing supply chain. ○ For the Southern Company Services project: Completed design of the fuel salt synthesis line (FSSL). Continued procurement of long-lead equipment for FSSL. Continued to support the	• Support execution of the Risk Reduction projects per established project plans and using current and prior year carryover funds. Specific project activities include: ○ For the Kairos project: Initiate operation of the second Engineering Test Unit (ETU) to demonstrate the design, modular construction, and high temperature operations of the Hermes reactor and heat transport systems. Complete detailed design for the Hermes reactor, start construction of the facility, and submit an operating license application to the NRC. ○ For the Westinghouse project: Begin irradiation of moderator material at the INL's ATR to characterize irradiation effects. Use NRC feedback on white papers and through regulatory engagement to identify future licensing actions and reduce regulatory risk. ○ For the BWXT project: Load ATR test capsules with fuel specimen, ready for irradiation. Complete additional fuel specimen irradiation at Oak Ridge National	• The increase reflects planned ramp-up in project activities to support long lead procurements and maintenance of project schedules.

[3] FY 2023 Enacted levels include $120 million for Risk Reduction for Future Development that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
development of nuclear safety basis documentation to enable DOE authorization of MCRE and ensure safe operations.	Laboratory in the High Flux Isotope Reactor (HIFR) ○ For the Holtec project: Issue plans for nuclear steam supply system equipment manufacturing. ○ For the Southern Company Services project: Initiate fuel salt production. Commission a non-nuclear mock-up of MCRE to de-risk operation of the fueled reactor experiment. Complete MCRE system level detailed design reviews.	

Regulatory Development

Description

The Regulatory Development subprogram coordinates with the Nuclear Regulatory Commission (NRC) and industry to address and resolve key regulatory framework issues that directly impact the “critical path” to advanced reactor demonstration and deployment. Part of the subprogram focuses on regulatory modernization activities such as developing adaptations of light water reactor (LWR)-based regulations for non-LWR advanced reactors, finalizing the establishment of risk-informed and performance-based license application guidance, and establishing clear expectations for license application content and review criteria. Other regulatory development activities include resolving the technical basis to support NRC endorsement of codes and standards important for the manufacture of advanced reactor components and expanding access to priority material property data to be used in safety codes and models in support of licensing. The Regulatory Development subprogram supports limited R&D aimed at producing broadly applicable results than can be used by an array of private sector companies to inform their regulatory requirements. Design-specific regulatory gaps for advanced reactors, including fast reactors, gas-cooled reactors, and molten salt reactors, are also addressed. In FY 2025, the Regulatory Development subprogram will provide resources for cost-share grants to applicants for the purpose of funding a portion of NRC fees for pre-application and licensing application review activities.

Regulatory Development

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Regulatory Development $12,065,000	**$15,000,000**	**+$2,935,000**
• Provided support for industry and NRC interactions that are establishing the advanced non-light water reactor regulatory framework. • Continued efforts to address unresolved and high impact NRC regulatory policy issues impacting advanced reactor licensing. • Developed the technical basis for material surveillance technologies to be used by owner/operators to implement a materials degradation management program for MSRs. • Utilized the Liquid Salt Test Loop (LSTL) at the Oak Ridge National Laboratory to test sensors and demonstrate tools in support of MSR development and deployment. • Developed and maintained the fast reactor database to archive historical data for fast reactor fuels and materials to preserve data, knowledge, and experience. • Continued development and testing to support inclusion of Alloy 709 (alloy with increased materials performance in high temperature advanced reactor operating environments) in the American Society of Mechanical Engineers (ASME) Code.	• Continue to coordinate with industry and the NRC to identify and resolve technology gaps and high impact challenges associated with advanced reactor regulation. • Continue efforts to establish a risk-informed and performance based advanced reactor regulatory framework. • Enable submittal of an industry-driven proposal to the NRC on Technology Inclusive Management of Safety Case (TIMaSC). • Complete quality assurance of legacy fast reactor fuel data from twelve experiments within the Fuels Irradiation and Physics Database to support fast reactor licensing activities. • Complete the data package preparation for the initial Alloy 709 ASME code case by utilizing the years of tensile, creep, fatigue and creep-fatigue testing data generated by the program. • Complete analyses to evaluate and inform MSR mechanistic source term gaps. • Continue execution of the Advanced Nuclear Energy Licensing Cost-Share Grant Program, including award selections.	• The increase reflects an expansion of the Advanced Nuclear Energy Cost-Share Grant Program to help reduce the regulatory risks for advanced reactors as they move closer to the demonstration phase.

Advanced Reactor Safeguards and Security

Description

The Advanced Reactor Safeguards and Security (ARSS) subprogram evaluates safeguards and security issues unique to advanced reactor designs and informs and improves advanced reactor designs by addressing issues such as diversion of advanced fuel forms, protection of remotely operated plants, and other proliferation and security concerns. Broadly, the ARSS subprogram also helps to reduce security costs by utilizing the latest technologies and approaches for plant monitoring and protection.

The research within the ARSS subprogram supports efforts found within National Security Memorandum 19, "Counter Weapons of Mass Destruction Terrorism and Advance Nuclear and Radioactive Material Security." Specifically, ARSS works to maintain robust security for advanced reactor high-activity radioactive sources during their lifecycle through our research on physical protection systems. ARSS also supports improvements to end-user capacities for long-term stewardship approaches that ensure these materials will be tracked and secured from theft or diversion domestically through our Material Control and Accountability (MC&A) research.

The ARSS subprogram focuses on both the systems level and technologies across three major elements: physical protection systems, material control and accountability (MC&A), and cybersecurity.

- Physical Protection Systems (PPS) – Develops advanced response technologies, tactics, and design approaches; advanced intrusion detection and advanced delay technologies for small modular reactors and microreactors. Also interfaces with international security programs and supporting the Gen-IV Proliferation Resistance & Physical Protection (PR&PP) Working Group.
- Material Control and Accountability – Evaluates the regulatory approach, determines the driving requirements, and develops baseline accountancy approaches for small modular reactors and microreactors. Develops and evaluates new tools, techniques, methods, and technologies for measurements and process monitoring. Also considers and incorporates international safeguards requirements and interfaces with international safeguards program.
- Cybersecurity – Develops cyber-informed engineering and defensive cyber architecture systems approach, as well as secure elements/tokens, control system component testing, and supply chain issues.

All three major elements work to mature these areas through vendor engagements with broadly applicable results. This work is completed at the DOE national laboratories and generates lessons learned and/or generic deliverables to share information broadly with the advanced reactor community.

The ARSS subprogram also coordinates with the Nuclear Regulatory Commission (NRC), the Department of Energy's (DOE) National Nuclear Security Administration (NNSA), DOE's Cybersecurity Research and Development Coordination Working Group, the nuclear industry, and university community to avoid duplication of activity and leverage nationwide expertise. Together, these safeguards and security activities help further advanced reactors development and deployment.

Advanced Reactor Safeguards and Security

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Advanced Reactor Safeguards and Security $9,250,000	**$11,000,000**	**+$1,750,000**
• Refined and expanded physical protection design alternatives for a diverse set of advanced reactors, to support cost effective, market competitive designs. • Developed a pebble bed burnup measurement strategy and experimental plan to assist pebble bed reactor vendors to meet key monitoring and accountancy requirements. • Engaged with advanced reactor vendors, in coordination with NNSA, to advance both domestic and international safeguards and security by design.	• Demonstrate burnup measurements on short-cooled TRI-structural ISOtropic particle (TRISO) fuel to advance MC&A technologies and techniques. • Demonstrate new measurement technologies on surrogate salt materials representative of MSR fuel. • Demonstrate a model-based systems engineering approach for advanced reactor cybersecurity design. • Expand maturation of design-specific PPS, MC&A, and cyber issues and generate lessons learned for the advanced reactor community.	• The increase from $8,065,000 to $11,000,000 reflects expanded activities across the program and focus on integrated safety, security, and safeguards by design for U.S. advanced reactors.

Construction

Description
Line-item capital projects are sometimes required to maintain the ability to support mission goals. These projects help achieve the Department's and Nuclear Energy (NE)'s strategic objectives by maintaining site services and providing critical information for future decisions. These activities are focused on two primary objectives: (1) identification, planning, and prioritization of projects required to meet NE program objectives, and (2) development and execution of these projects within approved cost and schedule baselines. While the Department's acquisition management process does not guarantee that a project will be completed once the initial information gathering and preliminary design phase are complete, it does provide an important decision-making framework that, when well executed, allows only the most critically necessary, cost-effective projects to proceed to construction.

23-E-200, Laboratory for Operations and Testing in the U.S. (LOTUS)
The LOTUS Project will enable and support the development and deployment of advanced nuclear systems by providing the infrastructure for advanced reactor developers to test fueled experiments that utilize Safeguards Category I materials for operation. First-of-a-kind nuclear technology developers need a location for testing, validating, and maturing new technologies or concepts, and for validating the safety and workability of systems or components individually or as part of the overall system. Advanced reactor developers also need to generate data on key phenomena relevant to the design and safe operation of their designs to aid in future licensing and commercial deployment of these technologies. Although not required for the commercial concepts, some experiments require higher enrichment fuel to keep the size of the experiment small while ensuring that neutronics and thermal hydraulics are representative of commercial designs. The LOTUS Project will make available a robust facility that can provide the appropriate containment capabilities and supporting infrastructure.

The Critical Decision (CD)-1, Approve Alternative Selection and Cost Range was approved for the LOTUS Project on June 1, 2023. Approval of CD-1 established the cost range of $65.6 million to $98.2 million for the design and construction of LOTUS. The approved alternative is to modify the Zero Power Physics Reactor facility at the Materials and Fuels Complex at Idaho National Laboratory. Consistent with Congressional guidance provided in the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2022 (P.L. 117-103), the Department initiated conceptual design activities in FY 2022.

The FY 2025 budget request supports initiation of construction activities associated with establishing the testbed capability following approval of the performance baseline, including construction award and long lead procurement of facility systems such as control room components, electrical equipment, ventilation equipment, and fire suppression systems.

Construction

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Change FY 2025 Request vs FY 2023 Enacted
Construction **$20,000,000**	**$18,748,000**	**–$1,252,000**
Laboratory for Operations and Testing in the U.S. (23-E-200) • Initiate preliminary design activities.	Laboratory for Operations and Testing in the U.S. (23-E-200) • Initiate construction related activities, including long lead procurement of facility systems.	Laboratory for Operations and Testing in the U.S. (23-E-200) • The decrease reflects continuation of LOTUS project consistent with performance baseline.

Advanced Reactor Demonstration Program
Construction Projects Summary ($K)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
23-E-200, LOTUS, INL						
Total Estimated Cost (TEC)	73,000	2,252	20,000	20,000	18,748	-1,252
Other Project Costs (OPC)[1]	25,200	4,557	1,000	1,000	9,000	+8,000
Total Project Cost (TPC) Project Number 23-E-200	**98,200**	**6,809**	**21,000**	**21,000**	**27,748**	**+6,748**
Total All Construction Projects						
Total Estimated Cost (TEC)	73,000	2,252	20,000	20,000	18,748	-1,252
Total Other Project Costs (OPC)	25,200	4,557	1,000	1,000	9,000	+8,000
Total Project Cost (TPC) All Construction Projects	**98,200**	**6,809**	**21,000**	**21,000**	**27,748**	**+6,748**

[1] OPC funding for 23-E-200, LOTUS is included within the National Reactor Innovation Center subprogram line.

23-E-200, Laboratory for Operations and Testing in the United States
Idaho National Laboratory
Project is for Design and Construction

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

Summary

The fiscal year (FY) 2025 Budget Request for the Laboratory for Operations and Testing in the United States (LOTUS) project is $18,748,000 of Total Estimated Cost (TEC) funding and $9,000,000 of Other Project Costs (OPC) funding. The current Total Project Cost (TPC) range for the design and construction of LOTUS is $65,600,000 to $98,200,000 and a Critical Decision (CD)-4 date is 2Q FY 2030.

The requested capital funding in FY 2025 supports initiation of construction activities following CD-2/3 approval including construction award and long lead procurement of facility systems, such as control room components, electrical and ventilation equipment, and fire suppression systems. In FY 2024, the project is expected to complete design and proceed with the approval of the performance baseline to support start of construction in FY 2025. Based on Congressional direction to establish test bed capabilities at INL to support experimental reactor demonstration activities, the project's acquisition strategy will utilize a tailored approach per DOE Order 413.3B. The LOTUS project will provide a dynamic test bed to support testing of experimental reactor concepts consistent with DOE safety and security requirements.

A Level 3 Federal Project Director (FPD) has been assigned to this project.

Significant Changes

This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS and does not include a new start for FY 2025. The ROM cost range at CD-0 was $28,000,000 to $97,000,000. The most recent Department of Energy (DOE) Order 413.3 B CD-1 was approved on June 1, 2023. Approval of CD-1 established a TPC range for the design and construction of LOTUS of $65,600,000 to $98,200,000. With the selection of the preferred alternative at CD-1, the project refined estimated costs specific to the preferred alternative versus the range of alternatives, resulting in a decrease in contingency and better alignment of TEC and OPC.

The approved alternative is to modify the existing Zero Power Physics Reactor (ZPPR) facility at the Materials and Fuels Complex, Idaho National Laboratory (INL).

Critical Milestone History

(Fiscal Quarter or Date)

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	Final Design Complete	CD-2/3	D&D Complete	CD-4
FY 2022	3/8/2022	1/13/2022	TBD	TBD	TBD	N/A	TBD
FY 2023	3/8/2022	1/13/2022	TBD	TBD	TBD	N/A	TBD
FY 2024	3/8/2022	1/13/2022	TBD	TBD	TBD	N/A	TBD
FY 2025	3/8/2022	1/13/2022	6/1/2023	3Q FY 2024	2Q FY 2025	N/A	2Q FY 2030

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
Final Design Complete – Estimated/Actual date the project design will be/was complete(d)
CD-2/3 – Approve Performance Baseline, and Approve Start of Construction
Construction Complete – Completion of construction
CD-4 – Approve Start of Operations or Project Closeout

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2022	TBD	N/A	N/A
FY 2023	TBD	N/A	N/A
FY 2024	TBD	N/A	N/A
FY 2025	TBD	N/A	N/A

CD-3A – Approve Long-Lead Procurements, Original Scope
CD-3B – Approve Long-Lead Procurements, Revised Scope (as needed)

Project Cost History

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Total	TPC
FY 2022	10,992	52,231	63,223	33,777	97,000
FY 2023	10,992	52,231	63,223	33,777	97,000
FY 2024	10,992	52,231	63,223	33,777	97,000
FY 2025	15,600	57,400	73,000	25,200	98,200 [a, b]

a. Project costs revised based on approved CD-1
b. Project costs are preliminary pending CD-2/3 approval and represent the high end of the cost range.

No construction will be performed until the project performance baseline is validated and CD-3 is approved.

2. Project Scope and Justification

Scope

Laboratory for Operations and Testing in the United States (LOTUS) will provide a dynamic test bed to support testing of advanced experimental reactor concepts. The test bed will be designed and constructed to meet the following minimum requirements:

- The test bed capability must have the supporting infrastructure to safely test experimental advanced reactor concepts and interface, as necessary, with reactor support systems.
- The test bed will provide approximately 10,000 square feet of new constructed area to support access roads and concrete pads, not enclosed or covered, for necessary equipment.
- The test bed capability must be able to satisfy Natural Phenomena Hazard (NPH) criteria. As a Hazard Category 2 nuclear facility, the test bed must meet the NPH requirements of DOE Order 420.1C, “Facility Safety”, including seismic, wind, flood, and volcanic hazards. Design and construction must ensure that systems, structures, and components will perform safety functions during and after design basis NPH events.
- The test bed capability must be able to provide confinement capability during postulated accident and design basis events. Specifically, it must prevent or control radioactive material release to the environment either in operation or from an accident; and it must ensure air supply and exhaust are controlled, and typically filtered. Confinement may be provided by some combination of leak tightness in the structure and active ventilation to maintain a negative pressure.
- The test bed capability must have the infrastructure (physical and resource) to appropriately control safeguards category I materials.
- The test bed capability must provide the minimum features necessary to conduct an experiment to validate an advanced reactor design. The test bed capability must be available for advanced reactor testing for a minimum of 20 years from the start of operation.

Key Performance Parameters (KPPs)

A KPP is a vital characteristic, function, requirement, or design basis that, if changed, would have a major impact on the facility or system performance, scope, schedule, cost, risk, or the ability of an interfacing project to meet its mission requirements. The preliminary threshold KPPs represent the minimum acceptable scope for successful delivery of the Laboratory for Operations and Testing in the United States (LOTUS) project. Achievement of KPPs will be a prerequisite for approval of CD-4. Final KPPs will be established at CD-2/3 when the project's Performance Baseline is established.

Preliminary Threshold KPPs

Performance Measure	Threshold
Provide the facility infrastructure to support the operation of experimental/test reactors that utilize fuels requiring enhanced security requirements.	Establishment of core infrastructure needed to support operation of experimental/test reactors in the test bed, with clearly defined boundaries: • Electrical supply and back-up power (as necessary) • Ventilation/exhaust for test bed cell • Support systems (e.g., compressed air, argon, fire protection, oxygen monitoring, criticality monitoring, chilled water loop system) • Establishment of control room area with appropriate data connections
Establish a Hazard Category 2 nuclear facility capable of supporting tests using safeguards category I quantities of material	Establishment of equipment access capability with required confinement and security features Approved Safety Analysis Report addressing test bed capability Completion of DOE Operational Readiness Review for the test bed capability in accordance with DOE Order 425.1D Completion of Vulnerability Assessment demonstrating compliance with applicable security requirements

Completion of operational readiness activities for first reactor tests utilizing LOTUS will not be requisite for determining successful project completion.

As applicable, LOTUS will be constructed using sustainable building considerations per Department of Energy Guide 413.3-6B, dated 4-5-2020, "High Performance Sustainable Buildings." The design will include provisions for meeting the 2016 and 2020 Guiding Principles for Sustainable Federal Buildings, as applicable. Design, construction, and documentation of the Guiding Principles ensure compliance with DOE Order 436.1, Departmental Sustainability.

Funds appropriated under this data sheet may be used to provide independent assessments related to project planning and execution.

Justification

Nuclear power remains an important part of our Nation's energy portfolio as we strive to reduce carbon emissions and address the threat of global climate change. Following the advent of nuclear power generation, the U.S. was an international leader in the development and testing of advanced nuclear reactor technologies. DOE and its predecessor organizations appropriately provided nuclear fuels and materials development capabilities and large-scale demonstration facilities in support of currently deployed nuclear reactor technologies. However, the existing industrial and DOE test bed facilities are not currently capable of supporting fueled advanced reactor tests and international facilities are not an option due to concerns with access, transportation, and technical equivalencies. Lack of domestic advanced reactor test bed capabilities is hampering the U.S. ability to move forward in the development of next generation nuclear reactors.

The Nuclear Energy Innovation Capabilities Act of 2017 (P.L. 115-248) (NEICA), Section 958, Enabling Nuclear Energy Innovation, authorized the National Reactor Innovation Center (NRIC) as a program to enable the testing and demonstration of reactor concepts to be proposed and funded, in whole or in part, by the private sector. As a result, the DOE Office of Nuclear Energy launched the NRIC in August 2019. NRIC is charged with developing the infrastructure needed for the testing and demonstration of multiple advanced reactor concepts. To fulfill that charge, NRIC has been exploring options to develop test bed capabilities to provide industry partners the infrastructure to startup, test, and operate experimental reactors in a safe and economical manner.

Establishment of the LOTUS capability will provide industry with the infrastructure necessary to support development and testing of experimental reactors requiring safeguards category I materials for operation. Testing of these reactor concepts will provide real data that can be used to validate models and support subsequent licensing activities to bring the reactors to market.

Establishment of the test bed is consistent with Congressional direction provided in the joint explanatory statements accompanying the Consolidated Appropriations Acts of 2021, and 2022.

3. Financial Schedule

($K)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2022	2,252	2,252	500
FY 2023	8,992	8,992	4,000
FY 2024	4,356	4,356	11,100
FY 2025	0	0	
Total, Design (TEC)	15,600	15,600	15,600
Construction			
FY 2023	11,008	11,008	0
FY 2024	27,644	27,644	0
FY 2025	18,748	18,748	25,000
Outyears	0	0	32,400
Total, Construction (TEC)	57,400	57,400	57,400
Total Estimated Costs (TEC)			
FY 2022	2,252	2,252	500
FY 2023	20,000	20,000	4,000
FY 2024	32,000	32,000	11,100
FY 2025	18,748	18,748	25,000
Outyears	0	0	32,400
Total TEC	**73,000**	**73,000**	**73,000**
Other Project Costs			
FY 2021	3,957	3,957	1,037
FY 2022	600	600	2,674
FY 2023	1,000	1,000	1,000
FY 2024	3,000	3,000	1,500
FY 2025	9,000	9,000	7,000

	Budget Authority (Appropriations)	Obligations	Costs
Outyears	7,643	7,643	11,989
Total OPC	25,200	25,200	25,200
Total Project Costs (TPC)			
FY 2021	3,957	3,957	1,037
FY 2022	2,852	2,852	3,174
FY 2023	21,000	21,000	5,000
FY 2024	35,000	35,000	12,600
FY 2025	27,748	27,748	32,000
Outyears	7,643	7,643	44,389
Grand Total	**98,200**	**98,200**	**98,200**

4. Details of Project Cost Estimate

(Budget Authority $K)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	13,180	6,281	TBD
Contingency	2,420	4,711	TBD
Total, Design	15,600	10,992	TBD
Construction			
Site Work	2,735	5,272	TBD
Equipment	0	0	TBD
Construction	43,285	24,577	TBD
Other, as needed	0	0	TBD
Contingency	11,380	22,382	TBD
Total, Construction	57,400	52,231	TBD
Other TEC (if any)			
Cold Startup	N/A	N/A	N/A
Contingency	N/A	N/A	N/A
Total, Other TEC	N/A	N/A	N/A
Total Estimated Cost	73,000	63,223	TBD
Contingency, TEC	13,800	27,093	TBD
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design/Planning	4,620	4,303	TBD

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Other OPC Costs	17,680	15,001	TBD
Contingency	2,900	14,473	TBD
Total, OPC	25,200	33,777	TBD
Contingency, OPC	2,900	14,473	TBD
Total Project Cost	98,200	97,000	TBD
Total Contingency (TEC+OPC)	16,700	41,566	TBD

5. Schedule of Appropriation Requests

($K)

Request Year	Type	Prior Years	FY 2022	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2022	TEC	0	2,000	20,000	32,000	N/A	9,223	63,223
	OPC	3,957	600	1,000	8,000	N/A	20,220	33,777
	TPC	3,957	2,600	21,000	40,000	N/A	29,443	97,000
FY 2023	TEC	0	2,000	20,000	32,000	N/A	9,223	63,223
	OPC	3,957	600	1,000	8,000	N/A	20,220	33,777
	TPC	3,957	2,600	21,000	40,000	N/A	29,443	97,000
FY 2024	TEC	0	2,000	20,000	32,000	N/A	9,223	63,223
	OPC	3,957	600	1,000	8,000	N/A	20,220	33,777
	TPC	3,957	2,600	21,000	40,000	N/A	29,443	97,000
FY 2025	TEC	0	2,252	20,000	32,000	18,748	0	73,000
	OPC	3,957	600	1,000	3,000	9,000	7,643	25,200
	TPC	3,957	2,852	21,000	35,000	27,748	7,643	98,200

5. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	4Q FY 2030
Expected Useful Life (number of years)	20
Expected Future Start of D&D of this capital asset (fiscal quarter)	4Q FY 2050

Related Funding Requirements
(Budget Authority $K)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations and Maintenance	TBD	22,412	TBD	575,000

Life-cycle operations and maintenance costs include escalation.

7. D&D Information

The new area being constructed in this project is modifying an existing facility.

	Square Feet
New area being constructed by this project at INL	Up to 10,000
Area of D&D in this project at INL	0
Area at INL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Area of D&D in this project at other sites	0
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Total area eliminated	0

Site location, building name or numbers, and square footages of existing facilities to be replaced: N/A

As an advanced reactor test bed (laboratory facility), the proposed LOTUS is not subject to Freeze the Footprint (>50% lab space).

8. Acquisition Approach Based on Congressional direction to establish test bed capabilities at INL to support advanced reactor demonstration activities, the project's acquisition strategy will utilize a tailored approach under DOE Order 413.3B. This tailoring approach allows for timely movement into capital design activities following selection of a preferred alternative for meeting the identified capability gap.

As a Hazard Category 2 nuclear facility, design, and construction of the LOTUS must be integrated with ongoing nuclear operations activities. Design and construction must also be coordinated/integrated with nuclear research and development programs. A design-bid-build project delivery method managed by the INL management and operating contractor will be used for the design and construction of LOTUS. A firm, fixed-price construction subcontract is anticipated for construction of the LOTUS test bed.

Infrastructure

Overview

Infrastructure consists of the Idaho National Laboratory (INL) Facilities Operations and Maintenance (IFM), Oak Ridge National Laboratory Nuclear Facilities Operations and Maintenance, and Construction subprograms.

The mission of the IFM subprogram is to manage the planning, acquisition, operation, maintenance, and disposition of the multi-program nuclear facilities and capabilities owned by the Office of Nuclear Energy (NE) along with the supporting infrastructure at INL. The IFM subprogram maintains the Department of Energy (DOE) mission-supporting facilities and capabilities at INL in a safe and compliant status (with DOE Orders, federal laws and regulations, and state agreements) to enable technological advancement in the existing nuclear fleet, advanced reactor pipeline, and fuel cycle missions. These key facilities and capabilities support NE research and development (R&D) necessary to revitalize nuclear energy in the U.S. These INL facilities and capabilities also support testing of naval reactor fuels, reactor core components and a diverse range of national security technology programs for the National Nuclear Security Administration (NNSA), isotope production for the Office of Science, and other federal agencies in critical infrastructure protection, nuclear nonproliferation, and incident response. The IFM subprogram integrates and closely coordinates with research programs to ensure proper alignment and prioritization of infrastructure investments, as well as availability of infrastructure for programmatic work.

Oak Ridge National Laboratory (ORNL) Nuclear Facilities Operations and Maintenance subprogram maintains Office of Science owned nuclear hot cells capabilities in a safe, compliant status.

The Construction subprogram plays a critical role in revitalizing the NE infrastructure. The subprogram focuses on addressing identified gaps created by either deteriorating critical infrastructure or evolving NE missions.

Highlights of the FY 2025 Budget Request

The Construction subprogram reflects completion of the Sample Preparation Laboratory (SPL) project capital funding profile.

The ORNL Nuclear Facilities Operations and Maintenance subprogram is fully funded in the Office of Science FY 2025 Request.

Infrastructure
Funding ($K) (Non-Comparable)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Infrastructure					
INL Facilities Operations and Maintenance[1]	318,924	318,924	333,922	+14,998	+4.7%
ORNL Nuclear Facilities O&M	20,000	20,000	0	-20,000	-100%
Construction	7,300	7,300	0	-7,300	-100%
Total, Infrastructure	**346,224**	**346,224**	**333,922**	**-12,302**	**-3.6%**

[1] Funding does not reflect the transfer of $99,747,000 in FY 2023 from Naval Reactors for maintenance and operation of the Advanced Test Reactor.

Infrastructure
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
INL Facilities Operations and Maintenance:	
The increase from $318,924,000 to $333,922,000 supports ongoing efforts to improve the reliability and availability of facilities at the Advanced Test Reactor and Materials and Fuels Complex and transition the Sample Preparation Laboratory to full operation.	**+14,998**
ORNL Nuclear Facilities Operations and Maintenance:	
The decrease from $20,000,000 to $0 reflects these activities are fully funded within the Office of Science FY 2025 Request.	**-20,000**
Construction:	
The decrease from $7,300,000 to $0 reflects completion of established baseline funding requirements for the Sample Preparation Laboratory (SPL) project.	**-7,300**
Total, Infrastructure	**-12,302**

INL Facilities Operations and Maintenance

Description

<u>INL Nuclear Research Reactor Operations and Maintenance</u>

This subcategory supports operations and maintenance of the nuclear research reactors at the Advanced Test Reactor (ATR) Complex and the Materials and Fuels Complex (MFC), including the ATR, the ATR Critical Facility (ATRC), the Transient Reactor Test Facility (TREAT), and the Neutron Radiography Reactor (NRAD).

The ATR is the primary research reactor at the Idaho National Laboratory (INL). The ATR supports the majority of the Office of Nuclear Energy (NE) research and development (R&D) programs, as well as the Naval Reactors (NR) Program in support of the U.S. Navy nuclear fleet and National Nuclear Security Administration (NNSA) programs. The ATR is also used by universities, laboratories, and industry and is the primary scientific capability of the Nuclear Science User Facilities (NSUF). R&D demand for thermal neutron irradiation at ATRC and neutron radiography and small component test irradiation at NRAD continues to be significant. The TREAT reactor, an air-cooled thermal spectrum test facility, continues to address technical challenges for reactor fuels related to nuclear fuel performance and qualification. All programmatic work is funded by the sponsoring federal programs. The cost to other users is determined in accordance with Department of Energy (DOE) regulations and depends upon the demands on the reactor and the nature of the user.

To satisfy the irradiation needs of ATR users, efforts will continue in FY 2025 to improve the availability and reliability of the ATR. FY 2025 request includes funds for repair, and replacement of end-of-life reactor components and systems. Additionally, in FY 2025, preliminary evaluation and planning will be initiated for modernizing or replacing end of life thermal neutron irradiation capabilities.

Operations at TREAT and NRAD will continue in FY 2025 to support a wide range of customers including NE R&D programs, commercial industry, and other Federal Agencies.

<u>INL Non-Reactor Nuclear Research Facility Operations and Maintenance</u>

This subcategory provides funding for operations, maintenance, and support of non-reactor nuclear and radiological research facilities primarily located at the MFC. Activities within this category sustain unique nuclear and radiological capabilities essential to multiple NE R&D programs. This includes maintaining a safe operating envelope by conducting maintenance (preventative and corrective) and refurbishments to sustain or improve core infrastructure capabilities. The non-reactor nuclear research facilities support core programmatic capabilities for inspecting, fabricating, and processing a myriad of radioactive and non-radioactive materials including:

- Post-irradiation Examination (PIE) and Fresh Fuel Characterization – Receipt of irradiated fuels and materials, non-destructive examinations, destructive examinations and analyses, and mechanical testing of highly radioactive materials.
- Experimental Fuel Fabrication – R&D on fabrication of multiple fuel types at various enrichment levels.
- Advanced Separation and Waste Form – Separation, pre-treatment technology development, electrochemical separation, and engineering scale waste form development.

To enable R&D activities at the MFC, efforts will continue in FY 2025 to ensure facility availability and equipment reliability is as high as feasible. In FY 2023, the cumulative facility availability for MFC was 91%. In FY 2025, MFC Plant Health investments will continue to focus on improving throughput in MFC mission facilities, such as hot cell window replacements, and manipulator refurbishments.

This subprogram also provides funding for the management of NE-owned special nuclear material (SNM), operation and maintenance of the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility, the Radioactive Scrap and Waste Facility (RSWF), support for Nuclear Regulatory Commission cask certifications and Other Project Costs (OPCs) for the Sample Preparation Laboratory (SPL) Project.

INL Engineering and Support Facility Operations and Maintenance

This subcategory provides funds for community and technical support activities including support for the Shoshone-Bannock Tribes, Idaho Department of Environment Quality, and environmental reviews and data collection to support future permits and NEPA reviews. This subcategory also funds Payment in Lieu of Taxes (PILT), Institute of Nuclear Power Operations, and Departmental cross-cutting infrastructure reporting requirements.

Since 1992, the Department of Energy (DOE) has a formal relationship via an Agreement in Principle (AIP) with the Shoshone-Bannock Tribes in recognition of the Tribes' connection and vested interest in the land upon which INL is located. Support is provided to the Tribes to participate in the review of Environmental Impact Statements and Environmental Assessments, cultural resource surveys and protection, environmental surveillance, and emergency response and preparedness.

INL Regulatory Compliance

This subcategory supports activities for continual compliance with the State and Federal environmental laws and other regulations applicable to INL. Compliance activities focus on air, soil, and water monitoring and waste disposal consistent with Federal and State permit requirements and agreements such as the INL Site Treatment Plan. Regulatory activities also include efforts that support compliance with the 1995 Settlement Agreement with the State of Idaho, which governs management and disposition of spent nuclear fuel and transuranic wastes at the INL. In November 2019, DOE and the State of Idaho signed a Supplemental Agreement to the 1995 Idaho Settlement Agreement that reaffirms DOE's and Idaho's commitment to remove Cold War legacy waste and special nuclear materials from Idaho. The FY 2025 funds will support spent fuel stabilization and legacy waste disposition consistent with approved plans.

INL Facilities Operations and Maintenance
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
INL Nuclear Research Reactor Operations and Maintenance $119,362,000	**$134,068,000**	**+$14,706,000**
• Maintained Advanced Test Reactor (ATR) availability at 75% with 119 irradiation days. • Continued investments to improve ATR availability and reliability through refurbishments and replacements of reactor systems and components. • Initiated planning for major maintenance and repair activities required to sustain ATR operations through 2040. • Maintained transient testing operations at the Transient Reactor Test Facility (TREAT) facility consistent with approved irradiation schedule. • Operated the Neutron Radiography Reactor (NRAD) consistent with research requirements.	• Maintains ATR availability at 85% with a target of 165 irradiation days during FY 2025. • Continues investments to improve ATR availability and reliability through modernization, refurbishments and replacements of reactor systems and components. • Continues planning activities for future thermal test reactor irradiation capabilities. • Continues transient testing operations at the TREAT facility and NRAD operations consistent with approved research plans.	• The increase supports funding for annual investments to address aging equipment and infrastructure.
INL Non-Reactor Nuclear Research Facility Operations and Maintenance $180,005,000	**$185,148,000**	**+$5,143,000**
• Met Materials and Fuels Complex (MFC) operational efficiency goals with cumulative facility and research equipment availability at 91 percent. • Completed scheduled modernization efforts to improve reliability, such as the MFC Analytical Lab Ventilation Upgrade Project. Completed planned off-site disposition of surplus NE-owned SNM consistent with programmatic needs. • Completed planned construction activities for the Sample Preparation Laboratory Project consistent with the baseline, achieving an overall 85% construction completion level.	• Operates and maintains MFC infrastructure, facilities, and equipment to support facility operations and availability for programmatic activities. • Performs maintenance and refurbishment activities within the MFC nuclear facilities and infrastructure consistent with the approved safety basis. • Continues infrastructure investments to improve reliability and availability of key MFC facilities. • Continues planning for future uranium-based fuel fabrication research capabilities. • Continues off-site disposition of surplus NE-owned SNM consistent with programmatic needs	• The increase reflects funding for investments to improve facility reliability and availability and to transition the Sample Preparation Laboratory to full operation.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	and approved nuclear material allotment forecasts. • Continue operational readiness activities for the Sample Preparation Laboratory.	
INL Engineering and Support Facility Operations and Maintenance $5,743,000	**$4,500,000**	**-$1,243,000**
• Continued to support federally funded activities to maintain operations at the INL such as Payment in Lieu of Taxes (PILT); environmental review and data collection to support future permits/NEPA assessments; and community support activities for local Shoshone- Bannock Tribes.	• Continues to support federally funded activities to maintain operations at the INL such as PILT; environmental review and data collection to support future permits/NEPA assessments; and community support activities for local Shoshone-Bannock Tribes.	• The decrease reflects anticipated costs to support planned assessments and surveys.
INL Regulatory Compliance $13,814,000	**$10,206,000**	**-$3,608,000**
• Continued regulatory compliance program management. Exceeded Idaho National Laboratory (INL) Site Treatment Plan milestones for treatment of two cubic meters of mixed low-level waste (MLLW) annually based on a three-year rolling average. • Received final shipments of Experimental Breeder Reactor (EBR)-II used nuclear fuel from wet storage in accordance with the 1995 Idaho Settlement Agreement. • Processed eleven batches of EBR-II fuel. • Completed environmental surveillance and monitoring activities.	• Continues regulatory compliance program management. • Meets INL Site Treatment Plan milestones for treatment of two cubic meters of MLLW annually based on a three-year rolling average. • Processes a minimum of 8 treatment batches of EBR-II fuel. Conduct environmental surveillance and monitoring activities.	• The decrease reflects completion of transfer of used nuclear fuel from wet storage to dry per the Idaho Settlement Agreement.

ORNL Nuclear Facilities O&M

Description

Consistent with congressional direction, this program provided funds in FY 2023 to support Oak Ridge National Laboratory (ORNL) hot cells, managed by the Office of Science. In FY 2025, full funding for the ORNL Nuclear Facilities is included in the Office of Science Request.

ORNL Nuclear Facilities O&M
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Oak Ridge Nuclear Infrastructure $20,000,000	**$0**	**-$20,000,000**
• Consistent with the FY 2023 Appropriation, the Oak Ridge Nuclear Facilities are managed by the Office of Science. FY 2023 accomplishments are captured in the Office of Science FY 2024 Request.	• No funding is requested.	• No funding is requested in FY 2025 as full funding for the ORNL Nuclear Facilities are included in the Office of Science Request.

Construction

Description

Line-item capital projects are sometimes required at the Idaho National Laboratory (INL) to maintain its ability to support mission goals. These projects help achieve the Department's and Nuclear Energy (NE)'s strategic objectives by maintaining site services and providing critical information for future decisions. This activity is focused on two primary objectives: (1) identification, planning, and prioritization of projects required to meet NE program objectives, and (2) development and execution of these projects within approved cost and schedule baselines.

Construction
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2024 Request
Construction $7,300,000	**$0**	**-$7,300,000**
Sample Preparation Laboratory (16-E-200) ($7,300,000) • Completed 85% of the Sample Preparation Laboratory (SPL) building construction.	*Sample Preparation Laboratory (16-E-200) ($0)* • No additional capital funding is required to complete the Sample Preparation Laboratory.	*Sample Preparation Laboratory (16-E-200) (-$7,300,000)* • The decrease reflects completion of established baseline funding requirements.

Infrastructure
Construction Projects Summary ($K)

	Total	Prior Years	FY 2023 Enacted	FY 2023 Actuals	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
16-E-200, Sample Preparation Laboratory, INL							
Total Estimated Cost (TEC)	144,600	137,300	7,300	7,300	7,300	0	-7,300
Other Project Costs (OPC)	21,400	7,647	6,903	5,662	5,662	2,091	-3,571
Total Project Cost (TPC) Project Number 16-E-200	**166,000**	**144,947**	**14,203**	**12,962**	**12,962**	**2,091**	**-10,871**
Total All Construction Projects							
Total Estimated Cost (TEC)	144,600	137,300	7,300	7,300	7,300	0	-7,300
Total Other Project Costs (OPC)	21,400	7,647	6,903	5,662	5,662	2,091	-3,571
Total Project Cost (TPC) All Construction Projects	**166,000**	**144,947**	**14,203**	**12,962**	**12,962**	**2,091**	**-10,871**

Idaho Sitewide Safeguards and Security

Overview

The Idaho Sitewide Safeguards and Security (S&S) program supports the Office of Nuclear Energy (NE) assets at Idaho National Laboratory (INL) and enables NE to conduct research and development (R&D) missions that utilize nuclear materials and protected information.

The FY 2025 Budget Request provides direct funding for NE's S&S base program. Strategic Partnership Projects (SPP) will continue to fund an allocable share of the S&S base program through full cost recovery. Extraordinary security requirements, such as dedicated security for non-NE infrastructure, special projects, or exercises, will be funded by SPP customers and recovered by the S&S program. Other Department of Energy (DOE) programs at the Idaho Site are responsible for directly funding their S&S costs.

Highlights of the FY 2025 Budget Request

In FY 2025, the S&S program will implement an updated cost recovery model to better match growing customer use. The S&S program will assure high confidence in the protection of NE-owned INL assets and a high degree of customer service by maintaining effective staffing levels, proactive preventive and corrective maintenance programs, and a robust cybersecurity program. The FY 2025 Budget Request will focus on protecting special nuclear material (SNM), emerging security technology investments, and enhanced cybersecurity program capabilities, including:

- Shifting the information security and personnel security programs to the cost recovery model; and
- Maintaining an effective cybersecurity program through the addition of lifecycle hardware/software upgrades and replacements including implementation of Executive Order 14028, *Improving the Nation's Cybersecurity,* continuous monitoring, maintaining Industrial Control Systems, essential cybersecurity positions, and associated training.

Idaho Sitewide Safeguards and Security
Funding ($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Idaho Sitewide Safeguards and Security					
Protective Forces	88,497	88,497	97,794	+9,297	+11%
Security Systems	12,203	12,203	13,420	+1,217	+10%
Information Security	5,016	5,016	0	-5,016	-100%
Cybersecurity	23,916	23,916	23,916	+0	+0%
Personnel Security	5,593	5,593	0	-5,593	-100%
Material Control & Accountability	5,825	5,825	6,570	+745	+13%
Program Management	8,000	8,000	8,300	+300	+4%
Security Infrastructure	950	950	0	-950	-100%
Total, Idaho Sitewide Safeguards and Security	**150,000**	**150,000**	**150,000**	**+0**	**+0%**

Idaho Sitewide Safeguards and Security
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Protective Forces: The increase from $88,497,000 to $97,794,000 reflects costs to train, equip, and maintain the Protective Force personnel staffing levels and associated equipment consistent with Departmental requirements and existing labor wage agreements.	**+9,297**
Security Systems: The increase from $12,203,000 to $13,420,000 supports planned maintenance and end-of-life replacement of security systems and components.	**+1,217**
Information Security: The decrease from $5,016,000 to $0 indicates a shift from direct funding to the cost recovery model.	**-5,016**
Cybersecurity No change.	**+0**
Personnel Security: The decrease from $5,593,000 to $0 indicates a shift from direct funding to the cost recovery model.	**-5,593**
Material Control & Accountability: The increase from $5,825,000 to $6,570,000 funds nuclear material equipment for special nuclear material identification and quantification.	**+745**
Program Management: No significant change.	**+300**
Security Infrastructure: The decrease from $950,000 to $0 reflects end of preconceptual planning activities for the Materials and Fuels Complex (MFC) Entry Control Facility Replacement project.	**-950**
Total, Idaho Sitewide Safeguards and Security	**+0**

Idaho Sitewide Safeguards and Security

Description

The Idaho Sitewide Safeguards and Security (S&S) program funds Office of Nuclear Energy (NE) base physical and cybersecurity activities for Idaho National Laboratory (INL), providing protection of the Department of Energy's (DOE) nuclear materials, classified and unclassified matter, government property, personnel, and other vital assets from theft, diversion, sabotage, espionage, unauthorized access, compromise, and other hostile acts that may cause adverse impacts on our national security; program continuity; or the health and safety of employees, the public, or the environment.

Protective Forces

Protective Forces provides security police officers and other specialized personnel, equipment, training, force on force exercise execution, and management needed during normal and security emergency conditions for the adequate protection of site assets consistent with site security plans. Protective force personnel are deployed 24 hours a day, 7 days a week, across 890 square miles to deter, detect, delay, and respond to adversarial threats.

Security Systems

Physical Security Systems provides preventive and corrective maintenance, performance testing, and replacement of intrusion detection and assessment systems, entry and search control equipment, barriers, secure storage, lighting, sensors, entry/access control devices, locks, explosives detection, and tamper-safe monitoring.

Information Security

Information Security provides for the protection and control of classified and sensitive matter that is generated, received, transmitted, used, stored, reproduced, and/or destroyed. Information Security subprogram also includes the Technical Security Countermeasures and Controlled Unclassified Information programs.

Cybersecurity

Cybersecurity maintains the staffing, computing infrastructure, and network security configuration necessary to support classified and unclassified information and electronic operations. Cybersecurity uses a graduated risk approach based on data sensitivity and impact of loss/compromise to ensure that electronic or computer information systems are protected in a manner consistent with upholding key priorities, including importance to national security, support of DOE missions and programs, vulnerability to threats, and the magnitude of harm that would result from an information system and industrial control systems compromise.

Personnel Security

Personnel Security provides access to classified and sensitive information and assignment of personnel in sensitive positions through the clearance program, adjudication, security awareness and education, U.S. citizen and foreign visitor control, Human Reliability Program, psychological/medical assessments, and administrative review costs.

Material Control and Accountability

Material Control & Accountability (MC&A) provides the personnel, equipment, and services required to account for and control special nuclear materials (SNM) from diversion.

Program Management

Program Management includes policy oversight, development, and update of site security plans, vulnerability assessments, investigations into incidents of security concern, and issuance of security infractions. Program management also ensures activities are conducted to analyze and identify the impacts of changes to Departmental policies and requirements on the site-wide safeguards and security program.

Security Infrastructure

Security Infrastructure provides upgrades, refurbishments, and/or replacements of security facilities, including associated planning and construction activities.

Idaho Sitewide Safeguards and Security

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Protective Forces $88,497,000	**$97,794,000**	**+$9,297,000**
• Maintained protective force staff levels, including planned hires for Phase IIB Implementation Plan protective force staffing requirements. • Purchased Protective Force equipment, including ammunition, weapons, protective gear, and maintained security vehicles.	• Maintains protective force staffing levels, consistent with the Site Security Plan and approved site labor wage agreements. • Procures specialized Protective Force equipment such as simulation devices, ammunition, weapons, protective gear, and maintains security vehicles.	• The increase funds training, equipping, and maintaining Protective Force staffing levels consistent with labor wage agreements and Departmental security requirements.
Security Systems $12,203,000	**$13,420,000**	**+$1,217,000**
• Planned and conducted preventive and corrective maintenance on physical security systems across multiple Idaho National Laboratory (INL) security areas. • Operated and maintained the INL central alarm stations, including life-cycle replacement of security alarm systems.	• Maintains preventive and corrective maintenance programs for physical security systems across INL multiple security areas. • Operates and maintains INL central alarm stations, including life-cycle replacement of security alarm systems. • Provides funds for security systems to maintain detection capabilities at INL security areas.	• The increase funds planned maintenance and end-of-life replacement of security systems and components.
Information Security $5,016,000	**$0**	**-$5,016,000**
• Completed information security activities to protect classified and sensitive unclassified matter including Classified Matter Protection and Control, Technical Surveillance Countermeasures, Classification/Declassification, and Operations Security programs. • Initiated efforts to establish a Controlled Unclassified Information (CUI) program for INL.	• Reflects shift to the cost recovery model.	• Reflects shift to the cost recovery model.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Cybersecurity $23,916,000	**$23,916,000**	**+$0**
• Provided 24/7 intrusion detection and prevention monitoring to ensure incidents and breaches are discovered and remediated. • Implemented cybersecurity vulnerability management tools to monitor Idaho National Laboratory (INL) network systems. • Completed life-cycle replacement of network boundary protection firewalls.	• Provide 24/7 intrusion detection and prevention monitoring to ensure incidents and breaches are discovered and remediated. • Continue implementation of requirements for Executive Order (EO) 14028 for the Zero Trust Architecture including the Data Pillar. • Implement and expand auditing and continuous monitoring capabilities to improve protective measures in the ICS network.	• No change.
Personnel Security $5,593,000	**$0**	**-$5,593,000**
• Conducted federal contractor personnel security programs to process clearances; operated Idaho National Laboratory (INL) badging office; processed foreign visits and assignments; and managed human reliability program activities.	• Reflects shift to the cost recovery model.	• Reflects shift to the cost recovery model.
Material Control & Accountability (MC&A) $5,825,000	**$6,570,000**	**+$745,000**
• Maintained INL's nuclear material database and tracking systems, coordinated on-and off-site material movements, and conducted accountable special nuclear material inventories.	• Maintains INL's special nuclear material database and tracking systems, manages on-and off-site material movements, and conducts accountable special nuclear material inventories. • Procures and installs equipment to ensure accountability of special nuclear materials.	• The increase funds required nuclear material tracking activities consistent with research and development operational schedules.
Program Management $8,000,000	**$8,300,000**	**+$300,000**
• Updated INL security plans to meet Design Basis Threat and Departmental security requirement changes. • Completed Vulnerability Assessment activities to ensure protection of Special Nuclear Material (SNM).	• Develops and maintains site security documentation, including vulnerability and risk assessments, to ensure alignment to Departmental requirements.	• No significant change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Security Infrastructure $950,000	**$0**	**-$950,000**
• Initiated preconceptual planning for the Materials and Fuels Complex (MFC) Entry Control Facility Replacement project.	• Reflects end of planning activities for MFC Entry Control Facility Replacement project.	• Reflects completion of planning activities.

Idaho Sitewide Safeguards and Security

Capital Summary ($K)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Minor Construction Projects							
Materials and Fuels Complex Protective Forces Building	15,600	15,600	0	0	0	+0	+0%
Consolidated Training Facility at the Central Facilities Area	12,000	12,000	0	0	0	+0	+0%
Materials and Fuels Complex Entrance Control Facility	25,000	0	950	950	0	-950	-100%
Total, Minor Construction Projects	**52,600**	**27,600**	**950**	**950**	**0**	**-950**	**-100%**
Total, Capital Summary	**52,600**	**27,600**	**950**	**950**	**0**	**-950**	**-100%**

Idaho Sitewide Safeguard and Security Reimbursable Costs

The FY 2025 Budget Request provides direct funding for the NE's S&S base program. Strategic Partnership Projects (SPP) will continue to fund an allocable share of the S&S base program through full cost recovery. Extraordinary security requirements, such as dedicated security for non-NE infrastructure, special projects, or exercises, will be funded by SPP customers and recovered by the S&S program. Other DOE programs at the Idaho Site are responsible for directly funding their S&S costs. Starting in FY 2025, information and personnel security functions are fully included in the cost recovery model given the transactional nature of the work. Information regarding SPP full cost recovery estimates are provided in the table below.

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs. FY 2023 Enacted ($)	FY 2025 Request vs. FY 2023 Enacted (%)
Idaho National Laboratory	12,056	12,852	30,194	+18,138	+150%

International Nuclear Energy Cooperation

Overview

The International Nuclear Energy Cooperation (INEC) program leads the Office of Nuclear Energy's (NE) international engagement through the development, coordination, and implementation of U.S. civil nuclear policy and integrates it with NE's technical programs. INEC works through bilateral and multilateral fora to promote U.S. government and industry civil nuclear equities while advancing nuclear energy as a key part of climate change and energy security objectives. INEC leverages the technical expertise of DOE and its national laboratories to partner and build capacity with countries on nuclear infrastructure and workforce development; explore financing options for new nuclear builds; develop and strengthen nuclear safety frameworks; and identify opportunities for multilateral collaboration to share best practices and solve shared challenges.

INEC contributes to U.S. interagency efforts to advance commercial interests, national security objectives, and diplomatic priorities related to civil nuclear energy by serving as Chair of TEAM USA and leading initiatives designed to strengthen the security and competitiveness of U.S. nuclear technology and industry. INEC provides technical support on civil nuclear issues and energy dialogues coordinated by the DOE Office of International Affairs as well as the Department of State's Foundational Infrastructure for the Responsible use of Small Modular Reactor Technology (FIRST) and Project Phoenix Initiatives. Further, INEC provides support to the Export-Import Bank, the U.S. Development Finance Corporation and U.S. Trade and Development Agency (USTDA) to consider the viability of studies and projects with strategic, international partners. INEC provides training on financing nuclear projects domestically and internationally.

INEC negotiates arrangements to facilitate cooperation in research and development, workforce capacity building, academic and professional training, and technical exchanges. These cooperative mechanisms help establish the foundational relationship necessary to lead to more advanced agreements and the path to a successful civil nuclear energy power program. Recently, INEC negotiated such instruments with the Czech Republic, Finland, Poland, Slovenia and the European Repository Development Organisation (ERDO) Association and expects to execute several more in Africa, the Baltics and Central Asia. Such instruments enable NE to assist countries identify needs for a civil nuclear program, including workforce makeup, safety framework capacity building, financing, siting, and legal and regulatory requirements.

INEC advances U.S. nuclear priorities in the International Atomic Energy Agency (IAEA) and its International Project on Innovative Nuclear Reactors and Fuel Cycles (IAEA/INPRO) by co-organizing workshops and training activities. Additionally, INEC contributes both funding and expert staffing to the IAEA and the Organization for Economic Cooperation and Development's Nuclear Energy Agency (NEA), and continues to leverage its leadership roles in the International Framework for Nuclear Energy Cooperation (IFNEC), the Nuclear Innovation: Clean Energy (NICE) Future Initiative under the Clean Energy Ministerial (CEM), and the Partnership for Transatlantic Energy and Climate Cooperation (P-TECC) to convene Ministerial-level events; and organize workshops and conferences globally that advance U.S. civil nuclear equities and promotes U.S. exports. INEC's expert contributions and leadership in these multilateral organizations is critical to shaping international practices that enhance transparency, safety, and security standards for this growing industry and shed light on anti-competitive behaviors that impede the expedient deployment of nuclear energy.

In FY 2025, INEC will develop strategic partnerships that support commercial opportunities for U.S. nuclear exports . INEC will continue to provide training, technical expertise, and research and development mechanisms to support countries in their early stages as they move forward with their plans for new nuclear. Building off the successful model of engaging early and often, in both bilateral and multilateral fora, INEC will continue to leverage its technical expertise and international network to provide support to our partners in need, as exemplified by our sourcing and delivery of fuel and components for the reactors in Ukraine.

Highlights of the FY 2025 Budget Request

The FY 2025 Request for INEC includes support for the following: deployment of an additional regional Clean Energy Training Centers (CETC) to provide workforce development and professional training in a priority market for U.S. export of advanced reactor technology; increased U.S. technical presence through bilateral nuclear cooperation in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, supporting workforce capacity building, academic and professional training, joint studies, and regional technical events; and expanded leadership and use of technical experts in multilateral organizations to advance U.S. civil nuclear energy priorities in the face of malign actors.

International Nuclear Energy Cooperation
Funding ($K)

	FY 2023 Enacted Comparable	FY 2024 Annualized CR Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted Comparable ($)	FY 2025 Request vs FY 2023 Enacted Comparable (%)
International Nuclear Energy Cooperation					
International Nuclear Energy Cooperation	3,320[1]	3,320	8,000	+4,680	+141.5%
Total, International Nuclear Energy Cooperation	**3,320**	**3,320**	**8,000**	**+4,680**	**+141.5%**

[1] In FY 2023, INEC was funded within the NE Program Direction account.

International Nuclear Energy Cooperation
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted Comparable
• INEC will initiate additional cooperative training activities in Europe and Southeast Asia. Additionally, INEC would broaden its scope and engagement with the USG interagency and U.S. nuclear industry to support critical, time-sensitive USG civil nuclear energy priorities and commercial opportunities.	**+4,680**
Total, International Nuclear Energy Cooperation	**+4,680**

International Nuclear Energy Cooperation

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted Comparable
International Nuclear Energy Cooperation $3,320,000	**$8,000,000**	**+$4,680,000**
• In FY 2023, INEC was funded at $3.3M within the NE Program Direction account. Funded activities included the following: • Provides for NE's international engagement activities. • Continue support for nuclear safety in Armenia and Ukraine, including emergency support due to the ongoing hostilities in Ukraine. • Continue deployment of CETCs to inform small and emerging nuclear states of U.S. nuclear technology within clean energy systems. • Increase U.S. technical presence through bilateral nuclear cooperation particularly in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, including workforce capacity building, academic and professional training, joint studies, and regional technical events. • Organize a nuclear energy management school. • Continue Fukushima Forensics activities that support improved operation and safety of U.S. domestic nuclear power plants. • Leverage U.S. sponsorship of subject matter experts in international organizations to advance U.S. nuclear equities. • Continue bilateral engagement to build U.S. nuclear cooperation in Baltics, Eastern Europe, Africa, and Asia.	• Continue support for nuclear safety in Armenia and Ukraine, including emergency support due to the ongoing hostilities in Ukraine. • Continue deployment of CETCs to inform civil nuclear states of U.S. nuclear commercial and technical capabilities. • Increase U.S. technical presence through bilateral nuclear cooperation in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, involving workforce capacity building, academic and professional training, joint studies, and regional technical events. • Co-sponsor and host IAEA nuclear energy technical schools. • Continue Fukushima Forensics activities supporting improved safety of U.S. domestic nuclear power plants. • Leverage U.S. sponsorship of subject matter experts in international organizations to advance U.S. nuclear equities. • Continue bilateral engagement to build U.S. nuclear collaboration in Baltics, Eastern Europe, Africa, and Asia. • INEC will initiate additional cooperative training activities in Europe, Africa, the Middle East, and Southeast Asia.	• INEC will initiate additional cooperative training activities in Europe and Southeast Asia. Additionally, INEC would broaden its scope and engagement with the USG interagency and U.S. nuclear industry to support critical, time-sensitive USG civil nuclear energy priorities and commercial opportunities

Program Direction

Overview

Program Direction provides the federal staffing resources and associated costs required to support the overall direction and execution of the Office of Nuclear Energy (NE) programs. NE has staff strategically located in multiple locations: Washington, D.C. Headquarters, Nevada Field Office, and the Idaho Operations Office. Activities within the site offices support inherently federal functions that facilitate the efficient execution of Department of Energy (DOE) programs or directly execute DOE mandated safety, security, business functions, and public outreach. In addition to NE federal personnel, Program Direction supports select federal staff and support for the Office of Human Capital Service Center.

The Support Services subprogram allows the Department to cost-effectively hire the best available industry experts to support federal staff in managing the nuclear programs and complex activities. The ability to acquire expertise quickly and on an "as needed basis" provides flexibility in team composition as the needs of NE evolve. Program Direction also includes the Other Related Expenses subprogram, which provides NE's directed funding contribution to the Department's Working Capital Fund (WCF). The WCF supports specific Departmental services and activities that are shared across DOE including: employee health and testing services, and consolidated training and recruitment initiatives; all established in previous fiscal years and supported in FY 2025.

In addition to appropriated funds, NE also manages approximately $450 million annually from other activities including: the Strategic Partnerships Program and reimbursable funding from the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD).

The FY 2025 Request will allow the Office of Nuclear Energy to support its increasing mission, address succession planning for critical technical positions, and continue to build a more diverse workforce. NE has successfully utilized the Department's direct hire authority, outreach through job fairs and social media, and the Oak Ridge Institute for Science and Education (ORISE) fellowships and scholars. The ORISE Fellowships and Scholars are focused on developing the environmental justice and equity strategies to include integrating Energy Justice into program areas, participating in key research and development, as well as collaborating with communities, Tribal Nations, and external stakeholders. In addition, NE is also utilizing more hiring incentives, such as recruitment bonuses, Advanced-in Hire, creditable leave accrual, and student loan repayments for all employees.

Highlights of the FY 2025 Budget Request

NE has been working to rebuild its workforce levels necessary to execute the robust Research and Development, and Infrastructure activities that NE is responsible for overseeing. NE plans on achieving a staffing level of 320 in FY 2024, and then sustaining that level in the FY 2025 Request and beyond.

Program Direction
Funding ($K)

	FY 2023 Enacted Comparable[1]	FY 2024 Annualized CR Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted Comparable ($)	FY 2025 Request vs FY 2023 Enacted Comparable (%)
Program Direction					
Salaries and Benefits	54,619	54,619	65,558	10,939	20.0%
Travel	1,600	1,600	1,775	175	10.9%
Support Services	12,326	12,326	14,837	2,511	20.4%
Other Related Expenses	13,135	13,135	14,830	1,695	12.9%
Total, Program Direction	**81,680**	**81,680**	**97,000**	**15,320**	**18.8%**

Nuclear Energy FTEs

	FY 2023 Enacted Comparable	FY 2024 Annualized CR Comparable	FY 2025 Request
Nuclear Energy FTEs			
Program Direction	277	313	320

[1] FY 2023 Enacted amount was $85,000,000. $3,320,000 is shown under International Nuclear Energy Cooperation comparable to the FY 2025 budget structure.

Program Direction
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted Comparable
Salaries and Benefits:	
The increase from $54,619 to $65,558 reflects the funds necessary to achieve and maintain a consistent level of staffing to support Headquarters and Idaho Operations Offices in FY 2025.	**10,939**
Travel:	
The increase from $1,600 to $1,775 reflects an appropriate funding level to support the travel of NE's increasing workforce.	**175**
Support Services:	
The increase from $12,326 to $14,837 reflects additional funding allocated for contractual support as needed to aid and support the increased federal workforce responsible for executing NE's requirements.	**2,511**
Other Related Expenses:	
The increase from $13,135 to $14,830 reflects funding to support other expenses related to the increase of NE's workforce that occurred in FY 2023 and will be sustained in FY 2024.	**1,695**
Total, Program Direction	**15,320**

Program Direction
Funding ($K)

	FY 2023 Enacted Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted Comparable
Program Direction Summary			
Washington Headquarters			
Salaries and Benefits	28,676	33,882	5,206
Travel	1,400	1,575	175
Support Services	7,621	10,252	2,631
Other Related Expenses	7,305	9,000	1,695
Total, Washington Headquarters	**45,002**	**54,709**	**9,707**
Nevada Field Office			
Salaries and Benefits	1,784	1,557	-227
Travel	0	0	0
Support Services	0	0	0
Other Related Expenses	115	115	0
Total, Nevada Field Office	**1,899**	**1,672**	**-227**
Idaho Operations Office			
Salaries and Benefits	24,159	30,119	5,960
Travel	200	200	0
Support Services	4,705	4,585	-120
Other Related Expenses	5,715	5,715	0
Total, Idaho Operations Office	**34,779**	**40,619**	**5,840**
Total Program Direction			
Salaries and Benefits	54,619	65,558	10,939
Travel	1,600	1,775	175
Support Services	12,326	14,837	2,511
Other Related Expenses	13,135	14,830	1,695
Total, Program Direction	**81,680**	**97,000**	**15,320**
Federal FTEs	**277**	**320**	**43**

	FY 2023 Enacted Comparable	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted Comparable
Support Services			
Technical Support			
Mission Related	1,110	1,335	225
Advisory and Assistance	2,588	3,116	528
Total, Technical Support	3,698	4,451	753
Management Support			
Administrative	2,588	3,115	527
IT	6,040	7,271	1,231
Total Management Support	8,628	10,386	1,758
Total, Support Services	**12,326**	**14,837**	**2,511**
Other Related Expenses			
Working Capital Fund	5,350	6,350	1,000
Training	150	150	0
Miscellaneous	5,553	5,898	345
Rents and Utilities	2,082	2,432	350
Total, Other Related Expenses	**13,135**	**14,830**	**1,695**

Program Direction
Funding

Activities and Explanation of Changes

FY 2023 Enacted Comparable	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted Comparable
Program Direction $81,680,000	**$97,000,000**	**$15,320,000**
Salaries and Benefits $54,618,440	**$65,557,977**	**$10,939,537**
• Provides salaries and benefits for 277 FTEs.	• Provides salaries and benefits for 320 FTEs.	• The increase reflects funding for salaries and benefits of an additional 43 FTE positions.
Travel $1,600,268	**$1,775,300**	**$175,032**
• Provides for travel of the federal staff including any necessary permanent change of duty status costs.	• Provides for travel of the federal staff including any necessary permanent change of duty status costs.	• The increase reflects funding to support travel related expenses due to the increase of NE's workforce.
Support Services $12,325,865	**$14,836,723**	**$2,510,858**
• Provides for technical and administrative support services for the Nuclear Energy (NE) federal staff.	• Provides for technical and administrative support services for the NE federal staff.	• The increase reflects additional funding allocated for contractual support as needed to aid and support the increased federal workforce responsible for executing NE's requirements.
Other Related Expenses $13,135,427	**$14,830,000**	**$1,694,573**
• Provides for NE's share of goods and services procured through the Department's Working Capital Fund (WCF); rents and utilities associated with the Idaho Operations Office; federal training expenses; and other miscellaneous expenses.	• Provides for NE's share of goods and services procured through the Department's WCF; rents and utilities associated with the Idaho Operations Office; federal training expenses; and other miscellaneous expenses.	• The increase reflects additional funding to support the overall FTE growth of NE in the areas of training, WCF, and all other miscellaneous expenses required to support NE's staff.

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

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request
NEUP SBIR/STTR and TCF			
SBIR	23,385	23,385	22,216
STTR	3,288	3,288	3,124
Total, SBIR	**23,385**	**23,385**	**22,216**
Total, STTR	**3,288**	**3,288**	**3,124**
Total, SBIR/STTR	**26,673**	**26,673**	**25,340**

Nuclear Energy
Safeguards and Security($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request
Idaho Sitewide Safeguards and Security			
Protective Forces	88,497	88,497	97,794
Security Systems	12,203	12,203	13,420
Security Infrastructure	950	950	0
Information Security	5,016	5,016	0
Personnel Security	5,593	5,593	0
Material Control & Accountability	5,825	5,825	6,570
Program Management	8,000	8,000	8,300
Cybersecurity	23,916	23,916	23,916
Total, Idaho Sitewide Safeguards and Security	**150,000**	**150,000**	**150,000**

Nuclear Energy
Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget and displayed below are intended to halt asset condition degradation. 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 2023 Actual Cost	FY 2023 Planned Cost	FY 2024 Planned Cost	FY 2025 Planned Cost
Idaho National Laboratory	52,003	33,503	34,450	35,423
Total, Direct-Funded Maintenance and Repair	52,003	33,503	34,450	35,423

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

	FY 2023 Actual Cost	FY 2023 Planned Cost	FY 2024 Planned Cost	FY 2025 Planned Cost
Idaho National Laboratory	28,445	22,797	23,372	30,590
Total, Indirect-Funded Maintenance and Repair	28,445	22,797	23,372	30,590

Report on FY 2023 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2023 to the amount planned for FY 2023, including congressionally directed changes.

Nuclear Energy
Total Costs for Maintenance and Repair ($K)

	FY 2023 Actual Cost	FY 2023 Planned Cost
Idaho National Laboratory	80,448	56,300
Total, Maintenance and Repair	**80,448**	**56,300**

Each year, the "Planned Cost" for maintenance and repair is a minimum target amount. The Nuclear Energy (NE) program met its planned minimum target in FY 2023. The NE program exceeded the minimum target amount due to strategic investments at the Advanced Test Reactor and Materials and Fuels Complex at the Idaho National Laboratory.

Nuclear Energy
Excess Facilities

Costs for Direct-Funded Excess Facilities ($K)

	FY 2023 Actual Cost	FY 2023 Planned Cost	FY 2024 Planned Cost	FY 2025 Planned Cost
Idaho National Laboratory	0	0	0	0
Total, Direct-Funded Excess Facilities	0	0	0	0

Costs for Indirect-Funded Excess Facilities ($K)

	FY 2023 Actual Cost	FY 2023 Planned Cost	FY 2024 Planned Cost	FY 2025 Planned Cost
Idaho National Laboratory	800	65	1,600	1,400
Total, Indirect-Funded Excess Facilities	800	65	1,600	1,400

In FY 2023, Idaho National Laboratory (INL):

- Removed MFC-713 Modular Office Building T-13

In FY 2024, INL plans to:

- Continue legacy underground storage tank (UST) removals and abandoned well closures; and
- Remove the CF-1704 15,000-gallon underground diesel fuel tank; and
- Demolish CF-638 Dosimetry Calibration Lab; and
- Remove the ATR Argon Delay Line

In FY 2025, INL plans to:

- Continue legacy UST removals and abandoned well closures; and
- Demolish MFC-717 Modular Office Building T-2 & T-2A; and
- Demolish PBF-632 Homeland Security Test Bed

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Argonne National Laboratory			
NEUP, SBIR/STTR, and TCF	4,461	0	0
Advanced SMR R&D	230	0	0
LWR Sustainability	249	0	0
Advanced Reactor Technologies	3,864	7,000	5,800
Integrated Energy Systems	0	0	3,500
Reactor Concepts RD&D	4,343	7,000	9,300
Materials Recovery and Waste Form Development	2,840	2,840	2,457
Accident Tolerant Fuels	30	30	26
TRISO and Graphite Qualification	155	155	0
Fuel Cycle Laboratory R&D	3,403	3,403	1,760
Advanced Nuclear Fuel Availability	250	250	375
Used Nuclear Fuel Disposition R&D	864	1,092	2,765
Integrated Waste Management System	2,105	2,848	4,000
Next Generation Fuels	0	0	1,507
Fuel Cycle Research & Development	9,647	10,618	12,890
Crosscutting Technology Development	7,064	6,059	0
Joint Modeling and Simulation Program	6,825	6,474	6,500
Nuclear Science User Facility	11	375	500
Advanced Materials and Manufacturing Technologies	0	0	4,200
Advanced Sensors and Instrumentation	0	0	1,200
Nuclear Energy Enabling Technologies	13,900	12,908	12,400
Regulatory Development	4,580	4,230	4,700
Advanced Reactor Safeguards	625	300	695
Advanced Reactors Demonstration Program	5,205	4,530	5,395
International Nuclear Energy Cooperation	320	320	400
Total Argonne National Laboratory	**37,876**	**35,376**	**40,385**
Argonne Site Office			
National Reactor Innovation Center	3,721	3,625	3,000
Advanced Reactors Demonstration Program	3,721	3,625	3,000
Total Argonne Site Office	**3,721**	**3,625**	**3,000**
Brookhaven National Laboratory			
NEUP, SBIR/STTR, and TCF	442	0	0
Accident Tolerant Fuels	305	305	262
Fuel Cycle Laboratory R&D	1,008	1,008	521
Fuel Cycle Research & Development	1,313	1,313	783
Advanced Reactor Safeguards	370	350	811
Advanced Reactors Demonstration Program	370	350	811
Total Brookhaven National Laboratory	**2,125**	**1,663**	**1,594**
Chicago Operations Office			
Nuclear Science User Facility	1	0	0
Nuclear Energy Enabling Technologies	1	0	0
Total Chicago Operations Office	**1**	**0**	**0**
Idaho National Laboratory			
University Fuel Services	0	0	28,180
NEUP, SBIR/STTR, and TCF	43,176	21,350	4,075
Advanced SMR R&D	610	0	0
LWR Sustainability	24,921	12,745	15,460
Advanced Reactor Technologies	21,433	27,200	24,300
Integrated Energy Systems	0	0	5,500
Reactor Concepts RD&D	46,964	39,945	45,260
Materials Recovery and Waste Form Development	36,763	36,763	31,905
Accident Tolerant Fuels	30,044	30,044	26,000
TRISO and Graphite Qualification	26,215	26,215	0
Fuel Cycle Laboratory R&D	13,672	13,672	7,072

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Advanced Nuclear Fuel Availability	12,905	12,905	19,358
Used Nuclear Fuel Disposition R&D	5,350	1,220	5,350
Integrated Waste Management System	3,028	5,000	5,000
Next Generation Fuels	0	0	24,386
Fuel Cycle Research & Development	127,977	125,819	119,071
Crosscutting Technology Development	17,012	14,600	0
Joint Modeling and Simulation Program	10,520	10,942	10,900
Nuclear Science User Facility	29,927	31,650	31,025
Advanced Materials and Manufacturing Technologies	0	0	4,500
Gateway for Accelerated Innovation in Nuclear	0	0	7,500
Advanced Sensors and Instrumentation	0	0	5,650
Nuclear Energy Enabling Technologies	57,459	57,192	59,575
National Reactor Innovation Center	62,052	62,875	26,500
Risk Reduction for Future Demonstrations	0	20,000	10,000
Regulatory Development	3,215	3,500	4,180
Advanced Reactor Safeguards	200	50	116
23-E-200 LOTUS Project	20,000	20,000	18,748
Advanced Reactors Demonstration Program	85,467	106,425	59,544
INL Facilities Operations and Maintenance	315,317	314,241	328,850
16-E-200 Sample Preparation Laboratory	7,300	7,300	0
Infrastructure	322,617	321,541	328,850
Idaho Sitewide Safeguards & Security (050)	148,600	148,600	150,000
International Nuclear Energy Cooperation	410	410	410
Program Direction - Nuclear Energy	3,880	3,880	4,250
Total Idaho National Laboratory	**836,550**	**825,162**	**799,215**
Idaho Operations Office			
University Nuclear Leadership Program	0	0	8,000
University Fuel Services	0	0	50
NEUP, SBIR/STTR, and TCF	58,406	6,600	550
Advanced SMR R&D	117,663	115,000	0
LWR Sustainability	10,220	21,955	11,140
Advanced Reactor Technologies	530	600	600
Reactor Concepts RD&D	128,413	137,555	11,740
Accident Tolerant Fuels	64,535	64,535	57,114
TRISO and Graphite Qualification	220	220	0
Advanced Nuclear Fuel Availability	5,558	5,558	8,337
Used Nuclear Fuel Disposition R&D	1,963	1,290	1,060
Integrated Waste Management System	14,145	12,000	14,022
Fuel Cycle Research & Development	86,421	83,603	80,533
Joint Modeling and Simulation Program	69	220	220
Nuclear Science User Facility	220	220	220
Advanced Materials and Manufacturing Technologies	0	0	6,000
Nuclear Energy Enabling Technologies	289	440	6,440
National Reactor Innovation Center	220	500	500
Risk Reduction for Future Demonstrations	0	30,000	58,000
Regulatory Development	172	220	220
Advanced Reactor Safeguards	50	0	0
Advanced Reactors Demonstration Program	442	30,720	58,720
INL Facilities Operations and Maintenance	2,410	3,486	3,401
Infrastructure	2,410	3,486	3,401
Idaho Sitewide Safeguards & Security (050)	1,400	1,400	0
International Nuclear Energy Cooperation	1,612	1,612	3,224
Program Direction - Nuclear Energy	30,899	30,899	36,369
Total Idaho Operations Office	**310,292**	**296,315**	**209,027**
Lawrence Berkeley National Laboratory			
Used Nuclear Fuel Disposition R&D	3,806	3,968	3,806
Fuel Cycle Research & Development	3,806	3,968	3,806
Joint Modeling and Simulation Program	150	150	150
Nuclear Energy Enabling Technologies	150	150	150
Total Lawrence Berkeley National Laboratory	**3,956**	**4,118**	**3,956**

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Lawrence Livermore National Laboratory			
Used Nuclear Fuel Disposition R&D	328	359	328
Fuel Cycle Research & Development	328	359	328
Total Lawrence Livermore National Laboratory	**328**	**359**	**328**
Los Alamos National Laboratory			
NEUP, SBIR/STTR, and TCF	849	0	0
Advanced Reactor Technologies	1,600	1,000	1,600
Reactor Concepts RD&D	1,600	1,000	1,600
Materials Recovery and Waste Form Development	250	250	216
Accident Tolerant Fuels	5,275	5,275	4,526
Fuel Cycle Laboratory R&D	2,848	2,848	1,473
Used Nuclear Fuel Disposition R&D	3,047	2,970	5,000
Next Generation Fuels	0	0	1,406
Fuel Cycle Research & Development	11,420	11,343	12,621
Crosscutting Technology Development	750	650	0
Joint Modeling and Simulation Program	3,915	3,711	3,800
Advanced Materials and Manufacturing Technologies	0	0	1,250
Nuclear Energy Enabling Technologies	4,665	4,361	5,050
Advanced Reactor Safeguards	430	415	961
Advanced Reactors Demonstration Program	430	415	961
Total Los Alamos National Laboratory	**18,964**	**17,119**	**20,232**
National Energy Technology Lab			
Crosscutting Technology Development	87	0	0
Nuclear Energy Enabling Technologies	87	0	0
Total National Energy Technology Lab	**87**	**0**	**0**
National Renewable Energy Laboratory			
NEUP, SBIR/STTR, and TCF	750	0	0
Integrated Energy Systems	0	0	350
Reactor Concepts RD&D	0	0	350
Crosscutting Technology Development	44	106	0
Nuclear Energy Enabling Technologies	44	106	0
National Reactor Innovation Center	0	2,000	0
Advanced Reactors Demonstration Program	0	2,000	0
International Nuclear Energy Cooperation	75	75	75
Total National Renewable Energy Laboratory	**869**	**2,181**	**425**
Nevada Field Office			
Program Direction - Nuclear Energy	1,899	1,899	1,672
Total Nevada Field Office	**1,899**	**1,899**	**1,672**
Oak Ridge Institute for Science & Education			
University Nuclear Leadership Program	0	0	500
NEUP, SBIR/STTR, and TCF	500	500	0
Total Oak Ridge Institute for Science & Education	**500**	**500**	**500**
Oak Ridge National Laboratory			
NEUP, SBIR/STTR, and TCF	1,415	0	0
Advanced SMR R&D	222	0	0
LWR Sustainability	4,960	6,150	5,000
Advanced Reactor Technologies	1,195	2,500	5,000
Integrated Energy Systems	0	0	150
Reactor Concepts RD&D	6,377	8,650	10,150
Materials Recovery and Waste Form Development	1,965	1,965	1,700
Accident Tolerant Fuels	11,016	11,016	9,452

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
TRISO and Graphite Qualification	2,620	2,620	0
Fuel Cycle Laboratory R&D	3,961	3,961	2,049
Advanced Nuclear Fuel Availability	485	485	728
Used Nuclear Fuel Disposition R&D	3,064	4,153	6,000
Integrated Waste Management System	6,980	8,152	5,000
Next Generation Fuels	0	0	5,067
Fuel Cycle Research & Development	30,091	32,352	29,996
Crosscutting Technology Development	2,184	3,443	0
Joint Modeling and Simulation Program	4,305	4,682	4,700
Nuclear Science User Facility	4,341	1,900	1,900
Advanced Materials and Manufacturing Technologies	0	0	4,950
Advanced Sensors and Instrumentation	0	0	1,250
Nuclear Energy Enabling Technologies	10,830	10,025	12,800
National Reactor Innovation Center	25	0	0
Risk Reduction for Future Demonstrations	0	0	2,000
Regulatory Development	1,655	1,600	2,000
Advanced Reactor Safeguards	550	550	1,274
Advanced Reactors Demonstration Program	2,230	2,150	5,274
ORNL Nuclear Facilities O&M	20,000	20,000	0
Infrastructure	20,000	20,000	0
International Nuclear Energy Cooperation	515	515	1,030
Total Oak Ridge National Laboratory	**71,458**	**73,692**	**59,250**
Oak Ridge Office			
Advanced Nuclear Fuel Availability	13	13	20
Fuel Cycle Research & Development	13	13	20
Total Oak Ridge Office	**13**	**13**	**20**
Pacific Northwest National Laboratory			
NEUP, SBIR/STTR, and TCF	648	0	0
Advanced Reactor Technologies	1,510	3,500	3,500
Reactor Concepts RD&D	1,510	3,500	3,500
Materials Recovery and Waste Form Development	2,640	2,640	2,200
Accident Tolerant Fuels	545	545	468
Fuel Cycle Laboratory R&D	2,605	2,605	1,347
Used Nuclear Fuel Disposition R&D	10,421	8,366	10,421
Integrated Waste Management System	21,272	16,000	17,000
Next Generation Fuels	0	0	10,728
Fuel Cycle Research & Development	37,483	30,156	42,164
Crosscutting Technology Development	1,540	2,170	0
Nuclear Science User Facility	0	75	75
Advanced Materials and Manufacturing Technologies	0	0	2,100
Advanced Sensors and Instrumentation	0	0	650
Nuclear Energy Enabling Technologies	1,540	2,245	2,825
National Reactor Innovation Center	202	0	0
Regulatory Development	230	200	400
Advanced Reactor Safeguards	500	400	926
Advanced Reactors Demonstration Program	932	600	1,326
International Nuclear Energy Cooperation	255	255	300
Total Pacific Northwest National Laboratory	**42,368**	**36,756**	**50,115**
Portsmouth Gaseous Diffusion Plant			
Advanced Nuclear Fuel Availability	30	30	45
Fuel Cycle Research & Development	30	30	45
Total Portsmouth Gaseous Diffusion Plant	**30**	**30**	**45**
Sandia National Laboratories			
NEUP, SBIR/STTR, and TCF	1,800	0	0
LWR Sustainability	3,750	3,250	2,500
Advanced Reactor Technologies	4,900	5,200	0

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Reactor Concepts RD&D	8,650	8,450	2,500
Accident Tolerant Fuels	60	60	52
Fuel Cycle Laboratory R&D	1,103	1,103	571
Used Nuclear Fuel Disposition R&D	17,790	21,284	11,000
Integrated Waste Management System	2,252	5,000	5,000
Fuel Cycle Research & Development	21,205	27,447	16,623
Crosscutting Technology Development	2,670	2,410	0
Joint Modeling and Simulation Program	250	0	0
Nuclear Energy Enabling Technologies	2,920	2,410	0
Regulatory Development	300	300	300
Advanced Reactor Safeguards	1,933	1,985	4,597
Advanced Reactors Demonstration Program	2,233	2,285	4,897
International Nuclear Energy Cooperation	7	7	7
Total Sandia National Laboratories	**36,815**	**40,599**	**24,027**
Savannah River National Laboratory			
Fuel Cycle Laboratory R&D	400	400	207
Advanced Nuclear Fuel Availability	810	810	1,215
Used Nuclear Fuel Disposition R&D	162	350	162
Integrated Waste Management System	1,752	4,000	2,978
Fuel Cycle Research & Development	3,124	5,560	4,562
Total Savannah River National Laboratory	**3,124**	**5,560**	**4,562**
Savannah River Site			
Advanced Nuclear Fuel Availability	2,190	2,190	3,285
Fuel Cycle Research & Development	2,190	2,190	3,285
Total Savannah River Site	**2,190**	**2,190**	**3,285**
Washington Headquarters			
Advanced SMR R&D	46,275	50,000	0
LWR Sustainability	900	900	900
Advanced Reactor Technologies	13,968	2,000	3,000
Reactor Concepts RD&D	61,143	52,900	3,900
Mining, Conversion, and Transportation	8	2,000	2,000
Materials Recovery and Waste Form Development	542	542	22
Accident Tolerant Fuels	2,190	2,190	0
TRISO and Graphite Qualification	239	239	0
Advanced Nuclear Fuel Availability	51,437	77,759	116,637
Used Nuclear Fuel Disposition R&D	205	1,823	96
Integrated Waste Management System	1,466	0	0
Next Generation Fuels	0	0	196
Fuel Cycle Research & Development	56,087	84,553	118,951
Crosscutting Technology Development	649	2,562	0
Joint Modeling and Simulation Program	2,466	2,321	2,330
Nuclear Science User Facility	500	780	780
Gateway for Accelerated Innovation in Nuclear	0	0	2,500
Advanced Sensors and Instrumentation	0	0	250
Nuclear Energy Enabling Technologies	3,615	5,663	5,860
National Reactor Innovation Center	3,780	1,000	1,000
Regulatory Development	98	200	3,200
Advanced Reactor Safeguards	92	700	1,620
Advanced Reactors Demonstration Program	3,970	1,900	5,820
INL Facilities Operations and Maintenance	1,197	1,197	1,671
Infrastructure	1,197	1,197	1,671
International Nuclear Energy Cooperation	126	126	2,554
Program Direction - Nuclear Energy	45,002	45,002	54,709
Total Washington Headquarters	**171,140**	**191,341**	**193,465**
Undesignated LPI			
NEUP, SBIR/STTR, and TCF	17,829	101,826	102,045

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Mining, Conversion, and Transportation	1,992	0	0
TRISO and Graphite Qualification	2,551	2,551	0
Advanced Nuclear Fuel Availability	26,322	0	0
Used Nuclear Fuel Disposition R&D	0	125	1,012
Fuel Cycle Research & Development	30,865	2,676	1,012
Risk Reduction for Future Demonstrations	120,000	70,000	72,500
Advanced Reactor Demonstration Program (ARDP)	60,000	60,000	0
Advanced Reactors Demonstration Program	180,000	130,000	72,500
Total Undesignated LPI	**228,694**	**234,502**	**175,557**
Total Funding by Site for TAS_0319 - Nuclear Energy	**1,773,000**	**1,773,000**	**1,590,660**

Nuclear Waste Disposal

Nuclear Waste Disposal

Nuclear Waste Disposal
Appropriation Language

For Department of Energy expenses necessary for activities to carry out the purposes of the Nuclear Waste Policy Act of 1982, Public Law 97–425, as amended, *$12,040,000,* to remain available until expended, which shall be derived from the Nuclear Waste Fund.

Nuclear Waste Fund Oversight

Overview

Under the Nuclear Waste Policy Act of 1982 (NWPA), the Department of Energy (DOE) is responsible for legal services and other support for nuclear waste disposal activities, including managing the Nuclear Waste Fund (NWF), administering the Standard Contract, providing legal services for nuclear waste disposal, and maintaining the security of the Yucca Mountain site.

Highlights of the FY 2025 Budget Request

The Nuclear Waste Fund Oversight program's FY 2025 Budget Request supports activities that include the following:

- Implementation of an appropriate investment strategy and prudent management of the NWF investment portfolio;
- Administration of the Standard Contract for the disposal of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) between contract holders and the government;
- Provision of legal services for activities related to nuclear waste disposal, including but not limited to interim storage;
- Management of the physical security requirements for the Yucca Mountain site under DOE Order 473.3A as well as site maintenance and fulfillment of environmental requirements;
- Execution of the annual agency financial report and audit; and
- Operation and maintenance costs for Yucca Mountain legacy licensing and data management system.
- Support meetings and other interactions with the Nuclear Waste Technical Review Board.

These funds are inclusive of program direction activities and management and technical costs necessary to carry out the mission.

Nuclear Waste Fund Oversight
Funding ($K)

($K)

Nuclear Waste Fund Oversight	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Nuclear Waste Fund Oversight	10,205	10,205	12,040	+1,835	+18.0%
Total	**10,205**	**10,205**	**12,040**	**+1,835**	**+18.0%**

Future Year Energy Program($K)					
	FY 2025 Request	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**
Nuclear Waste Disposal	12,040	12,000	13,000	13,000	13,000

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2025 - FY 2029. The outyear funding levels use the growth rates from and match the outyear account totals published in the FY 2025 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Outyear funding for the Nuclear Waste Fund Oversight program will continue support for the implementation of an appropriate investment strategy and prudent management of the NWF investment portfolio, the administration of the Standard Contract, the management of physical security requirements for the Yucca Mountain site, legal services for activities related to nuclear waste disposal, the annual agency financial report and audit, operation and maintenance costs for Yucca Mountain legacy licensing and data management system, and associated federal staff.

Explanation of Major Changes

Funding ($K)

	FY 2025 Request vs FY 2023 Enacted
Nuclear Waste Fund Oversight The increase from $10,205,000 to $12,040,000 reflects funding for the operation and maintenance costs for the Yucca Mountain legacy licensing and data management system being requested within the Nuclear Waste Fund Oversight program (Nuclear Waste Disposal account).	**+1,835**
Total, Nuclear Waste Fund Oversight	**+1,835**

Nuclear Waste Fund Oversight

Description

The United States (U.S.) utilizes nuclear technology for national defense, research and development, and electric power generation. These activities produce and create quantities of spent nuclear fuel (SNF) and high-level waste (HLW) that require safe storage and eventual disposal. Commercial electricity generation, the largest generator of SNF, has to date generated approximately 90,000 metric tons of initial heavy metal (MTHM) of SNF. The current nuclear power reactor fleet has the potential to generate an additional 50,000 MTHM by 2060, for a total of approximately 140,000 MTHM[1]. Nearly all existing commercial SNF is stored at the reactor sites where it was produced. Of the over 70 commercial power reactor sites storing SNF, approximately a quarter of these sites no longer have an operating reactor. The U.S. inventory of HLW includes HLW produced from commercial activities stored in one state and HLW produced from defense activities stored in three states.

Under the NWPA, the Federal government, specifically DOE, is responsible for the disposal of SNF and HLW. The Nuclear Waste Fund Oversight program is responsible for providing legal and other support for nuclear waste disposal activities associated with carrying out the purposes of the NWPA. The program will ensure the prudent management of the NWF investment portfolio and the administration of the Standard Contract. The program will also support legal services related to nuclear waste disposal activities, including but not limited to the NWF and the Standard Contract. Lastly, the program will continue to support requirements for the management and operation of physical security at the Yucca Mountain site under the Protection Program Operations Directive (DOE Order 473.3A).

[1] Peters, S., J. Carter, and K. Banerjee. Spent Nuclear Fuel and Reprocessing Waste Inventory, FCRD-NFST-2013-000263, Rev. 9, PNNL-33938, November 2022.

Nuclear Waste Fund Oversight

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Interim Storage and Nuclear Waste Fund Oversight $10,205,000	**Nuclear Waste Fund Oversight $12,040,000**	**+$1,835,000**
• Implemented an appropriate investment strategy for the NWF investment portfolio and prudently managed the NWF portfolio. • Administered the Standard Contract between contract holders and the government. • Maintained physical security requirements for the Yucca Mountain site under DOE Order 473.3A as well as provide site maintenance and fulfill environmental requirements. • Provided legal services for nuclear waste disposal activities. • Supported the agency financial report and audit. • Supported associated Federal staff and support.	• Implement an appropriate investment strategy for the NWF investment portfolio and prudently manage the NWF portfolio. • Administer the Standard Contract between contract holders and the government. • Maintain physical security requirements for the Yucca Mountain site under DOE Order 473.3A as well as provide site maintenance and fulfill environmental requirements. • Provide legal services for nuclear waste disposal activities. • Support the agency financial report and audit. • Support associated Federal staff and support. • Operate and maintain the Yucca Mountain legacy licensing and data management system. • Support meetings and other interactions with the Nuclear Waste Technical Review Board.	• The increase from $10,205,000 to $12,040,000 reflects funding for the operation and maintenance costs for the Yucca Mountain legacy licensing and data management system being requested within the Nuclear Waste Fund Oversight program (Nuclear Waste Disposal account).

DEPARTMENT OF ENERGY
Funding by Site
TAS_5227 - Nuclear Waste Disposal Fund - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Idaho Operations Office			
Nuclear Waste Fund Oversight	500	500	500
Total Idaho Operations Office	**500**	**500**	**500**
Pacific Northwest National Laboratory			
Nuclear Waste Fund Oversight	530	530	530
Total Pacific Northwest National Laboratory	**530**	**530**	**530**
Sandia National Laboratories			
Nuclear Waste Fund Oversight	0	0	1,835
Total Sandia National Laboratories	**0**	**0**	**1,835**
Washington Headquarters			
Nuclear Waste Fund Oversight	8,000	8,000	8,000
Total Washington Headquarters	**8,000**	**8,000**	**8,000**
Undesignated LPI			
Nuclear Waste Fund Oversight	1,175	1,175	1,175
Total Undesignated LPI	**1,175**	**1,175**	**1,175**
Total Funding by Site for TAS_5227 - Nuclear Waste Disposal Fund	**10,205**	**10,205**	**12,040**

Fossil Energy and Carbon Management

Fossil Energy and Carbon Management

Fossil Energy and Carbon Management (FECM)

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$890,000	$890,000	$900,000	+$10,000

Proposed Appropration Languange

For Department of Energy expenses necessary in carrying out fossil energy and carbon management research and development activities, under the authority of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition of interest, including defeasible and equitable interests in any real property or any facility or for plant or facility acquisition or expansion, and for conducting inquiries, technological investigations and research concerning the extraction, processing, use, and disposal of mineral substances without objectionable social and environmental costs (30 U.S.C. 3, 1602, and 1603), $900,000,000, to remain available until expended: Provided, That of such amount $97,000,000 shall be available until September 30, 2025, for program direction. *(Energy and Water Development and Related Agencies Appropriations Act, 2023.)*

Mission

FECM conducts research and development (R&D) that focuses on technologies to reduce carbon emissions and other environmental impacts from fossil energy production and use and from key industrial processes, particularly the hardest-to-decarbonize applications in the electricity and industrial sectors. Furthermore, the program advances technologies that convert and store carbon dioxide into value-added products and that remove carbon dioxide already in the atmosphere.

FECM recognizes that broad decarbonization is essential to meeting climate goals--100% carbon pollution free electricity by 2035 and net-zero greenhouse gas emissions economy-wide by 2050--and works to engage with international colleagues to leverage expertise in these areas. FECM is also committed to improving the economic and environmental conditions of communities, retaining and creating good-paying jobs and supporting domestic energy and industrial production and manufacturing across our nation.

Overview

FECM conducts research and development (R&D) to ensure responsible use and minimize the environmental impacts of fossil fuels, critical minerals and materials, and industrial processes, while working to achieve net-zero emissions across the economy. The Office’s programs use research, development, demonstration, and deployment (RDD&D) approaches to advance technologies to reduce carbon emissions and other environmental impacts from energy production and industrial processes and to manufacture responsible carbon-based products.

FECM is working to advance carbon management to achieve deep decarbonization, advance technologies that lead to sustainable production and use of energy resources, and advance domestic engagement and international collaboration to leverage expertise in these areas. This is done by funding technology priorities of point-source carbon capture, carbon transport and storage, carbon dioxide conversion, hydrogen with carbon management, carbon dioxide removal, methane mitigation, and critical mineral and materials production.

The FY 2025 Request for FECM will extend the impact of DOE’s R&D activities by leveraging creative funding mechanisms—such as prizes, competitions, technical assistance, and programs targeted to small businesses. The goal is to enable the commercialization of climate and clean energy innovations that will reduce costs, accelerate deployment, and spur job creation and do so across a more geographically diverse and impactful R&D portfolio. This request also includes funding for the basic operating costs of FECM and investment at the National Energy Technology Laboratory (NETL).

FY 2023 Key Accomplishments:

- **Office of Carbon Management Technologies**
  - **Point Source Carbon Capture:** Completed 12 front end engineering and design (FEED) studies at industrial and power sources; Completed one large pilot (10MW) for transformational Carbon Capture and Storage (CCS) at Technology Center Mongstad (TCM).
  - **Carbon Transport and Storage (CTS):** Five Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Phase III projects on near-term path to permitting at least 250 million metric tons of geologic storage; selected 1st round of IIJA-funded CarbonSAFE and carbon dioxide (CO_2) pipeline FEED study projects; and established Transport program R&D pathways for future multi-modal transport networks.
  - **Carbon Dioxide Removal (CDR)**: Launched Direct Air Capture (DAC) pre-commercial prizes: 1) Energy Program for Innovation Clusters (EPIC) prize for incubators; and 2) technology prize for innovators. In collaboration with the Office of Clean Energy Demonstrations (OCED), launched and selected projects under the Regional DAC Hubs IIJA provision.
  - **Carbon Dioxide Conversion:** Supported launch of the Clean Fuels & Products Earthshot. Announced the Carbon Utilization Procurement Grants Program.
  - **Hydrogen with Carbon Management (HCM):** FECM-funded Distributed Clean Energy Demonstration of 15 solid oxide fuel cell (SOFC) systems (1.5 kW each) installed, commissioned and operating at the National Aeronautics and Space Administration (NASA) Independent Verification and Validation (IV&V) facility in Fairmont, West Virginia.
  - **Federal Partnerships:** Led active engagement with over 160 CCS contacts from ten federal agencies.
  - **Strategic Engagement:** Developed an FECM engagement framework for use by communities and stakeholders; hosted series of webinars for Tribal communities on IIJA opportunities and held dialogues with Tribal leaders; piloted community workshops and gathered feedback themes and engagement opportunities; co-led launch of multinational Carbon Management Challenge; co-led carbon management initiatives in multilateral Clean Energy Ministerial and Mission Innovation.
- **Office of Resource Sustainability**
  - Created the Subsurface Hydrogen Assessment, Storage, and Technology Acceleration (SHASTA) Hydrogen Estimator for Logistical Planning (HELP) tool to assess existing natural gas storage sites and provide screening-level evaluation of potential underground hydrogen storage sites.
  - Successfully extracted and processed the first batch of high purity (>90%) mixed rare earth oxides from acid mine drainage at the West Virginia University (WVU)-Mount Storm pilot site.
  - Developed and tested a novel coal-derived anode (replacement for graphite) for lithium-ion batteries used for Tesla Model S. The technology received the Voltage Award from the Battery Innovation Center.
  - With the University of Oklahoma, developed a compressor retrofit technology that reduced methane emissions by 84% and volatile organic compounds (VOC) emissions by 63%.
  - Successfully completed a pilot-scale field test of optical fiber sensors to monitor natural gas pipeline conditions and detect leaks.
  - Developed a system for water capture and reuse in cooling towers that will enable a single 600-MW power plant to capture as much as 150 million gallons of water a year, enough to provide water to 1,369 average American households for a year.
- **FECM Front Office**
  - **Energy Asset Transformation**
    - Committed $3.5 million through the Partnership Intermediary Agreement to fund 35 communities across the country to generate ideas on best ways to work together to adopt new technologies and find ways for these communities to thrive beyond current operations. The program will help communities to successfully transition energy assets into clean energy initiatives to create enduring economic benefits.
    - NETL was awarded $600K to develop and disseminate energy storage knowledge and develop new metrics for energy storage when coupled to fossil energy assets.
    - Los Alamos National Laboratory (LANL) was awarded $1 million to explore a regional strategy for transitioning the intermountain western U.S. to a carbon-neutral energy economy based on options that are regionally relevant.

    - Visits were made to 11 communities in the U.S. that have been impacted with energy asset closures. Met with community leaders to discuss and assess various technology options and realistic timelines for deployment.
    - Worked with the Interagency Working Group on Coal and Power Plant Communities (IWG) in setting up the Illinois Rapid Response Team (RRT) to work with communities to develop relevant initiatives that can be supported by IIJA provisions.
  - **University Training and Research**
    - Made 18 awards through the University Training and Research program, totaling more than $7 million, with more than half (ten awards totaling nearly $3.5 million) going to Minority-Serving Institutions (MSIs).
  - **Special Recruitment**
    - In 2022, 49 campus visits were conducted, of which 94% were at MSIs, and 13 professional conferences were attended that brought together students and professionals from underrepresented groups in science, technology, engineering, and mathematics (STEM). This investment resulted in a 2023 class comprised of 56 Mickey Leland Energy Fellowship (MLEF) participants representing 43 academic institutions with 37% of participants attending an MSI. Participants also represented 20 states, Washington, D.C., and Puerto Rico.
- **NETL:** Received considerable recognition for its world-class staff, made significant progress towards enabling mission critical facilities, and advanced knowledge and technology critical in advancing the Administration's carbon goals:
  - ***People –*** NETL researchers: (1) Won an Arthur S. Flemming award, one of the nation's top honors presented to federal employees; (2) were recognized by the North American Membrane Society for substantial contributions in the development of CO_2 membranes; (3) four staff were identified by Research.com as the Best Scientists in the World; and two staff named Oppenheimer Fellows for 2023.
  - ***Facilities –*** NETL teams: (1) Begun preparation for the installation of a new high-performance computer; (2) completed designs and construction plans for an Advanced Alloy Development Center and a Computational Science & Engineering Center; and (3) constructed the first bench scale DAC test system while designing a pilot scale DAC facility.
  - ***Research –*** Research was advanced in the critical areas of carbon management and resource sustainability.
    - **Carbon Management –** (1) Launched airborne technology at a commercial-scale CO_2 geologic storage site to complete a first-of-its-kind electromagnetic survey and collect data needed to monitor greenhouse gas sequestered in the subsurface; (2) accelerated completion of permit applications for carbon storage; (3) strategically planned safe and sustainable routes for transportation of CO_2 from where it is captured to where it can be stored underground; (4) developed efficient DAC process using microwave regeneration; (5) released study on the H_2 storage potential in existing underground gas facilities;
    - **Resource Sustainability –** (1) Developed reliable, cost-effective technologies needed to permanently plug abandoned or orphaned oil and gas wells; (2) completed successful field tests of an extensive new collection of fiber optic sensor and surface acoustic wave sensor technologies for natural gas pipeline monitoring that can help ensure safer and more secure natural gas pipeline delivery and mitigate GHG methane emissions.

FECM's FY 2025 priorities include:

- **Accelerate Low-Carbon Hydrogen:** Develop technologies that leverage existing natural gas infrastructure for hydrogen production, transport, storage, and use, coupled to carbon management.
- **Facilitate the Future Demonstration of Point-Source Carbon Capture and Carbon Transport and Storage:** R&D for point-source CCS combined with CTS in the power and industrial sectors to enable wider, strategic commercial deployment and provide low-carbon alternatives for hard to decarbonize sectors to meet net-zero emissions goals by 2050.
- **Reduce Methane Emissions:** Develop technologies and regional initiatives to quantify, monitor and reduce methane emissions from fossil fuel infrastructure including oil, gas, and coal.
- **Advance Carbon Dioxide Removal and Carbon Dioxide Conversion:** Advance DAC, biomass with carbon removal and storage (BiCRS), marine and terrestrial CDR, and mineralization technologies and develop and advance novel approaches and enabling technologies to convert and use captured carbon emissions to create fuels and products.

- **Advance Critical Minerals, Rare Earth Elements (REE), and Mine Remediation:** Improving REE separation/recovery technologies to manufacture products from carbon ores and to address current market and process economics. Advancing R&D to address abandoned mines.
- **Increase Efficient Use of Big Data and Artificial Intelligence (AI):** Use AI, machine learning (ML), and data analysis to create learning algorithms to help discover new materials, optimize processes, and run autonomous systems.
- **Invest in Thoughtful Transition Strategies:** Invest in technologies and approaches and deploy regional initiatives that provide economic and environmental benefits to affected communities and invest in American workers as we transition to a net-zero carbon economy.

Fossil Energy and Carbon Management

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
Carbon Management Technologies					
Hydrogen with Carbon Management	95,000	95,000	85,000	-10,000	-10.53%
Carbon Transport and Storage	110,000	110,000	97,200	-12,800	-11.64%
Carbon Dioxide Removal	70,000	70,000	90,200	+20,200	28.86%
Carbon Dioxide Conversion	50,000	50,000	60,000	+10,000	20.00%
Point-Source Carbon Capture	135,000	135,000	96,200	-38,800	-28.74%
Carbon Management – Policy, Analysis, and Engagement	0	0	7,000	7,000	N/A
Subtotal, Carbon Management Technologies	**460,000**	**460,000**	**435,600**	**-24,400**	**-5.30%**
Resource Sustainability					
Advanced Remediation Technologies	55,000	55,000	15,000	-40,000	-72.73%
Methane Mitigation Technologies	60,000	60,000	75,800	+15,800	+26.33%
Natural Gas Decarbonization and Hydrogen Technologies	26,000	26,000	24,400	-1,600	-6.15%
Minerals Sustainability	54,000	54,000	78,200	+24,200	+44.81%
Resource Sustainability – Analysis and Engagement	0	0	2,000	+2,000	N/A
Subtotal, Resource Sustainability	**195,000**	**195,000**	**195,400**	**+400**	**+0.21%**
Energy Asset Transformation	**6,000**	**6,000**	**6,000**	**0**	**0%**
University Training and Research	**13,000**	**13,000**	**19,000**	**+6,000**	**+46.15%**
Special Recruitment	**1,000**	**1,000**	**1,000**	**0**	**0.00%**
Program Direction	**70,000**	**70,000**	**97,000**	**+27,000**	**+38.57%**
NETL Infrastructure	**55,000**	**55,000**	**51,000**	**-4,000**	**-7.27%**
NETL Research and Operations	**87,000**	**87,000**	**95,000**	**+8,000**	**+9.20%**
Interagency Working Group	**3,000**	**3,000**	**0**	**-3,000**	**-100.00%**
Total, Fossil Energy and Carbon Management	**890,000**	**890,000**	**900,000**	**+10,000**	**+1.12%**

SBIR/STTR:

- FY 2023 Enacted: SBIR $17,433; STTR: $3,060
- FY 2024 Annualized CR: SBIR $17,433; STTR: $3,060
- FY 2025 Request: SBIR $17,449; STTR: $2,454

Infrastructure Investment and Jobs Act (IIJA) Investments

FECM was appropriated funds through the IIJA (P.L. 117-58). Not all IIJA activities will be managed by the organization to which funds were appropriated. Activities that FECM will manage that are appropriated to other organizations are discussed below.

	($K)					
	FY 2022 IIJA Funding	FY 2023 IIJA Funding	FY 2024 IIJA Funding	FY 2025 IIJA Funding	FY 2026 IIJA Funding	Managing Org.
Regional Direct Air Capture Hubs	700,000	700,000	700,000	700,000	700,000	OCED
Carbon Storage Validation and Testing	500,000	500,000	500,000	500,000	500,000	FECM
Carbon Dioxide Transportation Infrastructure Finance and Innovation	3,000	2,097,000	0	0	0	LPO
Critical Material Innovation, Efficiency, and Alternatives Activities	230,000	100,000	135,000	135,000	0	FECM
Critical Material Supply Chain Research Facility	40,000	35,000	0	0	0	FECM
Rare Earth Elements Demonstration Facility	140,000	0	0	0	0	MESC
Rare Earth Mineral Security Activities	23,000	24,200	25,400	26,600	27,800	FECM
Carbon Capture Technology Program	20,000	20,000	20,000	20,000	20,000	FECM
Carbon Utilization Program	41,000	65,250	66,563	67,941	69,388	FECM
Commercial Direct Air Capture Technology Prize Competitions	100,000	0	0	0	0	FECM
Precommercial Direct Air Capture Technology Prize Competitions	15,000	0	0	0	0	FECM
Orphaned, Abandoned, or Idled Wells on Federal Land Activities	30,000	0	0	0	0	FECM
Total, FECM IIJA	**1,842,000**	**3,541,450**	**1,446,963**	**1,449,541**	**1,371,188**	

In consultation with other offices:

- **Regional DAC Hubs (with OCED) –** The goal of this investment is to establish a program under which the Secretary shall provide funding for eligible projects that contribute to the development of 4 regional DAC hubs.
- **Carbon Dioxide Transportation Infrastructure Finance and Innovation (CIFIA) (with Loan Program Office (LPO))** – The goal of this investment is to provide flexible, low-interest loans for CO_2 transport infrastructure projects and grants for initial excess capacity on new infrastructure to facilitate future growth. Modeled after the existing Transportation Infrastructure Finance and Innovation Act (TIFIA) and Water Infrastructure Finance and Innovation Act (WIFIA) programs for highway and water infrastructure, CIFIA will help facilitate private sector investment in infrastructure critical for reaching net-zero emissions.
- **Rare Earth Elements Demonstration Facility (with Manufacturing and Energy Supply Chains (MESC))** – The goal of this investment is to demonstrate the feasibility of a full-scale integrated REE extraction and separation facility and refinery. The facility established shall-- (A) provide environmental benefits through use of feedstock derived from acid mine drainage, mine waste, or other deleterious material; (B) separate mixed rare earth oxides into pure oxides of each REE; (C) refine rare earth oxides into rare earth metals; and (D) provide for separation of rare earth oxides and refining into rare earth metals at a single site. MESC will manage FECM's REE demonstration facility.

<u>Managed by FECM:</u>

- **Carbon Storage Validation and Testing –** The goal of this investment is to establish a program of research, development, and demonstration for carbon storage. Specifically, the activity will focus on development of new or expanded commercial large-scale geologic storage projects and associated CO_2 transport infrastructure, including funding for the feasibility, site characterization, permitting, and construction stages of project development.
- **Critical Material Innovation, Efficiency, and Alternatives Activities** – The goal of this investment is to conduct a program of research, development, demonstration, and commercialization to develop alternatives to critical materials, to promote their efficient production and use, and ensure a long-term secure and sustainable supply of them.
- **Critical Material Supply Chain Research Facility** – The goal of this investment is to support construction of a critical materials supply chain research facility.
- **Rare Earth Mineral Security Activities** – The goal of this investment is to conduct a program of R&D to improve security of supply for REEs.
- **Carbon Capture Technology Program** – The goal of this investment is to expand DOE's Carbon Capture Technology program to include a program for CO_2 transport infrastructure necessary to deploy carbon capture, conversion and geologic storage.
- **Carbon Utilization Program** – The goal of this investment is to establish a grant program for state and local governments to procure and use products derived from captured carbon oxides, and to invest in additional R&D activities to lower costs and prove technologies.
- **Commercial DAC Technology Prize Competitions** – The goal of this investment is to support large-scale direct air capture pilot and demonstration projects. Prizes will be awarded to projects that demonstrate the technical and commercial viability of technologies to reduce CO_2 emissions from the atmosphere. Projects will also include rigorous life cycle and techno-economic analyses to confirm net removal of CO_2.
- **Precommercial DAC Technology Prize Competitions** – The goal of this investment is to advance research, development, demonstration, and commercial application of DAC technologies. Prizes will be awarded to projects that achieve breakthrough innovation in DAC technologies.
- **Orphaned, Abandoned, or Idled Wells on Federal Land Activities** – The goal of this investment is to administer a program for plugging wells on Federal land, and for issuing grants to States and Tribes on State, private, and Tribal land.

Inflation Reduction Act (IRA) Investments

	($K) FY 2022 IRA Funding	Managing Organization
National Laboratory Infrastructure	150,000	FECM
Total, FECM IRA Funding	**150,000**	

- FECM was appropriated funds through the IRA of 2022.
- IRA funds Infrastructure and General Plant Projects at the NETL.

Carbon Management Technologies

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$460,000	$460,000	$435,600	-$24,400

Overview

The Office of Fossil Energy and Carbon Management (FECM) Carbon Management Technologies (CMT) program invests in transformational technologies that will help achieve the Administration's goals to decarbonize the electricity sector by 2035 and reach net-zero emissions economy-wide by 2050. The CMT program focuses its efforts on hydrogen with carbon management; carbon transport and storage (CTS); carbon dioxide removal (CDR); carbon dioxide conversion; point-source carbon capture, and policy, analysis, and engagement activities related to carbon management. The CMT program supports the Department of Energy (DOE) Energy Earthshots™.

The Carbon Management Technologies activities are focused on the following key priorities:

- **Accelerate Low-Carbon Hydrogen:** Develop technologies that leverage existing natural gas infrastructure for hydrogen production, transport, storage, and use, coupled to carbon management.
- **Facilitate the Future Demonstration of Point-Source Carbon Capture and Carbon Transport and Storage:** Research and Development (R&D) for point-source carbon capture and storage (CCS) combined with CTS in the power and industrial sectors to enable wider, strategic commercial deployment and provide low-carbon alternatives for hard to decarbonize sectors to meet net-zero emissions goals by 2050.
- **Advance Carbon Dioxide Removal and Carbon Dioxide Conversion:** Advance direct air capture (DAC), biomass with carbon removal and storage (BiCRS), marine and terrestrial CDR, and mineralization technologies. Develop and advance novel approaches and enabling technologies to convert and use captured carbon emissions to create fuels and products.
- **Increase Efficient Use of Big Data and Artificial Intelligence (AI):** Use AI, machine learning, and data analysis to create learning algorithms to help discover new materials, optimize processes, and run autonomous systems.
- **Invest in Thoughtful Transition Strategies:** Invest in technologies and approaches and deploy regional initiatives that provide economic and environmental benefits to affected communities and invest in American workers as we transition to a net-zero carbon economy.

The Carbon Management Technologies program will pursue the following major activities in FY 2025:

<u>**Hydrogen with Carbon Management**</u>

The FY 2025 Request for the Hydrogen with Carbon Management program is $85 million. The program comprises six activities: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells, (4) Advanced Energy Materials, (5) Sensors, Controls, and Other Novel Concepts, and (6) Simulation-Based Engineering. In FY 2025, these activities will provide a research platform for developing the advanced systems of the future capable of net-zero emissions operations. In FY 2025, the primary focus is on thermal and electrochemical power systems and hydrogen production, and improvements to these technologies are also applicable to other energy systems such as concentrated solar, nuclear, and the chemical industry. Improvements to new and existing plants will also support their efforts to be carbon neutral and allow these assets to provide low-cost baseload power and resilient flexible grid services. These activities align with the Administration's priority of reducing environmental impacts from the power sector and providing economic and environmental benefits to impacted communities.

<u>**Carbon Transport and Storage**</u>

The Request provides $97.2 million for the CTS program to accelerate innovation in CCS and storage-based CDR (e.g., DAC or BiCRS) technologies that will contribute to decarbonizing industry and developing a carbon removal industry. These activities include: (1) strategies to develop the infrastructure for CTS; (2) R&D to improve performance and reduce costs of site characterization and active/post-injection and transport operations; (3) technology transfer; (4) technical assistance to stakeholders for project development; and (5) community engagement.

Carbon Dioxide Removal

Many climate modeling scenarios project that CDR will be required in the future to achieve economy-wide decarbonization. CDR refers to activities that remove CO_2 from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. The FY 2025 Request for CDR is $90.2 million and includes: DAC, marine CDR, BiCRS, mineralization, terrestrial carbon removal and sequestration (e.g., agricultural land management, afforestation, reforestation), direct ocean capture, and coastal blue carbon (e.g., CO_2 storage in wetlands). Of this amount, $20 million is requested for marine CDR.

Carbon Dioxide Conversion

In FY 2025, the Request provides $60 million for the CO_2 conversion subprogram for lab- and bench-scale projects to advance carbon conversion technologies that have the potential to develop environmentally and socially beneficial low and zero-emission products facilitated by building markets for CO_2 and carbon monoxide as feedstocks. Areas of research include, but are not limited to, new technologies focused on catalytic conversion to higher value products such as fuels, chemicals, and polymers; mineralization to building materials; generation of synthetic aggregates; and algal systems with high CO_2 utilization efficiency in conversion to various bioproducts. Additional efforts will include developing guidance on benchmarking catalytic conversion technologies and techno-economic analysis. Funding will support the development of at least one fully-integrated, field-test-continuous system, as well as continued support for carbon conversion test facilities such as the National Carbon Capture Center.

Point-Source Carbon Capture

FY 2025 activities will focus on next-generation capture technologies to enable clean hydrogen and allow for the integration of advanced carbon capture technologies with both power and diverse industrial emission sources. Specifically, the FY 2025 Request provides $96.2 million for R&D on advanced gas separation technologies capable of deep decarbonization (at least 95% of CO_2 at high purity suitable for compression and transport). These investments can improve energy efficiency, reduce capital costs, and achieve high capture rates.

Carbon Management – Policy, Analysis, and Engagement

The Carbon Management – Policy, Analysis, and Engagement subprogram has a Request of $7 million and has three activities that it funds: 1) Carbon Management – Policy and Analysis, 2) Carbon Management – Engagement, and 3) Carbon Management – Federal Partnerships. It supports high impact and crosscutting analysis and engagement activities through close coordination within FECM technology programs and with other DOE offices, federal agencies, and global partners. This subprogram creates and disseminates tools and information for other external users to better understand the role of carbon management technologies in an ever-evolving energy economy and works with government agencies and other domestic and international stakeholders to accelerate the advancement and responsible deployment of technologies within the carbon management research, development, demonstration, and deployment (RDD&D) program portfolio. Funding will support domestic engagement efforts and international collaboration with various partners through bilateral and multilateral agreements alongside other DOE offices such as International Affairs. FECM will focus on disseminating analytical tools, building capacity, and working with interagency partners to ensure safe, effective, and efficient implementation of its programs. Policy, analysis, and engagement efforts will help FECM maximize the impact of its research dollars; track the impacts of FECM investments; support the Office of Policy's Department-wide work on greenhouse gas analytics and the reporting of climate, economic, environmental, and other impacts of fossil-fuel related BIL and IRA programming; and help ensure benefits for all Americans. This subprogram also supports strategic planning by identifying major challenges and opportunities to improve efficiency, cost, and socioenvironmental performance within all the subprograms of the CMT program.

Carbon Management Technologies

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023 $	FY 2025 vs FY 2023 %
Carbon Management Technologies					
Hydrogen with Carbon Management					
Gasification Systems	28,000	28,000	20,000	-8,000	-28.57%
Advanced Turbines	30,000	30,000	30,000	0	0%
Reversible Solid Oxide Fuel Cells	10,000	10,000	6,000	-4,000	-40.00%
Advanced Energy Materials	16,000	16,000	12,000	-4,000	-25.00%
Sensors, Controls and Other Novel Concepts	5,000	5,000	6,000	1,000	20.00%
Simulation-Based Engineering	6,000	6,000	11,000	5,000	83.33%
Subtotal, Hydrogen with Carbon Management	**95,000**	**95,000**	**85,000**	**-10,000**	**-10.53%**
Carbon Transport and Storage					
Storage Infrastructure	90,000	90,000	76,600	-13,400	-14.89%
Advanced Storage RDD&D	20,000	20,000	20,600	600	3%
Subtotal Carbon Transport and Storage	**110,000**	**110,000**	**97,200**	**-12,800**	**-11.64%**
Carbon Dioxide Removal	**70,000**	**70,000**	**90,200**	**20,200**	**28.86%**
Carbon Dioxide Conversion	**50,000**	**50,000**	**60,000**	**10,000**	**20.00%**
Point-Source Carbon Capture	**135,000**	**135,000**	**96,200**	**-38,800**	**-28.74%**
Carbon Management – Policy, Analysis, and Engagement					
Carbon Management – Policy and Analysis	0	0	3,500	3,500	N/A
Carbon Management – Engagement	0	0	3,000	3,000	N/A
Carbon Management – Federal Partnerships	0	0	500	500	N/A
Subtotal Carbon Management – Policy, Analysis, and Engagement	**0**	**0**	**7,000**	**7,000**	**N/A**
Supercritical Transformational Electric Power (STEP)[1]	**0**	**0**	**0**	**0**	**0%**
Total, Carbon Management Technologies	**460,000**	**460,000**	**435,600**	**-24,400**	**-5.30%**

SBIR/STTR:

- FY 2023 Enacted: SBIR $12,067; STTR: $2,118
- FY 2024 Annualized CR: SBIR $12,067; STTR: $2,118
- FY 2025 Request: SBIR $11,679; STTR: $1,642

[1] The Supercritical Transformational Electric Power (STEP) project was created within the Carbon Capture, Utilization and Storage and Power Systems Program by the Consolidated and Further Continuing Appropriations Act of 2015. The STEP program focuses on RDD&D to advance higher efficiency, lower cost technologies that use supercritical CO_2 (sCO_2) for power cycles. The project is fully funded. No funding is requested for STEP in FY 2025.

Carbon Management Technologies
Explanation of Major Changes
($K)

	FY 2025 Request vs FY 2023 Enacted
Hydrogen with Carbon Management: Funding continues to support efforts to achieve the Hydrogen Shot™ goal of $1/kg H_2 within a decade while ensuring sufficient funding for highest priority programs.	**-$10,000**
Carbon Transport and Storage: Funding continues to support our three interfacing initiatives (CarbonSAFE, CarbonBASE, and CarbonSTORE) which align storage resource assessment, utilization and performance designed to enable 2 billion metric tons of storage capacity by 2030. The requested funding ensures sufficient funding for highest priority programs.	**-$12,800**
Carbon Dioxide Removal: Increased funding continues to support key Administration priorities such as the Carbon Negative Shot™ by funding efforts on DAC, BiCRS, mineralization/enhanced weathering, marine CDR, and terrestrial carbon sequestration.	**+$20,200**
Carbon Dioxide Conversion: Increased funding supports the development and evaluation of new and existing processes for converting carbon oxides into industry relevant chemical and materials, as well as pilot-scale and Front-End Engineering Design studies.	**+$10,000**
Point-Source Carbon Capture: Funding continues to ensure progress to support Administration decarbonization goals and priority efforts to support industrial decarbonization while ensuring sufficient funding for highest priority programs.	**-$38,800**
Carbon Management – Policy, Analysis, and Engagement: Increased funding will be used for the enhancement and development of techno-economic models used for projecting future energy market conditions, enable international and domestic engagement, and support a well-coordinated and integrated Federal government role in supporting deployment of carbon management technologies.	**+$7,000**
Total, Carbon Management Technologies	**-$24,400**

Overview

The Hydrogen with Carbon Management (HCM) subprogram invests in research to evaluate low-carbon hydrogen (i.e., coupled to carbon capture and storage (CCS)) as a fuel and supports development of technologies to use low-carbon hydrogen from any source. The subprogram's efforts are an integral part of the Department of Energy's (DOE) Hydrogen Shot™, with a goal of reducing the cost of clean hydrogen by 80 percent to $1 per 1 kilogram (kg) within 1 decade (1-1-1), while expanding employment of the United States (U.S.) energy workforce. Seeking a cost-competitive decarbonized alternative to traditional unabated fossil fuels, the subprogram has a research, development and demonstration (RD&D) portfolio consisting of a new generation of low-carbon or net-negative greenhouse gas (GHG) emissions technologies. The subprogram is comprised of six RD&D areas: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells (R-SOFCs), (4) Advanced Energy Materials, (5) Sensors, Controls, and Other Novel Concepts, and (6) Simulation-Based Engineering.

This subprogram provides a platform for developing the advanced systems of the future capable of net-zero emissions operations. These efforts are complementary to the Bipartisan Infrastructure Law (BIL) Hydrogen Hubs, as many of the technology advancements being developed in Gasification Systems, Advanced Turbines and R-SOFCs will be deployed at Hydrogen Hubs over the next five to ten years. While the primary focus is on thermal and electrochemical power systems and hydrogen production, improvements to these technologies are also applicable to other energy systems such as concentrated solar, nuclear, and the chemical industry. Improvements to new and existing plants may also support their efforts to be carbon neutral and allow these assets to provide low-cost baseload power and resilient flexible grid services. These activities align with the Administration's priority of reducing environmental impacts from the power sectors and providing economic and environmental benefits to affected communities.

A description of each Hydrogen with Carbon Management activity is presented below:

Gasification Systems

Gasification technologies can potentially turn any carbonaceous feedstock into syngas and other chemical building blocks such as clean hydrogen, liquid fuels, chemicals (e.g., ammonia), and carbon products. Furthermore, feedstock blends that consist of legacy coal waste, municipal solid waste, waste plastics, and biomass (including biomass wastes) may afford a low-carbon (or even a carbon negative) emissions profile when used in combination with CCS. Gasification technology with integrated pre-combustion carbon capture is an efficient pathway to quickly roll out clean hydrogen to meet the ambitious cost and schedule goals articulated in the Hydrogen Shot initiative. An additional motivation for advancing flexible feedstock gasification technology is its potential to reduce environmental impacts on communities by consuming, and therefore eliminating, various carbon-based waste materials, a unique attribute that gasification may accomplish that other hydrogen production technologies cannot address. Strategic siting of new clean hydrogen production near waste landfills and similar waste storage stockpiles can improve economic and environmental conditions of communities by removing sources of contamination and obstacles to economic development, thus attracting commercial investment, and bringing steady, well-paying jobs to those communities.

The FY 2025 Budget Request provides $20 million for RD&D with industry, universities, and DOE National Laboratories to develop technologies that could overcome the constraints that have been inhibiting the deployment of conventional gasification-based plants. The Request will enable technology development in the following areas:

- Clean Hydrogen production: This sub-activity aims to advance and mature novel technologies capable of producing clean hydrogen with net-negative emissions, from co-gasification of blended biomass and wastes, including municipal solid waste, legacy coal waste, and unrecyclable plastics, to enable remediation and potentially improve the economic and environmental conditions of communities.
- Scale-up of moderate-technology readiness level (TRL) of advanced oxygen production technologies: The sub-activity aims to advance the TRL of emerging oxygen production technologies from air separation. Scale-up will allow for maturation of novel, highly efficient, and lower cost oxygen production technologies from DOE's National

Labs into commercially-relevant prominence, thus facilitating interest from the commercial sector and attracting technology transfer partner(s). Lower cost oxygen is crucial to enable gasification to leverage pre-combustion carbon capture and produce clean hydrogen at a low enough cost to meet the Hydrogen Shot initiative's goal. This technological maturation activity will improve the viability and economics of net-zero carbon gasification systems.

- Using novel microwaves for enhanced gasification robustness and quality: This sub-activity aims to advance waste cleanup/gasification technology by developing microwave enhancements that produce valuable hydrogen from organic impurities in syngas that might survive the primary gasification process. Addressing the concerns of condensable organic species in raw syngas increases the likelihood of commercial sector adoption of flexible and variable waste-feedstocks to clean hydrogen production. Incorporating microwave technology at a gasifier's exit offers the promise of destroying any remaining complex molecules into simple molecules like hydrogen, that will improve the systems reliability, availability, and maintainability, all of which allows greater impact on generating clean electricity with net-zero carbon emissions.
- Enhanced blended gasification feedstock pretreatment processes: This sub-activity aims to develop, investigate, and advance the TRL of various novel pretreatment techniques for blended feedstocks (biomass, mixed wastes, municipal solid waste, unrecyclable plastics, etc.). Blended feedstocks that include biomass are important for future gasification systems for production of power, hydrogen, and ammonia with net-zero emissions. However, blended feedstock-based systems are severely limited in scope due to two key issues: reliably feeding blended materials with different characteristics into the gasification process, and accessing, shipping, and storing the feedstock materials in a low- or zero-carbon intensity method. Development of these technologies focuses on addressing these two key issues.
- Clean hydrogen production systems integration and optimization: This sub-activity aims to improve integration of components within systems, hybridization of processes, and improving process reliability, to optimize hydrogen production efficiency and cost reductions given scale of the system, feedstock availability, and market factors.

Advanced Turbines

The FY 2025 Budget Request provides $30 million in funding to develop gas turbine combustion systems to accommodate hydrogen, ammonia and hydrogen-natural gas fuel blends while minimizing nitrogen oxide emissions and maintaining machine efficiency. RD&D investments will also support efficiency goals of 67 percent (lower heating value (LHV) natural gas) and 50 percent (LHV natural gas) for combined cycle and simple cycle machines, respectively. The program will also invest in RD&D to achieve 70 percent efficient combined cycle machine (LHV natural gas) by 2030.

Investments will be made in the application of advanced manufacturing and artificial intelligence and machine learning (AI/ML) to attain efficiency goals. The activity will be executed in cost-shared collaboration with capital equipment manufacturers, the secondary market supporting turbine technology, U.S. universities, and the DOE National Labs.

The Advanced Turbines activity supports four key technologies that will advance clean, low-cost power production while providing options for carbon dioxide (CO_2) mitigation. These key technologies include: (1) Advanced Combustion Turbines, (2) Pressure Gain Combustion, (3) Modular Turbine-Based Hybrid Heat Engines, and (4) Supporting the University Turbine Systems Research (UTSR) program. DOE's RD&D in advanced turbines technology develops and facilitates low-cost advanced energy options for energy ecosystems. Sub-elements of this program include:

- Advanced Combustion Turbines: The Request will support a significant investment in the development of hydrogen combustion systems for hydrogen and hydrogen carriers like ammonia for retrofit applications and new gas turbines. The Request will also support new designs for gas turbine components, advanced cooling techniques, aerodynamics, sealing, combustion systems and materials.
- Pressure Gain Combustion: Pressure gain combustion has the potential to significantly improve gas turbine performance by realizing a pressure increase versus a pressure loss through the combustor of the turbine. Hydrogen is a particularly attractive fuel for pressure gain combustion and is being explored in this program.
- Modular Turbine-based Hybrid Heat Engine: Projects seek to develop modular turbine-based hybrid heat engines that integrate with modular gasifiers, promote the clean use of stranded fuels, support energy storage cycles, make hydrogen generation more affordable, improve the efficiency and environmental performance of natural gas compression stations, and provide an affordable cost of electricity.

- University Turbine Systems Research: The Request also supports the UTSR sub-activity within the Advanced Turbines activity, which supports hydrogen turbine research at U.S. universities. This cost-shared activity, with industry endorsement, supports fundamental and applied RD&D projects that improve the efficiencies of turbines and related turbine technologies. Additionally, this program helps train the workforce of combustion turbine scientists, engineers, and technicians.

Reversible Solid Oxide Fuel Cells

Reversible Solid Oxide Fuel Cells use natural gas and/or up to 100% hydrogen to produce electricity, water and CO_2 when operating in a fuel cell mode. R-SOFCs can be configured to operate in reverse as an electrolyzer using power and water as inputs to produce hydrogen, with oxygen as a byproduct. This electrolyzer mode turns the R-SOFC into a Solid Oxide Electrolyzer Cell (SOEC). SOECs essentially function as an SOFC in reverse and optimize the use of these system to reduce overall costs. The CO_2 produced from the process with natural gas as a fuel in a fuel cell mode can then be sequestered for storage or use in other applications.

R-SOFCs can both store and produce energy with a single system and can contribute to clean energy generation/storage when paired with a renewable fuel such as hydrogen (in fuel cell mode) or renewable electricity (in electrolysis mode). Hydrogen created from R-SOFCs is a promising fuel source and can be stored for future use when renewable energy sources are not available. When the grid demands power, the R-SOFC consumes the stored hydrogen to produce electricity. R-SOFCs allow for a continuous stream of clean energy into the grid.

The focus areas for the R-SOFCs Program include:

- Clean hydrogen production from SOEC systems;
- Developing and validating the materials proposed for improving the cost, performance, and reliability of R-SOFC systems and to demonstrate small scale (up of 25-50 kW) R-SOFC to produce hydrogen and electricity using natural gas/hydrogen blends up to 100% hydrogen; and
- RD&D for degradation at start-up of SOEC operation and enabling technologies for dynamic operation of SOEC/SOFC Systems.

The Request provides $6 million to conduct additional RD&D to advance R-SOFC technologies, including operating as SOECs. This activity will identify advanced R-SOFC configuration concepts that enable the generation of ultra-efficient, low-cost electricity for the near-term deployment of distributed generation/modular power systems.

Advanced Energy Materials

The Advanced Energy Materials activity focuses primarily on material discovery and development that will lower the cost and improve flexibility and reliability while enabling high efficiency, low-carbon performance. Materials of interest are those that enable components and equipment to perform in the high temperature, high pressure, corrosive environments of an advanced energy system with specific emphasis on durability, availability, and cost. The activity also seeks to enhance the nation's supply chain for high-temperature materials to support a competitive U.S. industry base and create a skilled workforce. The activity has three main sub-activities:

- **Advanced Materials Development**: This sub-activity creates cost-effective structural and functional materials for advanced power generation technologies, and reduces the cost and time needed to develop and commercialize new materials for applications in extreme operating environments. Development focuses on advanced manufacturing methods for high-performance materials and computational materials modeling as enabling technologies. The National Energy Technology Lab (NETL) leads a National Laboratory consortium, Extreme Environment Materials (eXtremeMAT or XMAT), dedicated to changing how materials are conceived and developed. In addition, this sub-activity will evaluate the impact of hydrogen on materials to develop models critical to understanding hydrogen-related impacts to establish a new domestic supply chain of hydrogen resistant materials.
- **Supply Chain Development**: The Advanced Ultra-Supercritical (AUSC) consortium developed high temperature materials and manufacturing technologies that are now being used in applications such as natural gas combined cycles, concentrated solar, and high efficiency supercritical CO_2 plants. Continuing supply chain development work

includes large-scale manufacturing, forming and machining enhancements for high temperature alloys developed under the AUSC program, and techno-economic analyses (TEA) that ready the domestic supply chain to support construction of advanced generation technology power plants. This sub-activity also supports development of ceramic matrix composite material formulations for turbine applications (thermal barrier coatings or turbine blade materials) and advanced manufacturing methods to reduce fabrication costs and improve cyclic durability.

- **High-Performance Computing for Materials (HPC4Mat)**: This sub-activity aims to utilize the high-performance computing (HPC) resources of DOE's National Laboratories to help industry develop new or improved materials and resolve materials challenges for their applications.

The FY 2025 Request of $12 million will provide funding for RD&D to develop and commercialize new materials for applications in extreme operating environments and continue supply chain development efforts. The Request also supports the NETL-led XMAT National Lab Consortium to incorporate material-hydrogen interactions in materials models, develop prediction methods for component lifetimes, and accelerate the design of new materials.

Sensors, Controls, and Other Novel Concepts

This activity provides $6 million to fund early-stage RD&D on low-cost, reliable wired and wireless technologies to measure process temperature, pressure, and concentration of gas species. These technologies could be capable of providing real-time information critical to the operation, reliability, and efficiency of next generation power systems. This is needed as a part of greater efforts to achieve a carbon pollution-free power sector by 2035.

Technological advances will enable industry to shift from time-based preventive maintenance schedules to predictive condition-based maintenance to improve reliability and overall plant economics. Advanced sensors and controls can also be used to monitor, identify, and mitigate transients associated with a cyber-attack, providing increased asset security, safety, and grid stability. Novel instrumentation that can withstand harsh process environments can replace inferred process conditions with actual measurements. This facilitates optimized performance, improved component health monitoring, and faster/safer response times during flexible operations.

RD&D will focus on advanced data analytics and controls development for power plants and industrial facilities of the future. This activity builds off lessons learned from testing at existing power plants, emphasizing integration of materials lifetime modeling and control algorithms. By advancing research and development, technology prototypes are designed, packaged, ruggedized, and readied for plant integration. Other novel/emerging technologies will be developed to support future energy applications essential for energy security and efficiency. Technologies developed by this program could also be applied to hydrogen production and utilization; CCS; flexible-fuel boiler systems; and energy storage. Focus areas include the following:

- **Real Time Monitoring & Diagnostics:** Early-stage RD&D on low-cost and reliable multi-sensing wired and wireless technologies to conduct process monitoring and component health by measuring critical process parameters.
- **Advanced Controls:** Advanced control algorithm development is critical in the optimization of systems with highly coupled, nonlinear interactions. Dynamic controls and integration will enable flexible operation of energy systems, including load following, demand response, and hybrid energy integration, while enhancing safety and grid stability.
- **Condition-Based Maintenance:** Advances in sensor RD&D will enable industry to shift from time-based preventive maintenance to predictive condition-based maintenance with improved reliability and overall plant economics. This could save millions of dollars in maintenance costs across all power cycles.
- **Cyber-physical systems:** Enables deployment of integrated energy systems (IES) that combine CCS, intermittent renewable resources, and energy storage. Continued development and demonstration of cyber-physical systems (CPS) for design and integration of HCM systems. This will enable increased renewable energy and the transition to net-zero carbon reduction goals while also maintaining generation stability, reliability, security, and limiting the cost increases to consumers.

Simulation-Based Engineering

The Simulation-Based Engineering activity includes computational software development, HPC, advanced optimization, TEA, and AI/ML. Simulations generate information beyond the reach of experiments alone, rapidly, and inexpensively. They enable the discovery of new materials, optimization and troubleshooting of novel devices, and the design and optimization of complex process systems. This activity also comprises modeling, simulation, and TEA to resolve challenges and optimize power plants as they integrate with a dynamic, evolving electricity grid. Key objectives include improving the reliability, flexibility, and economics of the next generation fleet and the industrial and manufacturing sectors.

In FY 2025, the Budget Request for Simulation-Based Engineering provides $11 million to continue funding for DOE National Laboratory RD&D, including existing modeling and analysis projects funded under the Grid Modernization Initiative; and the NETL-led Institute for the Design of Advanced Energy Systems (IDAES), which develops process systems engineering tools and optimized approaches in the conceptual design and process intensification of innovative systems. IDAES activities will focus on continuing support for stakeholders and communities by developing new features and capabilities to address the challenges associated with the design and operation of IES to enable deep decarbonization of the energy and industrial sectors, with a specific focus on hydrogen, CCUS, and energy storage.

The Multiphase Flow with Interphase exchanges (MFiX) element, led by NETL, will also support computational efforts, including ML, in collaboration with industry, to gain deep insight into plant operation to improve performance outcomes and reduce unexpected, forced outages. In addition, the funding will allow the upkeep of capabilities associated with the Computational Fluid Dynamics for Advanced Reactor Design (CARD) and IDAES activities. The CARD activities include the development of models that allow the production of hydrogen from biomass and plastics.

The HCM subprogram closely coordinates its research, development, demonstration and deployment activities with the Office of Energy Efficiency and Renewable Energy (EERE) Hydrogen and Fuel Cell Technology Office to work collaboratively where appropriate and to ensure no duplication of effort. Intra-agency coordination includes the following DOE Offices: EERE, the Office of Fossil Energy and Carbon Management (FECM), the Office of Science, the Office of Nuclear Energy, Advanced Research Projects Agency-Energy, and the Office of Electricity. The Joint Strategy Teams for hydrogen production and conversion will strengthen collaboration with all DOE offices, including the crosscutting offices (such as the Office of Technology Transitions and the Loans Program Office) involved with various hydrogen initiatives.

Carbon Management Technologies
Hydrogen with Carbon Management

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Hydrogen with Carbon Management: $95,000,000	**$85,000,000**	**-$10,000,000**
Gasification Systems $28,000,000	**$20,000,000**	**-$8,000,000**
• Developed robust, fuel-flexible, load-following modular gasification systems, specifically for community-scale gasification of legacy coal waste and opportunity feedstocks. • Developed process technology that integrates oxygen separation from air and uses advanced techniques for gasification of waste feedstocks. • Developed small-scale, modular microwave reactor technologies that expand the capability to use low value and waste feedstocks (including waste plastics and legacy coal waste and biomass).	• Scale-up and maturation of novel, highly efficient and lower cost oxygen production technologies. • Support advancement of clean hydrogen production from co-gasification of blended waste and biomass to accomplish remediation and reduction of legacy pollution. • Support integration of components, hybridization of processes, and improving process reliability, to optimize hydrogen production efficiency from gasification and cost reductions given scale of the system, feedstock availability, and market factors.	• The decrease maintains these activities and reflects a reprioritized focus on technological maturation/scale-up techniques.
Advanced Turbines $30,000,000	**$30,000,000**	**$0**
• Supported new turbine component designs for hydrogen, ammonia, and gas with carbon capture, advanced cooling techniques, aerodynamics, sealing, combustion systems and materials. • Supported the UTSR program.	• Support experimental development and technology demonstration of retrofit combustor systems for hydrogen, ammonia, and hydrogen and natural gas blends. • Issue biannual UTSR funding opportunity announcement (FOA). • The funding will be utilized for FOAs addressing topic areas in 100% hydrogen turbines.	• Continue at current levels.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Reversible Solid Oxide Fuel Cells $10,000,000	**$6,000,000**	**-$4,000,000**
• Investigated R-SOFC/SOEC operation and system studies to integrate heat required for SOEC operation from other processes (e.g., nuclear). • Mature SOFC technologies and advanced RD&D on SOECs. • Focused on carbon neutral hydrogen production from SOECs.	• Develop the materials for improving the cost, performance, and durability of R-SOFC systems. • Focus on clean hydrogen production from SOECs.	• The decrease maintains these activities and conducts basic RD&D to advance R-SOFC technologies, including operating as SOFCs/SOECs.
Advanced Energy Materials $16,000,000	**$12,000,000**	**-$4,000,000**
• Evaluated the impacts of hydrogen on materials and developed models critical to understanding hydrogen-related impacts to establish a new domestic supply chain of hydrogen resistant materials.	• Extend models developed under XMAT to include the effects of hydrogen on materials and component life. • Continue development of models critical to understanding hydrogen-related materials impacts to establish a new domestic supply chain of hydrogen resistant materials.	• The decrease maintains these activities and develops alloy compositions and manufacturing techniques to improve resistance to hydrogen embrittlement.
Sensors and Controls & Other Novel Concepts $5,000,000	**$6,000,000**	**+$1,000,000**
• RD&D on low-cost and reliable multi-sensing wired and wireless technologies, focusing on hydrogen and CCS activities. • Developed technologies that monitor power plant networks to identify abnormal behaviors because of operational issues or a malicious cybersecurity event.	• Continue RD&D on advanced monitoring, controls, and integration techniques for optimized performance and reliability of hydrogen and carbon management systems. • Support the investigation of novel concepts/ disruptive, emerging technologies that may be impactful for future FECM-relevant systems, such as quantum sensing, blockchain and distributed ledger technologies. • Cultivate a robust technology development pipeline, focused on maturation of concepts through meaningful testing and demonstration, and technology transfer to industry.	• Increases funding for cyber-physical systems.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Simulation Based Engineering $6,000,000	**$11,000,000**	**+$5,000,000**
• Supported the development of interactive visualization technology and data communication optimization methods to improve the design and operation of advanced power systems with CCUS to meet decarbonization goals. • Provided first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes. • Continued the development, validation, application, and support of the MFiX computational fluid dynamics software suite. • Continued work on the design, scale-up, and optimization of pyrolysis and gasification reactors for hydrogen production from biomass and plastics.	• Continue the development, validation and application of flagship, open-source software codes, including MFiX and IDAES. • Leverage models and simulations to accelerate the design, optimization, and/or scale-up of complex, integrated technologies and systems, including but not limited to hydrogen production; carbon capture and conversion technologies and advanced scenarios for decarbonization. • Exploration of novel methodologies to increase computational speeds, including advanced computing architectures (e.g., graphics processing unit-accelerated systems for HPC, quantum computing, etc.) and deployment of novel AI/ML techniques.	• Funding increased for both IDAES and platforms to: (1) maintain and expand IDAES and MFiX stakeholder and user communities; and (2) ensure timely, reliable, documented, usable, and transparent releases of the IDAES Integrated Platform and MFiX to ensure adequate support for the growing base of users across several projects of interest to FECM.

Carbon Management Technologies
Carbon Transport and Storage

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$110,000	$110,000	$97,200	-$12,800

Overview

Carbon capture, utilization, and storage (CCUS) and carbon dioxide removal (CDR) are critical components of the Administration's broad and aggressive efforts to meet decarbonization targets leading to a net-zero carbon economy by 2050. Through the Bipartisan Infrastructure Law (BIL), the Inflation Reduction Act (IRA), and the Create Helpful Incentives to Produce Semiconductors (CHIPS) And Science Act of 2022, Congress has committed resources and established policies that will spur the growth of carbon management industries, including CCUS, CDR and associated transport infrastructure, as well as support for basic science research.

Critical components that will help catalyze the growth of the requisite subsurface and transport resources necessary for geologic storage of carbon dioxide (CO_2) captured from industrial facilities and power plants and removed from the atmosphere include, but are not limited to, strategies to develop the infrastructure for CO_2 transport and storage; and research, development, demonstration, and deployment (RDD&D) to improve performance and reduce costs of site characterization and active/post-injection and transport operations.

CCUS projects supported by the Department of Energy (DOE) and other organizations around the world have researched and demonstrated safe transport and secure geologic storage of CO_2 in a variety of different geologic formations and depositional environments. Since 2016, the Office of Fossil Energy and Carbon Management (FECM) has been focused on deploying carbon storage at scale in the U.S. with the launch of the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative. Since passage of BIL , the number of first-mover, large-scale commercial storage projects have substantially expanded, largely through policy changes that have incentivized CCUS and CDR and the construction of commercial carbon storage facilities funded by BIL Section 40305 (Carbon Storage Validation and Testing). FECM expects this increase in carbon storage projects will likewise increase the confidence in geologic storage of captured CO_2 among operators, regulators, insurers, financial institutions, environmental groups, local communities, and community leaders.

In FY 2025, the Carbon Transport and Storage (CTS) subprogram will continue to play an important role in accelerating CCUS infrastructure buildout and storage-based CDR by advancing next generation, cutting edge technologies intended to lower the cost of CO_2 storage facility development, improve operational performance, and help de-risk existing and future CarbonSAFE projects, as well as industry-led carbon storage projects.

The Request provides $97.2 million for the CTS subprogram for technology research and development (R&D) that will accelerate carbon capture and storage (CCS) and storage-based CDR (e.g., direct air capture (DAC)) and biomass with carbon removal and storage (BiCRS)) as clean energy innovations that will contribute toward decarbonizing industry and developing a carbon removal industry. These activities will leverage active field projects supported by prior year funding and the CarbonSAFE projects funded under BIL Section 40305. Activities include:

- Continuing the Carbon Basin-scale Assessment and Storage Evaluation (CarbonBASE) Initiative to collect necessary data, develop models, and apply decision tools to optimize secure CO_2 storage across geologic basins;
- Selecting additional Carbon Storage Technology and Operational Research (CarbonSTORE) facilities and supporting new research at these facilities;
- Continuing feasibility studies on various CO_2 transport modes, performing network optimization scenarios, and initiating research to validate models and tools;

- Continuing technical assistance for project developers, communities, and other key entities to leverage the national network of experts on geologic storage, permitting, and community engagement; and
- Advancing early-stage, cutting edge technologies that fill priority technology gaps and near-term industry needs, including AI-enabling/supporting technologies.

These initiatives and other activities are targeted to advance storage security, performance, and infrastructure buildout and are driving the CTS subprogram forward to accelerate commercial CCUS and storage-based CDR deployment. In FY 2025, the CTS program efforts will also be aligned with the technology development goals of the relevant DOE Energy Earthshots (Hydrogen Shot™, Carbon Negative Shot™, Industrial Heat Shot™, Enhanced Geothermal Shot™, and Clean Fuels and Products Shot™) as well as the DOE Subsurface Energy Innovations (SEI) Crosscut, which target cross-cutting innovations in characterization, monitoring, drilling, and engineering across DOE's subsurface programs with consideration to common data needs and basic science gaps.

Storage Infrastructure

The FY 2025 CTS Request includes $76.6 million for Storage Infrastructure activities that will leverage active field projects supported by prior year base funding and the CarbonSAFE projects funded under BIL Section 40305. These projects perform feasibility studies of potential on- and offshore storage sites that could support the deployment of CCUS for the power sector, hydrogen production facilities, hard-to-decarbonize industries (e.g., steel, cement), and storage-based CDR (e.g., DAC with CO_2 storage and BiCRS). For FY 2025, new CarbonSAFE projects will be covered by funds appropriated under the BIL Section 40305. The Storage Infrastructure activities will include the research and development work to support the CarbonBASE Initiative, focusing on characterization of dedicated saline and mafic/serpentine rock storage formations in geologic basins with the most promising geologic formations that are likely to host multiple large-scale storage projects throughout the country. Emphasis will include characterization of basins that are data poor or where storage resources may be undiscovered. Coupled with collaborative efforts with multiple entities (Federal and State leasing agencies, National labs, regulatory agencies, academia, industry), CarbonBASE projects will develop basin-scale models and decision support tools to support the management of multiple commercial projects to include active reservoir management, pore space utilization optimization, potential interference assessments of pressure and plumes, seismicity management, and storage accounting procedures. A key outcome of CarbonBASE will be tools and approaches for resource managers to define and utilize pore and pressure space efficiently and safely. This will be an important project de-risking component for future CarbonSAFE projects funded under BIL. CarbonBASE will seek opportunities to collaborate with other FECM offices and DOE programs through the SEI crosscut, as well as with relevant offices in other agencies such the Department of the Interior and the Department of Transportation Pipeline and Hazardous Materials Safety Administration.

The FY 2025 Storage Infrastructure Request will also support the development and implementation of a technical assistance strategy that leverages existing data and the national network of expertise on carbon storage. Funding will support technical assistance initiatives, such as FECM's Regional Initiatives and DOE's Communities Local Energy Action Program (LEAP), to support carbon management hub development, basin scale management, regional geologic characterization, and community engagement to help ensure that communities see tangible economic, environmental, and jobs benefits from the deployment of projects and infrastructure and to help ensure project success.

To make further improvements in the cost and performance of applied monitoring technologies, the Storage Infrastructure activity will also seek to competitively award additional CarbonSTORE projects with encouragement to integrate within or site in proximity to CarbonSAFE projects or other commercial storage facilities or at-scale analog sites. CarbonSTORE facilities serve as field laboratories for testing new technologies, monitoring storage performance, and providing public data for program-wide efforts, and project de-risking. Any new CarbonSTORE projects selected this fiscal year would target priority areas and research opportunities not covered by CarbonSTORE projects selected in the prior year.

FY 2025 activities will also leverage the experience and findings of on-going and new field efforts to improve understanding of national infrastructure and transport needs, onshore/offshore deployment, leveraging existing oil and gas infrastructure and natural CO_2 deposits to convert these systems for CO_2 transport or dedicated CO_2 storage. Analyses will include evaluations of financial incentives to deployment, and storage hub resource assessments and efficiencies. Research will also be conducted through national laboratories and/or funding opportunity announcements in support of new field projects and to complete on-going field studies that were initiated with prior year appropriations. Systems modeling of a transportation system to support the wide-scale transport and storage of CO_2 will also be supported to determine opportunities for multi-modal and inter-modal transport systems. Overall, the sub-activities within the Storage Infrastructure activity will be designed to support and align with congressional direction on CCS and storage-based CDR as outlined in relevant sections of the BIL, including those addressing CO_2 transport (i.e., Sections 40304 and 40303).

Advanced Storage
The CTS Request includes $20.6 million for Advanced Storage R&D that will continue high-priority activities to advance technologies specific to CO_2 geologic storage targeting enhanced plume imaging/tracking, high-temporal and high-spatial resolution monitoring, improved geomechanical stress/strain characterization and measurement, high fidelity sensing, and automation and intelligent systems including AI-enabling/supporting technologies. FY 2025 funds will also support individual site and hub screening and characterization tools and techniques for improved storage capacity assessments and pore/pressure space optimization at project and basin scales. FY 2025 funds will support testing and validation and system performance at CarbonSTORE facilities. Targeted research by national laboratories and other research institutions includes advancing fault/fracture networks characterization and associated stress state, fluid/pressure migration management, basin-scale modeling for evaluating storage resource management strategies, legacy wellbore characterization, repurposing of oil, gas, and CO_2 production infrastructure, intelligent monitoring systems, and developing approaches/methods for adaptive reservoir management. The program will also support R&D on the transformation of transport infrastructure that is used for other gases/fluids, as well as research on new materials, material performance and contaminant impacts.
FY 2025 funds will also continue to support the curation of data from CTS supported projects into the DOE National Energy Technology Laboratory Energy Data Exchange (EDX), which serves as the portal for public access to CTS data products.

Carbon Management Technologies
Carbon Transport and Storage

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
Storage Infrastructure	90,000	90,000	76,600	-13,400	-14.9%
Advanced Storage R&D	20,000	20,000	20,600	+600	+3.0%
Total, CTS Program	**110,000**	**110,000**	**97,200**	**-12,800**	**-11.6%**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Carbon Transport and Storage: $110,000,000	**$97,200,000**	**-$12,800,000**
Storage Infrastructure: $90,000,000	**$76,600,000**	**-$13,400,000**
• Supported competitive selection of additional Phase II CarbonSAFE projects to characterize, evaluate, and analyze the feasibility of onshore and offshore storage sites and hubs for dedicated storage in saline formations, depleted oil and gas assets, CO_2 domes, and deposits for mineralization. • Supported competitive selection of CarbonSTORE projects to serve as field laboratories at commercial CO_2 storage sites for dedicated storage, which will be critical for testing new and potentially lower-cost storage monitoring technologies and systems and providing real-world data for program-wide RDD&D efforts. • Supported Regional Initiative as regional technical assistance to CCUS stakeholders and project developers. • Supported capabilities development in support of national transport network planning and cost analyses. • Supported economic and market analysis for commercial-scale onshore and offshore geologic storage of CO_2.	• Supports continued competitive selection of CarbonBASE projects to collect data in the most promising geologic formations for the development of storage resource assessment tools and analyses. • Supports competitive selection of additional CarbonSTORE projects to serve as field laboratories at commercial CO_2 storage sites for transport and storage. • Supports technical assistance initiatives, on- and offshore to regional CCUS and storage-based CDR project developers and stakeholders, including strong community engagement. • Supports capabilities development for national and multi-modal CO_2 transport network planning and cost analyses. • Supports economic and market analysis for commercial-scale onshore and offshore transport and geologic storage of CO_2.	• No funding is requested for CarbonSAFE since this initiative is now covered by funds appropriated under the BIL Section 40305. • Funding allows for continued selection of CarbonBASE and CarbonSTORE projects to expand the portfolio to include other depositional settings. • Funding continues technical assistance initiatives to support key entities and stakeholders, including communities to help ensure that communities see tangible economic, environmental, and jobs benefits from CCS and storage-based CDR deployment.

Advanced Storage: RDD&D: $20,000,000	$20,600,000	+$600,000
• Supported competitive selection of R&D projects on high priority topics including legacy well assessment, above-zone monitoring methods and tools, existing well and pipeline repurposing for CO_2 transport and storage. • Supported R&D on advance tools, sensors and monitoring systems that create data and data streams compatible with Science-informed Machine learning to Accelerate Real-Time machine learning algorithms and capabilities. Topics of interest include advanced fiber optic sensing, wireless power systems, data integration/inversion methods, low-cost continuous monitoring systems. • Supported R&D on the characterization and analysis of mineralization of CO_2 in geologic deposits with reactive materials, such as serpentines. • Continued support for EDX data curation and platform maintenance.	• Supports competitive selection of R&D projects on high priority topics including legacy well characterization, above-zone monitoring methods and tools, basin-scale characterization and monitoring, prefeasibility studies for various CO_2 transport modes, existing well and pipeline repurposing for CO_2 transport and storage. • Supports R&D on advanced tools, sensors and monitoring systems that create data, and processing data streams that enable intelligent monitoring systems and AI-based technologies. Topics of interest include advanced fiber optic sensing, wireless power systems, data integration/inversion methods, low-cost continuous monitoring systems, edge computing. • Support R&D on the characterization and analysis of mineralization of CO_2 in geologic deposits with reactive materials, such as basalts. • Continued support for EDX data curation and platform maintenance.	• The increase reflects the funding level needed to adequately address priority research and technology development that enables safe and efficient CCUS/CDR deployment growth.

Carbon Management Technologies
Carbon Dioxide Removal

Overview

Many climate modeling scenarios project that carbon dioxide (CO_2) removal (CDR) will be required in the future to achieve economy-wide decarbonization. CDR refers to activities that remove CO_2 from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. CDR activities include direct air capture (DAC), direct ocean capture (DOC) or marine CDR (mCDR), biomass with carbon removal and storage (BiCRS), mineralization, and terrestrial carbon removal and sequestration (e.g., agricultural land management, afforestation, reforestation, and CO_2 storage in wetlands).

The Office of Fossil Energy and Carbon Management (FECM) has been working on carbon capture and storage projects for almost 20 years and has invested heavily in the development of technologies to capture relatively higher concentrations of CO_2 from industrial facilities and power plants. More recently, the Department has been applying this technology development to various negative emissions technologies, including BiCRS and DAC, which requires capture of extremely low concentration CO_2 from the atmosphere.

An objective of the Department of Energy's (DOE) work on CDR is to advance technologies that make significant progress towards reaching the Carbon Negative Shot™ target of less than $100/net metric ton CO_2 equivalent by 2030 for both capture and permanent storage. Investments in various CDR approaches can help reduce cost and optimize performance. Through these investments, DOE will help advance promising technologies in partnership with industry, academia, and national laboratories, while ensuring future deployment occurs in a manner that provides demonstrable economic and environmental benefits to communities and workers.

The FY 2025 Budget Request of $90.2 million is focused on scaling CDR technologies pathways of DAC, mCDR, BiCRS, and mineralization, as well as necessary system analysis tools such as monitoring, reporting, verification (MRV), technoeconomic analysis (TEA) and life cycle analysis (LCA). The Request also supports the efforts of the Carbon Negative Shot™.

Activities to develop and commercialize DAC systems largely follow known chemical-based separations processes (e.g., solvents and solid sorbents). Due to the low concentration of CO_2 in the air, the volume of gas flow per ton of CO_2 captured is much larger for direct air capture systems compared to point sources. Subsequently, the power requirements to overcome the pressure drop in packed configurations contributes to high operating costs while the requirement to process more inert gas (e.g., nitrogen in air) with CO_2 in low purity (e.g., 417 parts per million in air based on National Oceanic and Atmospheric Administration estimates) correlates to increased contactor areas and high capital costs.

Concerted research and development (R&D) can reduce costs and the energy penalty, and improve scalability, siting, and operations. Efforts will focus on conducting materials and components R&D, including preliminary work on CDR pilots such as front-end engineering and design (FEED) studies, and pre-FEEDs. Both the pilot-scale testing and the FEED studies can complement the Infrastructure Investment and Jobs Act's Regional Direct Air Capture Hubs program. It should be noted that first-generation technologies will also continue to improve, and R&D conducted for transformational technologies may also improve the processes and components of first-generation technologies. FECM will also continue to analyze the economic circumstances for commercial deployment.

Marine CDR activities will focus on areas of FECM expertise, such as separations processes, ocean alkalinity enhancement and engineered designs. For example, FECM has applied electrochemical separations and conversion systems as part of its point-source capture, DAC, and carbon conversion programs, which can be applied to DOC. In addition, FECM also investigates biological carbon sequestration in deep ocean water through macroalgae and other living marine resources. In FY 2025, FECM will explore such routes, with an explicit focus on robust MRV to achieve high quality and permanent removal.

BiCRS offers an opportunity for near-term deployment of CDR technologies. Biomass can be used to produce various products—power, fuels, chemicals—like other carbon-based feedstocks such as coal, oil, and natural gas. During its growing phase, biomass consumes CO_2 from the atmosphere through photosynthesis and releases this CO_2 when it is subsequently processed and consumed (i.e., power generation, fermentation, etc.). However, if this CO_2 is captured and permanently stored, the CO_2 is ultimately removed from the atmosphere, rather than returned.

Technology improvements in capital and operating costs, reducing the energy penalty, and systems integration are directly applicable in the case of power generation and gasification processes, which are areas where FECM has historical knowledge and capabilities. FECM will also leverage its activities on carbon storage to ensure that BiCRS approaches leverage resources through that sub-program. FECM will continue to collaborate with colleagues in the Department's Office of Energy Efficiency and Renewable Energy's Bioenergy Technologies Office to ensure accurate assessment of the life cycle implications of explored BiCRS routes.

Mineralization is part of the Carbon Transport and Storage subprogram's activities where there has been an extensive R&D program on geologic carbon storage over the past two decades. This work has included studies and field tests on injection of CO_2 into subsurface formations such as basalts. FECM previously conducted various studies and experimental work on surface carbon mineralization. A more recent analysis by the United States (U.S.) Geological Survey[1] (USGS) provides a summary of the potential for ex-situ and in-situ carbon mineralization opportunities in the U.S. The study suggests that the use of mine tailing and alkaline industrial wastes already at the surface can be a competitive option for CO_2 removal.

For all the CDR approaches, LCA are critical to confirm that a given technology is removing more CO_2 from the atmosphere than is generated by the process over its life cycle. While LCA is a common tool and approach in many industries and for many processes, it is currently evolving in the CDR arena. Many technologies are relatively new, and the energy inputs required can significantly impact the LCA. R&D can provide the fundamental scientific and technical basis for LCA tools and methodologies applied to CDR applications. Coupling together R&D, LCAs and TEAs will ensure assessments can be made on the best available information, which will also inform global assessment models and decarbonization scenario analyses.

[1] Blondes, M.S., Merrill, M.D., Anderson, S.T., and DeVera, C.A., 2019, Carbon dioxide mineralization feasibility in the United States: USGS Investigations Report 2018–5079, 29 p., https://doi.org/10.3133/sir20185079

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Carbon Dioxide Removal: $70,000,000	**$90,200,000**	**+$20,200,000**
• Continued development of transformational materials and components, and feasibility studies of current DAC systems. • Continued R&D on mineralization and enhanced weathering applications. • Evaluated BiCRS applications at existing facilities.	• Continue development of transformational materials and components, and feasibility studies of current DAC systems. • Continue R&D on mineralization and enhanced weathering applications. • Evaluate BiCRS applications at existing facilities. • Continue development of DOC and mCDR.	• Additional funding will enable R&D on mCDR pathways including biological systems (nutrient transportation and fertilization and macroalgae cultivation and sinking), ocean alkalinity enhancement pathways, and other engineered mCDR approaches, with a focus on MRV to ensure comprehensive greenhouse gas accounting, social and ecosystem impact assessment, and carbon storage permanence. • Allow for continued and enhanced support of the Carbon Negative Shot™, including pilots for mineralization and BiCRS, mCDR, and CDR testbed facilities.

Overview

The Carbon Dioxide Conversion subprogram develops technologies to convert carbon oxides (carbon monoxide (CO) and carbon dioxide (CO_2)) into economically valuable products manufactured in a commercially viable and environmentally and socially beneficial manner. Research and development (R&D) activities within the subprogram address the challenges and potential opportunities associated with maturing conversion technologies, scaling systems to commercial deployment, and integrating systems with various emission point sources or carbon capture systems. The subprogram plays an important role in meeting the goals of the Department's Clean Fuels and Products Shot, which focuses on decarbonizing the fuel and chemical industry through alternative sources of carbon to advance cost-effective technologies with a minimum of 85 percent lower greenhouse gas (GHG) emissions by 2035.

Each conversion technology comes with challenges and opportunities. A critical challenge across conversion technology pathways (mineralization, catalytic conversion, and bio-mediated) is the cost-effective, energy-efficient, and selective upgrading of CO_2, which is a stable, non-reactive molecule that typically requires heat or electricity and other reactants to be converted into products. The efficiency of reaction conversion, the amount of CO_2 stored in a product and energy use of these utilization processes also represent critical barriers. Other challenges include the energy-intensive preparation of reactants to achieve feasible conversion and required additives that must be regenerated and recycled, which results in an energy penalty for the conversion process. Other hurdles include higher cost for novel processes, conservative risk attitudes in established product markets such as the building sector, and limited field trials and demonstrations to prove viability and diminish risk.

Federal government sponsored R&D in this area can validate the emissions reductions from carbon-based products, support achievement of economic viability, and facilitate the broader ecosystem for technology deployment. This is an area of national research interest since it has long-term economic and environmental benefits for the U.S. and industry. Beyond R&D, realizing these benefits may be further supported by financial incentives to utilize or convert carbon oxides into products, such as the expanded Federal Section 45Q tax credit, the California Low Carbon Fuel Standard, and regional procurement policies for lower-carbon or sustainably produced materials. Further advancements in carbon conversion technology will help ensure that industry has verifiable information to assess economically and accurately the GHG life cycle of carbon-based products. In addition, carbon conversion technologies can use excess low-carbon electricity, industrial waste heat, and components in byproduct streams such as wastewater and flue gas to create valuable products.

There are many opportunities to improve carbon conversion systems performance and to reduce costs. For example, R&D can enhance product yields by improving catalyst selectivity and energy efficiency, integrate carbon-neutral hydrogen production, and advance process engineering and design. This subprogram will work to address the need for enabling technologies that support decarbonized pathways for fuels and products such as using carbon-neutral hydrogen with carbon dioxide in the synthesis of fuels and chemicals in new carbon conversion and utilization technology pathways and maintaining an alkalinity source for mineralization.

The FY 2025 Budget Request provides $60 million for this subprogram and supports lab- and bench-scale carbon conversion technologies that have the potential to develop carbon-based products that promise GHG and environmental benefits over incumbent products. Areas of research include, but are not limited to, new projects focused on the catalytic conversion to higher value products such as fuels, chemicals, and polymers; mineralization to building materials; generation of synthetic aggregates; and biological systems with high CO_2 utilization efficiency of conversion to various bioproducts. Additional efforts will include guidance on benchmarking prototypical catalytical conversion, such as electrochemical reduction, for carbon conversion, developing techno-economic analysis guidance for screening various technology pathways or product markets; and evaluating opportunities for the fuels and chemicals refinery of the future that utilizes carbon oxides.

Carbon Management Technologies
Carbon Dioxide Conversion

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Carbon Dioxide Conversion: $50,000,000	**$60,000,000**	**+$10,000,000**
• Lab- and bench-scale technologies converted CO_2 into valuable products such as chemicals, fuels, bioproducts and building materials. • Increased field-scale testing of technologies to pilot scale. • Standardized benchmarking for catalytic conversion systems.	• Lab- and bench-scale technologies to convert carbon oxides into valuable products such as chemicals, fuels, bioproducts and building materials. • Continued development of at least two carbon conversion integrated systems across technology pathways. • Standardized benchmarking for catalytic conversion systems.	• Increased funding will allow for continued scale up and higher-technology readiness level field testing of promising conversion technologies, such as at the National Carbon Capture Center. • Funding will enable additional support for activities under the Clean Fuels & Products Earthshot™.

Carbon Management Technologies
Point-Source Carbon Capture

Overview

Advancements in carbon capture technologies can support U.S. efforts to decarbonize industry and power generation. Transformational carbon capture technologies will advance U.S. leadership in low-emission generation, clean hydrogen innovation, and decarbonization of a range of industries, thus supporting efforts to achieve a decarbonized electricity sector by 2035 and net-zero emissions economy-wide by 2050. Carbon capture technologies can be applied to a wide variety of industries, such as electric power, ethanol, hydrogen, fertilizer, cement, steel, aluminum, chemicals, refining, pulp and paper, glass, natural gas processing and liquefaction, and others. Research and development (R&D) focus on adapting technologies to under-investigated applications like heavy industry and natural gas power generation to make them robust enough to capture greater than 95 percent of the carbon dioxide (CO_2) emissions from a wide variety of sources. R&D can address materials and systems configuration challenges such as differences in pollution control systems, oxygen content, CO_2 concentrations, and unique integration issues associated with industrial applications.

R&D can improve economies of scale and address the technical challenges posed by increased capture efficiency, such as improved thermodynamics (reduced energetic requirements, lower pressure drops, lower temperature, process optimization) and both diffusion and reaction kinetics. Process intensification and advanced manufacturing can reduce capital and operating costs. Scalability, durability, and flexibility are challenges that must be met to ensure long-term performance and the ability to work with variable power and capture rates.

FECM's Point-Source Carbon Capture subprogram is focused on research, development and demonstration (RD&D) of carbon capture technologies that play a key role in decarbonizing committed emissions associated with hard-to-decarbonize industries and the power sector. The Point-Source Carbon Capture subprogram is developing capture technologies that are flexible to complement the ever-changing power grid, while simultaneously capable of achieving deep decarbonization of emission sources.

The subprogram has completed its efforts in 1st generation technology through successful demonstration projects. FY 2025 activities represent a focus on validating transformational carbon capture technologies for industrial applications and flexible power generation, as well as developing enabling technologies to support the large pilot-scale testing and integrated demonstrations of carbon capture technologies being implemented by DOE's Office of Clean Energy Demonstration. Specifically, the FY 2025 Budget Request provides $96.2 million to capture R&D on transformational gas separation technologies capable of deep decarbonization (at least 95 percent of CO_2 at high purity suitable for compression and transport). The subprogram participates in the Industrial Decarbonization Science and Energy Technology Team and the Hydrogen Energy Earthshot groups and provides funding and analysis to support their goals. These investments can improve energy efficiency, reduce capital costs, achieve high capture rates, enhance co-benefits, and reduce the potential for adverse environmental impacts.

These transformational technologies will be designed to adapt to the operational demands of current and future power systems including the increasing need for thermal power plants to, at times, be load-following/demand-responsive electricity generators. The activity will investigate approaches to optimize the capture process for natural gas-based power systems, including both natural gas combined cycle systems and simple cycle operations. Additionally, the subprogram will leverage its prior and current R&D experience on carbon capture technology development for application to industrial applications. R&D will focus on optimization of technologies for these applications to reduce cost and improve performance.

Key RD&D challenges include:

- Improving Scalability – providing economic viability at all relevant process scales across all types of CO_2 emissions sources in the power and industrial sectors.
- Improving Thermodynamics – reducing energetic requirements through lower regeneration energy, lower pressure drops, lower required temperatures, and process optimization.
- Improving Kinetics – improving equipment through faster, more selective chemical/physical separation pathways.

- Reducing Capital Cost – reducing equipment size and costs through advanced manufacturing, process intensification, integration, and optimization.
- Improving Durability – providing rugged long-term performance with slow degradation rates.
- Improving Flexibility – improving process dynamics by improving turn down and operation at variable capture rates.
- Minimizing Environmental Impact – providing technologies that minimize air pollution release and minimizing waste generation.

The Point-Source Carbon Capture subprogram will prioritize both front-end engineering design (FEED) studies, as well as pilot scale validation for carbon capture systems installed at industrial sources and power plants. FEED studies are a critical step in the process for eventual technology deployment, as they help define the design of the system and provide valuable technical input for eventual investment decisions. FEED studies also help identify potential areas for R&D and information to validate techno-economic studies and lifecycle analyses. FEED studies for industrial sources allow decisions regarding both the aggregation of numerous emission points and the possible integration of the capture system with the industrial facility, and other decarbonization process options (e.g., low carbon fuel switching and feedstock substitutions; indirect heating of kiln or kiln electrification; process or energy efficiency improvement) to achieve facility-wide decarbonization. FEED studies will focus on the carbon capture systems installed on emissions sources co-located with the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) projects, which are funded by the Carbon Transport and Storage subprogram, and/or the EPA permit application sites to prepare projects for integrated testing and development of Carbon Hubs (e.g., multiple point sources connected to one sink). Pilot scale validation of carbon capture technologies integrated with other low carbon decarbonization process options at hard-to-abate industrial facilities will also be a priority of the Point-Source Carbon Capture sub-program.

In FY 2025, Point-Source Carbon Capture subprogram will also support the development of transformational emission control/reduction systems that utilize high-performance computing, artificial intelligence, advanced manufacturing and engineering tools which result in enhanced co-benefits and reduce the potential for adverse environmental impacts from installing carbon capture technologies at industrial facilities and coal- and natural gas-based power generation facilities. Funding will continue to support the National Carbon Capture Center (NCCC) to provide testing of these enabling technologies on actual flue gas. Additionally, funding will be provided to develop cost effective carbon capture technologies for industrial decarbonization based on oxy-combustion, chemical looping, and reactive capture approaches.

The FY 2025 Request also includes separation of CO_2 from synthesis gas streams prior to its combustion for power production, or the separation of CO_2 to produce hydrogen or other products.[1] Specifically, hydrogen from natural gas can be generated from various technological approaches such as steam methane reformers, autothermal reformers, and partial oxidation. Steam methane reformers remain the most economical and widespread way to produce hydrogen and currently account for over 90% of the hydrogen produced globally. New autothermal reformer construction is becoming increasingly more common as the process concentrates CO_2 and allows for deeper decarbonization using pre-combustion technologies at lower cost than steam methane reformers. Partial oxidation is another method for hydrogen production that has potential for commercialization. Following the passage of the Inflation Reduction Act and the enhancements for clean hydrogen production, many projects are anticipated.

The Point-Source Carbon Capture sub-program is also focusing on reducing the costs and emissions of non-CO_2 pollutants associated with the use and combustion of carbon-containing fuels. This effort includes systems analyses and technical assessments to identify and address issues associated with non-CO_2 emissions from power plants and industrial applications (e.g., trace and heavy metal emissions in solid, liquid, and gaseous effluents that are potential areas of concern). This will also include evaluation of possible emissions and waste streams from carbon capture technologies to ensure these systems are environmentally robust.

[1] Syngas is primarily hydrogen (H_2) and carbon monoxide (CO) but can include other gaseous constituents. After the syngas is produced, it is further processed in a Water Gas Shift (WGS) reactor to prepare it for pre-combustion capture. WGS converts CO and water to additional H_2 and CO_2.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Point-Source Carbon Capture $135,000,000	**$96,200,000**	**-$38,800,000**
• Continued support for several transformational bench scale carbon capture tests on actual flue gases from coal and natural gas, focused on capture rates >95% and determination of co-benefits of capture. • Supported transformational R&D and pilot-scale carbon capture projects for industrial sources of CO_2. • NCCC: Funded and operated the NCCC post-combustion carbon capture test facility for transformational technology development. • Supported up to 10 carbon capture FEED studies for industrial and natural gas sources of CO_2. • Conducted transformational carbon capture development that supports hydrogen production and other industrial applications. • Conducted R&D, systems analyses and technical/economic assessments to identify and address non-CO_2 emissions from power plants and industrial sources (e.g., trace metals emissions in solid, liquid, and gaseous effluents that are potential areas of concern) as well as legacy storage facilities such as ash impoundments and landfills.	• Support transformational pilot-scale carbon capture projects for industrial sources of CO_2. • NCCC: Fund and operate the NCCC post-combustion carbon capture test facility for transformational technology development. • Support up to 6 carbon capture FEED studies for industrial and natural gas sources of CO_2, matched up with CarbonSAFE projects, and/or the EPA permit application sites. • Fund reactive capture and conversion, oxy-combustion, and chemical looping projects for industrial decarbonization. • Support evaluation of emissions sources from carbon capture technologies and corresponding mitigation solutions to facilitate successful implementation of carbon capture large pilots and integrated carbon capture and storage (CCS) demos. (e.g., emissions/ measurement, reporting, and verification; engineering control methods/equipment tailored for specific technologies; and capture material reclamation). • Conduct R&D, systems analyses and technical/economic assessments to identify and address non-CO_2 emissions from power plants and industrial sources (e.g., trace metals emissions in solid, liquid, and gaseous effluents that are potential areas of concern).	• The funding request complements the $3.5 billion in IIJA funding for CCUS demonstrations and pilot projects and reflects prioritization on key areas of transformational technologies for higher capture rates, secondary emission engineering controls, pilot-scale tests, and FEED studies for industrial and natural gas-derived sources of CO_2.

Carbon Management Technologies
Carbon Management – Policy, Analysis, and Engagement

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$0	$0	$7,000	+$7,000

Overview
Carbon Management – Policy, Analysis, and Engagement supports high-impact and crosscutting, integrative analysis, and engagement activities through close coordination within the Office of Fossil Energy and Carbon Management (FECM) technology programs, other Department of Energy (DOE) offices, federal agencies, and global partners. The subprogram funds three separate activities: 1) Carbon Management – Policy and Analysis, 2) Carbon Management – Engagement, and 3) Carbon Management – Federal Partnerships. The Request provides $7 million to support activities in this subprogram.

This subprogram provides portfolio-wide analysis for decision-makers and extensive data, tools, and technical assistance to relevant stakeholders as the Nation embarks on an unprecedented build-out of carbon management research, development, demonstration, and deployment (RDD&D) efforts in support of the Administration's goals. Policy, analysis, and engagement efforts will help FECM maximize the impact of its research dollars, track the impacts of FECM investments, and help ensure benefits for all Americans. This subprogram also supports strategic planning by identifying major challenges and opportunities to improve efficiency, cost, and socioenvironmental performance within all the subprograms of the Carbon Management Technologies program.

Carbon Management – Policy and Analysis
The Carbon Management – Policy and Analysis activity evaluates potential economic, employment, and socioenvironmental benefits from the deployment of carbon management technologies. It also creates and disseminates tools and information for external users to better understand the role of carbon management technologies in an ever-evolving energy and industrial economy. The FY 2025 Budget Request of $3.5 million supports the following activities:

- Allows FECM to perform and disseminate economic and environmental benefit assessments for the Office of Carbon Management's RDD&D portfolio using advanced modeling methodologies. Advanced modeling methodologies include the use of modified versions of the Energy Information Administration's (EIA's) National Energy Modeling System (NEMS), big data analytics on key energy and industrial market metrics, and the use of production cost modeling to understand electricity market dynamics.
- Informs Carbon Management's RDD&D strategic planning and decision-making by studying current and potential future market conditions, which might influence future technology marketability. These studies seek to identify potential market-driven opportunities, which might aid in the deployment of carbon management technologies. It also seeks to identify potential market needs, which can be addressed by RDD&D activities.
- Disseminates best practices and approaches for carbon management technologies in economic and market models. Organizations including the Environmental Protection Agency (EPA), EIA, and others depend on FECM systems analysis to characterize and represent future decarbonization opportunities.
- Analyzes crosscutting issues which have the potential to affect the deployment of carbon management technologies including electric power grid integration, infrastructure deployment, and competitiveness implications of changing energy and industrial markets as they seek to reduce their greenhouse gas (GHG) emissions.

Carbon Management - Engagement
The Carbon Management – Engagement activity supports RDD&D of carbon management technologies through engagement with key partners within the U.S. and globally. Funding will support domestic and international engagement efforts in collaboration with other DOE offices. FECM will work with various entities and stakeholders to build a foundation for expeditiously administering several new investments, leveraging existing programs and developing new relationships with stakeholder networks and communities. Scaling up technologies within the carbon management RDD&D program

portfolio is also a global challenge that requires effective international engagement. FECM accomplishes this work through strategic partnerships with other governments, research organizations, bilateral and multilateral stakeholder efforts and through technical support and capacity-building assistance provided to other countries. Additionally, the success of domestic scale-up of carbon management technologies requires effective project-level community engagement. The FY 2025 Request of $3 million supports the following:

- Facilitate and regularly engage in exchanges of information and insights with partners and stakeholders on RDD&D progress and needs, as well as policy tools and public-private partnerships.
- Accelerate the advancement and responsible demonstration and deployment of carbon management projects through partnerships with industry, academia, non-profit organizations, Tribes, and State and local governments.
- Work with international partners committed to carbon management to accelerate technology development and deployment, complementing, and amplifying the impact of domestic RDD&D investments.
- Make targeted engagements with select countries, facilitating development of carbon management ecosystems that are prime major global markets for American technologies and services.
- Work with stakeholders and communities to provide the resources and informational tools needed to effectively understand and engage with the new and augmented federal investments in carbon management projects and their potential benefits and impacts.
- Conduct proactive, place-based community engagement and planning processes that includes carbon management in the context of broader decarbonization options, to empower and benefit communities and workers.
- Develop and disseminate a framework for effective project-level community engagement to ensure that carbon management projects benefit communities. FECM accomplishes this by developing requirements and resources for FECM-funded projects to engage with communities and stakeholders; and establishing and maintaining broad principles for responsible carbon management through the Responsible Carbon Management Initiative (Initiative). The Initiative is intended to encourage and recognize project developers and others in industry to pursue the highest levels of safety, environmental stewardship, accountability, community engagement, and societal benefits in carbon management projects. The Initiative will provide funding to assist project operators in implementing the Responsible Carbon Management Principles, conduct verification, and enhance transparency.

Carbon Management – Federal Partnerships

The Carbon Management – Federal Partnerships activity focuses on policy, regulatory, and interagency engagement needed to successfully execute DOE's carbon management RDD&D programs, including the Office of Carbon Management's interactions with other government agencies on environmental, legislative, and regulatory matters related to carbon management technologies within the RDD&D portfolio. Support will be for interagency engagement and facilitating dialogue on regulatory and permitting issues among industry, states, and other interested parties to advance the Office of Carbon Management's mission. The Request of $0.5 million supports the following activities:

- Leading government-wide efforts to enhance interagency collaboration and coordination on carbon management with a focus on sharing information about DOE's research and development programs and leveraging expertise within the Department to support government-wide efforts associated with carbon management technologies and approaches.
- Conducting outreach and engagement with a range of federal and state regulators and external entities to build awareness and technical capacity to develop and implement new regulations, update existing best practices, issue permits, develop monitoring technologies and protocols, and evaluate any regulatory or policy barriers for DOE projects. This includes managing the Federal Advisory Committees focused on Carbon Dioxide Capture, Utilization, and Storage permitting mandated by the Utilizing Significant Emissions with Innovative Technologies Act, in accordance with the Memorandum of Understanding[1] signed by DOE and the White House Council on Environmental Quality.
- Supporting Congressional, Administration, and DOE priorities associated with deployment of carbon management technologies and approaches, which are policy or regulatory in nature and require significant interagency

[1] Signed by DOE and the White House Council on Environmental Quality on October 31, 2023.

collaboration, such as the Internal Revenue Service tax credit policy development/execution, federal advisory committees, and reports to Congress.

- Serving as a key focal point across the U.S. Government for interagency collaboration on technical, policy, and regulatory issues related to carbon capture, utilization, and storage and carbon dioxide removal.
- Providing a central point of contact for stakeholders to ensure timely resolution of technical concerns and enable efficient, orderly, and responsible development of carbon management technologies at increased scale.
- Working with other agencies to develop and improve accounting frameworks and tools to accurately measure carbon removal and storage methods and technologies[2].

($K)

	FY 2023 Enacted	**FY 2024 Annualized CR**	**FY 2025 Request**	**FY 2025 vs FY 2023**	
				$	**%**
Carbon Management – Policy and Analysis	0	0	3,500	+3,500	N/A
Carbon Management – Engagement	0	0	3,000	+3,000	N/A
Carbon Management – Federal Partnerships	0	0	500	+500	N/A
Total, Carbon Management – Policy, Analysis, and Engagement	0	0	7,000	+7,000	N/A

[2] The Energy Act of 2020 requires the Secretary of Energy to collaborate with the EPA and other relevant Federal agencies “to develop and improve accounting frameworks and tools to accurately measure carbon removal and sequestration methods and technologies.”

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Carbon Management - Policy, Analysis, Engagement: $0	**$7,000,000**	**+$7,000,000**
Carbon Management – Policy and Analysis: $0	**$3,500,000**	**+$3,500,000**
• No funding was enacted in FY 2023.	• Perform economic and environmental benefits assessments for the Office of Carbon Management's RDD&D portfolio using advanced modeling methodologies, study current and potential future market conditions which might change future technology viability, analyze crosscutting issues which have the potential to affect the deployment of Carbon Management technologies, and provide technical and economic support as part of intergovernmental activities.	• Funding will expand the capabilities of the analysis division, allowing work on hydrogen technologies and infrastructure; carbon capture, utilization, and storage; and general systems-based energy and carbon management modeling. This includes integration of advanced enhancements to EIA's NEMS to analyze potential future deep decarbonization scenarios and carbon management technologies contribution to reliability and resilience. • Funding will also enable integrated analysis of market driven opportunities in the industrial and power sector for carbon management technologies. This will enable further inventory and systems analyses to highlight lower cost opportunities for achieving carbon reductions.
Carbon Management – Engagement: $0	**$3,000,000**	**+$3,000,000**
• No funding was enacted in FY 2023.	• Support domestic and international engagement activities and agreements, including key global partnerships to advance DOE's RDD&D programs.	• Funding will support expanded domestic engagement, including support of the Initiative, as well as new international agreements supporting decarbonization priorities.
Carbon Management – Federal Partnerships: $0	**$500,000**	**+$500,000**
• No funding was enacted in FY 2023.	• Conduct policy, regulatory, and interagency engagement needed to successfully execute DOE's carbon management RDD&D programs, including working with federal partners on permitting.	• Funding will support interagency engagement and facilitating dialogue on regulatory and permitting issues among industry, states, and other interested parties to advance the program's mission.

Resource Sustainability

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$195,000	$195,000	$195,400	+$400

Overview
The Resource Sustainability Program addresses the critical environmental and safety issues associated with the historical and continued United States (U.S.) production and use of fossil fuels. Specifically, the Program's mission is to conduct research, development, demonstration, and deployment that reduces environmental impacts from the development, extraction, transportation, distribution, and storage of fossil fuels. The program comprises five subprograms: Advanced Remediation Technologies, Methane Mitigation Technologies, Natural Gas Decarbonization and Hydrogen Technologies, Minerals Sustainability, and Resource Sustainability – Analysis and Engagement.

The Resource Sustainability Program will pursue the following major activities in FY 2025:

Advanced Remediation Technologies
The Advanced Remediation Technologies program focuses on developing solutions that address the environmental and community impacts of oil and natural gas exploration and production. The Environmentally Prudent Stewardship subprogram will conduct research, development, and demonstration (RD&D) to address wellbore integrity, induced seismicity, produced water treatment, water management for coal related wastes, and offshore safety and spill prevention. In addition, the Program will continue research using Field Laboratories to explore the potential to combine carbon dioxide enhanced oil recovery (CO_2-EOR) in unconventional reservoirs with permanent storage of captured CO_2 emissions. This combination can provide an important pathway to accelerate carbon storage and help reduce the overall carbon footprint of the oil produced today during the transition to a net-zero energy and industrial economy.

Methane Mitigation Technologies
The Methane Mitigation Technologies program will conduct RD&D to advance methane sensor technologies to detect and quantify methane emissions from production fields, pipelines, infrastructure equipment, storage facilities, and abandoned wells; pipeline materials, sensors, and data management and computational tools; and advanced modular natural gas conversion technologies for the purpose of beneficially utilizing otherwise flared or stranded natural gas. The program will collect, analyze, and distribute methane emissions data, information, and knowledge to inform efforts on methane mitigation technology development and support the Environmental Protection Agency's Greenhouse Gas Inventory; expand field research on methane measurement technologies and analysis methods for quantifying emissions at basin-level assessments; and implement a strategy to reconcile methane emissions estimates from surface-based measurements (bottom-up) and atmospheric measurements (top-down) that will minimize and resolve the difference between these two segments on a large-scale.

Natural Gas Decarbonization and Hydrogen Technologies
The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) Program supports the development of hydrogen technologies that help contribute to a net-zero emissions economy. The fastest and lowest cost near and medium-term path to advance a hydrogen economy is to build on readily available natural gas and existing natural gas infrastructure, which can facilitate the development and buildout of electrolytic hydrogen and other types of clean hydrogen. The NGDHT program will support RD&D to advance clean hydrogen production and infrastructure for natural gas decarbonization; hydrogen production from produced water; technologies for enabling safe and efficient transportation within the U.S. natural gas pipeline system; and research to enable subsurface hydrogen storage. Programmatic activities will be conducted in support of, and in coordination with, the Hydrogen and Carbon Management Division within the Office of Fossil Energy and Carbon Management and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy.

Minerals Sustainability

The Minerals Sustainability Program will advance technologies to support development of the domestic supply chain networks required for the economically and environmentally sustainable, and geopolitically secure production and processing of critical minerals and materials (CMM). This mission will be accomplished by prioritizing the use of unconventional resources such as coal, coal production and combustion wastes, and other waste streams such as acid mine drainage, mine tailings, and produced water from oil and gas production for domestic CMM, rare earth elements and carbon ore to products production. The program will also focus on utilizing materials to be recycled from currently mined and previously mined resources outside of traditional thermal and metallurgical markets that can support high-wage employment and value-added production in communities and regions dependent on traditional mining. This effort will seek to significantly reduce the environmental, human health, and community impacts of mining through the development of technologies that can enable more "laparoscopic" approaches to mining, which will enable at least a tenfold reduction in the amount of waste material produced on the surface at a mine site.

Resource Sustainability - Analysis and Engagement

Analysis and Engagement will focus on analysis and studies that support environmentally prudent production, transport, storage, and use of domestic fossil fuels with an understanding of their role as a strategic asset for the U.S. and its allies for global energy security, as well as provide evidence-based, portfolio-wide analysis for decision-makers. This includes economic and environmental analysis, modeling, analysis of markets and market volatility; studies that support the overall Resource Sustainability Program; and data driven assessments of the impacts of different tools and levers that can be used to provide reliable and affordable fossil energy supplies to the domestic market. The program will inform research priorities and engagement with domestic and international governments and organizations and provide market and industry analysis to inform the Department on fossil energy resources.

Resource Sustainability

	($K)				
	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
RESOURCE SUSTAINABILITY					
Advanced Remediation Technologies					
Environmentally Prudent Stewardship	25,000	25,000	15,000	-10,000	-40.00%
Gas Hydrates	20,000	20,000	0	-20,000	-100.00%
Water Management Technologies	10,000	10,000	0	-10,000	-100.00%
Subtotal Advanced Remediation Technologies	**55,000**	**55,000**	**15,000**	**-40,000**	**-72.73%**
Methane Mitigation Technologies	**60,000**	**60,000**	**75,800**	**15,800**	**26.33%**
Natural Gas Decarbonization and Hydrogen Technologies	**26,000**	**26,000**	**24,400**	**-1,600**	**-6.15%**
Minerals Sustainability					
Critical Minerals	44,000	44,000	21,000	-23,000	-52.27%
Carbon Ore Processing	10,000	10,000	4,200	-5,800	-58.00%
Resource Characterization Technologies	0	0	30,000	30,000	N/A
Advanced Critical Material Recovery Technologies	0	0	23,000	23,000	N/A
Subtotal Minerals Sustainability	**54,000**	**54,000**	**78,200**	**24,200**	**44.81%**
Resource Sustainability – Analysis and Engagement	**0**	**0**	**2,000**	**2,000**	**N/A**
TOTAL, RESOURCE SUSTAINABILITY	**195,000**	**195,000**	**195,400**	**+400**	**+0.21%**

SBIR/STTR:

- FY 2023 Enacted: SBIR $5,189: STTR: $911
- FY 2024 Annualized CR: SBIR $5,189: STTR: $911
- FY 2025 Request: SBIR $5,587: STTR: $786

Resource Sustainability
Explanation of Major Changes ($K)

	FY 2025 Request vs FY 2023 Enacted
Resource Sustainability	
Advanced Remediation Technologies: Funding decrease reflects the completion of gas hydrates field work in the Gulf of Mexico and the completion of the Alaska production test. No funding is requested for the treatment of effluent waters from coal wastes. The program will focus on research to develop solutions that address the environmental impacts of oil and natural gas development in FY 2025.	**-40,000**
Methane Mitigation Technologies: Funding increase reflects a focus on the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, and maintainable integrated methane monitoring platform that will enable early detection and, ultimately, quantification of emissions along the natural gas supply chain. This integrated methane monitoring platform will incorporate surface level sensors, autonomous, low-cost optical methane sensors and imagers on unmanned aerial systems, integration of methane emissions data acquired from geospatial satellites, and new multidimensional data modeling and predictive capabilities using machine learning tools. In addition, the funding increase will enable the scale-up and field validation of advanced pipeline materials, methane sensor technologies, compressor and engine leak mitigation components, and computational technologies for emissions reduction in oil and gas infrastructure; conversion technologies for stranded and vented gas; and advanced remote detection technologies.	**+15,800**
Natural Gas Decarbonization and Hydrogen Technologies: Funding decrease reflects a lower level of effort in extramural research on hydrogen storage for FY 2025 and strategic focus on conversion, blending, and transportation research activities.	**-1,600**
Minerals Sustainability: Funding increase will support new priority research on developing sustainable and responsible approaches to mining for CMM.	**+24,200**
Resource Sustainability - Analysis and Engagement: Funding increase will support the technical, economic, and socio-economic studies to support the Department and other agencies regarding methane emissions, critical minerals, hydrogen storage, and other crosscutting efforts. Funding will provide economic, market, and industry analysis on oil, gas, coal, and petrochemical resources. It will also support the international and domestic engagements with governments, states, industry, and other entities to reduce methane emissions related to fossil fuel use, and to pursue the development of critical materials from domestic fossil resources.	**+2,000**
Total, Resource Sustainability	**+400**

Resource Sustainability
Advanced Remediation Technologies

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$55,000	$55,000	$15,000	-$40,000

Overview
Fossil fuels have contributed to America's economy and have provided fuel for vehicles, heat for homes, industrial goods, plastics, and other important products. These many benefits from oil, natural gas, and coal also come with impacts to the climate, the environment, and communities. The Advanced Remediation Technologies Program conducts research, development, and demonstration (RD&D) that reduces the climate, environmental, and community impact from the development, transportation, distribution, and storage of fossil energy resources.

The Environmentally Prudent Stewardship subprogram focuses on developing solutions that address these impacts. Hydraulic fracturing requires the use of large amounts of water and chemicals, which need to be cleaned and safely disposed of without potentially contributing to induced seismic events. Offshore oil development carries the risk of oil spills and contamination to important ecosystems. Many communities that rely on oil, natural gas, and coal development for jobs and economic activity are also the same communities that could benefit from improved air and water quality, reduced risk for oil spills, and less seismicity.

In the FY 2025 Budget Request, the Environmentally Prudent Stewardship subprogram will conduct RD&D to address wellbore integrity, induced seismicity, produced water treatment, water management for coal-related wastes, and offshore safety and spill prevention. In addition, the Program will continue research using Field Laboratories to explore the potential to combine carbon dioxide enhanced oil recovery (CO_2-EOR) in unconventional reservoirs with permanent storage of captured CO_2 emissions. This combination can provide an important pathway to accelerate carbon storage and help reduce the overall carbon footprint of the oil produced today during the transition to a net-zero energy and industrial economy.

Note: No funding is requested for the Water Remediation or the Gas Hydrates subprograms in FY 2025.

Resource Sustainability
Advanced Remediations Technologies

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
Advanced Remediations Technologies					
Environmentally Prudent Stewardship	25,000	13,000	15,000	-10,000	-40%
Gas Hydrates	20,000	0	0	-20,000	-100%
Water Remediation Technologies	10,000	0	0	-10,000	-100%
Total, Advanced Remediations Technologies	**55,000**	**13,000**	**15,000**	**-40,000**	**-72.73%**

Explanation of Major Changes
($K)

	FY 2025 Request vs FY 2023 Enacted
Environmentally Prudent Stewardship: The funding level acknowledges the successes of this program and allows continued research to develop solutions that address the environmental impacts of oil and natural gas development at the appropriate level.	**-$10,000**
Gas Hydrates: No funding requested in FY 2025 due to the completion in FY 2024 of field work in the Gulf of Mexico and the Alaska production test.	**-$20,000**
Water Management Technologies: No funding requested in FY 2025, but research related to water management is requested within the Environmentally Prudent Stewardship subprogram focused on produced water from unconventional oil and gas production.	**-$10,000**
Total, Advanced Remediation Technologies	**-$40,000**

Environmentally Prudent Stewardship

The Environmentally Prudent Stewardship subprogram will focus on addressing the environmental impacts from oil and natural gas development, including unconventional development and offshore safety and spill prevention. The program will build on previous research conducted and data collected from the Department of Energy's (DOE) 17 Field Laboratory projects, which resulted in a substantial body of knowledge about the geochemistry, geomechanics, and geophysics of oil and gas reservoirs from this program.

Research under the Field Laboratory program will focus on understanding the potential to combine CO_2-EOR in unconventional reservoirs with permanent storage of captured CO_2 emissions. This combination can provide an important pathway to accelerate carbon storage and help reduce the overall carbon footprint of the oil produced today during the transition to a net-zero emissions energy and industrial economy.

DOE's offshore safety and spill prevention research will focus on identifying and mitigating risks from ocean currents and seafloor hazards, such as landslides; reducing risks associated with infrastructure used to deliver chemicals to the well and to bring produced fluids to the platform; and assessing, predicting, and mitigating the risks associated with an aging offshore infrastructure. DOE is working with the Department of the Interior, under a Memorandum of Collaboration, to pursue collaborative offshore research to increase safety and reduce environmental risk.

Gas Hydrates

There is no funding requested for the Gas Hydrates subprogram in FY 2025 due to the completion of field work in FY 2024 in the Gulf of Mexico and the Alaska production test.

Water Remediation Technologies

There is no funding requested for the Water Remediation Technologies subprogram in FY 2025. Research related to water management is requested within the Environmentally Prudent Stewardship subprogram focused on produced water from unconventional oil and gas production.

Resource Sustainability
Advanced Remediation Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Advanced Remediation Technologies $55,000,000	**$15,000,000**	**-$40,000,000**
Environmentally Prudent Stewardship $25,000,000	**$15,000,000**	**-$10,000,000**
• Research on reducing the environmental footprint of unconventional oil and gas development. • Funding Opportunity Announcement (FOA) on climate and environmentally focused field test sites program. • FOA on produced water treatment research.	• Funding will support research that addresses the environmental impacts of fossil fuel development. These topics include wellbore integrity, produced water remediation, and oil spill prevention. In addition, the Program will continue research using Field Laboratories to explore the potential to combine CO_2-EOR in unconventional reservoirs with permanent storage of captured CO_2 emissions.	• This request represents a continuation of research that addresses the environmental impacts of fossil fuel development at an appropriate level of effort. These topics include wellbore integrity, produced water remediation, and oil spill prevention.
Gas Hydrates $20,000,000	**$0**	**-$20,000,000**
• No funding was requested within the Advanced Remediation Technologies Budget Request in FY 2023.	• No funding is requested.	• No funding is requested due to the completion of field work in FY 2024 in the Gulf of Mexico and the Alaska production test.
Water Management Technologies $10,000,000	**$0**	**-$10,000,000**
• No funding was requested for Water Management Technologies in FY 2023.	• No funding is requested.	• No funding is requested. • Funding related to water management research is requested within the Environmentally Prudent Stewardship subprogram focused on produced water from unconventional oil and gas production.

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
60,000	60,000	75,800	+$15,800

Overview

The Methane Mitigation Technologies Program addresses methane emissions associated with the production, processing, transportation, and storage of domestic oil and natural gas. Methane is the second largest source of anthropogenic greenhouse gas (GHG) emissions and is more potent than carbon dioxide. The Program's mission is to conduct research, development, and demonstration (RD&D) of technologies and solutions that detect, quantify, reduce, and mitigate methane emissions throughout the oil and natural gas value-chain.

The program supports RD&D focused on advanced materials, innovative sensors, natural gas compressors and engines, infrastructure components, and analytical technologies that enable the detection and mitigation of leaks, and improve the reliability of natural gas transmission, distribution, and storage facilities. The program will address natural gas flaring and venting through the development of modular technologies that can be deployed to the field and capture and convert natural gas into high-value, readily transportable products. The program develops and demonstrates technologies for detecting and quantifying methane emissions from oil and natural gas production areas, processing facilities, transportation networks, storage systems, and existing infrastructure (e.g., abandoned wells). Efforts will also be focused on accelerating the application of real-time emissions monitoring capabilities across broad areas (basin-wide) and on resolving current differences between surface-based (“bottom-up”) and remote sensing (“top-down”) emissions detection and measurement approaches through the development of integrated monitoring platforms.

The Methane Mitigation Technologies Program will pursue the following major activities in FY 2025:

- Developing technologies in advanced pipeline materials, pipeline sensors and systems, pipeline data management and computational tools, in-pipe inspection and repair technologies, and compressor and engine methane slip mitigation technologies.
- Developing advanced modular natural gas conversion technologies, capable of being deployed near wellheads, natural gas processing facilities, and transportation infrastructure, for the purpose of beneficially utilizing otherwise flared or stranded natural gas.
- Developing advanced methane sensor technologies to detect and quantify methane emissions from production fields, pipelines, infrastructure equipment, storage facilities, and abandoned wells.
- Developing and validating methane emissions detection and measuring technologies to accelerate adoption of the most accurate and cost-effective methods, including superior and even transformational technologies that have yet to gain a significant market share.
- Collecting, analyzing, and distributing methane emissions data, information, and knowledge to inform methane mitigation technology development and the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory.
- Expanding field research on methane measurement technologies and analysis methods for quantifying methane emissions and expanding to basin-level assessments. The program will implement a strategy to achieve a convergence of methane emissions estimates from the surface-based natural gas and oil emission estimates (bottom-up) and the atmospheric emission measurements (top-down)—to minimize and transparently resolve the difference between these two segments on a large-scale.

Resource Sustainability
Methane Mitigation Technologies

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
Methane Mitigation Technologies	60,000	60,000	75,800	+$15,800	+26.33%
Total, Methane Mitigation Technologies	**60,000**	**60,000**	**75,800**	**+$15,800**	**+26.33%**

Explanation of Major Changes
($K)

	FY 2025 Request vs FY 2023 Enacted
Methane Mitigation Technologies:	
Funding increase reflects a focus on the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, and maintainable integrated methane monitoring platform that will enable early detection and, ultimately, quantification of emissions along the natural gas supply chain. This integrated methane monitoring platform will incorporate surface level sensors, autonomous, low-cost optical methane sensors and imagers on unmanned aerial systems, integration of methane emissions data acquired from geospatial satellites, and new multidimensional data modeling and predictive capabilities using machine learning (ML) tools. In addition, the funding increase will enable the scale-up and field validation of advanced pipeline materials, methane sensor technologies, compressor and engine leak mitigation components, and computational technologies for emissions reduction in oil and gas infrastructure; conversion technologies for stranded and vented gas; and advanced remote detection technologies.	**+$15,800**
Total, Methane Mitigation Technologies	**+$15,800**

Description

The Methane Mitigation Technologies program is committed to developing advanced, cost-effective technologies to reduce emissions from fossil energy infrastructure. Priority areas for the program include research on technologies to detect, measure, and mitigate emissions. This includes remote sensors, advanced materials for pipeline integrity, data management and systems, tools that employ artificial intelligence (AI), and more efficient and flexible compressors to adapt to varying pipeline conditions and additional fluids.

The program will accelerate advances in remote sensor technologies that can detect and locate emissions from pipelines, natural gas storage, and existing legacy infrastructure. The program will conduct research on materials and remediation technologies that can be deployed by states, industry, or other government agencies to aid in the remediation of emitters.

The program will advance technologies for the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, and maintainable integrated methane monitoring platform. This integrated methane monitoring platform will incorporate surface level sensors, autonomous, low-cost optical methane sensors and imagers on unmanned aerial systems, integration of methane emissions data acquired from geospatial satellites, and new multidimensional data modeling and predictive capabilities using Artificial Intelligence/Machine Learning (AI/ML) tools.

The program will accelerate advances in materials science that can enhance pipeline integrity, reduce leaks, and improve the efficiency of infrastructure operations. Research will support the development of low cost, low maintenance sensor technologies that can provide predictive analytics on pipeline corrosion rates via detection and monitoring of temperature, pressure, chemical composition of materials, vibration, and strain.

The program will develop advanced modular technologies capable of being deployed near wellheads and natural gas processing and transportation infrastructure for the purpose of beneficially utilizing otherwise flared, vented, or stranded natural gas. The program envisions an RD&D effort focused on developing and field testing new and disruptive technologies aimed at converting the otherwise wasted resource, consisting primarily of methane and ethane into electricity or value-added, easily transportable products.

The program will focus on developing advanced technologies to detect, locate, and measure emissions. This will include the development and validation of measurement and sensor technologies for the collection, dissemination, and analysis of emissions data, and will provide support to EPA's Greenhouse Gas Inventory. These activities will also inform future research efforts and priorities; improve analytics and modeling; and inform mitigation and remediation efforts for oil and natural gas production and processing sites, natural gas pipelines, storage facilities, and legacy infrastructure.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Methane Mitigation Technologies $60,000,000	**$75,800,000**	**+$15,800,000**
• Research on materials, coatings, and sensors to improve the reliability, safety, and reduce emissions from natural gas supply and delivery infrastructure. • New and innovative technologies aimed at converting flared and vented methane into value-added products. • Advanced methane detection and measurement technology validation. • Conducted basin-level methane emissions measurements.	• Funding for advanced remote detection technologies for natural gas infrastructure. • Funding to develop technologies in advanced materials, data management tools, in-pipe inspection and repair technologies, and dynamic compressor R&D. • Funding to develop advanced modular conversion technologies for stranded and flared natural gas. • Funding for the development of modular remediation materials and solutions. • Funding to support the development of integrated direct and remote measurement sensor technologies for the collection, dissemination, and analysis of emissions data. • Research, data collection, and analytics that support EPA's Greenhouse Gas Inventory.	• Funding increase reflects a focus on the need to support the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, and maintainable integrated methane monitoring platform that will enable early detection and, ultimately, quantification of emissions along the natural gas supply chain. • Scale-up and field validation of advanced pipeline materials, methane sensor technologies, compressor and engine leak mitigation components, and computational technologies (AI/ML) to enhance pipeline integrity. • Scale-up and pilot-scale field testing of technologies to eliminate natural gas flaring and venting.

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Guidance Level	FY 2025 vs FY 2023
$26,000	$26,000	$24,400	-$1,600

Overview

The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) program will focus on technologies for low-carbon (1) production of clean hydrogen; (2) transportation of hydrogen and fluid hydrogen carriers; and (3) geologic storage that leverages existing natural gas resources and infrastructure. Technology development and maturation will focus on decarbonizing natural gas production infrastructure; ensuring safe and effective hydrogen blending within existing natural gas pipeline transportation; and characterizing, demonstrating, and supporting the deployment of bulk subsurface storage infrastructure. The program will also develop analytical tools and models that are able to evaluate potential advanced technologies, technology performance metrics, technoeconomic and lifecycle analyses, and resource evaluations.

The FY 2025 Budget Request for the NGDHT Program will focus on extramural research and development (R&D) related to (1) clean hydrogen production and infrastructure for natural gas decarbonization; (2) hydrogen production from produced water; (3) technologies for enabling the safe and efficient transportation of clean hydrogen within the U.S. natural gas pipeline system; and (4) research to enable high-volume subsurface hydrogen storage. Programmatic activities will be conducted in support of and coordination with the Hydrogen and Carbon Management Division within Office of Fossil Energy and Carbon Management (FECM) and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE).

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
Natural Gas Decarbonization and Hydrogen Technologies	26,000	26,000	24,400	-1,600	-6.15%
Total, Natural Gas Decarbonization and Hydrogen Technologies	**26,000**	**26,000**	**24,400**	**-1,600**	**-6.15%**

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Description

The NGDHT program was formally initiated in the FY 2022 Omnibus. The program coordinates with other DOE offices to support the transition towards a clean hydrogen-enabled economy through the decarbonization of natural gas conversion, transportation, and storage. The NGDHT program addresses specific methane utilization challenges including: 1) hydrogen production research that focuses on technology maturation for next-generation production pathways to convert natural gas into hydrogen or application-specific co-products; 2) enabling more effective pipeline transport of hydrogen and natural gas blends by advancing the viability of related materials and technologies that emphasize sensors and sensing capabilities that can detect low concentrations of hydrogen and quantify emissions during transport within natural gas infrastructure; and 3) progress toward the development and demonstration of subsurface storage technologies to reliably inject and withdraw hydrogen and natural gas blends within characterized geologic systems, including depleted oil and natural gas reservoirs, salt caverns, hard rock caverns, and saline aquifers. The NGDHT program can leverage DOE assets and expertise to engage industry to accelerate technology demonstration and deployment opportunities across a decarbonized natural gas value chain in support of Administration goals.

The NGDHT will support the development of hydrogen technologies that help contribute to a carbon-pollution-free economy. The NGDHT program's mission is supported by analytical tools and models, which can provide better insight on utilizing natural gas to enable a more decarbonized hydrogen economy. The fastest and lowest-cost near- and medium-term path to advance a hydrogen economy is to build on low-cost, readily available natural gas and existing natural gas infrastructure. The NGDHT program will focus on advancing technologies to adapt existing natural gas infrastructure for the transportation and storage of hydrogen, and to convert natural gas into hydrogen.

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Natural Gas Decarbonization and Hydrogen Technologies $26,000,000	**$24,400,000**	**-$1,600,000**
• Researched production of low-carbon hydrogen from methane, including novel conversion technologies. • Developed blending and separation technologies for natural gas with hydrogen and materials and components for dual use of infrastructure. • Researched utilization of natural gas storage for hydrogen.	• Research on production of hydrogen from methane and produced water. • Develop sensing and sensor technologies to ensure safe and effective transport while mitigating leaks and emissions. • Research on utilizing natural gas storage for hydrogen and pilot-scale technology demonstration.	• Decrease reflects a lower level of effort for extramural research on underground hydrogen storage and a strategic focus on conversion, blending and transportation research activities.

Resource Sustainability
Minerals Sustainability

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$54,000	$54,000	$78,200	+$24,200

Overview
Building the United States (U.S.) clean energy and industrial economy to meet energy security and climate goals will require ever larger quantities of minerals and metals than are currently being consumed. Unfortunately, the U.S. import dependency on many of the minerals and metals needed for these technologies has continued to increase dramatically over the past 30 years, primarily because of the environmental and societal impacts of mining, processing, and refining technology and associated challenges in permitting and securing local support for projects.

The Office of Fossil Energy and Carbon Management's (FECM) Minerals Sustainability program, along with complementary investments in the Office of Energy Efficiency and Renewable Energy (EERE) and the Office of Manufacturing and Energy Supply Chains (MESC), is reversing this trend and providing the U.S. a path to reestablish itself as a leader in developing extraction and processing technologies to support a domestic supply chain for clean energy and national defense within the next decade, especially through the Critical Minerals and Materials (CMM), Science and Energy Technology Team (SETT) and the Critical Materials Collaborative (CMC).

Developing more sustainable domestic CMM resources for meeting current and future demand has become a national priority. New mining projects often take more than a decade to get permitted and begin operations, so it is critical to diversify supply by enabling sustainable mining operations, and by bringing unconventional and secondary sources to market. Development of sustainable and resilient CMM supply chains using secondary and unconventional feedstocks has the potential to address environmental concerns traditionally associated with mining, to revitalize domestic manufacturing capabilities, and to create new and good paying jobs. Production of CMM from coal, coal wastes, and other mining and oil and gas waste streams has the potential to create a mineral processing workforce in energy and mining communities by building co-production of CMM and carbon products. Moreover, unconventional co-production provides the U.S. with the added advantage of removing environmentally adverse materials that have the potential to disproportionately harm residents of those communities as we transition to a clean energy and industrial economy. Finally, unconventional and secondary resources provide an alternative source of CMM to support more sustainable domestic resources. In some cases, they can replace newly mined minerals, ideally on a faster timeline, because they have already been removed from the ground and the processing of them may be simpler to permit.

The Minerals Sustainability program will support resilient domestic supply chains required for the economically, environmentally sustainable, and geopolitically secure production of CMM. This mission will be accomplished by prioritizing the use of unconventional and secondary resources such as coal, coal waste and by-products from industry feedstocks for domestic CMM, rare earth elements (REE) and carbon ore to products production. This includes coal refuse; overburden; underburden, and interstitial clay/shale/sandstone materials; ash; and aqueous effluents such as acid mine drainage (AMD), and associated solids and precipitates resulting from AMD treatment. In addition, critical mineral extraction associated with produced water from the fossil fuel industry; industrial by-products associated with steel, cement, and refining industries; phosphate sludge, bauxite residuals, and other waste materials; and by-products from hard rock mining and mine tailings are also being considered.

In FY 2025, the program will focus on the following:

- Further advance facilities to produce large quantities of high purity, commercial grade REE and other CMM, through front-end engineering and design (FEED) studies and large-scale pilots, which is the next stage of development to broadly enable extraction of REE and other CMM from unconventional feedstocks (such as coal refuse and AMD) towards a commercial industry and taking advantage of existing pilot facilities, where applicable.

- Support the maturation of transformational separation and extraction technologies, potentially through laboratory and/or bench-scale innovative process concept development, as well as modeling and validation of models for optimization and efficiency improvements that would improve process economics.
- Develop technologies for creating new products such as synthetic graphite that are useful for the energy transition or have better lifetime performance characteristics than current materials, as well as provide economic value in the co-production of other CMM.
- Support techno-economic characterization, life cycle analyses (LCA), and health and safety studies to assess the environmental impacts for coal and coal waste-derived carbon products.
- Support Phase II of the regional basin projects (the Carbon Ore Rare Earth-Critical Mineral (CORE-CM) Initiative), covering larger portions of the country by regions, including the development of assessment methodology and technology for many unconventional and secondary feedstocks, including machine learning (ML), and optimization modeling for characterization of CMM/REE.
- Work with the U.S. Geological Survey (USGS) to improve exploration and characterization technologies to reduce time, cost, and environmental impact, thereby enabling more rapid new upstream CMM projects from secondary and unconventional feedstocks to proceed.
- Initiate research, development, and demonstration (RD&D) programs centered on developing next-generation mining and extraction technologies, using surgical precision to target and recover critical minerals from the subsurface. Such technologies would include advanced drilling technologies, novel geophysics, digital subsurface applications (autonomous operations, robotics, real-time extraction), in-situ mineral extraction, tailings management, marine mineral production, and novel processing.
- Begin development of a capability for mineral traceability throughout the supply chain, enabling transparency and validation of claims made by sources, processors, and manufacturers.

Critical Minerals Processing

The development of a domestic, economically competitive supply chain for CMM is needed to help fuel the nation's economic growth; transition to clean energy and industrial technologies; secure U.S. energy independence by reducing reliance on foreign CMM and REE sources; and increase national security. The Critical Minerals Processing subprogram focuses on the sustainable extraction and recovery of all CMM, especially REE, throughout midstream and downstream processes by prioritizing the use of unconventional resources as beneficial primary feedstocks for domestic production that build on longstanding FECM program areas and expertise.

The Critical Minerals Processing subprogram activities will continue to develop advanced technologies throughout the supply chain, improve the economics of future projects through the evaluation of co-production of other valuable products (both critical and noncritical), and enable large-scale processing, separation, and metallization pilot-projects.

Since 2014, research and development (R&D) has provided successful results for Pilot-Scale REE-CMM Separation facilities at the University of North Dakota, University of Kentucky, West Virginia University, Physical Sciences Inc. in Massachusetts and Winner Water Services in Pennsylvania. These facilities have demonstrated the technical feasibility of extracting and producing CMM and REE from carbon ore and related waste materials in small quantities. These were first-of-a-kind projects to demonstrate the capability to extract CMM/REE from coal, coal refuse, coal ash, and AMD. These small-scale projects were the foundation for the development of future the large-scale demonstration projects. Pre-FEED studies have been completed and will be a pre-cursor to new FEED studies for the development of demonstration-scale facilities that will produce 1-3 tonnes/day mixed REE and other CMM, and one such demonstration facility will be funded through the Infrastructure Investment and Jobs Act (IIJA).

The primary R&D focus areas will be conducted for Sustainable Resource Extraction and Separation Technology Development. Novel technology development and validation for conventional and unconventional extraction to enable the recovery of CMM/REE from sources that are not currently being recovered or that could be recoverable with more sustainable practices. This includes the extraction of CMM from unconventional feedstocks such as abandoned mining or other industrial process residuals while maximizing environmental controls (coordinated with IIJA funding and EERE).

Carbon Ore Processing

The Carbon Ore Processing activity is focused on utilizing materials from currently and previously mined coal resources beyond the traditional thermal and metallurgical markets that can support high-wage employment and value-added production in communities and regions dependent on traditional mining and coal-fired power generation. This activity is focused on developing transformational technologies to enable domestic manufacturing of strategic materials and superior building products from carbon ore at competitive market prices, while ensuring worker safety and environmental responsibility. The goal is for these transformational technologies to have strong safety requirements, superior product performance, and better lifecycle emissions levels for new and existing products in the market.

R&D in the Carbon Ore Processing activity will further efforts for the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated from coal and coal waste and refuse; and identify the potential markets for carbon products if production costs are reduced to make it more competitive with the current state of the art. Transformational technology development and validation will be conducted to enable future commercial industries in these areas:

- High-value carbon products, especially those needed for the clean energy and industrial economy, such as synthetic graphite, battery anodes, and supercapacitor materials from carbon ore, as well as graphene, quantum dots, activated carbon, and conductive inks;
- Universal infrastructure components (e.g., components for mass transit, sewers and tunnels, roads and bridges); and
- Continuous industrial processes to reduce capital and operating costs for future carbon products.

The FY 2025 Budget Request for Carbon Ore Processing combines basic chemistry and combustion/pyrolysis science along with basic and fundamental research on physical properties, materials interactions, and heat transfer to improve how carbon ore from coal and coal waste is processed and utilized to expand market opportunities. This work is coordinated with other Department of Energy (DOE) Offices and DOE's CMM SETT. The funding will be used to:

- Develop new technologies for creating new products such as synthetic graphite that are useful for the energy transition and have better lifetime performance characteristics than current materials, as well as provide economic value in the co-production of other CMM.
- Support techno-economic characterization, LCA, and health and safety studies to assess the environmental impacts for coal and coal waste-derived carbon products.

Resource Characterization Technologies

The Resource Characterization Technologies Subprogram focuses on the sustainable recovery of all CMM, including REE and carbon ore, by prioritizing the use of unconventional and secondary resources as environmentally sustainable feedstocks for domestic production.

The Resource Characterization Subprogram leverages the success of former R&D, including the technologies and the capability to assess and characterize unconventional and secondary feedstocks, but also demonstrates the technical feasibility of recovering CMM from a diversity of coal-based feedstocks in small quantities. Building on this success, this activity will continue to enable future commercial technologies while minimizing land disturbance and maximizing environmental stewardship. This will be accomplished through technology development and validation—including ML and artificial intelligence, and existing basin partnerships developed through the CORE-CM Initiative, including public-private partnerships. This includes mineral characterization and analysis that has been conducted on thousands of samples from 14 coal-producing states. Initial geologic characterization research activities have shown positive indicators for finding materials (in Appalachia and other basins) associated with carbon ore beds that exceed the ore grades of some REE mining projects under development worldwide. This work has found the presence of materials from which REE can be recovered using an ion-exchange solution, a technique that accounts for about 30% of Chinese REE production. Minerals of this type have been unknown to exist in the U.S., and thus offers an opportunity for REE production with less intensive processing steps required to produce REE from conventional ores.

The primary focus areas are:

- Resource Characterization Methods Development – Technology development and validation for environmentally sustainable exploration and production from various sources. This includes regional opportunities and assessments, the economic recovery of CMM through identification (including physical and chemical properties), mineral assays, prediction and assessment of resources and volumes of CMM/REE from various feedstocks. This work is coordinated with the Department of Interior (especially the USGS) and the Environmental Protection Agency.

- Sensors and data connection and analysis – This includes development of new technologies for assessment of recoverable resources (drones, real time sensing and analytics, and micro drilling technologies) and of technologies and methods for rapidly analyzing data. This work is coordinated with the USGS.
- International Engagements, Standards, Supply Chain Development, and Characterization Technology Development – Prioritize leadership among international allies to address sustainable practices throughout the world, across the supply chain, from exploration through manufacturing, including certification approaches and methods for traceability throughout supply chains.

Advanced Critical Material Recovery Technologies

The mining industry has been in decline for the past 40 years. With the expected need for substantially larger amounts of CMM in the coming decades, there is now substantial risk of supply chain disruptions if more minerals cannot be sourced domestically. Recycling and secondary and unconventional sources are not likely to be able to satisfy the full expected demand, especially in the near and medium-term. Mining of conventional ore bodies will be necessary to fully meet expected demand, while reducing the risk of supply chain disruptions from foreign sources. Additionally, processes to ensure that manufactured products are sourced responsibly will be needed to enable stablity of responsible supply chains.

However, the challenges to expanding domestic production of CMM from conventional sources are twofold: 1) length of time to production (exploration and permitting) and 2) lack of societal acceptance for new mining, primarily due to legacy issues from past mining that involved rudimentary technologies and practices that removed and discarded large volumes of waste rock, with lasting impacts that endure to this day. With regards to the timeframe to develop new mines, it often takes several years and tens to hundreds of millions of dollars to go through all of the exploration stages that are required before there is enough certainty about the volume and disposition of the resources in a potential mine to warrant production to start. The USGS has recently expanded their efforts through the Earth Mapping Resources Initiative (Earth MRI) program to identify where potential critical minerals may be located, creating a number of new locations where new mineral reserves could be found. Unfortunately, for every successful new mine site, there are hundreds of sites investigated but then determined that the resource is not rich enough or there are other issues that make it infeasible.

Current mining practices, although much more environmentally friendly than prior methods, still produce hundreds of times more waste material than the amount of pure target material that is recovered. This voluminous waste materialis has significant impacts on land and water. Mining practices also require substantial amounts of energy and other resources (e.g., water), and produce substantial greenhouse gas (GHG) emissions. FECM programs will build off of efforts at DOE, the Advanced Research Projects Agency's (ARPA-E) Mining Innovations for Negative Emissions Resources (MINER) program, and external U.S. government programs, to identify novel technologies that can substantially reduce waste, resource use, and GHG emissions from new mining.

A primary focus area for research, development, demonstration and deployment will be:

- Novel mining technology development **–** RD&D of technologies that can enable more "laparoscopic” approaches to mining, targeted to enabling at least a tenfold reduction in the amount of waste material produced on the surface at a mine site.

Resource Sustainability
Minerals Sustainability

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
Minerals Sustainability					
Critical Minerals Processing	$44,000	$44,000	$21,000	-$23,000	-52.27%
Carbon Ore Processing	$10,000	$10,000	$4,200	-$5,800	-58%
Resource Characterization Technologies	0	0	$30,000	+$30,000	+100%
Advanced Critical Material Recovery Technologies	0	0	$23,000	+$23,000	+100%
Total, Minerals Sustainability	**$54,000**	**$54,000**	**$78,200**	**+$24,200**	**+44.81%**

Explanation of Major Changes
($K)

	FY 2025 Request vs FY 2023 Enacted
Critical Minerals Processing: This decrease represents the breakout of the Resource Characterization as a separate subprogram. Research in this area will continue in the development of existing and new technologies and identification of projected markets for everyday and high value carbon products generated predominantly from coal and coal waste and refuse; and identification of the potential markets for carbon products if production costs are reduced to make it more competitive with current state of the art.	**-$23,000**
Carbon Ore Processing: This decrease in funding represents a shift in focus to the Resource Characterization efforts mentioned below. Research will continue into the utilization of materials to be recycled from currently mined and previously mined resources outside of traditional thermal and metallurgical markets that can support high-wage employment and value-added production in communities and regions dependent on traditional mining.	**-$5,800**
Resource Characterization: This increase fully supports Phase 2 of the CORE-CM Initiative, which was initiated in FY 2024, covering larger portions of the country by regions, as well as the program to accelerate mineral exploration, and the preparation for Phase 3 of the CORE-CM Initiative, which will start in FY 2027.	**+$30,000**
Advanced Critical Material Recovery Technologies: This increase is for a new effort for responsible mining technology development.	**+$23,000**
Total, Minerals Sustainability	**+$24,200**

Resource Sustainability
Minerals Sustainability

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Minerals Sustainability $54,000,000	**$78,200,000**	**+$24,200,000**
Critical Minerals $44,000,000	**$21,000,000**	**-$23,000,000**
• Supported R&D FEED studies for technology development of CMM including REE from unconventional feedstocks to produce large quantities of high purity, commercial grade REE and other CMM. • Furthered development of regional basin projects (the CORE-CM Initiative), and the development of transformational technologies for individually separated highly purified, individual CMM/REE, including individual separation, reduction to metals, and alloying. • Supported the maturation of transformational separation and extraction technologies, characterization of CMM/REE, ML and optimization modeling.	• Preparation for intermediate scale pilot facilities to generate REE/CMM from secondary and unconventional feedstocks. • Support the maturation of transformational separation and extraction technologies, characterization of CMM/REE, ML and optimization modeling.	• This decrease represents the breakout of the Resource Characterization as a separate subprogram.
Carbon Ore Processing $10,000,000	**$4,200,000**	**-$5,800,000**
• Developed existing and new technologies to turn coal and coal waste and refuse into synthetic graphite and graphene. • Supported R&D on carbon fiber production at Oak Ridge National Laboratory's Carbon Fiber Technology Facility. • Supported the development of next generation carbon-based building materials and infrastructure products with superior mechanical properties.	• Support safe and environmentally sustainable coal and coal waste to products work. • Continue to support additive manufacturing of products via 3D printing using coal and coal refuse to reclaim abandoned coal mining land. • Continue to support R&D of high value carbon-based products such as quantum dots and memristor computer chips, using novel technologies.	• This decrease in funding represents a shift in focus to Resource Characterization and responsible mining efforts. • Research continues into the utilization of recycled materials from currently and previously mined coal resources outside of traditional thermal and metallurgical markets that can support communities and economies in regions traditionally reliant on mining.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Resource Characterization Technologies $0	**$30,000,000**	**+$30,000,000**
• No funding requested in FY 2023.	• Further development of regional basin projects (the CORE-CM Initiative) in its second Phase and in preparation for phase 3, and the development of an updated national prospectus that will provide information on potential resources across the country. • Improve exploration and characterization technologies to reduce time, cost, and environmental impact, especially for unconventional and secondary resources.	• This increase represents the creation of a new subprogram to continue and to expand the CORE-CM Initiative.
Advanced Critical Material Recovery Technologies $0	**$23,000,000**	**+$23,000,000**
• No funding requested in FY 2023.	• Develop next-generation novel and extraction technologies that use surgical precision to target and recover critical minerals from the subsurface • Begin development of a capability for mineral traceability throughout the supply chain, enabling transparency and validation.	• This increase represents the beginning of advanced critical material recovery technologies efforts.

Resource Sustainability
Resource Sustainability - Analysis and Engagement

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$0	$0	$2,000	+$2,000

Overview

The United States (U.S.) continues to produce and use fossil energy, specifically oil and natural gas, at historically high rates. Fossil energy will continue to provide for a portion of domestic energy consumption and help underwrite the energy security of our Nation and allies overseas, even as the U.S. transitions to a net-zero carbon economy. As that transition occurs, FECM is engaging with domestic and international stakeholders alongside other Department of Energy (DOE) program offices, advancing research and technologies, and bringing together critical programs and funding to reduce the environmental and climate impacts of fossil energy production and use. The U.S. and its global partners have an opportunity to decarbonize fossil energy production and use. This requires a robust analytical capability to prioritize and support the Resource Sustainability research portfolio, analyze shifting market conditions, and provide data driven analysis, studies, and reports to Departmental leadership and government policy makers.

The Resource Sustainability - Analysis and Engagement Program will focus on economic and environmental analysis, modeling, market analysis, and studies that provide support to the overall Resource Sustainability Program, including informing research priorities, engagement with domestic and international governments and organizations, and providing market and industry analysis to inform the Department on fossil energy resources. Specifically, the program conducts analysis and studies that support the environmentally prudent production, transport, storage, and use of domestic fossil fuels. This includes analysis of markets during volatility, providing data driven assessments of the impacts of different tools and levers that can be used to provide safe, environmentally responsible, reliable, and affordable fossil energy supplies to the domestic market.

The program also engages with domestic and international stakeholders on activities associated with technologies and approaches that will reduce the environmental impacts of historical and continued use of oil and natural gas. This includes support for activities to inform key Office of the Fossil Energy and Carbon Management (FECM) audiences and stakeholders about DOE's work to foster a clean energy and industrial economy and to address climate change, as well as support for communities near fossil energy production and assets. Funding will support domestic engagement efforts and international collaboration with various partners through bilateral and multilateral agreements regarding technologies and approaches that serve to decarbonize the production, transport, and end uses of fossil fuels. Activities under this area include technical exchanges, studies, and reports.

The Resource Sustainability – Analysis and Engagement Program will pursue the following major activities in FY 2025:

- Perform analyses of pathways to achieve domestic and global climate goals, including lifecycle and market analysis.
- Assess market conditions to determine impacts to energy markets and technology development.
- Leverage experience in working successfully with governments, organizations, and stakeholders internationally through a variety of bilateral and multilateral mechanisms to accelerate the advancement and responsible deployment of methane mitigation technologies through both policy and technical expertise, along with forward-looking research, development, demonstration, and deployment (RDD&D) and capacity-building.
- Work with international partners to prioritize a decarbonized natural gas value chain by 2050 to move their countries and regions toward net-zero goals. FECM expertise can provide leverage, develop long-term projects and relationships for technical exchange and joint RDD&D with these partners.
- Serve as a key focal point and provide analysis and data across the U.S. Government for interagency collaboration on technical and policy issues related to methane mitigation technologies.
- Work with other agencies to develop and improve accounting frameworks and tools to accurately measure and reduce greenhouse gases and other impacts from fossil fuel production and use.

Resource Sustainability – Analysis and Engagement

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Resource Sustainability – Analysis and Engagement: $0	**$2,000,000**	**+$2,000,000**
• No funding requested in FY 2023.	• This activity will provide funding for technical, economic, and socio-economic studies, technical expertise and analysis needed to support the Environmental Protection Agency (EPA) and other agencies regarding methane emissions, critical minerals, hydrogen storage, and other crosscutting efforts. • Provide economic, market, and industry analysis and studies on oil, gas, coal, and petrochemical resources. • Support international and domestic engagements with industry, governments, and non-governmental organizations to reduce methane emissions related to fossil fuel use, and to pursue the development of critical minerals and materials (CMM) from domestic fossil resources such as coal, coal waste, and produced water from oil and gas production.	• Increase in funding will provide funding for technical, economic, and socio-economic studies, technical expertise and analysis needed to support EPA and other agencies regarding methane emissions, critical minerals, hydrogen storage, and other crosscutting efforts. • Increase in funding will provide economic, market, and industry analysis and studies on oil, gas, coal, and petrochemical resources. • Increase in funding will support international and domestic engagements with industry, governments, and non-governmental organizations to reduce methane emissions related to fossil fuel use, and to pursue the development of CMM from domestic fossil resources, such as coal, coal waste and produced water from oil and gas production.

NETL Infrastructure

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$55,000	$55,000	$51,000	-$4,000

Overview

The National Energy Technology Laboratory (NETL) Infrastructure Program supports the fixed costs of NETL's laboratory footprint in three geographic locations: Morgantown, WV; Pittsburgh, PA; and Albany, OR. Table 1 provides information on the size of each site.

The NETL Infrastructure Program comprises the following subprograms:

(1) **High-Performance Computer (Supercomputer)** provides funding for the lease of Joule 3, NETL's Supercomputer. The FY 2025 Budget Request includes $6.0 million for the continuation of a 4-year lease.
(2) **Laboratory and Sitewide Facilities** includes repairs to existing laboratory facilities, general-purpose buildings, and sitewide infrastructure and the continued management of deferred maintenance balances. Priorities for funding are established to ensure compliance with life safety standards, critical laboratory research facilities and infrastructure, and compliance with High Performance Sustainable Building (HPSB) goals.
(3) **Safeguards and Security** provides funds to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the Office of Fossil Energy and Carbon Management (FECM) mission.
(4) **Environmental Restoration** supports NETL's obligations to the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) across all NETL sites and one off-site location in Wyoming.

The FY 2025 Budget Request for NETL Infrastructure is $51 million. The most significant component is Laboratory and Sitewide Facilities with a total of $35 million, as follows: (1) $17 million for General Plant Projects (GPP), prioritizing investments in reducing NETL's carbon footprint and managing deferred maintenance balances; (2) $15 million for fixed operational costs such as building and grounds maintenance, utilities, fleet management, and information technology (IT) licenses and agreements; and (3) $3 million to operate and maintain certain new research facilities being constructed with Inflation Reduction Act infrastructure funds and projected to be operational by FY 2025. In addition, $6 million is requested for NETL's high performance computer (HPC) lease. HPC is an essential element in more than 50% of NETL's research projects. The balance of the request is for safeguards and security ($8M), environmental compliance and remediation ($2M).

Funding supports the Administration's Cybersecurity Priorities released by the Office of Management and Budget's (OMB) Memorandum (M-23-18), including implementing zero trust architectures, improving incident detection and response capabilities, addressing supply chain risks, and increasing automation across IT infrastructure operation/maintenance (O&M), portfolio management, cybersecurity risk management.

Table 1[1]: Comparison of Physical Footprint, Workforce, and Value of Assets by Campus and in Total, National Energy Technology Laboratory as of September 9, 2023.

	Morgantown	Pittsburgh	Albany	Total NETL
Buildings	42	30	56	**128**
Sq. Ft. of Building Space (000s)	442	433	250	**1,125**
Acres	136.0	57.4	47.4	**240.8**
NETL Federal Workforce (FTEs)	206	233	48	**523**[2]
NETL Contractor Workforce (FTEs)	348	420	81	**893**[3]
Assets Replacement Value	$341.7 million	$290.4 million	$207.5 million	**$839.6 million**

[1] Table 1 compares physical footprint, workforce, and value of assets as of September 9, 2023.

[2] Total NETL includes five employees located in Houston, TX and 31 with a remote-U.S. duty station. Total NETL excludes 78 employees funded through the Infrastructure Investment and Job Act and the Inflation Reduction Act.

[3] Total NETL includes 5 contractors located in Houston, TX and 39 located offsite.

NETL Infrastructure

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023 ($)	FY 2025 vs FY 2023 (%)
NETL Infrastructure					
Supercomputer	6,000	6,000	6,000	0	0%
Laboratory- & Site-Wide Facilities	39,000	39,000	35,000	-4,000	-10.3%
Safeguards and Security	8,000	8,000	8,000	0	0%
Environmental Restoration	2,000	2,000	2,000	0	0%
Total, NETL Infrastructure	**55,000**	**55,000**	**51,000**	**-$4,000**	**-7.3%**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
NETL Infrastructure $55,000,000	**$51,000,000**	**-$4,000,000**
High Performance Computer $6,000,000	**$6,000,000**	**$0**
• Funding for the 4-year lease of Joule 3, NETL's Supercomputer.	• Funding is for the 4-year lease of Joule 3, NETL's Supercomputer.	• No change.
Laboratory and Site wide Facilities $39,000,000	**$35,000,000**	**-4,000,000**
• Funding included repairs to existing laboratory facilities and general-purpose buildings and site-wide infrastructure. • Request included fixed operational costs such as utilities, routine building and grounds maintenance, safeguards and security, environmental compliance and remediation, and IT licenses and agreements.	• Funding includes repairs to existing laboratory facilities and general-purpose buildings and site-wide infrastructure. • Request also includes fixed operational costs such as utilities, routine building and grounds maintenance, and IT licenses and agreements.	• Funding includes an increase for O&M of new research facilities; projected to be operational by FY 2025. • Funding includes a decrease for contractor support for site O&M activities, GPP, and IT development, modernization, and enhancement
Safeguard and Securities $8,000,000	**$8,000,000**	**$0**
• Funding ensured protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the FECM RDD&D mission.	• Funding is to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the FECM RDD&D mission.	• No change.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Environmental Restoration $2,000,000	**$2,000,000**	**$0**
• Active O&M of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12. • On-site RCRA hazardous waste compliance and management activities. • Albany ground water investigation and compliance activities.	• Active O&M of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12. • On-site RCRA hazardous waste compliance and management activities. • Albany ground water investigation and compliance activities.	• No change.

NETL Research and Operations

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023 ($)
$87,000	$87,000	$95,000	+$8,000

Overview

The National Energy Technology Laboratory (NETL) is an integral part of the U.S. Department of Energy (DOE) national laboratory system. There are 17 National Laboratories in the DOE laboratory system; NETL is the only government-owned, government-operated laboratory (GOGO). NETL supports the DOE mission by addressing energy and environmental challenges through transformative science and technology solutions. NETL is recognized for its capabilities in applied material science, computation science, chemical and systems engineering, subsurface science, decision science, and government contract and project management.

The NETL Research and Operations Program comprises three subprograms:

(1) **Research, Development, Demonstration, and Deployment** supports Federal researcher salaries and benefits, travel, personal protective equipment, and other employee costs for the NETL staff of scientists and engineers who conduct in-house research activities for FECM RDD&D programs. This subprogram funds the salaries, benefits, travel, and other employee costs for the NETL staff of engineers and technical professionals who conduct project management for FECM RDD&D programs. This subprogram also funds partnership, technology transitions, and other collaborative research activities with universities, other National Laboratories, state and local governments, and industry, as well as strategic energy analysis and research data management.

(2) **Site Operations** includes funding for: (a) building operations and maintenance such as non-capital repairs and routine upkeep; (b) grounds maintenance including parking lot repair, lighting, groundskeeping, snow removal, etc.; and (c) information technology operations.

(3) **Program Oversight** includes funding for Federal employees and contractors performing research-enabling functions such as managing financial assistance and providing legal and finance oversight of research grants and awards.

NETL's Chief Diversity Officer collaborates with the DOE Office of Environmental Justice and Equity in planning and executing Diversity, Equity, Inclusion, and Accessibility (DEIA) programs initiatives. Funding in the NETL Research and Operations request enables DEIA activities in workforce planning, employee engagement, and accessibility measures.

The NETL Research and Operations Request is $95 million. The Request includes $79.3 million to fully fund federal salaries and benefits at the requested full-time equivalent (FTE) level. An additional $12.2 million is for contractor support in the areas of information technology operations, technology transitions and business outreach, research data management, and strategic energy analysis. The balance of the request funds travel, training, material, supplies, and other employee costs for the federal staff and NETL's Laboratory-Directed Research and Development contribution.

NETL Research and Operations

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023	
				$	%
NETL Research and Operations					
Research, Development, Demonstration, and Deployment	55,000	55,000	66,000	11,000	20.0%
Site Operations	21,000	21,000	18,000	-3,000	-14.3%
Program Oversight	11,000	11,000	11,000	0	0%
TOTAL, NETL Research and Operations	**87,000**	**87,000**	**95,000**	**+8,000**	**+9.2%**

Explanation of Major Changes

($K)

	FY 2025 Request vs FY 2023 Enacted
NETL Research and Operations:	
• Increase reflects fully funding federal headcount at projected FY 2025 average salary and benefits. The Request includes the FY 2024 Cost of Living Adjustment (COLA) of 5.2% and an assumed FY 2025 COLA of 2%.	**+$8,000**
Total, NETL Research and Operations	**+$8,000**

NETL Research and Operations

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
NETL Research and Operations $87,000,000	**$95,000,000**	**+$8,000,000**
Research, Development, Demonstration, and Deployment $55,000,000	**$66,000,000**	**+$11,000,000**
• RDD&D funding supported salaries and benefits, travel, personal protective equipment, and other employee costs for the NETL staff of scientists and engineers who conduct in-house research activities for FECM RDD&D programs. • Funding supported NETL's Research & Innovation Center strategic efforts such as the FECM Roadmap and NETL Science & Technology competency assessments. • RDD&D funding provided for collaborative activities, including Federal salaries/benefits, travel and employee costs for engineers, and technical project managers associated with the FECM programs. • Funding provided for costs targeted toward collaboration, strategic energy analysis and research data management areas. Funding provided for ongoing operation and maintenance of project management information systems.	• RDD&D funding supports salaries and benefits, travel, personal protective equipment, and other employee costs for the NETL staff of scientists and engineers who conduct in-house research activities for FECM RDD&D programs. • Funding also supports NETL's Research & Innovation Center strategic efforts such as the FECM Roadmap and NETL Science & Technology competency assessments. • RDD&D funding also provides for collaborative activities, including Federal salaries/benefits, travel and employee costs for engineers, and technical project managers associated with the FECM programs. • Funding provides for costs targeted toward collaboration, strategic energy analysis and research data management areas. Funding also provides for ongoing operation and maintenance of project management information systems.	• Increase reflects fully funding federal headcount at projected FY 2025 average salary and benefits. The requested increase includes COLA ($5 million) and other strategic recruitments ($1 million).
Site Operations $21,000,000	**$18,000,000**	**-$3,000,000**
• Site Operations funding supported variable costs of operating NETL's laboratories and research sites. Funding provided for operations personnel along with support contractors for building operations, grounds maintenance, etc.	• Site Operations funding supports variable costs of operating NETL's laboratories and research sites. Funding provides for operations personnel along with support contractors for building operations, grounds maintenance, etc.	• Reduction in contractor support for information technology operational areas, fleet operations, and janitorial scope of services.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Program Oversight $11,000,000	**$11,000,000**	**$0**
• Program Oversight funding at NETL supported salaries/benefits for federal employees performing research-enabling support functions necessary for the performance of NETL's research activities.	• Program Oversight funding at NETL supports salaries/benefits for federal employees performing research-enabling support functions necessary for the performance of NETL's research activities.	• No change.

Interagency Working Group

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$3,000	$3,000	$0	-$3,000

Overview

On January 27, 2021, President Biden signed Executive Order (EO) 14008, "*Tackling the Climate Crisis at Home and Abroad.*" EO 14008, Section 218, established an Interagency Work Group (IWG) on Coal and Power Plant Communities and Economic Revitalization. The IWG is co-chaired by the Director of the National Economic Council and the National Climate Advisor, and it is administered the Secretary of Energy. In April 2021, the IWG prepared an Initial Report to the President on Empowering Workers through Revitalizing Energy Communities that identifies 25 communities across the country hard-hit by coal mine and power plant closures. The IWG will promote investments that support economic revitalization and job creation in these and other energy communities and will also proactively promote investments in communities likely to be impacted by these closures in the near-term. These communities include workers directly employed in coal mining and power generation, those in related jobs in logistics and services, and residents who are dependent on coal and power plant-related tax revenue to fund schools, public services, and infrastructure, as well as fenceline communities and other communities impacted by the environmental and health effects of fossil energy generation.

Highlights of the FY 2025 Request

The Office of State and Community Energy Programs (SCEP) will request funding and manage the IWG in FY 2025.

Interagency Working Group

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 vs FY 2023
Interagency Working Group $3,000,000	**$0**	**-$3,000,000**
• Continued targeted, place-based interventions using an interagency approach that leverages existing federal and technical assistance resources to assist energy communities, including displaced energy workers. • Established a concierge function to provide direct technical assistance to energy communities on how to access Federal resources. • Streamlined the process for applying Federal funding. Created a pilot that uses a common application for two or more agencies. • Maintained the clearinghouse on Federal funding opportunities available to energy communities.	• The IWG will request funding through SCEP.	• The IWG will be managed by SCEP.

Special Recruitment Programs

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$1,000	$1,000	$1,000	$0

Overview

The Office of Fossil Energy and Carbon Management (FECM) emphasizes educational programs to support an increase in the number of women and underrepresented groups entering science (including social science), technology, engineering, and mathematics (STEM) career fields within the U.S. workforce. FECM programs, including the Mickey Leland Energy Fellowship (MLEF) and other educational programs, offer undergraduate and graduate students majoring in STEM disciplines opportunities to learn about programs, policies, and research, development, demonstration, and deployment (RDD&D) initiatives. Students learn of the multiple challenges and opportunities in providing clean, affordable energy for future generations. FECM also utilizes Departmental programs such as the Minority Educational Institution Student Partnership Program (MEISPP), the Department of Energy (DOE) Scholars Program, and the DOE Science, Technology and Policy (STP) Program to provide students the opportunity to gain work experience and learn about the FECM and DOE missions to support preparation for careers with DOE and in the STEM workforce. The Special Recruitment Programs aligns with the Administration's Justice40 Initiative and equity priorities.

Highlights of the FY 2025 Request

In FY 2025, FECM will recruit and select a diverse group of undergraduate and graduate students in STEM majors to participate in FECM and DOE educational programs such as the MLEF, MEISPP, DOE Scholars, STP, and other student programs. Recruitment emphasis will be on Historically Black Colleges and Universities (HBCUs) and other Minority Serving Institutions (MSIs). All participants in the MLEF, MEISPP, DOE Scholars, STP, and other FECM and DOE educational programs will complete challenging assignments supporting the FECM mission through hands-on research and development (R&D) projects under the mentorship of an FECM scientist, researcher, or program official.

Special Recruitment Programs

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 vs FY 2023
Special Recruitment Programs $1,000,000	**$1,000,000**	**+$0**
• A diverse group of undergraduate, graduate, and post-graduate students in STEM majors were recruited and selected to participate in the MLEF, MEISPP, DOE Scholars, DOE STP, or other educational programs. Provides students opportunities to gain hands-on research and work experience and learn more about the DOE and the FECM missions.	• A diverse group of undergraduate and graduate students in STEM majors will be recruited and selected to participate in the MLEF, MEISPP, DOE Scholars, DOE STP, or other educational programs. Provides students opportunities to gain hands-on research and work experience and learn more about the DOE and FECM missions.	• No changes.

Program Direction

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$70,000	$70,000	$97,000	+$27,000

Overview

Program Direction funds the Headquarters (HQ) workforce responsible for the oversight and administration, including monitoring (oversight and audit) activities for the Department of Energy's (DOE) Office of Fossil Energy and Carbon Management (FECM) research, development, demonstration, and deployment (RDD&D) portfolio of the FECM, the National Energy Technology Laboratory (NETL) technical staff (who perform acquisition, finance and legal functions), federal workforce who provide management of the laboratory, and federal and contractor support for communications. NETL scientific researchers or project managers are not funded by Program Direction. They are funded by the NETL Research and Operations control point. Program Direction also funds the following:

- Continued information technology (IT) modernization and the Administration's cybersecurity priorities established by the Office of Management and Budget and DOE, including implementing zero trust architectures, improving incident detection and response capabilities, addressing supply chain risks, and increasing automation across IT infrastructure operations and maintenance, portfolio management, and cybersecurity risk management;
- Operations, federal staff, and contractor support of the Import/Export Authorization Office, which is managed by the Division of Natural Gas Regulation within the Office of Resource Sustainability and has responsibility for regulating natural gas and liquefied natural gas (LNG) imports and exports under the Natural Gas Act of 1938, section 3;
- DOE Office of Human Resource Operations and Compensation; and
- FECM program office contribution to the DOE Working Capital Fund (WCF).

The FY 2025 Program Direction Request is $97 million, which includes $61 million to fully fund the projected FY 2025 average federal salaries and benefits for the requested full-time equivalent (FTE) level, travel, support services and other related expenses. An increased federal staffing level is required to maintain appropriate program oversight and administration of FECM programs, including support efforts at NETL to oversee, award, manage, and close out RDD&D programs and projects. These efforts increase the effectiveness of government-sponsored RDD&D and reduce the risk of noncompliance.

Program Direction

($K)

Program Direction Summary	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023 $	FY 2025 vs FY 2023 %
Washington Headquarters					
Salaries and Benefits	25,732	25,732	35,351	+9,619	+37.38%
Travel	400	400	1,677	+1,277	+319.25%
Support Services	2,620	2,620	7,022	+4,402	+168.02%
Other Related Expenses	8,418	8,418	11,995	+3,577	+42.49%
Total, Washington Headquarters	**37,170**	**37,170**	**56,045**	**+18,875**	**+50.78%**
National Energy Technology Laboratory					
Salaries and Benefits	19,300	19,300	23,300	+4,000	+20.73%
Travel	400	400	400	0	0%
Support Services	7,100	7,100	5,800	-1,300	-18.31%
Other Related Expenses	3,100	3,100	3,600	+500	+16.13%
Total, National Energy Technology Laboratory	**29,900**	**29,900**	**33,100**	**+3,200**	**+10.70%**
Import/Export Authorization					
Salaries and Benefits	1,930	1,930	2,232	+302	+15.65%
Travel	20	20	24	+4	+20.00%
Support Services	450	450	4,958	+4,508	+1,001.78%
Other Related Expenses	530	530	641	+111	+20.94%
Total, Import/Export Authorization	**2,930**	**2,930**	**7,855**	**+4,925**	**+168.09%**
Total Program Direction					
Salaries and Benefits	46,962	46,962	60,883	+13,921	+29.64%
Travel	820	820	2,101	+1,281	+156.22%
Support Services	10,170	10,170	17,780	+7,610	+74.83%
Other Related Expenses	12,048	12,048	16,236	+4,188	+34.76%
Total Program Direction	**70,000**	**70,000**	**97,000**	**+$27,000**	**+38.57%**

Program Direction Summary	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023 ($K)	
				$	%
Federal FTEs – HQ	141	141	168	+27	+19.15%
Federal FTEs – NETL[1]	138	138	140	+2	+1.45%
Federal FTEs – Total	**279**	**279**	**308**	**+29**	**10.39%**
Support Services					
Technical Support					
Headquarters	2,620	2,620	7,022	+4,402	+168.02%
NETL	0	0	0	0	0%
Import/Export Authorization	450	450	4,958	+4,508	+1,001.78%
Total, Technical Support	**3,070**	**3,070**	**11,980**	**+8,910**	**290.23%**
Management Support					
Headquarters	0	0	0	0	0%
NETL	7,100	7,100	5,800	-1,300	-18.31%
Import/Export Authorization	0	0	0	0	0%
Total Management Support	**7,100**	**7,100**	**5,800**	**-1,300**	**-18.31%**
Total, Support Services	**10,170**	**10,170**	**17,780**	**+7,610**	**+74.83%**
Other Related Expenses					
Headquarters	8,418	8,418	11,995	**+3,577**	**+42.49%**
NETL	3,100	3,100	3,600	**+500**	**+16.13%**
Import / Export Authorization	530	530	641	**+111**	**+20.94%**
Total, Other Related Expenses	**12,048**	**12,048**	**16,236**	**+4,188**	**+34.76%**

[1] Additional NETL FTEs are funded within the NETL Research and Operations budget line.

Program Direction

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Program Direction $70,000,000	**$97,000,000**	**+$27,000,000**
Salaries and Benefits $46,962,000	**$60,883,000**	**+$13,921,000**
• Funding supported HQ Federal staff who provide monitoring (oversight and audit) activities for the FECM RDD&D portfolio. • Funding supported the technical Federal staff at NETL. The staff covered in this area provide for management of the Lab, communications, legal, acquisition and finance activities.	• Funding supports HQ federal staff who provide oversight and administration, including monitoring (oversight and audit) activities for the FECM RDD&D portfolio. • Funding supports technical staff (who perform acquisition, finance, and legal functions), federal workforce who provide management of the laboratory, and federal and contractor support for communications.	• The HQ increase reflects additions to FTEs to support FECM's mission as well as a 2% pay raise for federal staff in FY 2025, the Federal Employees Retirement System (FERS) increase, and awards pool funding increase in FY 2025.
Travel $820,000	**$2,101,000**	**+$1,281,000**
• Travel includes funding for management meetings, training, etc.	• Travel includes funding for management meetings, training, etc.	• Travel increase is due to the return to a normal travel schedule with COVID restrictions being lifted.
Support Services $10,170,000	**$17,780,000**	**+$7,610,000**
• Support Services at HQ includes technical support, IT support, site operations support, administrative support. • Support services at NETL include management and communications support, as well as finance and acquisition technicians.	• Support Services at HQ includes technical support, IT support, site operations support, and administrative support. • Support services at NETL include management and communications support, as well as finance and acquisition technicians.	• Increase in Import/Export Program Direction support services covers anticipated studies and environmental reviews, Fossil Energy Regulatory Gas Activity System, and 2% pay raise for federal staff in 2025, the FERS increase, and awards pool funding increase. • As FTEs increase, cost categories such as WCF, training, supplies, rent (not included in the WCF), equipment, and IT expenses increase as well.
Other Related Expenses $12,048,000	**$16,236,000**	**+$4,188,000**
• Activities supported include E-Government initiatives, WCF, computer systems and support, contractual services for HQ and environment, health, safety, and security (EHSS) requirements at HQ and Human Resources shared service center payments.	• The activities supported by this line item include E-Government initiatives, WCF computer systems and support, contractual services for HQ and EHSS requirements at HQ and Human Resources shared service center payments.	• Request reflects an increase due to the anticipated increase in FTEs.

Energy Asset Transformation

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$6,000	$6,000	$6,000	$0

Overview

Over the next few decades, the U.S. and the world will need to dramatically reduce greenhouse gas (GHG) emissions to halt ongoing contributions to climate change. This imperative implies an unprecedented transition in the energy and industrial system away from unabated GHG-emitting fuels (coal, oil, and natural gas) and toward clean energy sources that include fossil energy with carbon capture, utilization, and storage, in addition to wind, solar, geothermal, nuclear, hydropower, and other alternative energy sources. This transition will be challenging for a variety of technical, political, and socio-economic reasons.

Power plant retirements can result in significant job losses, but thoughtful and proactive planning and analysis can help lay the groundwork for productive alternative economic use of the remaining transmission and distribution infrastructure, electrical interconnection equipment, site and permitting licenses, and other infrastructure. As the Nation reduces its carbon footprint and deploys new technology and infrastructure, productively transforming energy assets allows communities and regions to participate actively in building a clean energy and industrial economy and to maximize economic, social, and environmental opportunities. Many existing energy assets offer private sector actors a skilled workforce with knowledge of industrial operations; community relationships; access to rail lines, ports, and waterways; highway transportation, transmission, and distribution infrastructure; electrical interconnect equipment and direct grid connections; industrial land, facilities; long-duration energy storage; and potentially even site and permitting licenses among other benefits. This can help retain the local skilled workforce, keep former plant sites economically active, maximize the value of infrastructure, and provide grid stability benefits.

The Energy Asset Transformation program will support transformation of decommissioned and retiring energy assets across the U.S. for use in clean energy and manufacturing by providing technical and financial assistance and developing publicly available tools and resources. This will help ensure that energy communities have a path forward and can benefit from both short-term and permanent employment, opportunities for worker retraining programs, access to local work that does not require relocation, and opportunities to work in cutting-edge technology sectors. Importantly, transformation allows communities to become active participants in crafting their own economic future.

The FY 2025 Request will fund activities such as:

- Direct assistance (through funding on ongoing projects, prizes, technical assistance, and Partnership Intermediary Agreements (PIAs)) to communities hosting an asset undergoing transformation.
- Transformation activities and early-stage concepts development through prizes, competitive solicitations and technical assistance. The intent is to support transformation efforts that lead to additional support for pre-front-end engineering and design (FEED) studies, demonstration funding, loan support, and other work.
- Development of publicly available tools and resources (e.g., analysis through supporting work at the Department of Energy (DOE) headquarters, the National Labs, industry, or academia). The Request will fund research and case studies focused on safety and reliability challenges for assets reaching end of life in the near and medium term, particularly given dynamic operational constraints.
- Contribution to DOE's funding of the Rapid Response Teams (RRTs) associated with the Interagency Working Group on Coal and Power Plant Communities to support place-based interagency efforts related to energy transition and energy asset transformation.

Success will be measured by the number of applications (and indicator of need) and the number of projects funded (and indicator of project quality). Where appropriate, success will be measured by the projects' impacts on their host communities and contributions to further funding applications. The Request will also fund stakeholder and community outreach and studies regarding how existing energy assets can safely and reliably support energy services as decarbonization proceeds.

Energy Asset Transformation

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 vs FY 2023
Energy Asset Transformation $6,000,000	**$6,000,000**	**$0**
• Funding supports both direct assistance to energy asset host communities (through mechanisms like prizes, PIAs, and technical assistance) and financial support for project development (through mechanisms like competitive solicitations and prizes), in addition to analysis and outreach efforts at headquarters. Funding also supports DOE engagement in RRT, and other place-based initiatives focused on energy transitions.	• Funding will be used to support transformation activities and develop early-stage concepts through prizes, competitive solicitations, and technical assistance, potentially leading to some pre-FEED for asset transformation and adaptive use given new and challenging operational constraints. • Funding will be used for development of publicly available tools and resources (e.g., paper case studies through supporting work at DOE headquarters, the National Labs, industry, or academia). • Funding will continue to contribute to the RRTs.	• **N**o changes.

SBIR/STTR:

- FY 2023 Enacted: SBIR $177: STTR: $31
- FY 2024 Annualized CR: SBIR $177: STTR: $31
- FY 2025 Request: SBIR $183: STTR: $26

Fossil Energy and Carbon Management
University Training and Research

($K)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
$13,000	$13,000	$19,000	+$6,000

Overview

The Department of Energy's (DOE) FY 2025 Request increases funding for foundational research and development (R&D) and workforce development at U.S. academic institutions of higher learning. These programs will prepare the next generation of students entering the workforce. The University Training and Research (UTR) program focuses on introducing students to the diversity of research topics pursued in support of the Office of Fossil Energy and Carbon Management (FECM) mission and goals and preparing them for jobs in related fields such as clean hydrogen production and use, carbon dioxide removal (CDR), point-source carbon capture, carbon conversion, carbon transport and storage, and critical mineral and rare earth element extraction. The UTR program is FECM's flagship program for funding workforce development and building research capacity at the nation's traditionally underserved HBCUs and MSIs. Projects funded under UTR enable principal investigators at HBCU and other MSIs to competitively apply for funding in a restricted eligibility FOA and facilitate training in key R&D areas of our nation's underserved students.

The UTR program provides funding to colleges and universities to support early-stage research (and education into the societal and human impacts) of new technology development and deployment consistent with FECM's mission to further DOE and the Administration's commitment to help ensure that communities see tangible economic, environmental and jobs benefits from the development and deployment of projects and infrastructure. The UTR program comprises of two subprograms: the University Carbon Research (UCR) program and the Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI) program. The UCR and HBCU/MSI programs provide resources to:

1. Conduct directed energy research in an innovative environment.
2. Expand the research capabilities and education of students in science, technology, engineering, and mathematics (STEM), humanities, and other disciplines.
3. Develop research-based solutions to support the Administration's research, development, demonstration, and deployment (RDD&D) goals and commitment to communities.
4. Maintain and enhance the educational, training, and research capabilities of HBCUs/MSIs.
5. Address FECM and DOE-wide priorities, including the DOE Energy Earthshots™ (Carbon Negative Shot™ and Clean Fuels & Products Shot™).

The FY 2025 Request funds a new competitive funding opportunity announcement (FOA) that will support curriculum design; build research and education capacity in FECM mission-related areas; foster the completion of research in STEM and/or humanities disciplines that advance the FECM mission; and establish programs that foster workforce development and community engagement in FECM mission-related fields. The funding will also support educational fellowship opportunities at DOE for students.

FECM places a special emphasis on supporting HBCUs/MSIs to help expand the future STEM workforce. The HBCU-MSI subprogram funds research exclusively conducted at MSIs. Specifically, grants under the HBCU-MSI program promote the expansion of MSI research capacity and increase training opportunities for underrepresented minority students in STEM fields.

Fossil Energy and Carbon Management
University Training and Research

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 vs FY 2023
University Training and Research $13,000,000	**$19,000,000**	**+$6,000,000**
University Carbon Research $5,000,000	**$5,000,000**	**+$0**
• Released competitive funding opportunity announcements (FOA) for U.S. academic institutions of higher learning to support fundamental research that cuts across the FECM research focus areas.	• Funding through a FOA(s) to the national university program for research in energy, environmental, science, social science, engineering, and humanities that focus on innovative and fundamental investigations pertinent to advancing the goals of the program.	• Continues to support R&D and student training in FECM priority areas and facilitates partnerships with HBCUs and other MSIs and college- or university-hosted workforce development programs.
HBCU/MSI $8,000,000	**$14,000,000**	**+$6,000,000**
• Released competitive FOAs for U.S. academic institutions of higher learning to support fundamental research that cuts across FECM's research focus areas.	• Funding increase through a FOA(s) to the national university program for research in energy, environmental, science, social science, engineering, and humanities that focus on innovative and fundamental investigations pertinent to advancing the goals of the program.	• The funding increase supports the Carbon Negative Shot™, Clean Fuels & Products Shot™, student training, building capacity for FECM-related research and activities at HBCUs and other MSIs, including curriculum design, research on successful recruitment and retention methods, development of outreach, mentorship programs, fellowships, college- or university-hosted workforce development programs, and building science, engineering research, and education capacity.

Fossil Energy and Carbon Management
Facilities Maintenance and Repair

The Department of Energy's (DOE) Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded by this budget are displayed below.

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 Energy Technology Laboratory	19,462	19,780	19,036	19,000
Total, Direct-Funded Maintenance and Repair	**19,462**	**19,780**	**19,036**	**19,000**

Report on FY 2023 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. Conf. Rep. No. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests DOE provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2023 to the amount planned for FY 2023, including Congressionally directed changes.

Total Costs for Maintenance and Repair

	($K)	
	FY 2023 Actual Cost	FY 2023 Planned Cost
National Energy Technology Laboratory	19,000	19,036
Total, Direct-Funded Maintenance and Repair	**19,000**	**19,036**

In review of the planned vs actual costs for FY 2023, costs are tracking to the plan. FY 2023 costs were slightly lower than plan due to certain costs originally planned for FY 2023 not being incurred until FY 2024.

Fossil Energy and Carbon Management
Excess Facilities

Excess Facilities are facilities no longer required to support the Department's needs, present or future missions or functions, or the discharge of its responsibilities. This table reports the funding to deactivate and dispose of excess infrastructure, including stabilization and risk reduction activities at high-risk excess facilities, resulting in surveillance and maintenance cost avoidance and reduced risk to workers, the public, the environment, and programs. This includes 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 Excess Facilities

	($K)			
	FY 2022 Actual Cost	**FY 2022 Planned Cost**	**FY 2023 Planned Cost**	**FY 2024 Planned Cost**
National Energy Technology Laboratory (All)	54	40	40	30
NA	0	0	0	0
Total, Direct-Funded Excess Facilities	**54**	**40**	**40**	**30**

Fossil Energy and Carbon Management
Capital Summary

	($K)					
	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 vs FY 2023
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))						
Capital Equipment >$500,000 (including MIE)	n/a	0	0	0	0	0
Minor Construction Project (>$5 million)	25,000	25,000	0	0	0	0
Total, Capital Operating Expenses	**25,000**	**25,000**	**0**	**0**	**0**	**0**
Capital Equipment > $500,000 (including MIE)						
Total Non-MIE Capital Equipment	n/a	0	0	0	0	0
Total, Capital Equipment (including MIE)	**n/a**	**0**	**0**	**0**	**0**	**0**
Minor Construction Projects (>$5 million)						
Direct Air Capture Center	25,000	25,000	0	0	0	0
Total, Minor Construction Projects	**25,000**	**25,000**	**0**	**0**	**0**	**0**
Total, Capital Summary	**25,000**	**25,000**	**0**	**0**	**0**	**0**

Fossil Energy and Carbon Management
Safeguards and Security

($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Protective Forces	3,164	3,164	3,164	0	0.0%
Physical Security Systems	171	171	171	0	0.0%
Information Security	163	163	169	+6	+3.7%
Cybersecurity[1]	4,416	4,416	10,870	+6,454	+146.2%
Personnel Security	358	358	382	+24	+6.7%
Material Control and Accountability	0	0	0	0	N/A
Program Management	320	320	392	+72	+22.5%
Security Investigations	0	0	0	0	N/A
Transportation Security	0	0	0	0	N/A
Construction	0	0	0	0	N/A
Total, Safeguards and Security	**8,592**	**8,592**	**15,148**	**+6,556**	**+76.3%**

National Energy Technology Laboratory (NETL) - Funding will support continued information technology (IT) modernization and the Administration's cybersecurity priorities established by OMB and DOE, including implementing zero trust architectures, improving incident detection and response capabilities, addressing supply chain risks, and increasing automation across IT infrastructure operation/maintenance, portfolio management, cybersecurity risk management. For the Office of Fossil Energy and Carbon Management (FECM) research, development, demonstration, and deployment (RDD&D), this includes operation and enhancement of the FECM RDD&D cybersecurity policy and program as it relates to the enterprise computing environment at field locations. Key activities include cybersecurity policy implementation, governance and oversight activities, incident detection and response through continuous monitoring and diagnostics, and meeting Departmental requirements for the Identity Control and Access Management initiative.

Protective Forces and Physical Security Systems funding reflects the physical security costs (contractor and federal oversight) of maintaining round-the-clock physical security at NETL's three research campuses.

[1] Does not include FECM RDD&D-funded Headquarter cybersecurity (FY 2023 Enacted, $1.8 million; FY 2024 Annualized CR, $1.8 million, FY 2025 Request, $2.8 million)

DEPARTMENT OF ENERGY
Funding by Site
TAS_0213 - Fossil Energy and Carbon Management - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Ames Laboratory			
Hydrogen with Carbon Management	421	421	376
Carbon Management Technologies	421	421	376
Advanced Remediation Technologies	95	95	26
Resource Sustainability	95	95	26
Total Ames Laboratory	**516**	**516**	**402**
Argonne National Laboratory			
Hydrogen with Carbon Management	1,325	1,325	1,185
Carbon Transport and Storage	59	59	52
Carbon Dioxide Removal	235	235	302
Carbon Utilization	583	583	0
Carbon Dioxide Conversion	0	0	699
Carbon Capture	56	56	0
Point-Source Carbon Capture	0	0	40
Carbon Management Technologies	2,258	2,258	2,278
Methane Mitigation Technologies	1,586	1,586	2,003
Natural Gas Decarbonization and Hydrogen Technologies	227	227	213
Mineral Sustainability	78	78	113
Resource Sustainability	1,891	1,891	2,329
Program Direction - Fossil Energy	11	11	16
Total Argonne National Laboratory	**4,160**	**4,160**	**4,623**
Brookhaven National Laboratory			
Carbon Dioxide Removal	986	986	1,270
Carbon Utilization	6	6	0
Carbon Dioxide Conversion	0	0	7
Carbon Management Technologies	992	992	1,277
Mineral Sustainability	1,246	1,246	1,805
Resource Sustainability	1,246	1,246	1,805
Total Brookhaven National Laboratory	**2,238**	**2,238**	**3,082**
Chicago Operations Office			
Hydrogen with Carbon Management	1	1	1
Carbon Management Technologies	1	1	1
Natural Gas Decarbonization and Hydrogen Technologies	70	70	66
Resource Sustainability	70	70	66
Total Chicago Operations Office	**71**	**71**	**67**
Idaho National Laboratory			
Carbon Transport and Storage	89	89	79
Carbon Utilization	413	413	0

DEPARTMENT OF ENERGY
Funding by Site
TAS_0213 - Fossil Energy and Carbon Management - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Carbon Dioxide Conversion	0	0	495
Carbon Capture	84	84	0
Point-Source Carbon Capture	0	0	60
Carbon Management Technologies	586	586	634
Mineral Sustainability	44	44	63
Resource Sustainability	44	44	63
Energy Asset Transformation (formerly Repurposing Fossil Energy Assets)	145	145	145
Total Idaho National Laboratory	**775**	**775**	**842**
Lawrence Berkeley National Laboratory			
Hydrogen with Carbon Management	958	958	857
Carbon Dioxide Removal	3,022	3,022	3,894
Carbon Utilization	579	579	0
Carbon Dioxide Conversion	0	0	695
Carbon Capture	948	948	0
Point-Source Carbon Capture	0	0	675
Carbon Management Technologies	5,507	5,507	6,121
Advanced Remediation Technologies	503	503	137
Methane Mitigation Technologies	1,030	1,030	1,301
Natural Gas Decarbonization and Hydrogen Technologies	110	110	103
Mineral Sustainability	1,949	1,949	2,823
Resource Sustainability	3,592	3,592	4,364
Total Lawrence Berkeley National Laboratory	**9,099**	**9,099**	**10,485**
Lawrence Livermore National Laboratory			
Carbon Transport and Storage	1,021	1,021	903
Carbon Dioxide Removal	6,993	6,993	9,011
Carbon Capture	3,649	3,649	0
Point-Source Carbon Capture	0	0	2,601
Carbon Management Technologies	11,663	11,663	12,515
Methane Mitigation Technologies	1,030	1,030	1,301
Natural Gas Decarbonization and Hydrogen Technologies	234	234	219
Resource Sustainability	1,264	1,264	1,520
Total Lawrence Livermore National Laboratory	**12,927**	**12,927**	**14,035**
Los Alamos National Laboratory			
Hydrogen with Carbon Management	707	707	633
Carbon Transport and Storage	1,249	1,249	1,103
Carbon Utilization	421	421	0
Carbon Dioxide Conversion	0	0	506
Carbon Capture	1,122	1,122	0
Point-Source Carbon Capture	0	0	800
Carbon Management Technologies	3,499	3,499	3,042
Advanced Remediation Technologies	74	74	20
Methane Mitigation Technologies	1,030	1,030	1,301

DEPARTMENT OF ENERGY
Funding by Site
TAS_0213 - Fossil Energy and Carbon Management - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Mineral Sustainability	1,867	1,867	2,704
Resource Sustainability	2,971	2,971	4,025
Energy Asset Transformation (formerly Repurposing Fossil Energy Assets)	967	967	967
NETL Research and Operations - Fossil Energy	455	455	497
Total Los Alamos National Laboratory	**7,892**	**7,892**	**8,531**
National Energy Technology Lab			
Hydrogen with Carbon Management	78,495	78,495	70,234
Carbon Transport and Storage	104,047	104,047	91,940
Carbon Dioxide Removal	18,118	18,118	23,348
Carbon Utilization	6,008	6,008	0
Carbon Dioxide Conversion	0	0	7,210
Carbon Capture	117,278	117,278	0
Point-Source Carbon Capture	0	0	83,571
Carbon Management Technologies	323,946	323,946	276,303
Advanced Remediation Technologies	50,646	50,646	13,813
Methane Mitigation Technologies	52,150	52,150	65,884
Natural Gas Decarbonization and Hydrogen Technologies	23,760	23,760	22,299
Mineral Sustainability	34,246	34,246	49,593
Resource Sustainability	160,802	160,802	151,589
Energy Asset Transformation (formerly Repurposing Fossil Energy Assets)	996	996	996
University Training and Research (previous 2 controls)	11,940	11,940	17,450
Program Direction - Fossil Energy	28,560	28,560	39,576
NETL Infrastructure - Fossil Energy	49,319	49,319	45,732
NETL Research and Operations - Fossil Energy	83,826	83,826	91,534
NETL Interagency Working Group	2,974	2,974	0
Total National Energy Technology Lab	**662,363**	**662,363**	**623,180**
National Renewable Energy Laboratory			
Hydrogen with Carbon Management	852	852	762
Carbon Dioxide Removal	983	983	1,267
Carbon Utilization	2,937	2,937	0
Carbon Dioxide Conversion	0	0	3,524
Carbon Capture	947	947	0
Point-Source Carbon Capture	0	0	675
Carbon Management Technologies	5,719	5,719	6,228
Natural Gas Decarbonization and Hydrogen Technologies	112	112	105
Resource Sustainability	112	112	105
Total National Renewable Energy Laboratory	**5,831**	**5,831**	**6,333**
Nevada National Security Site			
NETL Infrastructure - Fossil Energy	10	10	10
Total Nevada National Security Site	**10**	**10**	**10**

DEPARTMENT OF ENERGY
Funding by Site
TAS_0213 - Fossil Energy and Carbon Management - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Oak Ridge Institute for Science & Education			
Hydrogen with Carbon Management	1,433	1,433	1,282
Carbon Transport and Storage	96	96	84
Carbon Dioxide Removal	646	646	833
Carbon Utilization	333	333	0
Carbon Dioxide Conversion	0	0	400
Carbon Capture	151	151	0
Point-Source Carbon Capture	0	0	108
Carbon Management Technologies	2,659	2,659	2,707
Advanced Remediation Technologies	414	414	113
Methane Mitigation Technologies	483	483	610
Natural Gas Decarbonization and Hydrogen Technologies	9	9	9
Mineral Sustainability	435	435	630
Resource Sustainability	1,341	1,341	1,362
Special Recruitment Programs	886	886	886
Program Direction - Fossil Energy	149	149	207
NETL Interagency Working Group	26	26	0
Total Oak Ridge Institute for Science & Education	**5,061**	**5,061**	**5,162**
Oak Ridge National Laboratory			
Hydrogen with Carbon Management	3,408	3,408	3,049
Carbon Utilization	2,520	2,520	0
Carbon Dioxide Conversion	0	0	3,024
Carbon Capture	1,339	1,339	0
Point-Source Carbon Capture	0	0	954
Carbon Management Technologies	7,267	7,267	7,027
Methane Mitigation Technologies	493	493	623
Mineral Sustainability	8,232	8,232	11,921
Resource Sustainability	8,725	8,725	12,544
Total Oak Ridge National Laboratory	**15,992**	**15,992**	**19,571**
Pacific Northwest National Laboratory			
Hydrogen with Carbon Management	1,630	1,630	1,458
Carbon Transport and Storage	624	624	551
Carbon Dioxide Removal	508	508	654
Carbon Utilization	894	894	0
Carbon Dioxide Conversion	0	0	1,073
Carbon Capture	1,403	1,403	0
Point-Source Carbon Capture	0	0	999
Carbon Management Technologies	5,059	5,059	4,735
Methane Mitigation Technologies	740	740	935
Natural Gas Decarbonization and Hydrogen Technologies	234	234	219
Mineral Sustainability	1,867	1,867	2,704
Resource Sustainability	2,841	2,841	3,858

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Program Direction - Fossil Energy	261	261	362
Total Pacific Northwest National Laboratory	**8,161**	**8,161**	**8,955**
Sandia National Laboratories			
Hydrogen with Carbon Management	1,310	1,310	1,172
Carbon Dioxide Removal	1,296	1,296	1,670
Carbon Utilization	272	272	0
Carbon Dioxide Conversion	0	0	327
Carbon Management Technologies	2,878	2,878	3,169
Methane Mitigation Technologies	1,030	1,030	1,301
Natural Gas Decarbonization and Hydrogen Technologies	1,169	1,169	1,097
Mineral Sustainability	1,510	1,510	2,186
Resource Sustainability	3,709	3,709	4,584
Total Sandia National Laboratories	**6,587**	**6,587**	**7,753**
Savannah River National Laboratory			
Carbon Capture	168	168	0
Point-Source Carbon Capture	0	0	120
Carbon Management Technologies	168	168	120
Total Savannah River National Laboratory	**168**	**168**	**120**
SLAC National Accelerator Laboratory			
Carbon Dioxide Removal	235	235	302
Carbon Management Technologies	235	235	302
Mineral Sustainability	778	778	1,127
Resource Sustainability	778	778	1,127
Total SLAC National Accelerator Laboratory	**1,013**	**1,013**	**1,429**
Washington Headquarters			
Hydrogen with Carbon Management	4,460	4,460	3,991
Carbon Transport and Storage	2,815	2,815	2,488
Carbon Dioxide Removal	36,978	36,978	47,649
Carbon Utilization	35,034	35,034	0
Carbon Dioxide Conversion	0	0	42,040
Carbon Capture	7,855	7,855	0
Point-Source Carbon Capture	0	0	5,597
Carbon Management - Policy, Analysis and Engagement (previous 2 controls)	0	0	7,000
Carbon Management Technologies	87,142	87,142	108,765
Advanced Remediation Technologies	3,268	3,268	891
Methane Mitigation Technologies	428	428	541
Natural Gas Decarbonization and Hydrogen Technologies	75	75	70
Mineral Sustainability	1,748	1,748	2,531
Resource Sustainability - Analysis and Engagement	0	0	2,000
Resource Sustainability	5,519	5,519	6,033

DEPARTMENT OF ENERGY
Funding by Site
TAS_0213 - Fossil Energy and Carbon Management - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Energy Asset Transformation (formerly Repurposing Fossil Energy Assets)	3,892	3,892	3,892
University Training and Research (previous 2 controls)	1,060	1,060	1,550
Special Recruitment Programs	114	114	114
Program Direction - Fossil Energy	41,019	41,019	56,839
NETL Infrastructure - Fossil Energy	5,671	5,671	5,258
NETL Research and Operations - Fossil Energy	2,719	2,719	2,969
Total Washington Headquarters	**147,136**	**147,136**	**185,420**
Total Funding by Site for TAS_0213 - Fossil Energy and Carbon Management	**890,000**	**890,000**	**900,000**

Critical and Emerging Technologies

Critical and Emerging Technologies

Office of Critical and Emerging Technology
Program Direction

FY 2023 Enacted	FY 2024 Request	FY 2025 Request
$0	**$0**	**$5,000**

Overview

On October 30, 2023, the White House issued an Executive Order 14110 on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence that tasked DOE to establish an office to coordinate development of AI and other critical and emerging technologies across Department of Energy (DOE) programs and its 17 national laboratories. In response, DOE has established the Office of Critical and Emerging Technology (CET). The office has primary responsibility for coordinating efforts to ensure a unified Departmental voice on issues related to critical and emerging technologies, including artificial intelligence (AI) and machine learning (ML), quantum information science and technology, semiconductors and microelectronics, and biotechnology (including biomanufacturing, synthetic biology, genomics, pandemic surveillance and detection).

DOE houses world-class expertise, facilities, and capabilities in critical and emerging technology; however, these competencies are spread across numerous program offices and laboratories, including but not limited to: the Office of Science; the National Nuclear Security Administration; the Office of Electricity; the Office of Energy Efficiency and Renewable Energy; the Office of Fossil Energy and Carbon Management; the Office of Nuclear Energy; the Office of Cybersecurity, Energy Security, and Emergency Response; the Advanced Research Projects Agency-Energy (ARPA-E), International Affairs; the Office of the Chief Information Officer; the Office of Intelligence and Counterintelligence, the Office of Technology Transitions, and the 17 national laboratories.

At first, CET will lead coordination across these diverse elements to coordinate implementation of EO 14110, E.O. 14081 (Advancing Biotechnology and Biomanufacturing Innovation), and E.O. 14080 (Implementation of the CHIPS Act), working with other federal agencies, the Executive Office of the President (EOP), the National Security Council, national and international organizations and institutions, industry, and other external stakeholders. In the context of EO 14110, this coordination will be especially important to drive a coherent approach across DOE, including developing partnerships to advance foundation models for science, energy, and security; working across DOE and with interagency partners to make testbeds available for the development of safe and trustworthy AI; building and expanding our AI workforce; conduct red-teaming activities to manage risks posed by AI; and assessing model capabilities. In addition, CET houses DOE's Chief AI Officer, who will be responsible for leading the Department's efforts to advance AI governance and vision.

Activities include but are not limited to: coordinating across program elements to track and troubleshoot progress in executing the aforementioned executive orders; leveraging expertise from program offices and national laboratories to develop coordinated responses to White House data calls and policy processes; engaging external stakeholders and building strategic partnerships; supporting DOE leadership on engagements related to critical and emerging technology; and organizing meetings, workshops, and conferences to ensure the Department is mobilizing its collective resources to support the Nation's mission.

The office will report to the Undersecretary for Science and Innovation because that office oversees the bulk of the Department's activities in the development and use of critical and emerging technologies across the applied energy offices and in the Office of Science, which together run 13 of DOE's 17 national labs. The office will serve as the executive secretariat for the AI Advancement Council, which was chartered by the Deputy Secretary and is co-chaired by the Under Secretary for Science and Innovation and the Under Secretary for Nuclear Security to coordinate efforts across the entirety of the DOE. In addition, the office will organize the Department on other technology areas including biotechnology, microelectronics, and quantum information science and technology.

The office will be staffed by an interdisciplinary team of experts with the requisite technical and communication skills to formulate a coherent vision and strategy to ensure that DOE's capabilities in critical and emerging technology are leveraged across the Department, the interagency, and external stakeholders. Staff will include leads on AI, biotechnology, microelectronics, quantum, stakeholder engagement, each supported with detailees from programs and/or the national laboratories. The Request also includes support for contractors and fellows, who will perform activities such as data processing and analysis, coordination of engagement plans or reports to advance these areas in response to directives, and strategic planning. The Request includes travel necessary to draw on national laboratory capabilities, support for internal and external workshops and other stakeholder engagements, support for DOE leadership engagements on critical and emerging technologies, and activities to advance strategic technology partnerships with industry and other stakeholders, including with allies and partners.

Program Direction
Funding

	FY 2023 Enacted	FY 2024 Request	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Washington Headquarters					
Salaries and Benefits	0	0	1,840	+1840	N/A
Travel	0	0	80	+80	N/A
Support Services	0	0	2,430	+2,430	N/A
Other Related Expenses	0	0	650	+650	N/A
Total, Program Direction	0	0	5,000	+5,000	N/A
Federal FTEs	0	0	8	+8	
Support Services					
Other Support Services	0	0	2,440	+2,440	N/A
Total, Support Services	0	0	2,440	+2,440	N/A
Other Related Expenses					
Working Capital Fund	0	0	360	+360	N/A
Training	0	0	100	+100	N/A
Energy IT Services	0	0	190	+190	N/A
Total, Other Related Expenses	0	0	650	+650	N/A

CET Future-Years Spending

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2026 - FY 2029. The outyear funding levels use the growth rates in outyear account totals published in the FY 2025 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Future priorities will include coordination of activities that capture emergent opportunities and manage risks posed by expected advances in these technologies. These can include support for new analyses or for the development of new or expanded partnerships to advance the state of the art.

Future Years

Funding ($K)

	FY 2025 Request	FY 2026 Estimate	FY 2027 Estimate	FY 2028 Estimate	FY 2029 Estimate
Total, Program Direction	5,000	5,115	5,233	5,353	5,476
Federal FTEs	8	8	8	8	8

Office of Critical and Emerging Technology

Activities and Explanation of Changes

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs. FY 2023 Enacted
Program Direction $0	**$5,000,000**	**$5,000,000**
Salaries and Benefits $0	**$1,840,000**	**$1,840,000**
	• Funding for salaries and benefits for 8 FTEs.	• Funding provides for salaries/benefits, overtime, lump sum leave, award allocations and performance awards for 8 FTEs.
Travel $0	**$80,000**	**$80,000**
	• Travel to support 8 FTEs, as well as detailees and fellows	• Funding supports staff travel, including travel to accompany the Secretary and DOE senior leadership as well as regular travel to engage with the national laboratories. This also includes increased travel necessary to draw on national laboratory capabilities, support workshops, other external engagements, and support strategic technology cooperation with allies and partners.
Support Services $0	**$2,430,000**	**$2,430,000**
	• Supports ability to obtain research tools, annual subscriptions, other specialized contractor support used for analysis activities. Analysis activities include data processing and analysis to develop reports and facilitate projects in aid of Executive Order directives, as well as strategic planning documents.	• Support services needed for the office to operate effectively.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs. FY 2023 Enacted
	The Request also provides contractor support for subject matter experts and administrative support.	
Other Related Expenses $0	**$650,000**	**$650,000**
	• Provides funding to support business costs associated with the Department's Working Capital Fund; IT equipment and support for 8 FTEs.	• Funding for necessary overhead expenses associated with 8 FTEs.

DEPARTMENT OF ENERGY
Funding by Site
TAS_NEW_CET - Critical and Emerging Technologies - FY 2025
($K)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Washington Headquarters			
Critical and Emerging Technologies Program	0	0	5,000
Total Washington Headquarters	**0**	**0**	**5,000**
Total Funding by Site for TAS_NEW_CET - Critical and Emerging Technologies	**0**	**0**	**5,000**

GENERAL PROVISIONS—DEPARTMENT OF ENERGY

Sec. 301.

(a) No appropriation, funds, or authority made available by this title for the Department of Energy shall be used to initiate or resume any program, project, or activity or to prepare or initiate Requests For Proposals or similar arrangements (including Requests for Quotations, Requests for Information, and Funding Opportunity Announcements) for a program, project, or activity if the program, project, or activity has not been funded by Congress.

(b)

(1) Unless the Secretary of Energy notifies the Committees on Appropriations of both Houses of Congress at least 3 full business days in advance, none of the funds made available in this title may be used to—

(A) make a grant allocation or discretionary grant award totaling $1,000,000 or more;

(B) make a discretionary contract award or Other Transaction Agreement totaling $1,000,000 or more, including a contract covered by the Federal Acquisition Regulation;

(C) issue a letter of intent to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B); or

(D) announce publicly the intention to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B).

(2) The Secretary of Energy shall submit to the Committees on Appropriations of both Houses of Congress within 15 days of the conclusion of each quarter a report detailing each grant allocation or discretionary grant award totaling less than $1,000,000 provided during the previous quarter.

(3) The notification required by paragraph (1) and the report required by paragraph (2) shall include the recipient of the award, the amount of the award, the fiscal year for which the funds for the award were appropriated, the account and program, project, or activity from which the funds are being drawn, the title of the award, and a brief description of the activity for which the award is made.

(c) The Department of Energy may not, with respect to any program, project, or activity that uses budget authority made available in this title under the heading "Department of Energy--Energy Programs", enter into a multiyear contract, award a multiyear grant, or enter into a multiyear cooperative agreement unless—

(1) the contract, grant, or cooperative agreement is funded for the full period of performance as anticipated at the time of award; or

(2) the contract, grant, or cooperative agreement includes a clause conditioning the Federal Government's obligation on the availability of future year budget authority and the Secretary notifies the Committees on Appropriations of both Houses of Congress at least 3 days in advance.

(d) Except as provided in subsections (e), (f), and (g), the amounts made available by this title shall be expended as authorized by law for the programs, projects, and activities specified in the "Final Bill" column in the "Department of Energy" table included under the heading "Title III--Department of Energy" in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act).

(e) The amounts made available by this title may be reprogrammed for any program, project, or activity, and the Department shall notify the Committees on Appropriations of both Houses of Congress at least 30 days prior to the use of any proposed reprogramming that would cause any program, project, or activity funding level to increase or decrease by more than $5,000,000 or 10 percent, whichever is less, during the time period covered by this Act.

(f) None of the funds provided in this title shall be available for obligation or expenditure through a reprogramming of funds that—

(1) creates, initiates, or eliminates a program, project, or activity;

(2) increases funds or personnel for any program, project, or activity for which funds are denied or restricted by this Act; or

(3) reduces funds that are directed to be used for a specific program, project, or activity by this Act.

(g)

(1) The Secretary of Energy may waive any requirement or restriction in this section that applies to the use of funds made available for the Department of Energy if compliance with such requirement or restriction would pose a substantial risk to human health, the environment, welfare, or national security.

(2) The Secretary of Energy shall notify the Committees on Appropriations of both Houses of Congress of any waiver under paragraph (1) as soon as practicable, but not later than 3 days after the date of the activity to which a requirement or restriction would otherwise have applied. Such notice shall include an explanation of the substantial risk under paragraph (1) that permitted such waiver.

(h) The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

(i) Subsections (d), (e), and (f) shall not apply to funds made available in this Act for applied energy research, development, demonstration, and commercial application that are utilized pursuant to section 1001 of the Energy Policy Act of 2005 (42 U.S.C. 16391). Administration and selection of awards pursuant to such section will be in coordination with the offices that oversee the appropriations accounts to which the relevant funding was originally appropriated.

Sec. 302. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 3094) during fiscal year 2024 until the enactment of the Intelligence Authorization Act for fiscal year 2023.

Sec. 303. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of Enterprise Assessments to ensure the project is in compliance with nuclear safety requirements.

Sec. 304. None of the funds made available in this title may be used to approve critical decision-2 or critical decision-3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

Sec. 305. Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), upon a determination by the President in this fiscal year that a regional supply shortage of refined petroleum product of significant scope and duration exists, that a severe increase in the price of refined petroleum product will likely result from such shortage, and that a draw down and sale of refined petroleum product would assist directly and significantly in reducing the adverse impact of such shortage, the Secretary of Energy may draw down and sell refined petroleum product from the Strategic Petroleum Reserve. Proceeds from a sale under this section shall be deposited into the SPR Petroleum Account established in section 167 of the Energy Policy and Conservation Act (42 U.S.C. 6247), and such amounts shall be available for obligation, without fiscal year limitation, consistent with that section.

Sec. 306. No funds shall be transferred directly from "Department of Energy--Power Marketing Administration--Colorado River Basins Power Marketing Fund, Western Area Power Administration" to the general fund of the Treasury in the current fiscal year.

Sec. 307. None of the funds made available in this title may be used to support a grant allocation award, discretionary grant award, or cooperative agreement that exceeds $100,000,000 in Federal funding unless the project is carried out through internal independent project management procedures.

Sec. 308. From the unobligated balances of amounts made available to the Department of Energy to carry out activities to improve the resilience of the Puerto Rican electric grid under Public Law 117-328, thirty-five hundredths of one percent of the amounts made available under that section shall be transferred no later than September 30, 2025, to the Office of Inspector General of the Department of Energy to carry out the provisions of the Inspector General Act of 1978, to remain available until expended: Provided, That any amounts so transferred that were previously designated by the Congress as an emergency requirement pursuant to the Balanced Budget and Emergency Deficit Control Act of 1985 or a concurrent resolution on the budget are designated by the Congress as an emergency requirement pursuant to section 251(b)(2)(A)(i) of the Balanced Budget and Emergency Deficit Control Act of 1985: Provided further, That such amounts shall be available only if the President designates such amount as an emergency requirement pursuant to section 251(b)(2)(A)(i).

TITLE V—GENERAL PROVISIONS

SEC. 501. None of the funds appropriated by this Act may be used in any way, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913. SEC.

502. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations).

SEC. 503. (a) None of the funds made available in this Act may be used to maintain or establish a computer network unless such network blocks the viewing, downloading, and exchanging of pornography.

(b) Nothing in subsection (a) shall limit the use of funds necessary for any Federal, State, Tribal, or local law enforcement agency or any other entity carrying out criminal investigations, prosecution, or adjudication activities.