Fossil Energy and Carbon Management (FECM)
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
825,000	890,000	905,475	+$15,475	+1.7%

Overview

The Office of Fossil Energy and Carbon Management (FECM) conducts research and development (R&D) that focuses on technologies to reduce carbon emissions and other environmental impacts from fossil fuel 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 (CO_2) into value-added products and technologies on carbon dioxide removal (CDR) to remove atmospheric and legacy emissions of CO_2.

To meet these challenges, the Budget focuses funding on technology priority areas of point-source carbon capture, carbon transport and storage, carbon conversion, hydrogen (H_2) with carbon management, methane emissions reduction, critical mineral production, and CDR. FECM recognizes that broad decarbonization is essential to meeting climate goals – 100 percent carbon pollution free electricity by 2035 and net-zero greenhouse gas (GHG) 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 Energy Communities[1], retaining and creating good-paying jobs and supporting domestic energy and industrial production and manufacturing across our nation.

FECM prioritizes the meaningful engagement and participation of communities, with special focus on disadvantaged communities and emphasis on improving the economic and environmental conditions of those communities, retaining and creating good-paying jobs and supporting domestic energy and industrial production and manufacturing across our nation. These priorities are at the center of funding decisions and partnership development.

The FY 2024 Budget Request for FECM will extend the impact of the Department of Energy's (DOE) 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 research, development, demonstration and deployment (RDD&D) portfolio. This request also includes funding for the basic operating costs of FECM and investment at the National Energy Technology Laboratory (NETL).

FECM's FY 2024 priorities follow:

- **Facilitate the Future Deployment of Point Source Carbon Capture:** R&D for point-source carbon capture and storage (CCS) in the power and industrial sectors to enable wider, strategic commercial deployment 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 coal, oil, and gas.
- **Advance CDR and Carbon Dioxide Conversion:** Advance direct air capture (DAC), biomass with carbon removal and storage, and mineral carbonation technologies and develop novel approaches to recycle captured carbon emissions.
- **Advance Critical Minerals (CM), Rare Earth Elements (REE), and Mine Remediation:** Improve REE separation/recovery technologies to manufacture products from CO_2 and 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, and data analysis to create learning algorithms within large dataset to help discover new materials, optimize processes, and run autonomous systems.

[1] https://energycommunities.gov/

- **Accelerate Carbon-Neutral Hydrogen:** Develop technologies that leverage the natural gas infrastructure for hydrogen production, transport, storage, and use, coupled to carbon management.
- **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.

Highlights and Major Changes in the FY 2024 Budget Request
Recognizing recent developments in the United States (U.S.) and global energy landscape, the FY 2024 FECM Budget Request is adjusted relative to the FY 2023 Enacted Level:

- Next-generation decarbonized technologies can achieve a net-zero carbon economy. This requires a strategic investment and prioritization of carbon management activities, including point-source carbon capture, DAC, carbon conversion, and CO_2 storage.
- Recent analyses[2] are converging on the importance of zero-carbon and carbon-neutral hydrogen to achieve net-zero emissions, economy wide, by 2050. In partnership with the Office of Energy Efficiency and Renewable Energy's Hydrogen and Fuel Cell Technologies Office, DOE is investing in a wide array of hydrogen technologies to expedite the hydrogen energy economy.
- Methane is one of the most potent GHGs. It is critical that we reduce unabated methane emissions. To that end, FECM will invest in approaches to identify and mitigate methane emissions from the oil, gas (e.g., fugitive methane and flaring), and coal (methane emissions from active and abandoned mines) industries toward the production of useful chemicals such as hydrogen and ammonia.
- The U.S. must increase domestic production and processing capacity to build CM and REE supply chains here at home. FECM will focus on the characterization of CM and REE as well as the sustainable production and processing of CM using unconventional resources such as coal waste and byproducts from the industry. This work will help support communities and regions of the U.S. that are heavily dependent on this industry today.

For comparability, all discussions of funding changes that follow assume the FY 2024 proposed budget structure. Funding crosswalks in the Budget Structure Crosswalks chapter of this narrative provide details of the proposed changes.

Office of Carbon Management Technologies ($464M)
The Office of Carbon Management (OCM) supports RDD&D aimed at achieving a net-zero carbon economy by focusing on the entire carbon management value chain of capture, removal, conversion, transport and geologic storage. OCM addresses emissions associated with the power and industrial sectors, as well as the accumulated emissions in the atmosphere, and seeks to permanently store CO_2 in geologic formations and/or convert CO_2 to reduce negative climate impacts.

Descriptions of major funding and programmatic changes and highlights within the Carbon Management Technologies (CMT) program for the FY 2024 Budget Request are as follows:

- **Hydrogen with Carbon Management ($85M)**
  The Hydrogen with Carbon Management (HCM) subprogram invests in research, development and demonstration (RD&D) to evaluate carbon-based clean hydrogen (i.e., coupled to CCS) as a fuel and support development of technologies to use hydrogen from any source. The subprogram's efforts are an integral part of DOE's recently launched Hydrogen Shot™, with a goal of reducing clean H_2 costs by 80 percent to $1 per 1 kilogram within 1 decade (1-1-1) while expanding employment of the U.S. energy workforce. Seeking a cost-competitive decarbonized alternative to unabated fossil fuels, the subprogram has an R&D portfolio consisting of a new generation of carbon neutral or net-negative GHG emissions technologies. Gasification, reversible solid oxide fuel cells (R-SOFCs), technologies in H_2 turbines, and advanced materials, sensors and controls all support this goal.

  The FY 2024 Budget Request for HCM of $85 million for these activities will provide research with a platform for developing the advanced systems of the future, while reducing emissions. In FY 2024, the subprogram will not fund RDD&D specific to traditional fossil power generation, but rather, will narrow the focus to work on hydrogen-fueled

[2] https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf

turbines, fuel cells, CCS-relevant technologies, and production of clean hydrogen through gasification. Improvements to these technologies are also applicable to other energy systems. These improvements to new and existing plants will also make them less carbon intensive and allow these assets to provide continued low-cost baseload power and resilient flexible grid services. This subprogram aligns with the Administration's priority to reduce the environmental impact of the power sectors, especially regarding disadvantaged communities. As such, the subprogram is working to address local air quality issues associated with nitrogen oxide emissions that could be produced as a byproduct of hydrogen combustion – and working to ensure that impacts to disadvantaged communities are robustly considered when siting new hydrogen infrastructure.

- **Carbon Transport and Storage ($110M)**
  The Carbon Transport and Storage (CTS) subprogram is uniquely positioned to support the U.S. as it helps the carbon transport and storage industry achieve the scale necessary to decarbonize the economy while considering associated economic, environmental and social benefits and impacts. This subprogram is making key investments in advanced technology R&D, and large-scale transport scenario analysis will facilitate the deployment of commercial-scale storage facilities, and regional transport and storage hubs that achieve economies of scale reducing costs and enabling deeper emissions reductions. Critical components that will help catalyze deployment at-scale include, but are not limited to, strategies to develop the infrastructure for carbon storage, R&D to improve technology performance and reduce costs, educational partnerships to grow the workforce, technology transfer, and technical assistance to stakeholders.

  The FY 2024 Budget Request provides $110 million for the CTS subprogram activities that address the performance challenges of operating and monitoring commercial scale CO_2 storage sites. The activities supported by the CTS subprogram will aim to improve storage and operational efficiency, improve understanding of overall costs, and advance de-risking strategies to reduce those costs. Achieving each of these elements through site characterization and developing advanced monitoring and modeling tools is critical for enabling a CCS industry that is safe, economically viable, and environmentally benign.

- **Carbon Dioxide Removal ($70M) and Carbon Dioxide Conversion ($50M)**
  The Carbon Dioxide Removal subprogram advances a diverse set of technology pathways in service of facilitating gigatonne-scale removal by mid-century. It emphasizes rigorous analysis of life cycle impacts and consideration of project design to ensure clear benefits to affected communities. The subprogram invests in R&D of CDR technologies, such as DAC and direct ocean capture (DOC) with permanent storage; biomass with carbon removal and storage; and mineralization to remove accumulated emissions from the atmosphere to counterbalance emissions from hard-to-abate sectors in order to achieve net-zero GHG emissions by mid-century.

  The Carbon Dioxide Conversion subprogram invests in R&D to advance technologies that recycle CO_2 into value-added products, such as building materials, fuels, and chemicals, through mineralization, catalytic conversion, and biological approaches. Through these investments, the Carbon Dioxide Conversion subprogram can help the U.S. achieve the goals of a net-zero carbon economy by 2050, while simultaneously developing technologies that help traditional industries build new business models for the future, while creating high-wage jobs and reducing GHG and other emissions in communities dependent on and impacted by energy and industrial production.

  In FY 2024, the Budget Request provides $70 million for CDR and $50 million in the Carbon Dioxide Conversion subprograms. CDR funding will support continued activities to advance novel DAC and DOC materials and processes to help optimize and reduce the cost, front-end engineering and design (FEED) studies for biomass with carbon removal and storage, and novel approaches that can leverage industrial waste minerals and naturally occurring minerals to capture atmospheric CO_2.

  Technologies for the Carbon Dioxide Conversion subprogram have the potential to develop additional markets for carbon-based products. Areas of research include, but are not limited to, new projects focused on the catalytic conversion of carbon waste streams to higher value products such as fuels, chemicals, polymers, and nutraceuticals; mineralization to building products; generation of solid carbon products; and algal systems designed to integrate captured CO_2. Specific focus on catalysts made from low-cost materials and improved reactor designs will be pursued to lower the energy penalty and capital cost of the conversion process.

- **Point-Source Carbon Capture ($144M)**
  The Point-Source Carbon Capture RDD&D subprogram focuses on committed emissions associated with infrastructure that are expected to persist through mid-century. Natural gas power generation and carbon dioxide-emitting industrial sectors, such as cement, steel, pulp and paper, and hydrogen production are particular priorities. The FY 2024 Budget Request provides $144 million in the Point-Source Carbon Capture subprogram for pre- and post-combustion capture R&D on transformational gas separation technologies that can help achieve decarbonization goals. This includes technologies such as non-aqueous solvents, sorbents, membranes, and cryogenic processes. R&D activities will investigate approaches that can be flexible in operation and result in higher rates of CO_2 capture. Additionally, the Point-Source Carbon Capture subprogram will leverage its extensive experience on carbon capture technology development for power sector applications to increase focus on hard to decarbonize industrial applications, specifically, cement, steel, pulp and paper, and hydrogen production. In FY 2024, R&D will focus on optimization of technologies for these applications to reduce cost and improve performance. Funding will also maintain progress on R&D to decarbonize power generation.

- **Carbon Management – Policy, Analysis, and Engagement ($5M)**
  The Office of Carbon Management conducts systems, economic, and environmental analysis that is primarily focused on: cost and performance for carbon management technologies; the role of carbon management in energy markets; life cycle analysis; energy markets assessments; integration of carbon management technologies with the U.S. power grid; and effects of carbon management deployment in local communities.

  A variety of analysis methodologies are used in combination to provide a robust understanding of the cost, performance, and barriers to the deployment of carbon management technologies. Through a system of coordinated efforts and thoughtful engagement with stakeholders, realistic scenarios can be crafted using market and technology-based information. This subprogram has three activities that it funds: 1) Carbon Management – Policy and Analysis, 2) Carbon Management – Engagement, and 3) Carbon Management – Federal Partnerships. The Budget Request provides $5 million to support activities in this subprogram.

  The FY 2024 Request supports R&D of CMT through engagement with key partners within the U.S. and globally. Funding will support domestic engagement efforts as well as international collaboration with various partners through bilateral and multilateral agreements. FECM will focus on building capacity and working with interagency partners to ensure safe, effective, and efficient implementation of its programs. FECM will work with various stakeholders to build a foundation for expeditiously administering several new investments, leveraging existing programs and developing new relationships with stakeholder networks and communities.

Office of Resource Sustainability ($179M)

The Resource Sustainability Office addresses critical issues associated with reducing the environmental impacts of fossil energy production and use. This includes conducting R&D that reduces environmental impact from the extraction, development, transportation, distribution, and storage of fossil fuels and reducing emissions throughout the supply chain. Descriptions of major programmatic changes and highlights within the Resource Sustainability program for the FY 2024 Budget Request, which totals $179 million, are as follows:

- **Advanced Remediation Technologies ($13M)**
  The Advanced Remediation Technologies program will conduct R&D of novel technologies and approaches to address wellbore integrity, induced seismicity, produced water treatment, and offshore safety and spill prevention. A redesigned field program will focus on conducting research to minimize the environmental impacts associated with unconventional oil and gas production, and exploration of pathways that would result in a positive impact on climate, such as coupling production with carbon dioxide storage.

- **Methane Mitigation Technologies ($100M)**
  The Methane Mitigation Technologies program will conduct R&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, pipeline sensors, and pipeline 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 (EPA) Greenhouse Gas Inventory. The program will expand field research on methane measurement technologies and analysis methods for quantifying emissions at basin-level assessments. The program will 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 ($20M)**
  The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) subprogram will support R&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 fundamental research to enable subsurface hydrogen storage. Programmatic activities will be conducted in support and coordination with the Hydrogen and Carbon Management Division within FECM and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

- **Mineral Sustainability ($45M)**
  The Mineral Sustainability Program will advance technologies to support domestic supply chain networks required for the economically, environmentally, and geopolitically sustainable production and processing of critical minerals. This mission will be accomplished by prioritizing the use of unconventional resources such as coal waste and by-products from industry feedstocks for domestic critical minerals, rare earth elements and carbon ore-to-products production. The program will also focus on utilizing materials to be recovered 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.

- **Resource Sustainability – Analysis and Engagement ($1M)**
  Analysis and Engagement will focus on analysis and studies that support the 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 and provides evidence-based, portfolio-wide analysis for decision-makers. This includes economic and environmental analysis, modeling, market analysis, analysis of markets during volatility, studies that provide support to 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, engagement with domestic and international governments and organizations, and provide market and industry analysis to inform the Department on fossil energy resources.

Other FECM Program Activities

Energy Asset Transformation ($6M)

The Energy Asset Transformation program will help leverage and transform decommissioned and retiring energy assets, including coal power plants, coal mines, and abandoned oil and gas wells, by repurposing them for clean energy and manufacturing. This is one of the best ways to unite industry, environmental and community interests in places where employment and opportunity is on the decline. 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; and potentially even site and permitting licenses among, other benefits. As innovative clean energy and manufacturing companies fan out across the country, it increasingly makes sense for them to choose to locate in energy communities to leverage existing infrastructure. In some instances, repurposing can ensure that historic 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, repurposing allows communities to become active participants in crafting their own economic future.

The FY 2024 Budget Request of $6 million will support energy asset transformation efforts across the U.S., through both direct assistance and paper case studies. It will also continue to support place-based interagency efforts related to energy

transition and energy asset transformation, including by contributing to DOE's funding of the Rapid Response Teams associated with the Interagency Working Group on Coal and Power Plant Communities. The program will fund concept development through prizes or a competitive solicitation to repurpose the existing energy assets, with the intent of supporting transformation efforts in seeking additional support for FEED studies and other work. The program will support 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.

University Training and Research ($19M)
The request of $19 million provides funding for University Training and Research (UTR), which comprises funding for University Carbon Research (UCR), Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI).

The Transformational Coal Pilots, STEP, and Unconventional FE Technologies programs are at the end of their scheduled programming and will not require additional funding in FY 2024.

National Energy Technology Laboratory (NETL)

	($K)		
	FY 2022 Enacted	**FY 2023 Enacted**	**FY 2024 Request**
NETL Program Direction	29,400	29,900	31,550
NETL Infrastructure	75,000	55,000	55,000
NETL Research and Operation	83,000	87,000	89,000
Interagency Working Group	0	3,000	0
Subtotal, NETL	**187,400**	**174,900**	**175,550**
Special Recruitment	1,001	1,000	1,000
HQ Program Direction (includes Import/Export)	37,400	40,100	60,925
Subtotal, Remaining Programs	**38,401**	**41,100**	**61,925**

FECM is committed to supporting NETL's capabilities and competitiveness. NETL, whose primary funding source is FECM, is the only Government-Owned, Government-Operated (GOGO) Laboratory in the DOE National Laboratory system. The FY 2024 Budget Request for NETL is $175.55 million and an additional $61.45 million for HQ Program Direction and Special Recruitment – see table above for funding breakdown.

- **NETL and Headquarters (HQ) Program Direction and Special Recruitment Programs:** The Request of $92.5 million for NETL/HQ program direction and $1 million for Special Recruitment provides for the FECM organization's headquarters federal workforce and contractor support including salaries and benefits, support service contracts, travel, training, the working capital fund, and other employee costs. These staff are responsible for the oversight and administration of the FECM programs and natural gas regulatory activities. In addition, funding for NETL federal technical staff and contractor support that provide Acquisition, Finance and Legal functions is supported.
- **NETL Infrastructure:** The FY 2024 Budget Request of $55 million supports the fixed costs of maintaining NETL's lab footprint in three geographic locations: Morgantown, WV; Pittsburgh, PA; and Albany, OR. The footprint of these sites is approximately 240 acres, including 165 research laboratories. The Request provides funding for general plant projects to maintain research capabilities and combat deferred maintenance, the lease of NETL's next generation high performance computer, support for AI infrastructure to accelerate innovation, and for information technology (IT) development, modernization, and enhancement.
- **NETL Research and Operations:** The Request of $89 million supports the salaries, benefits, travel, and other employee costs for the NETL staff of scientists, engineers and technical professionals who conduct onsite research and project management activities for FECM programs. The Request also funds partnership, technology transfer, and other collaborative research activities and supports the variable operating costs of NETL's research sites.
- **Interagency Working Group:** The Interagency Working Group will be managed by the Office of State and Community Energy Programs, instead of FECM. Thus, FECM is not requesting FY 2024 funding.

Fossil Energy and Carbon Management
Funding by Congressional Control ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Carbon Management Technologies					
Hydrogen with Carbon Management	101,000	95,000	85,000	(10,000)	-10.5%
Carbon Transport and Storage	97,000	110,000	110,000	0	0%
Carbon Dioxide Removal	49,000	70,000	70,000	0	0%
Carbon Dioxide Conversion	29,000	50,000	50,000	0	0%
Point-Source Carbon Capture	99,000	135,000	144,000	9,000	6.7%
Carbon Management – Policy, Analysis, and Engagement	2,400	0	5,000	5,000	N/A
Supercritical Transformational Electric Power (STEP)	15,000	0	0	0	0
Subtotal, Carbon Management Technologies	**393,400**	**460,000**	**464,000**	**4,000**	**0.9%**
Resource Sustainability					
Advanced Remediation Technologies	55,600	55,000	13,000	(42,000)	-76.4%
Methane Mitigation Technologies	39,000	60,000	100,000	40,000	66.7%
Natural Gas Decarbonization and Hydrogen Technologies	20,000	26,000	20,000	(6,000)	-23.1%
Mineral Sustainability	53,000	54,000	45,000	(9,000)	-16.7%
Resource Sustainability – Analysis and Engagement	0	0	1,000	1,000	N/A
Subtotal, Resource Sustainability	**167,600**	**195,000**	**179,000**	**(16,000)**	**-8.2%**
Energy Asset Transformation	**5,000**	**6,000**	**6,000**	**0**	**0%**
University Training and Research	**13,000**	**13,000**	**19,000**	**6,000**	**46.2%**
Special Recruitment	**1,001**	**1,000**	**1,000**	**0**	**0%**
Program Direction	**66,800**	**70,000**	**92,475**	**22,475**	**32.1%**
NETL Infrastructure	**75,000**	**55,000**	**55,000**	**0**	**0%**
NETL Research and Operations	**83,000**	**87,000**	**89,000**	**2,000**	**2.3%**
Interagency Working Group	**0**	**3,000**	**0**	**0**	**-100%**
Congressionally Directed Projects	**20,199**	**0**	**0**	**0**	**N/A**
Total, Fossil Energy and Carbon Management	**825,000**	**890,000**	**905,475**	**+15,475**	**1.7%**
Federal FTEs	**709**	**719**	**733**	**+14**	**+1.9%**

SBIR/STTR:

- FY 2022 Enacted: SBIR $13,959; STTR: $1,963
- FY 2023 Enacted: SBIR $17,966; STTR: $2,527
- FY 2024 Request: SBIR $16,626; STTR: $2,338

Bipartisan Infrastructure Law (BIL) Investments

FECM 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 FECM will manage that are appropriated to other organizations are discussed below.

($K)

Fossil Energy and Carbon Management	FY 2022 BIL Funding	FY 2023 BIL Funding	FY 2024 BIL Funding	Managing Organization
Regional Direct Air Capture Hubs	700,000	700,000	700,000	OCED
Carbon Storage Validation and Testing	500,000	500,000	500,000	FECM
Carbon Dioxide Transportation Infrastructure Finance and Innovation (CIFIA)	3,000	2,097,000	0	LPO
Critical Material Innovation, Efficiency, and Alternatives Activities	230,000	100,000	135,000	FECM
Critical Material Supply Chain Research Facility	40,000	35,000	0	FECM
Rare Earth Elements Demonstration Facility	140,000	0	0	MESC
Rare Earth Mineral Security Activities	23,000	24,200	25,400	FECM
Carbon Capture Technology Program	20,000	20,000	20,000	FECM
Carbon Utilization Program	41,000	65,250	66,563	FECM
Commercial Direct Air Capture Technology Prize Competitions	100,000	0	0	FECM
Precommercial Direct Air Capture Technology Prize Competitions	15,000	0	0	FECM
Orphaned, Abandoned, or Idled Wells on Federal Land Activities	30,000	0	0	FECM
Total, Fossil Energy and Carbon Management	**1,842,000**	**3,541,450**	**1,446,963**	

- **In consultation with other offices:**
  - **Regional Direct Air Capture Hubs (with the Office of Clean Energy Demonstrations (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 the Loan Programs Office)** – The goal of this investment is to provide flexible, low-interest loans for carbon dioxide 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 the Office of Manufacturing and Energy Supply Chains)** – 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 rare earth element; (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. OCED will manage FECM's REE demonstration facility.

- **Managed by FECM:**
  - **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 carbon sequestration projects and associated carbon dioxide 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 carbon dioxide 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.
- **Commercial Direct Air Capture Technology Prize Competitions** – The goal of this investment is to support large-scale DAC 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 Direct Air Capture Technology Prize Competitions** – The goal of this investment is to advance research, development, demonstration, and commercial application of direct air capture 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

FECM was appropriated funds through the Inflation Reduction Act of 2022 (IRA).

Fossil Energy and Carbon Management	FY 2022 IRA Funding ($K)	Managing Organization
National Laboratory Infrastructure	150,000	FECM
Total, Fossil Energy and Carbon Management	**150,000**	

- **National Laboratory Infrastructure:** The goal of this investment is to fund Infrastructure and General Plant Projects at the National Energy Technology Laboratory (NETL).

Carbon Management Technologies (CMT)
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
393,400	460,000	464,000	+4,000	+0.9%

Overview

The Carbon Management Technologies program invests in transformational technologies that will help achieve the Administration's goals to decarbonize the electricity sector by 2035 and the economy by 2050. The program focuses its efforts on hydrogen with carbon management; carbon transport and storage; carbon dioxide removal; carbon dioxide conversion; point-source carbon capture, and carbon management as it relates to policy, analysis, and engagement activities. There is a long history of investment in federal research, development, demonstration, and deployment (RDD&D) of technologies to reduce emissions from power plants and industrial sources.

The Carbon Management Technologies activities are focused on the following key priorities:

- **Facilitate the Future Deployment of Point Source Carbon Capture:** R&D for point-source carbon capture and storage (CCS) in the power and industrial sectors to enable wider, strategic commercial deployment to meet net-zero emissions goals by 2050.
- **Advance Carbon Dioxide Removal (CDR) and Carbon Dioxide Conversion:** Advance direct air capture, biomass with carbon removal and storage, and mineral carbonation technologies and develop novel approaches to recycle captured carbon emissions.
- **Increase Efficient Use of Big Data and Artificial Intelligence (AI):** Use AI, machine learning, and data analysis to create learning algorithms within large dataset to help discover new materials, optimize processes, and run autonomous systems.
- **Accelerate Carbon-Neutral Hydrogen:** Develop technologies that leverage the natural gas infrastructure for hydrogen production, transport, storage, and use, coupled to carbon management.
- **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.

Highlights of the FY 2024 Budget Request

The Carbon Management Technologies program will pursue the following major activities in FY 2024:

<u>Hydrogen with Carbon Management</u>

The FY 2024 Budget 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 2024, these activities will provide a research platform for developing the advanced systems of the future capable of net-zero emissions operations. In FY 2024, 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, especially in disadvantaged communities.

<u>Carbon Transport and Storage</u>

The Budget Request provides $110 million for the Carbon Transport and Storage subprogram to accelerate innovation in CCS and storage-based CDR (e.g., direct air capture or biomass with carbon removal) technologies that will contribute to decarbonizing industry and developing a carbon removal industry. These activities include: (1) strategies to develop the infrastructure for carbon transport and storage; (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 carbon dioxide removal will be required in the future to achieve economy-wide decarbonization. Carbon dioxide removal refers to activities that remove carbon dioxide from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. The FY 2024 Budget Request for Carbon dioxide removal is $70 million and includes: direct air capture (DAC), direct ocean capture, biomass with carbon removal and storage and mineralization, terrestrial carbon removal and sequestration (e.g., agricultural land management, afforestation, reforestation), and coastal blue carbon (e.g., carbon dioxide storage in wetlands).

Carbon Dioxide Conversion

In FY 2024, the Budget Request provides $50 million for the carbon dioxide 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 carbon dioxide and carbon monoxide as a feedstock. 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 carbon dioxide utilization efficiency in conversion to various bioproducts. Additional efforts will include developing guidance on benchmarking catalytical 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 (NCCC).

Point-Source Carbon Capture

The Point-Source Carbon Capture subprogram has completed its efforts in 1st generation technology through successful demonstration projects. FY 2024 activities represent a 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 2024 Budget Request provides $144 million to the point-source carbon capture activities 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 Budget Request of $5 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, crosscutting, analysis, and engagement activities through close coordination within the Office of Fossil Energy and Carbon Management (FECM) technology programs and with other DOE offices, federal agencies, and global partners. 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 projects and infrastructure 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 Technologies
Funding by Congressional Control ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Carbon Management Technologies					
Hydrogen with Carbon Management					
Gasification Systems	44,000	28,000	30,000	2,000	7.1%
Advanced Turbines	30,000	30,000	30,000	0	0%
Reversible Solid Oxide Fuel Cells	5,000	10,000	5,000	-5,000	-50.0%
Advanced Energy Materials	15,000	16,000	9,000	-7,000	-43.8%
Sensors, Controls and Other Novel Concepts	3,000	5,000	5,000	0	0%
Simulation-Based Engineering	4,000	6,000	6,000	0	0%
Subtotal Hydrogen with Carbon Management	**101,000**	**95,000**	**85,000**	**-10,000**	**-10.5%**
Carbon Transport and Storage					
Storage Infrastructure	75,000	90,000	85,000	(5,000)	-5.6%
Advanced Storage RDD&D	22,000	20,000	25,000	5,000	25.0%
Subtotal Carbon Transport and Storage	**97,000**	**110,000**	**110,000**	**0**	**0%**
Carbon Dioxide Removal	**49,000**	**70,000**	**70,000**	**0**	**0%**
Carbon Dioxide Conversion	**29,000**	**50,000**	**50,000**	**0**	**0%**
Point-Source Carbon Capture	**99,000**	**135,000**	**144,000**	**9,000**	**6.7%**
Carbon Management – Policy, Analysis, and Engagement					
Carbon Management – Policy and Analysis	2,400	0	3,500	3,500	N/A
Carbon Management – Engagement	1,000	0	1,000	1,000	N/A
Carbon Management – Federal Partnerships	0	0	500	500	N/A
Subtotal Carbon Management – Policy, Analysis, and Engagement	**3,400**	**0**	**5,000**	**5,000**	**N/A**
Supercritical Transformational Electric Power (STEP)	**15,000**	**0**	**0**	**0**	**0%**
Total, Carbon Management Technologies	**393,400**	**460,000**	**464,000**	**4,000**	**0.9%**

SBIR/STTR:

- FY 2022 Enacted: SBIR $11,187; STTR: $1,573
- FY 2023 Request: SBIR $12,451; STTR: $1,751
- FY 2024 Request: SBIR $12,035; STTR: $1,692

Carbon Management Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Hydrogen with Carbon Management: Funding will accelerate development of co-gasification systems for flexible waste feedstocks such as legacy coal waste, plastics, and sustainably-sourced biomass, with CCS to reach negative emissions. The funding will be utilized for funding opportunity announcements addressing topic areas in 100% hydrogen turbines.	**-$10,000**
Carbon Transport and Storage: Funding level ensures the launch of CarbonBASE and the selection of additional CarbonSAFE Phase II and CarbonSTORE projects that will have broad and immediate applicability to CCS and storage-based CDR activities. Funding also continues the DOE Regional Initiative to provide technical assistance to project developers and facilitate community and stakeholder engagement to help ensure appropriately designed CCS and storage-based CDR deployment and project success. The request prioritizes R&D to enable technologies and approaches for optimizing performance of commercial-scale transport and storage operations. Funding level maintains priority R&D on improving site/hub characterization tools and techniques critical for assessing practical CO_2 storage resources and resource management, including CO_2 mineralization.	**$0**
Carbon Dioxide Removal: The funding continues efforts on mineralization and enhanced weathering concepts.	**$0**
Carbon Dioxide Conversion: Funding allows for continued scale up and higher-technology readiness level field testing of promising conversion technologies, such as at the National Carbon Capture Center.	**$0**
Point-Source Carbon Capture: The funding request complements the $3.5 billion in BIL funding for CCS demonstrations and pilot projects and reflects prioritization of key areas of advanced technologies for achieving higher capture rates, pilot-scale tests, and FEED studies for industrial and natural gas-derived sources of CO_2.	**+$9,000**

	FY 2024 Request vs FY 2023 Enacted
Carbon Management – Policy, Analysis, and Engagement: The increase in funding will expand the capabilities of the analysis division, allowing work on hydrogen technologies and infrastructure, carbon capture, transport and storage, and general systems-based energy and carbon management modeling. This includes integration of advanced enhancements to the FECM version of the National Energy Modeling System to analyze potential future deep decarbonization scenarios and carbon management technologies' contribution to reliability and resilience. The funding increase 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. Additional funding will support expanded domestic engagement of communities, key stakeholder and state and local officials in regions where project deployment is expected to occur to help ensure communities and key stakeholders see tangible economic, environmental and jobs benefits from the deployment of projects and infrastructure to help ensure project success, as well as engagement with key countries and international partners working to advance carbon management globally. The increased request will support FECM's activities to support domestic interagency cooperation and to provide technical and other information on regulatory and permitting issues to industry, states, and other interested parties to advance FECM's mission.	**+$5,000**
Supercritical Transformational Electric Power: No funding is requested for FY 2024.	**$0**
Total, Carbon Management Technologies	**+$4,000**

Carbon Management Technologies
Hydrogen with Carbon Management

Overview

The Hydrogen with Carbon Management subprogram invests in research to evaluate carbon-neutral hydrogen (i.e., coupled to carbon capture and storage, or CCS) as a fuel and supports development of technologies to use carbon-neutral hydrogen from any source. The subprogram's efforts are an integral part of the Department of Energy's (DOE) launched Hydrogen Shot, with a goal of reducing clean hydrogen costs by 80% to $1 per 1 kilogram (kg) within 1 decade (1-1-1), while expanding employment of the U.S. energy workforce. Seeking a cost-competitive decarbonized alternative to traditional unabated fossil fuels, the subprogram has a research and development portfolio consisting of a new generation of carbon neutral or net-negative greenhouse gas (GHG) emissions technologies. The subprogram comprises of six RDD&D activities: (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 Infrastructure Investment and Jobs Act (IIJA) 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 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 sectors, especially in disadvantaged 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 carbon neutral (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 in its potential to reduce environmental impacts on affected communities by consuming, and therefore eliminating, various liability [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 conditions of marginalized communities by removing sources of contamination and obstacles to economic development, thus attracting commercial investment, and bringing steady, well-paying jobs to economically depressed regions.

The FY 2024 Budget Request provides $30 million for R&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 nonrecyclable plastics, to enable remediation and reduction of legacy pollution.

- **Scale-up of moderate-technology readiness level advanced oxygen production technologies**: The sub-activity aims to advance the Technology Readiness Level 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, which 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, MSW, 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 & 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 2024 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 (NOx) emissions and maintaining machine efficiency. R&D investments will also support efficiency goals of 67% (lower heating value, or LHV natural gas) and 50% (LHV natural gas) for combined cycle and simple cycle machines, respectively. The program will also invest in a long-term goal of a 70% efficient combined cycle machine (LHV natural gas).

Investments will be made in the application of advanced manufacturing and machine learning/artificial intelligence (AI) 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 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 program. DOE's R&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 University Turbine Systems Research 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 R&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 (R-SOFCs) use natural gas and 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 a SOFC in reverse and optimize the use of these system to reduce overall costs. The carbon dioxide 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 Reversible Solid Oxide Fuel Cells 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
- R&D for degradation at start-up of SOEC operation and enabling technologies for dynamic operation of SOEC/SOFC Systems.

The Request provides $5 million to conduct additional R&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 four main themes:

- **Advanced Materials Development**: This sub-activity creates cost-effective structural and functional materials for advanced fossil energy 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 consortium developed high temperature materials and manufacturing technologies that are now being exploited in applications such as natural gas combined cycles, concentrated solar, and high efficiency plants. The recently completed supply chain development effort includes R&D, large-scale component manufacturing trials, American Society of Mechanical Engineers (ASME) code cases, and techno-economic analyses (TEA) that readied the domestic supply chain to support construction of advanced power generation technology power plants.
- **Work Force Development:** This sub-activity supports the education and training of advanced technical workers who are trained in skills necessary to manufacture and repair components suitable for applications and industries that will be necessary for a decarbonized electricity sector by 2035 and economy by 2050. This sub-activity provides funding to eligible applicants proposing to provide training in target skills while addressing the employment and training needs of the local and regional workforce. These training programs are created in collaboration with community partners and in coordination with existing economic development strategies to support worker training for coal and power plant communities.
- **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 2024 Request of $9 million will provide funding for supply chain R&D to develop ceramic matrix composite (CMC) materials for turbine applications (thermal barrier coatings or turbine blade materials) and carbon management advanced manufacturing methods to reduce fabrication costs and improve cyclic durability. The Request 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 $5 million to fund early-stage R&D on low-cost, reliable wired and wireless technologies to measure process temperature, pressure, and concentration of gas species. With additional investment by industry, 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.

R&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:

- **Real Time Monitoring & Diagnostics:** Early-stage R&D on low-cost and reliable multi-sensing wired and wireless technologies to conduct process monitoring and component health by measuring critical process parameters that, with additional investment by industry, could be capable of providing real-time information critical to the operation, reliability, and efficiency of next-generation power systems.
- **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 R&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 Security:** Project areas focus on the protection of assets from cyber threats. This focus area conducts gap analyses to develop automated awareness technologies, data integration tools, and blockchain technologies to harden potential targets. Some sub-areas are:
    - **Machine Learning (ML):** Develops technologies that monitor power plant networks to identify abnormal behaviors because of operational issues or a malicious cybersecurity event.
    - **Blockchain and Distributed Ledger Technology**: Blockchain can facilitate detection of manipulated data. Its ability to secure data in a distributed and decentralized manner gives utilities protection against unauthorized access. Testing programs are needed to properly evaluate blockchain-based concepts.

Simulation-Based Engineering

The Simulation-Based Engineering activity includes computational software development, high performance computing, advanced optimization, TEA, and AI and 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 2024, the Budget Request for Simulation-Based Engineering provides $6 million to continue funding for DOE National Laboratory R&D, including existing modeling and analysis projects funded under the Grid Modernization Initiative (GMI); and the NETL-led Institute for the Design of Advanced Energy Systems (IDAES) in collaboration with Sandia National Laboratory (SNL) and Lawrence Berkeley National Laboratory (LBNL), which develops process systems engineering tools and optimized approaches in the conceptual design and process intensification of innovative systems. 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 (CFD) 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 physics-based model will allow for proper scale-up when the technology is ready for commercialization. IDAES activities will focus on continuing support for the stakeholder communities and developing new features and capabilities to address the challenges associated with the design and operation of integrated energy systems to enable deep decarbonization of the energy and industrial sectors.

The Hydrogen with Carbon Management subprogram closely coordinates its RDD&D activities with the Office of Energy Efficiency and Renewable Energy (EERE) Hydrogen and Fuel Cell Technology Office (HFTO) to work collaboratively where appropriate and to ensure no duplication of effort. Intra-agency coordination includes the

following DOE Offices: EERE, FECM, Office of Science (SC), Office of Nuclear Energy (NE), Advanced Research Projects Agency (ARPA-E) and the Office of Electricity (OE). The Science and Energy Technology Team will strengthen collaboration with all DOE offices, including the crosscutting offices (such as the Office of Technology Transitions (OTT) and the Loans Program Office (LPO)) involved with various hydrogen initiatives.

Carbon Management Technologies
Hydrogen with Carbon Management

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydrogen with Carbon Management: **$95,000,000**	**$85,000,000**	**-$10,000,000**
Gasification Systems $28,000,000	**$30,000,000**	**+$2,000,000**
• Develop robust, fuel-flexible, load-following modular gasification systems, specifically for community-scale gasification of legacy coal waste and opportunity feedstocks. • Develop process technology that integrates oxygen separation from air and uses advanced techniques for gasification of waste feedstocks. • Develop 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.	• Additional funding will accelerate development of co-gasification systems for flexible waste feedstocks such as legacy coal waste, plastics, and waste biomass, with CCS to reach negative emissions.
Advanced Turbines $30,000,000	**$30,000,000**	**$0**
• Support new turbine component designs for hydrogen, ammonia, and gas with carbon capture, advanced cooling techniques, aerodynamics, sealing, combustion systems and materials. • Supports University Turbine Systems Research.	• Support experimental development and technology demonstration of retrofit combustor systems for hydrogen, ammonia, and hydrogen and natural gas blends. • Issue biannual University Turbine Systems Research funding opportunity announcement. • The funding will be utilized for FOAs addressing topic areas in 100% hydrogen turbines.	• Continue at current levels.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Reversible Solid Oxide Fuel Cells $10,000,000	**$5,000,000**	**-$5,000,000**
• Investigate reversible SOFC/SOEC operation and system studies to integrate heat required for SOEC operation from other processes (e.g., nuclear). • Mature SOFC technologies and advance R&D on SOECs. • Focus 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.	• Conduct basic R&D to advance R-SOFC technologies, including operating as SOECs.
Advanced Energy Materials $16,000,000	**$9,000,000**	**-$7,000,000**
• Funding is shifted to focus on areas that will have a significantly greater impact on achieving a net-zero carbon economy by mid-century. • Evaluate the impacts of hydrogen on materials to develop 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.	• Develop alloy compositions and manufacturing techniques to improve resistance to hydrogen embrittlement.
Sensors and Controls and other Novel Concepts $5,000,000	**$5,000,000**	**$0**
• R&D on low-cost and reliable multi-sensing wired and wireless technologies, focusing on hydrogen and CCS activities. • Develop technologies that monitor power plant networks to identify abnormal behaviors because of operational issues or a malicious cybersecurity event.	• Continue R&D on advanced monitoring, controls, and integration techniques for optimized performance and reliability of hydrogen and carbon management systems. • Supports 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.	• Continue at current levels.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Simulation Based Engineering $6,000,000	**$6,000,000**	**$0**
• Supports the development of interactive visualization technology and data communication optimization methods to improve the design and operation of advanced power systems with CCS to meet decarbonization goals. • Provides first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes. • Continue the development, validation, application, and support of the multiphase flow with Interphase eXchanges (MFiX) computational fluid dynamics (CFD) software suite. • Continue working 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 Multiphase Flow with Interphase Exchanges (MFIX) and the Institute for the Design of Advanced Energy Systems (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 high-performance computing, quantum computing, etc.) and deployment of novel AI/ML techniques.	• Continue at current levels.

Carbon Management Technologies
Carbon Transport and Storage

Carbon capture, use, 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 support for basic science research.

Critical components that will help catalyze the growth of the requisite subsurface and transport resources necessary for storing 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 carbon transport and storage; research and development (R&D) to improve performance and reduce costs of site characterization and active/post-injection and transport operations; technology transfer; and technical assistance to stakeholders for project development and community engagement.

CCUS projects supported by DOE and other organizations around the world have demonstrated safe transport and secure geologic storage of CO_2 in a variety of different geologic formations and depositional environments. Since 2016, 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 the 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. FECM expects this increase in storage projects will likewise increase the confidence among operators, regulators, insurers, financial institutions, environmental groups, local communities, and community leaders that geologic storage of captured CO_2 is secure.

In FY 2024, 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 and to improve operational performance.

The Budget Request provides $110 million for the Carbon Transport and Storage subprogram for technology R&D that will accelerate CCS and storage-based CDR (e.g., direct air capture, or DAC) as clean energy innovations that will contribute toward decarbonizing industry and developing a carbon removal industry. These activities include:

- Continuing the competitive solicitation and selection of CarbonSAFE Phase II projects to increase eligibility for later-phase CarbonSAFE projects funded under BIL Section 40305;
- Launching 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 and performing network optimization scenarios;
- Continuing support for the DOE Regional Initiative, which supports technical assistance for project developers and states 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 2024, CTS program efforts will also be aligned with the technology development goals of the DOE Subsurface Energy Innovations Crosscut (in progress), which target cross-cutting innovations in characterization, monitoring, drilling, and engineering across DOE's subsurface programs with consideration to basic science gaps.

Storage Infrastructure

The CTS budget request includes $85 million for Storage Infrastructure activities that will leverage active field projects supported by prior year funding and continue support for the competitive selection of CarbonSAFE Phase II projects. 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). The Storage Infrastructure activities will also kickoff the CarbonBASE Initiative that will focus on drilling deep characterization wells in dedicated saline and mafic/serpentine rock storage formations to collect data in the most promising geologic formations that are likely to host multiple large-scale storage projects throughout the country. Coupled with collaborative efforts with multiple stakeholders (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, interference assessments of pressure and plumes, management of basin-scale seismicity, and 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 activity will also include collaboration with other DOE programs to assess potential crosscutting benefits from the production of brine (as a pressure management strategy) such as opportunities for geothermal energy and critical minerals extraction from the produced brine.

FY 2024 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 DOE Regional Initiative projects to provide technical assistance on carbon management hub development, basin scale management, regional geologic characterization, and technical assistance to stakeholders in state governments that may be responsible for regulating or overseeing carbon transport and storage efforts. Technical assistance activities will include strong community engagement to ensure social equity and to communicate community benefits.

In an effort 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 integrated with later-Phase CarbonSAFE projects or other commercial storage facilities. CarbonSTORE facilities serve as field laboratories for testing new technologies, monitoring storage performance, and providing data for program-wide efforts. 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 2024 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 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.

Advanced Storage

The CTS Budget Request includes $25 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, high fidelity sensing, and automation and intelligent systems including AI-enabling/supporting technologies. FY 2024 funds will also support individual site and hub screening and characterization tools and techniques for improved storage capacity assessments and pore/pressure space optimization. FY 2024 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 repurposing of transport infrastructure that are used for other gases/fluids, as well as research on material performance and new materials. FY 2024 funds will also continue to support the curation of data from CTS supported projects into the DOE National Energy Technology Laboratory (NETL) Energy Data Exchange (EDX), which has been serving as the portal for public access to CTS data products.

Carbon Management Technologies
Carbon Transport and Storage

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Transport and Storage: $110,000,000	**$110,000,000**	**$0**
Storage Infrastructure: $90,000,000	$85,000,000	-$5,000,000
• Supports 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. • Supports 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. • Supports Regional Initiative as regional technical assistance to CCUS stakeholders and project developers. • Supports capabilities development in support of national transport network planning and cost analyses. • Supports economic and market analysis for commercial-scale onshore and offshore geologic storage of CO_2.	• Supports 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 Phase II CarbonSAFE projects to characterize, evaluate, and analyze the feasibility of onshore and offshore storage sites and hubs for CO_2 transport and dedicated storage in saline formations, depleted oil and gas assets, CO_2 domes, and deposits for mineralization. • Supports competitive selection of additional CarbonSTORE projects to serve as field laboratories at commercial CO_2 storage sites for transport and dedicated storage. • Supports the DOE Regional Initiative to provide technical assistance 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.	• Funding ensures launch of CarbonBASE and the selection of additional CarbonSAFE Phase II and CarbonSTORE projects that will have broad and immediate applicability to BIL funded CCS and storage-based CDR activities. • Funding also continues the DOE Regional Initiative to provide technical assistance to project developers and help facilitate socially equitable CCS and storage-based CDR deployment.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Advanced Storage: RDD&D: $20,000,000	$25,000,000	+$5,000,000
• Supports 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. • Supports 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 (SMART) machine learning (ML) algorithms and capabilities. Topics of interest include advanced fiber optic sensing, wireless power systems, data integration/inversion methods, low-cost continuous monitoring systems. • Support R&D on the characterization and analysis of mineralization of CO_2 in geologic deposits with reactive materials, such as serpentines. • Continued support for Energy Data Exchange (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, feasibility 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 serpentines. • Continued support for Energy Data Exchange (EDX) data curation and platform maintenance.	• Funding is prioritized to enable technologies and approaches for optimizing performance of commercial-scale transport and storage operations. Funding level maintains priority R&D on improving site/hub characterization tools and techniques critical for assessing practical CO_2 storage resources and resource management, including CO_2 mineralization.

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, direct ocean capture, biomass with carbon removal and storage, mineralization, and terrestrial carbon removal and sequestration (e.g., agricultural land management, afforestation, reforestation, and CO_2 storage in wetlands).

The U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management (FECM) supported a 2019 study by the National Academies of Sciences, Engineering, and Medicine (NASEM) on CDR. Two key findings of the report are:

- Negative emissions technologies (NETs) or CDR, are best viewed as part of a decarbonization portfolio that first achieves maximum emissions reductions from existing sources.
- NETs/CDR need to play a large role on the order of gigaton removal in order to meet the Administration's goal of net-zero greenhouse gas emissions by midcentury.

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 NETs, including biomass with carbon removal and storage and direct air capture, which requires capture of extremely low concentration CO_2 from the atmosphere.

An objective of DOE's CDR work is to advance technologies to make significant progress towards reaching the Carbon Negative Shot target of less than $100/net metric ton CO_2 equivalent 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 CDR portfolio builds on FECM's work on mineralization, co-firing of biomass, and capture technology development to support achieving net zero emissions economywide by 2050. The FY 2024 Budget Request is focused on scaling CDR technologies pathways of DAC, DOC, BiCRS, and mineralization, as well as necessary system analysis tools such as monitoring, reporting, verification, technoeconomic analysis and life cycle analysis.

Activities to develop and commercialize direct air capture 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 ppm in air based on National Oceanic and Atmospheric Administration (NOAA) 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 Bipartisan Infrastructure Law 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.

Direct Ocean Capture (DOC) 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, direct air capture, and carbon conversion programs, which can be applied to direct ocean capture. In FY 2023, FECM is working to establish a coordinated funding opportunity with NOAA. This partnership and shared learning will help direct FECM's expertise and investment into DOC into FY 2024.

Biomass with carbon removal and storage 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.

The carbon capture technologies that currently exist and are being developed for power generation and industrial sources through the Point-Source Carbon Capture subprogram can be applied to biomass conversion facilities. 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 biomass with carbon removal and storage approaches leverage resources through that sub-program.

The NASEM report characterizes carbon mineralization as occurring at the surface as well as subsurface. Carbon mineralization has the potential to use alkaline-containing rocks and minerals, including materials such as mine tailings and wastes, to react with CO_2 and permanently store it as a solid material.

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 Geological Survey (USGS),[1] 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, life cycle analyses (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 techno-economic analyses (TEAs) will ensure assessments can be made on the best available information, which will also inform global assessment models and decarbonization scenario analyses.

As the range of CDR technologies under development expands, FECM must also ensure that appropriate monitoring, reporting and verification (MRV) is being conducted on projects in which it invests. FECM will continue to fund tailored MRV approaches for the specific types of projects in our portfolio.

[1] Blondes, M.S., Merrill, M.D., Anderson, S.T., and DeVera, C.A., 2019, Carbon dioxide mineralization feasibility in the United States: U.S. Geological Survey Scientific Investigations Report 2018–5079, 29 p., https://doi.org/10.3133/sir20185079

Carbon Management Technologies
Carbon Dioxide Removal

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Dioxide Removal: $70,000,000	**$70,000,000**	**+$0**
• Continue development of transformational materials and components, and feasibility studies of current direct air capture systems. • Continue R&D on mineralization and enhanced weathering applications. • Evaluate biomass with carbon removal and storage applications at existing facilities.	• Continue development of transformational materials and components, and feasibility studies of current direct air capture systems. • Continue R&D on mineralization and enhanced weathering applications. • Evaluate biomass with carbon removal and storage applications at existing facilities. • Continue development of direct ocean capture.	• No change to current funding levels.

Carbon Management Technologies
Carbon Dioxide Conversion

Overview

The Carbon Dioxide Conversion subprogram develops technologies to convert carbon oxides (carbon monoxide, or CO, and carbon dioxide, or 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.

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 recently 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 greenhouse gas (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. Other challenges include the energy-intensive preparation of reactants to achieve feasible conversion or 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.

Carbon Dioxide Conversion

The Carbon Dioxide Conversion subprogram focuses on novel approaches to recycle carbon oxide emissions, into value-added products. Potential feedstocks include flue gas from power generation, industrial point sources, captured/concentrated CO_2, aqueous sources, mixed gas streams, or CO_2 captured from the atmosphere. These carbon sources are then converted through a bio-mediated, catalytic, mineralization, or hybrid pathway. Some processes are already commercially available while others are in the very early stages of R&D. This subprogram engages in a variety of collaboratives efforts and analysis across science and applied energy programs at DOE.

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. CO_2 is a stable, non-reactive molecule that typically requires heat or electricity, and other reactants to be converted into products. This subprogram will work to address the need for enabling technologies, including using carbon-neutral hydrogen as a reactant in the synthesis of fuels and chemicals and maintaining an alkalinity source for mineralization. The efficiency of reaction conversion, the amount of CO_2 stored in a product and energy use of these utilization processes also represent critical challenges that the Office of Fossil Energy and Carbon Management (FECM) is uniquely positioned to assess and invest in the development of these technologies.

The FY 2024 Budget Request provides $50 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 algal systems with high CO_2 utilization efficiency of conversion to various bioproducts. The subprogram aims to continue investment activities from FY 2023, such as reactive capture and conversion, and progress first generation

conversion technologies to field-scale testing. Additional efforts will include guidance on benchmarking prototypical catalytical conversion, such as electrochemical reduction, for carbon conversion, as well as developing techno-economic analysis (TEA) guidance for screening various technology pathways or product markets. Funding will support the development of at least one fully integrated, field-test continuous system and continue support for carbon conversion test facilities at the National Carbon Capture Center.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Dioxide Conversion: $50,000,000	**$50,000,000**	**$0**
• Lab- and bench-scale technologies to convert 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. • Standardized benchmarking for catalytic conversion systems.	• Continued scale up and higher-technology readiness level field testing of promising conversion technologies, such as at the National Carbon Capture Center.

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 power sector by 2035 and a decarbonized economy by 2050. Carbon capture technologies can be applied to a wide variety of industries, such as electric power, ethanol, fertilizer, cement, steel, chemicals, refining, pulp and paper, natural gas processing and liquefaction, and others. Research and development (R&D) is focused 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 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 kinetics (faster, more selective chemical/physical separation pathways). 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.

The Department of Energy's (DOE) Office of Fossil Energy and Carbon Management's (FECM) Point-Source Carbon Capture subprogram is focused on R&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 2024 activities represent a 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 2024 Budget Request provides $144 million to capture R&D on transformational gas separation technologies capable of deep decarbonization (at least 95% 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, and achieve high capture rates.

These advanced 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 all point sources such as 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 RDD&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 better 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 focus on carbon capture front-end engineering design (FEED) studies for power plants and industrial sources. FEED studies are a critical step in the process for eventual technology deployment. 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 allows decisions regarding both the aggregation of numerous emission points and the possible integration of the capture system with the industrial facility. One FEED study of interest is emissions sources co-located with the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) projects, which is funded by the Carbon Transport and Storage subprogram. Pilot projects at industrial facilities will also be a focus of the Point-Source Carbon Capture sub-program.

Although FEEDs and pilots will be a central focus, activities in FY 2024 will continue to some extent on R&D for CO_2 capture technologies such as non-aqueous solvents, membranes, advanced sorbents, and cryogenic processes that may lead to significantly decreased energy needs. This will be achieved using advanced computational tools for rational material discovery, design of advanced capture systems components, use of advanced manufacturing, and synthesis of these materials with characterization of their physical properties. Initial work on reactive capture and conversion projects was started in FY 2021 and follow-on work from those successful projects can be initiated in FY 2024. Funding will continue to support the National Carbon Capture Center (NCCC) to provide testing on actual flue gas.

The FY 2024 request also includes separation of CO_2 from synthesis gas streams derived from gasification (or other high-pressure 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. Additional broad research objectives include technologies to reduce and analyze environmental legacy issues related to ash storage facilities. Where applicable, the impacts of and the correlation between feedstocks, their content of basic and trace elements, and geochemical interactions in-situ, and the correlation of geology on ash composition are topics of consideration.

[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 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Point-Source Carbon Capture $135,000,000	**$144,000,000**	**+$9,000,000**
• Continue 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. • Support transformational R&D and 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 10 carbon capture FEED studies for industrial and natural gas sources of CO_2. • Conduct transformational carbon capture R&D for hydrogen production from gasification-based systems using fossil fuels, biomass, and waste plastics. • Conduct transformational carbon capture development that supports hydrogen production and other industrial applications. • 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) 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 12 carbon capture FEED studies for industrial and natural gas sources of CO_2. • Fund follow-on promising reactive capture and conversion projects. • Funding supports evaluation of emissions sources from carbon capture technologies and corresponding mitigation solutions. • 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) as well as legacy storage facilities such as ash impoundments and landfills.	• The funding request complements the $3.5 billion in Bipartisan Infrastructure Law funding for CCUS demonstrations and pilot projects and reflects prioritization on key areas of transformational technologies for higher capture rates, 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

Description

Carbon Management – Policy, Analysis, and Engagement supports high-impact, crosscutting, integrative analysis, and engagement activities through close coordination within the Office of Fossil Energy and Carbon Management (FECM) technology programs, other DOE offices, other federal agencies, and other global partners. It has three activities that it funds: 1) Carbon Management – Policy and Analysis, 2) Carbon Management – Engagement, and 3) Carbon Management – Federal Partnerships. The Budget Request provides $5 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 used by other external users to better understand the role of carbon management technologies in an ever-evolving energy economy. The Budget Request of $3.5 million for this activity:

- Allows FECM to perform 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 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. Entities like 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 like electric power grid integration, infrastructure deployment, and competitiveness implications of changing energy and industrial markets as they seek to reduce their 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. Scaling up technologies within the carbon management RDD&D program portfolio is 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. FECM will work with various stakeholders to build a foundation for expeditiously administering several new investments, leveraging existing programs and developing new relationships with stakeholder networks and communities. The $1 million Budget Request for this activity:

- Accelerates the advancement and responsible deployment of technologies within the carbon management RDD&D program portfolio globally, through both policy and technical expertise, along with forward-looking RDD&D, and capacity building.

- Works with international partners committed to carbon management as a long-term climate strategy and to prioritizing decarbonization by 2050 through concerted global actions.
- Makes targeted investments in international carbon management efforts with select countries that can accelerate technological development for climate mitigation and prime major global markets for American technologies and services.
- Works with stakeholders and communities to build a foundation for effectively administering new and augmented federal investments in carbon capture and storage (CCS), carbon dioxide removal (CDR), and other carbon management technologies and infrastructure.
- Facilitates and regularly engages 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 in the U.S.
- Conducts proactive, place-based community engagement and planning processes that include consideration of CCS and CDR development, in the context of broader decarbonization options, to ensure that carbon management projects benefit communities.

Carbon Management – Federal Partnerships

The Carbon Management – Federal Partnerships activity is focused 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 for the Office 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 Budget Request of $0.5 million for this activity:

- Leads government-wide efforts to enhance interagency collaboration and coordination on carbon management with a particular focus on sharing information about DOE R&D programs and leveraging technical expertise within the Department to support government-wide efforts associated with carbon management technologies and approaches.
- Conducts outreach and engagement with a wide range of federal and state regulators 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 other regulatory or policy barriers for the DOE projects.
- Supports 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 collaboration such as IRS tax credit policy development/execution, federal advisory committees, and reports to Congress. This includes implementation of specific Congressional mandates or Executive Orders.
- Serves as a key focal point across the U.S. Government for interagency collaboration on technical, policy, and regulatory issues related to CCS and CDR.
- Serves as 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.
- Works with other agencies to develop and improve accounting frameworks and tools to accurately measure carbon removal and storage methods and technologies. Per the Energy Act of 2020, the Secretary of Energy "shall collaborate with the Administrator of the EPA and the heads of other relevant Federal agencies to develop and improve accounting frameworks and tools to accurately measure carbon removal and sequestration methods and technologies." (Title IV—Carbon Management and Title V— Carbon Removal, Section 5001, Energy Act of 2020, Division Z of P.L. 116-260).

Carbon Management Technologies
Carbon Management – Policy, Analysis, Engagement

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Management - Policy, Analysis, Engagement: $0	**$5,000,000**	**+$5,000,000**
Carbon Management – Policy and Analysis: $0	**$3,500,000**	**+$3,500,000**
• Evaluate potential economic, jobs, and environmental benefits and impacts from the deployment of carbon management and fossil technologies.	• 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 support as part of intergovernmental activities in areas of expertise (e.g., EPA, Internal Revenue Service (IRS) Section 45Q and 45V, LCA Guidelines).	• The increase in funding will expand the capabilities of the analysis division, allowing work on hydrogen technologies and infrastructure, carbon capture and storage, and general systems-based energy and carbon management modeling. This includes integration of advanced enhancements to the National Energy Modeling System to analyze potential future deep decarbonization scenarios and carbon management technologies contribution to reliability and resilience. • Funding increase 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	**$1,000,000**	**+$1,000,000**
• Support domestic and international engagement activities and agreements.	• Support domestic and international engagement activities and agreements, including key global partnerships to advance DOE's RDD&D programs.	• Additional funding will support expanded domestic engagement as well as new international agreements supporting the administration's decarbonization priorities.
Carbon Management – Federal Partnerships: $0	**$500,000**	**+$500,000**
• This is a new activity in the FY 2024 Request.	• Conduct policy, regulatory, and interagency engagement needed to successfully execute DOE's carbon management RDD&D programs, including working with federal partners on permitting.	•Additional funding will support 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.

Carbon Management Technologies
Supercritical Transformational Electric Power (STEP)

Description

The Supercritical Transformational Electric Power (STEP) activity line was created within the Carbon Capture, Utilization and Storage (CCUS) and Power Systems Program by Public Law 113-235 Consolidated and Further Continuing Appropriations Act, 2015).

The STEP program focuses on research, development, demonstration, and deployment (RDD&D) to advance higher efficiency, lower cost technologies that use supercritical CO_2 (sCO_2) for power cycles. In FY 2024, the program will continue to work toward design, construction, start-up, shakedown, and operation of the 10 MWe pilot facility and support initial testing to establish operability and performance of a simple sCO_2 cycle. This effort includes the design, development, and fabrication of major components in the cycle (i.e., turbomachinery, recuperators, heat source integration, etc.).

No funding is requested for the STEP 10 MWe pilot in the FY 2024 Budget Request. Currently, the project is fully funded for Phase 2 of the original scope of work (SOW) and will complete the existing SOW in FY 2024-Q1.

The FY 2024 Budget Request does not provide additional funds for this activity.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Supercritical Transformational Electric Power (STEP)		
$0	**$0**	**$0**
• No funding was enacted in FY 2023.	• No funding is requested in FY 2024.	• No funding requested in FY 2024.

Resource Sustainability
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
167,600	195,000	179,000	-16,000	-8.2%

Overview

Methane is a potent greenhouse gas (GHG) and is the second most abundant anthropogenic source of GHG emissions after carbon dioxide (CO_2). Reducing the impacts associated with the production, transportation, and storage of oil, natural gas, and coal is critical to achieving net-zero GHG emissions. Looking ahead, innovative technologies will provide alternative solutions, such as conversion of flared or vented methane to high-value products and cleaning water produced from hydraulic fracturing operations for agriculture use.

The U.S. has the most extensive natural gas production, gathering, processing, storage, and delivery infrastructure systems in the world. The natural gas pipeline network includes more than 300,000 miles of interstate and intrastate pipelines, and this infrastructure is facing operational challenges including the leaking of methane emissions into the atmosphere, risks of delivery disruptions, and public safety. It is critical to safely monitor and repair pipeline infrastructure and develop new technologies and solutions for reducing the risks of future leaks and delivery disruptions as the infrastructure system grows and pipelines age.

The Resource Sustainability Program addresses the critical environmental and safety issues associated with the U.S.' historical and continued production and use of fossil fuels. Specifically, the Program's mission is to conduct research, development, demonstration, and deployment (RDD&D) 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, Mineral Sustainability, and Resource Sustainability – Analysis and Engagement.

The Advanced Remediation Technologies program focuses on developing solutions that address the environmental and social impacts of oil and natural gas exploration and production. Oil and gas development results in large volumes of produced water which could be cleaned and used to benefit local communities or safely disposed of without causing induced seismic events. Offshore oil development carries the risk of oil spills and contamination to important ecological environments. Many communities that rely on oil and natural gas development for jobs and economic activity are also the same communities affected by poor air quality, water contamination, oil spills, and induced seismicity.

The Methane Mitigation Technologies program supports activities focused on innovative sensors, compressors, infrastructure components, and analytical technologies that enable the detection, quantification, and mitigation of emissions and improve the reliability of natural gas transmission, distribution, and storage facilities. Given the Nation's reliance on natural gas, it is critical to ensure the safety and reliability of related infrastructure. This program will develop advanced technologies to detect, locate, and measure emissions that will inform research, analytics, and remediation efforts. Finding and measuring emissions from natural gas production fields, transportation and storage systems, and legacy infrastructure, including abandoned and orphaned wells, is critical to reducing emissions and addressing negative impacts to air quality and ground water that impact communities. The program will also develop innovative technologies to reduce flaring and venting of natural gas through conversion of the flared and vented natural gas to high-value, readily transportable products.

The Natural Gas Decarbonization and Hydrogen Technologies program supports the development of hydrogen technologies that help contribute to a carbon-pollution-free economy. The fastest and most reliable path to advance a hydrogen economy is to build on low-cost, readily available natural gas and existing natural gas infrastructure. The Natural Gas Decarbonization and Hydrogen Technologies program will focus on advancing technologies for the carbon-neutral production, transportation, and storage of hydrogen sourced from natural gas. The program will also leverage the Office of Fossil Energy and Carbon Management's (FECM's) extensive experience with underground storage of natural gas to develop technologies for underground storage of hydrogen.

The Resource Sustainability - Analysis and Engagement program provides analytical capability to prioritize efforts across the Resource Sustainability research program, informs research decisions, conducts natural gas economic and environmental life cycle analysis, and analysis of fossil energy markets and industry to better inform the Department on fossil energy resources. The program also engages with domestic and international stakeholders on activities associated with technologies and approaches related to fossil energy.

Highlights of the FY 2024 Budget Request

The Resource Sustainability Program will pursue the following major activities in FY 2024:

Advanced Remediation Technologies

The Advanced Remediation Technologies program will conduct R&D to address wellbore integrity, induced seismicity, produced water treatment, and offshore safety and spill prevention. A redesigned field program will focus on conducting research to minimize the environmental impacts associated with unconventional oil and gas production, and exploration of pathways that would result in a positive impact on climate, such as coupling production with CO_2 storage.

Methane Mitigation Technologies

The Methane Mitigation Technologies program will conduct R&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, pipeline sensors, and pipeline data management and computational tools; and advanced modular natural gas conversion technologies for the purpose of beneficially utilizing otherwise flared or stranded natural gas. In addition, 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 (EPA) 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 (NGDHT)

The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) Program will support R&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 fundamental research to enable subsurface hydrogen storage. Programmatic activities will be conducted in support of and coordination with the Hydrogen and Carbon Management Division within FECM and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

Mineral Sustainability

The Mineral Sustainability Program will advance technologies to support development of the domestic supply chain networks required for the economically, environmentally, and geopolitically sustainable production and processing of critical minerals (CM). This mission will be accomplished by prioritizing the use of unconventional resources such as coal waste and by-products from industry feedstocks for domestic CM, rare earth elements (REE) 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.

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 and provides evidence-based, portfolio-wide analysis for decision-makers. This includes economic and environmental analysis, modeling, market analysis, analysis of markets during volatility, studies that provide support to 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, engagement with domestic and international governments and organizations, and provide market and industry analysis to inform the Department on fossil energy resources.

Resource Sustainability
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
RESOURCE SUSTAINABILITY					
Advanced Remediation Technologies					
Environmentally Prudent Stewardship	41,000	25,000	13,000	-12,000	+48.00%
Gas Hydrates	10,000	20,000	0	-20,000	-100.00%
Water Management Technologies	4,600	10,000	0	-10,000	-100.00%
Subtotal Advanced Remediation Technologies	**55,600**	**55,000**	**13,000**	**-42,000**	**-76.4%**
Methane Mitigation Technologies	**39,000**	**60,000**	**100,000**	**+40,000**	**+66.7%**
Natural Gas Decarbonization and Hydrogen Technologies	**20,000**	**26,000**	**20,000**	**-6,000**	**-23.1**
Mineral Sustainability					
Critical Minerals	44,000	44,000	12,000	-32,000	-72.73%
Carbon Ore Processing	9,000	10,000	4,000	-6,000	-60.00%
Resource Characterization Technologies	0	0	29,000	+29,000	N/A
Subtotal Mineral Sustainability	**53,000**	**54,000**	**45,000**	**-9,000**	**-16.7%**
Resource Sustainability – Analysis and Engagement	**0**	**0**	**1,000**	**+1,000**	**N/A**
TOTAL, RESOURCE SUSTAINABILITY	**167,600**	**195,000**	**179,000**	**-16,000**	**-8.21%**

SBIR/STTR:

- FY 2022 Enacted: SBIR $2,772: STTR: $390
- FY 2023 Enacted: SBIR $5,348: STTR: $752
- FY 2024 Request: SBIR $4,037: STTR: $568

Resource Sustainability
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Resource Sustainability	
Advanced Remediation Technologies: This 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 2024.	**-42,000**
Methane Mitigation Technologies: Funding increase reflects a focus on the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, maintainable, and low-cost 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.	**+40,000**
Natural Gas Decarbonization and Hydrogen Technologies: Decrease reflects a lower level of effort in research on hydrogen storage for FY 2024 and strategic focus on conversion, blending, and transportation.	**-6,000**
Mineral Sustainability: Funding decrease reflects reduced funding for coal-based building materials composed of carbon ore, while maintains partial funding for supporting large-scale pilot development through FEED studies to produce large quantities of high purity, commercial-grade REE and other CMs, and maturation of transformational processing from unconventional resources.	**-9,000**
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 stakeholders to reduce methane emissions related to fossil fuel use, and to pursue the development of critical materials from domestic fossil resources.	**+1,000**
Total, Resource Sustainability	**-16,000**

Resource Sustainability
Advanced Remediation Technologies

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 climate and the environment. The Advanced Remediation Technologies Program addresses these critical issues. The Program conducts research and development(R&D) that reduces the climate and environmental impacts from the development, transportation, distribution, and storage of fossil energy resources.

The Environmentally Prudent Stewardship subprogram will focus on developing solutions that address the environmental, climate, and social impacts of fossil fuel development. Hydraulic fracturing requires the use of large amounts of water and chemicals, which need to be cleaned and safely disposed of without causing 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 affected by poor air quality, water contamination, oil spills and/or induced seismicity.

There is no funding requested for the Water Remediation subprogram in FY 2024.

There is no funding requested for the Gas Hydrates subprogram in FY 2024.

Highlights of the FY 2024 Budget Request

The Environmentally Prudent Stewardship subprogram will conduct R&D technologies to address wellbore integrity, induced seismicity, produced water treatment, water management for coal related wastes, and offshore safety and spill prevention.

Resource Sustainability
Advanced Remediations Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Advanced Remediations Technologies					
Environmentally Prudent Stewardship	41,000	25,000	13,000	-12,000	-48.00%
Gas Hydrates	10,000	20,000	0	-20,000	-100.00%
Water Remediation Technologies	4,600	10,000	0	-10,000	-100.00%
Total, Advanced Remediations Technologies	**55,600**	**55,000**	**13,000**	**-42,000**	**-76.4%**

Resource Sustainability
Advanced Remediation Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Advanced Remediation Technologies	
Environmentally Prudent Stewardship: This decrease reflects continued research to develop solutions that address the environmental impacts of oil and natural gas development.	**-12,000**
Gas Hydrates: No funding requested in FY 2024 due to the completion of field work in the Gulf of Mexico and the Alaska production test.	**-20,000**
Water Management Technologies: No funding requested in FY 2024.	**-10,000**
Total, Advanced Remediation Technologies	**-42,000**

Overview

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 to inform future research. These field projects conducted research on multiple facets of the production process in unique geological basins, including capturing environmental data before, during, and after hydraulic fracturing operations. Research included mapping and visualization of the subsurface, wellbore integrity, produced water research, groundwater contamination, air quality, and data analytics.

The Field Laboratory program focused on conducting research to minimize the environmental impacts associated with unconventional oil and gas production. There has been a substantial body of knowledge gained about the geochemistry, geomechanics, and geophysics of oil and gas reservoirs from this program. Artificial Intelligence/Machine Learning (AI/ML) efforts are being applied to leverage this knowledge and data to the storage of CO_2 in depleted conventional and unconventional oil and gas reservoirs. Research will continue to focus on minimizing the environmental impacts associated with unconventional oil and gas production, as well as exploration of pathways that will result in a positive impact on climate, such as coupling production with CO_2 storage.

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 (DOI), under a Memorandum of Collaboration, to pursue collaborative offshore research to increase safety and reduce environmental risk.

Water Remediation Technologies

There is no funding requested for the Water Remediation Technologies subprogram in FY 2024.

Gas Hydrates

There is no funding requested for the Gas Hydrates subprogram in FY 2024.

Resource Sustainability
Advanced Remediation Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Advanced Remediation Technologies **$55,600,000**	**$13,000,000**	**-$42,000,000**
Environmentally Prudent Stewardship **$25,000,000**	**$13,000,000**	**-$12,000,000**
• Research on reducing the environmental footprint of unconventional oil and gas development. • Funding Opportunity Announcement (FOA), on an 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.	• 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 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 within the Advanced Remediation Technologies Budget Request.	• No funding is requested within the Advanced Remediation Technologies Request due to the completion of field work 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 within the Advanced Remediation Technologies Budget Request.	• No funding is requested within the Advanced Remediation Technologies Budget Request. 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
Methane Mitigation Technologies

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 highest anthropogenic greenhouse gas (GHG) and is more potent than carbon dioxide. The Program's mission is to conduct research and development, (R&D) of technologies and solutions that detect, quantify, reduce, and mitigate methane emissions throughout the oil and natural gas value-chain.

The program supports R&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 as 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 legacy 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.

Highlights of the FY 2024 Budget Request

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

- 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.
- The program will expand 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
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Methane Mitigation Technologies	39,000	60,000	100,000	+$40,000	+66.7%
Total, Methane Mitigation Technologies	**39,000**	**60,000**	**100,000**	**+$40,000**	**+66.7%**

Resource Sustainability
Methane Mitigation Technologies
Explanation of Major Changes ($K)

	FY 2024 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, maintainable, and low-cost 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.	**+$40,000**
Total, Methane Mitigation Technologies	**+$40,000**

Resource Sustainability
Methane Mitigation Technologies

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, 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 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 legacy emitters.

The program will advance technologies for the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, maintainable, and low-cost 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 pipe 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 R&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.

Resource Sustainability
Methane Mitigation Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Methane Mitigation Technologies $60,000,000	**$100,000,000**	**+$40,000,000**
• 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. • Conduct 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 research and development. • 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, maintainable, and low-cost 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 (Artificial Intelligence/Machine Learning) 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

Overview

The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) program will focus on technologies for carbon-neutral 1) production of clean hydrogen; 2) transportation of hydrogen and fluid hydrogen carriers; and 3) geologic storage technologies that leverage 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.

Highlights of the FY 2024 Budget Request

The NGDHT Program will focus on extramural 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) Fundamental 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 FECM and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Natural Gas Decarbonization and Hydrogen Technologies	20,000	26,000	20,000	-6,000	-23.1%
Total, Natural Gas Decarbonization and Hydrogen Technologies	**20,000**	**26,000**	**20,000**	**-6,000**	**-23.1%**

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Natural Gas Decarbonization and Hydrogen Technologies: Decrease reflects a lower level of effort in research on hydrogen storage for FY 2024 and strategic focus on conversion, blending, and transportation.	**-$6,000**
Total, Natural Gas Decarbonization and Hydrogen Technologies	**-$6,000**

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Description

The Natural Gas Decarbonization and Hydrogen Technologies (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.

Highlights of the FY 2024 Budget Request

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 most reliable 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 flared natural gas into hydrogen.

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Natural Gas Decarbonization and Hydrogen Technologies $26,000,000	**$20,000,000**	**-$6,000,000**
• Research on production of carbon-neutral hydrogen from methane, including novel conversion technologies. • Develop blending and separation technologies for natural gas with hydrogen and materials and components for dual use of infrastructure. • Research on utilizing 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 in research on utilizing natural gas storage for hydrogen and pilot-scale technology demonstration.

Resource Sustainability
Mineral Sustainability

Overview

Building our clean energy and industrial economy to meet our energy security and climate goals will require ever larger quantities of minerals and metals than are currently being consumed. Unfortunately, the U.S.'s import dependency on many of the minerals and metals needed for these technologies has continued to increase dramatically over the past 30 years.

The Mineral Sustainability program activities in the DOE Office of Fossil Energy and Carbon Management (FECM), along with complementary investments in the Office of Energy Efficiency and Renewable Energy (EERE), and the Manufacturing and Energy Supply Chains (MESC) Office are 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).

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 has the potential to address environmental concerns traditionally associated with mining, revitalize domestic manufacturing capabilities, and create good paying jobs. Production of waste from coal and industrial sectors has the potential to create a mineral processing workforce in local disadvantaged coal and power plant communities by building co-production of CM and carbon products. Moreover, unconventional co-production provides our country with the added advantage of removing environmentally adverse materials that might disproportionately harm residents of those disadvantaged communities as we transition to a clean energy and industrial economy. Finally, unconventional and secondary resources provide an alternative source of CMM to support and in some cases replace newly mined minerals.

The Mineral Sustainability program will support resilient domestic supply chains required for the economically, environmentally, and geopolitically sustainable production of critical minerals (CM). 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 CM, rare earth elements (REE) and carbon ore to products production.

These unconventional and secondary resources are defined as coal, coal waste, and industrial by-products. This includes coal refuse, clay/sandstone materials, ash, 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 byproducts associated with steel, cement, and refining industries, phosphate sludge and other waste materials, and byproducts from hard rock mining and mine tailings will also be considered.

<u>Critical Minerals Processing (formerly part of Critical Minerals)</u>

The development of a domestic, economically competitive supply chain for CMs is needed to help fuel our nation's economic growth; transition to clean energy and industrial technologies; secure our energy independence by reducing our reliance on foreign CM and REE sources; and increase our national security. The Critical Minerals Processing subprogram focuses on the sustainable processing of all CM, including REE throughout the midstream and downstream supply chain by prioritizing the use of unconventional resources as an environmentally beneficial primary feedstock resource for domestic production and one that builds on longstanding FECM program areas and expertise.

The Critical Minerals 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.

Other activities within the Critical Mineral subprogram leverages the success of the former, fully integrated "Feasibility of Recovery of Rare Earth Element" RDD&D that developed separation and recovery technologies and the capability to assess and characterize feedstocks, but also demonstrated the technical feasibility of recovering CMs from a diversity of carbon ore feedstocks. 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 machine learning and artificial intelligence, small- and large-scale pilot projects—including public-private partnerships, and existing regional partnerships developed through Carbon Ore Rare Earth-Critical Mineral Initiative (CORE-CM).

Since 2014, R&D has provided successful results for Pilot-Scale REE-CM Separation facilities at the University of North Dakota, University of Kentucky, West Virginia University and at Physical Sciences Inc. in Massachusetts and Winner Water Services in Pennsylvania, which have demonstrated the technical feasibility of extracting and producing CMs and REEs from carbon ore and related waste materials in small quantities. These facilities were the first-of-a-kind projects to demonstrate the capability to extract CMs/REEs 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-front end engineering and design (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 REEs and other CMs, and one such demonstration facility will be funded through the Infrastructure Investment and Jobs Act (IIJA).

There are two key focus areas in which R&D will be conducted:

- **Sustainable Resource Extraction and Separation Technology Development** – Novel technology development and validation for conventional and unconventional extraction to enable the recovery of CMs/REEs from sources that are not currently being recovered or that could be recoverable with more sustainable practices. This includes the extraction of CMs from unconventional feedstocks such as abandoned mining or other industrial process residuals while maximizing environmental controls.
- **Extractive Metallurgy, Reduction, and Alloying Technology Development**– Advanced technology development for concentration and processing of CMs and REEs. This area also includes technology development of individual high-purity elements and metallization. High purity elements will be critical to future metallization technology development and eventual use in manufactured products. This work is coordinated with ongoing work in EERE.

Highlights of the FY 2024 Budget Request

- Further advance facilities to produce large quantities of high purity, commercial grade REEs and other CMs, through FEED studies and large-scale pilots, which is the next stage of development to broadly enable extraction of REEs and other CMs from unconventional feedstocks (such as coal refuse and acid mine drainage) towards a commercial industry.
- Further support the regional basin projects (the CORE-CM Initiative), covering larger portions of the country by regions, and the development of transformational technologies for individually separated highly purified, individual CMs/REEs, including individual separation, reduction to metals, and alloying. This work is coordinated with ongoing work in EERE.
- 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.

Carbon Ore Processing

The Carbon Ore Processing activity (formerly Advanced Coal Processing) is focused on utilizing materials from currently and previously mined 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. 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. These transformational technologies have minimal emissions, superior product performance, and better lifecycle 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 three 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, such as 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 2024 Budget Request of $4 million 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 DOE Offices and DOE's CMM SETT. The funding will be used to:

- Develop new technologies for creating products such as synthetic graphite.
- Support techno-economic characterization, life cycle analyses, and health and safety studies to assess the environmental impacts for coal and coal waste-derived carbon products.

Resource Characterization Technologies (formerly part of Critical Minerals)

The development of a domestic, economically competitive supply of CMs are needed to help fuel our nation's economic growth; transition to clean energy technologies; secure our energy independence by reducing our reliance on foreign CM and REE sources; and increase our national security. The Resources Characterization Technologies Subprogram focuses on the sustainable recovery of all CM, including REE and carbon ore, by prioritizing the use of unconventional and secondary resources as an environmentally sustainable feedstocks for domestic production.

The Resource Characterization Subprogram leverages the success of the 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 CMs from a diversity of carbon ore-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 machine learning and artificial intelligence, and existing basin partnerships developed through Carbon Ore Rare Earth-Critical Mineral Initiative (CORE-CM), 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 REEs 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 previously unknown to exist in the U.S., and thus

offers an opportunity for REE production with less intensive processing steps required to produce REEs from conventional ores.

The two primary focus areas for RDD&D will be:

- **Resource Characterization and Technology Development** – Technology development and validation for environmentally sustainable exploration and production from various sources. This includes regional opportunities and assessments, the economic recovery of CMs through identification (including physical and chemical properties), mineral assays, prediction and assessment of resources and volumes of CMs/REEs from various feedstocks. It also includes development of new technologies for assessment of recoverable resources (drones, real time sensing and analytics, and micro drilling technologies). This work is coordinated with the U.S. Geological Survey (USGS) in the Department of Interior and the Environmental Protection Agency.
- **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.

Highlights of the FY 2024 Budget Request

- Initiate Phase II of the regional basin projects (the 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, and optimization modeling for characterization of CMs/REEs.
- Work with the USGS to improve exploration and characterization technologies to reduce time, cost, and environmental impact, thereby enabling more rapid new upstream CMM projects to proceed.

Resource Sustainability
Mineral Sustainability
Explanation of Major Changes ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Mineral Sustainability					
Critical Minerals Processing	44,000	44,000	12,000	-32,000	-72.73%
Carbon Ore Processing	9,000	10,000	4,000	-6,000	-60.00%
Resource Characterization Technologies	0	0	29,000	+29,000	N/A
Total, Advanced Remediations Technologies	**53,000**	**54,000**	**45,000**	**-9,000**	**-16.67%**

Resource Sustainability
Mineral Sustainability
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Mineral Sustainability	
Critical Minerals Processing: This decrease represents the breakout of the Resource Characterization as a separate subprogram as shown below. Research in this area will continue into the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated predominantly 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 current state of the art.	**$-32,000**
Carbon Ore Processing: This decrease in funding represents a shift in focus to the Resource Characterization efforts mentioned below. Research will continue into the utilization of materials to be recycled from currently and previously mined resources outside of traditional thermal and metallurgical markets that can contribute to the U.S. gross domestic product.	**$-6,000**
Resource Characterization: This increase represents the breakout of this new subprogram, formerly part of Critical Minerals, that will initiate Phase II of the regional basin projects (the CORE-CM Initiative), covering larger portions of the country by regions.	**+$29,000**
Total, Mineral Sustainability: This decrease reflects a greater emphais on the CORE-CM initiative under the new Resource Characterization subprogram.	**-$9,000**

Resource Sustainability
Mineral Sustainability

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Mineral Sustainability $54,000,000	**$45,000,000**	**-$9,000,000**
Critical Minerals $44,000,000	**$12,000,000**	**-$32,000,000**
• R&D to support FEED studies for technology development of CM including REE from unconventional feedstocks to produce large quantities of high purity, commercial grade REE and other CMs. • Further development of regional basin projects (the CORE -CM Initiative), and the development of transformational technologies for individually separated highly purified, individual CMs/REEs, including individual separation, reduction to metals, and alloying. • Support the maturation of transformational separation and extraction technologies, characterization of CMs/REEs, machine learning and optimization modeling.	• R&D to support FEED studies for technology development of CM including REE from unconventional feedstocks to produce large quantities of high purity, commercial grade REE and other CMs. • Support the maturation of transformational separation and extraction technologies, characterization of CMs/REEs, machine learning and optimization modeling. • Supporting the CORE-CM initiative, which will be moving to the Resources Characterization Technologies Subprogram.	• This decrease represents the breakout of the Resource Characterization as a separate subprogram. Research in this area will continue into the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated predominantly 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 current state of the art.
Carbon Ore Processing $10,000,000	**$4,000,000**	**$-6,000,000**
• Develop existing and new technologies to turn coal and coal waste and refuse into synthetic graphite and graphene. • R&D on carbon fiber production at Oak Ridge National Laboratory's (ORNL) Carbon Fiber Technology Facility (CFTF). • Support 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 the Resource Characterization efforts mentioned below. Research will continue into the utilization of materials to be recycled from currently and previously mined resources outside of traditional thermal and metallurgical markets that can support communities and economies in regions traditionally reliant on mining.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Resource Characterization Technologies $0	**$29,000,000**	**+$29,000,000**
• No funding requested in FY 2023	• Further development of regional basin projects (the CORE-CM Initiative), and the development of transformational technologies for individually separated highly purified, individual CMs/REEs, including individual separation, reduction to metals, and alloying. • 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 former CORE-CM Initiative.

Resource Sustainability
Resource Sustainability –Analysis and Engagement

Overview

The United States 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 as the U.S. transitions to a net zero economy. As that transition occurs, the Office of Fossil Energy and Carbon Management is engaging with domestic and international stakeholders, advancing research and technologies, and bringing together critical programs and funding to reduce the environmental and climate impacts of our fossil energy production and use.

The United States and our global partners have an opportunity to decarbonize our energy 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 Department 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 provides market and industry analysis to inform the Department on Fossil Energy resources.

The Resource Sustainability –Analysis and Engagement Program conducts analysis and studies that support the 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. 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 reliable and affordable fossil energy supplies to the domestic market. Strategic Analysis provides evidence-based, portfolio-wide analysis for decision-makers.

The program also engages with domestic and international stakeholders on activities associated with technologies and approaches that will reduce the environmental impacts of our historical and continued dependence on coal, oil, and natural gas. This includes support for activities to inform key FECM audiences and stakeholders about FECM's work to foster a clean energy and industrial economy and to address climate change, as well as support for communities that host 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 program will work with various stakeholders to build a foundation for expeditiously administering several new approaches to recognizing and detecting fossil fuel greenhouse gas emissions and impacts, leveraging existing programs and developing new relationships with stakeholder networks and communities.

Highlights of the FY 2024 Budget Request

The Resource Sustainability – Analysis and Engagement Program will pursue the following major activities in FY 2024:

- Perform analysis on various pathways to achieve domestic and global climate goals, including lifecycle analysis.
- Assesses market conditions to determine impacts to energy markets and technology development.
- Leverage experience in working successfully with global governments, organizations, and stakeholders 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 R&D, and capacity building.
- Work with international partners committed to reducing methane emissions as a long-term climate strategy and partnerships that prioritize a decarbonized economy by 2050 through concerted global actions. These partners are willing and able to work with FECM to move their countries and regions toward net-zero goals, and where FECM expertise can provide leverage, develop long-term projects and relationships for technical exchange and joint R&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 Technologies
Resource Sustainability – Analysis and Engagement

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Resource Sustainability – Analysis and Engagement: $0	**$1,000,000**	**+$1,000,000**
Policy & Analysis $0	$1,000,000	+$1,000,000
• No funding requested in FY 2023	• This activity will provide funding for technical, economic, and socio-economic studies as well as technical expertise and analysis needed to support 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 sources critical minerals and materials from domestic fossil resources such as coal waste.	• Increase in funding will provide funding for technical, economic, and socio-economic studies as well as 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 critical minerals and materials from domestic fossil resources such as coal waste.

NETL Infrastructure
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
75,000	**55,000**	**55,000**	**+$0**	**0%**

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 (Super Computer)** provides funding for the lease of Joule, NETL's high-performance computer (HPC) at Morgantown, WV. The FY 2024 Budget Request includes $6.0 million for a new 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, ensure critical laboratory research facilities and infrastructure, and comply with High Performance Sustainable Building (HPSB) goals. Funding also includes information technology (IT) development, modernization, and enhancement (DME) investment as well as AI infrastructure support.

(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) research, development, demonstration, and deployment (RDD&D) 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.

Table 1[1]: Comparison of Physical Footprint, Workforce, and Value of Assets by Campus and in Total, National Energy Technology Laboratory as of January 31, 2023.

	Morgantown	Pittsburgh	Albany	Total NETL
Buildings	43	31	37	**111**
Sq. Ft. of Building Space (000s)	445	433	253	**1,131**
Acres	136.0	57.4	43.9	**237.3**
NETL Federal Workforce	167	192	45	**497[2]**
NETL Contractor Workforce (FTEs)	348	420	81	**893[3]**
Assets Replacement Value	$292.9 million	$243.9 million	$180.9 million	**$717.7 million**

Table 2: Reconciliation of FECM RDD&D Federal Employees (FTEs).

	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
NETL Program Direction	138	140*	+2
NETL Research & Operations	440	460	+20
TOTAL, NETL	**578**	**600**	**+22**

[1] Table 1 reflects on board employees as of January 31, 2023 and Table 2 reflects authorized and requested FTEs.

[2] Total NETL includes two employees located in Houston, TX and ninety-one with a remote duty station. Total NETL excludes forty-five employees funded through the Infrastructure Investment and Job Act.

[3] Total NETL includes five contractors located in Houston, TX and thirty-nine located offsite.

FECM-HQ Program Direction	141	168	+27
TOTAL, FECM RDD&D	**719**	**768**	**+49**

*The FY 2024 Request includes 127 FTE funded through the FECM appropriations and 13 FTE funded with Program Direction from other Program Offices (EERE, OE, CESER).

Highlights of the FY 2024 Budget Request

The FY 2024 Budget Request for NETL Infrastructure is $55 million. This request includes $20 million for General Plant Projects (GPP), prioritizing research laboratory upgrades in key FECM areas such as Artificial Intelligence, Materials Characterization, and Geological Environmental Sciences. Additional GPP investments include deferred maintenance management projects and investments in reducing NETL's carbon footprint. An additional $6 million is requested for NETL's high performance computer lease. High performance computing is an essential element in more than 50% of NETL's research projects. The balance of the request is for investments in information technology (IT) development, modernization, enhancements, and fixed operational costs such as utilities, IT licenses and agreements, safeguards and security, environmental compliance and remediation, and routine building maintenance, along with support for a Net Zero Lab Initiative.

Funding will support 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.

NETL Infrastructure
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
NETL Infrastructure					
Super Computer	6,000	6,000	6,000	0	0%
Laboratory- & Site-Wide Facilities	59,500	39,000	39,000	0	0%
Safeguards and Security	7,500	8,000	8,000	0	0%
Environmental Restoration	2,000	2,000	2,000	0	0%
Total, NETL Infrastructure	**75,000**	**55,000**	**55,000**	**0**	**0%**

NETL Infrastructure
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
NETL Infrastructure: No Change.	**0**
Total, NETL Infrastructure	**0**

NETL Infrastructure

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
NETL Infrastructure $55,000,000	**$55,000,000**	**+$0**
High Performance Computer (Super Computer) $6,000,000	**$6,000,000**	**$0**
• Funding is for the 4-year lease of Joule, National Energy Technology Laboratory's (NETL) high performance computer (HPC) at Morgantown, WV.	• Funding is for the 4-year lease of Joule, NETL's HPC at Morgantown, WV.	• No change.
Laboratory and Site wide Facilities $39,000,000	**$39,000,000**	**$0**
• Funding includes repairs to existing laboratory facilities and general-purpose buildings and site-wide infrastructure. Priorities for funding are established to ensure compliance with life safety standards, ensure critical laboratory research facilities and infrastructure and comply with High Performance Sustainable Building (HPSB) goals.	• Funding includes repairs to existing laboratory facilities and general-purpose buildings and site-wide infrastructure, including AI. Priorities for funding are established to ensure compliance with life safety standards, ensure critical laboratory research facilities and infrastructure and comply with HPSB goals.	• No change.
Safeguard and Securities $8,000,000	**$8,000,000**	**$0**
• Funding is to ensure 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 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Environmental Restoration $2,000,000	**$2,000,000**	**$0**
• Continue active operation and maintenance of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12 under the guidance of the Wyoming Department of Environmental Quality (DEQ). • Continue all NETL on-site Resource Conservation and Recovery Act (RCRA) hazardous waste compliance and management activities. • Continue all NETL Albany ground water investigation and compliance activities.	• Continue active operation and maintenance of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12 under the guidance of the Wyoming DEQ. • Continue all NETL on-site RCRA hazardous waste compliance and management activities. • Continue all NETL Albany ground water investigation and compliance activities.	• No change.

Plant and Capital Equipment
Capital Summary ($K)

	Total	Prior Years	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
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	0	25,000	0	0	0
Total, Capital Operating Expenses	**25,000**	**0**	**25,000**	**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	0	25,000	0	0	0
Total, Minor Construction Projects	**25,000**	**0**	**25,000**	**0**	**0**	**0**
Total, Capital Summary	**25,000**	**0**	**25,000**	**0**	**0**	**0**

NETL Research and Operations
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
83,000	87,000	89,000	+$2,000	2.3%

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 unique in that it is the only government-owned, government-operated laboratory. 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, as well as its expertise in government contract and project management.

The NETL Research and Operations Program comprises three subprograms:

(1) **Research, Development, Demonstration, and Deployment** (RDD&D) funding 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 Fossil Energy and Carbon Management (FECM) RDD&D programs. This subprogram also 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 transfer, 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, routine upkeep, and pandemic protocols; and (b) grounds maintenance including parking lot repair, lighting, groundskeeping, snow removal, etc.

(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.

Highlights of the FY 2024 Budget Request

The NETL Research and Operations Request is $89.0 million. The request includes $78.5 million to fully fund federal salaries and benefits at the requested FTE level. An additional $7.0 million is for contractor support in the areas of information technology operations, technology transfer 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 (LDRD) contribution.

Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
NETL Research and Operations					
Research, Development, Demonstration, and Deployment	51,000	55,000	57,000	+2,000	+3.6%
Site Operations	21,000	21,000	21,000	0	0%
Program Oversight	11,000	11,000	11,000	0	0%
TOTAL, NETL Research and Operations	**83,000**	**87,000**	**89,000**	**+2,000**	**2.3%**
Federal FTEs	**430**	**440**	**460**	**+20**	**+4.5%**

Federal FTEs shown above include technical project managers and procurement and finance personnel providing support to DOE's Office of Energy Efficiency and Renewable Energy (EERE), Office of Cybersecurity, Energy Security, and Emergency Response (CESER), and Office of Electricity (OE). These NETL personnel are funded by those non-FECM RDD&D offices to the extent that their time is spent supporting those offices.

NETL Research and Operations
Explanation of Major Changes
($K)

	FY 2024 Request vs FY 2023 Enacted
NETL Research and Operations:	**+$2,000**
• Increase reflects fully funding authorized federal headcount at projected FY 2024 average salary and benefits. Contractor support in key research areas is being scaled back as NETL strengthens the depth of our federal workforce.	
Total, NETL Research and Operations	**+$2,000**

NETL Research and Operations
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
NETL Research and Operations $87,000,000	**$89,000,000**	**+$2,000,000**
Research, Development, Demonstration, and Deployment $55,000,000	**$57,000,000**	**+2,000,000**
• Research, Development, Demonstration, and Deployment (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 the Office of Fossil Energy and Carbon Management (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 research, development, demonstration, and deployment 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.	• 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 research, development, demonstration, and deployment 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 authorized federal headcount at projected FY 2024 average salary and benefits. Contractor support in key research areas is being scaled back as NETL strengthens the depth of our federal workforce
Site Operations $21,000,000	**$21,000,000**	**$0**
• Site Operations funding supports variable costs of operating NETL's laboratories and research sites. Funding provides for operations personnel	• Site Operations funding supports variable costs of operating NETL's laboratories and research sites. Funding provides for operations personnel	• No change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
along with support contractors for building operations, grounds maintenance, etc.	along with support contractors for building operations, grounds maintenance, etc.	
Program Oversight $11,000,000	**$11,000,000**	**+$0**
• 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.	• 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 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2022 Request vs FY 2023 Enacted (%)
0	3,000	0	-$3,000	-100%

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; co-chaired by the Director of the National Economic Council and the National Climate Advisor, and 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 and 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 2024 Budget Request

The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.

Interagency Working Group
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Interagency Working Group:	**-$3,000**
• The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.	
Total, Interagency Working Group	**-$3,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Interagency Working Group $3,000,000	**$0**	**-$3,000,000**
• Continue targeted, place-based interventions using an interagency approach that leverages existing federal and technical assistance resources to assist energy communities, including displaced energy workers. • Establish a concierge function to provide direct technical assistance to energy communities on how to access Federal resources. • Streamline the process for applying Federal funding. Create a pilot that uses a common application for two or more agencies. • Maintain the clearinghouse on Federal funding opportunities available to energy communities.	• The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.	• The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.

Special Recruitment Programs
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
1,001	1,000	1,000	0	N/A

Overview

The Office of Fossil Energy and Carbon Management (FECM) emphasizes educational programs to support an increase in the number of women and under-represented minorities 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, graduate, and post-graduate students majoring in STEM disciplines opportunities to learn about programs, policies, and research, development, demonstration, and deployment (RDD&D) initiatives within FECM and the challenges 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 2024 Budget Request

In FY 2024, FECM will recruit and select a diverse group of undergraduate, graduate, and post-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 R&D projects under the mentorship of an FECM scientist, researcher, or program official.

Special Recruitment Programs
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Special Recruitment Programs	1,001	1,000	1,000	0	N/A
Total, Special Recruitment Programs	**1,001**	**1,000**	**1,000**	**0**	**N/A**

Special Recruitment Programs
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Special Recruitment Programs:	**+$0**
• The FY 2024 Budget Request level supports administration of the MLEF, MEISPP, DOE Scholars, STP, or other educational programs.	
Total, Special Recruitment Programs	**+$0**

Special Recruitment Programs

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Special Recruitment Programs $1,000,000	**$1,000,000**	**+$0**
• A diverse group of undergraduate, graduate, and post-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 opportunity to gain hands-on research and work experience and learn more about the DOE and the FECM missions.	• A diverse group of undergraduate, graduate, and post-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 change.

Program Direction
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
66,800	70,000	92,475	+$22,475	+32.1%

Overview

Program Direction provides for the Headquarters (HQ) workforce responsible for the oversight and administration of the Office of Fossil Energy and Carbon Management (FECM). It also supports technical staff at the National Energy Technology Laboratory (NETL) who perform procurement, finance and legal functions, as well as Federal workforce and contractor support for communications. It does not include NETL scientific researchers or project managers who are funded through the NETL Research and Development control point.

Funding also support continued 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, and cybersecurity risk management.

Program Direction also includes funding for the operations of the Import/Export Authorization Office, which is managed by the Division of Natural Gas Regulation within the Office of Resource Sustainability. The program has responsibility for regulating natural gas and liquefied natural gas (LNG) imports and exports under the Natural Gas Act of 1938, section 3, using both Federal staff and contractor support.

Each of these elements also fund the Department of Energy's (DOE) Oak Ridge Human Resources Shared Service Center and the FECM program office contribution to the DOE Working Capital Fund.

Highlights of the FY 2024 Budget Request

The FY 2024 Program Direction Budget Request is $92.475 million. The Request includes $58 million to fully fund federal salaries and benefits at the requested FTE level. Increase reflects fully funding authorized federal headcount at projected FY 2024 average salary and benefits. 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 closeout RDD&D programs and projects. These efforts increase the effectiveness of government sponsored RDD&D and reduce the risk of noncompliance. This funding level also supports the Department's efforts to evaluate ways to improve operational efficiency.

Program Direction
Funding ($K)

Program Direction Summary	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Washington Headquarters					
Salaries and Benefits	25,860	25,732	34,624	+8,892	+34.6%
Travel	400	400	1,508	+1,108	+277.0%
Support Services	550	2,620	4,124	+1,504	+57.4%
Other Related Expenses	7,710	8,418	13,709	+5,291	+62.9%
Total, Washington Headquarters	**34,520**	**37,170**	**53,965**	**+16,795**	**+45.2%**
National Energy Technology Laboratory					
Salaries and Benefits	19,300	19,300	21,500	+2,200	+11.4%
Travel	400	400	400	0	0.0%
Support Services	6,600	7,100	6,150	-950	-13.4%
Other Related Expenses	3,100	3,100	3,500	+400	+12.9%
Total, National Energy Technology Laboratory	**29,400**	**29,900**	**31,550**	**+1,650**	**+5.5%**
Import/Export Authorization					
Salaries and Benefits	1,845	1,930	1,845	-85	-4.4%
Travel	20	20	207	+187	+935.0%
Support Services	485	450	3,205	+2,755	+612.2%
Other Related Expenses	530	530	1,703	+1,173	+221.3%
Total, Import/Export Authorization	**2,880**	**2,930**	**6,960**	**+4,030**	**+137.5%**
Total Program Direction					
Salaries and Benefits	47,005	46,962	57,969	+11,007	+23.4%
Travel	820	820	2,115	+1,295	+157.9%
Support Services	7,635	10,170	13,479	+3,309	+32.5%
Other Related Expenses	11,340	12,048	18,912	+6,864	+57.0%
Total Program Direction	**66,800**	**70,000**	**92,475**	**+22,475**	**+32.1%**
Federal FTEs – HQ	**141**	**141**	**168**	**+27**	**+19.1%**

Program Direction Summary	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Federal FTEs – NETL[1]	**138**	**138**	**140**	**+2**	**+1.4%**
Federal FTEs – Total	**279**	**279**	**308**	**+29**	**+10.4%**
Support Services					
Technical Support					
Headquarters	550	2,620	4,124	+1,504	+57.4%
NETL	0	0	0	0	0.0%
Import/Export Authorization	485	450	3,205	+2,755	+612.2%
Total, Technical Support	**1,035**	**3,070**	**7,329**	**+4,259**	**+138.7%**
Management Support					
Headquarters	0	0	0	0	0.0%
NETL	6,600	7,100	6,150	-950	-13.4%
Import/Export Authorization	0	0	0	0	0.0%
Total Management Support	**6,600**	**7,100**	**6,150**	**-950**	**-13.4%**
Total, Support Services	**7,635**	**10,170**	**13,479**	**+3,309**	**+32.5%**
Other Related Expenses					
Headquarters	7,710	8,418	13,709	+5,291	+62.9%
NETL	3,100	3,100	3,500	+400	+12.9%
Import / Export Authorization	530	530	1,703	+1,173	+221.3%
Total, Other Related Expenses	**11,340**	**12,048**	**18,912**	**+6,864**	**+57.0%**

[1] Additional NETL FTEs are funded within the NETL Research and Operations budget line.

Program Direction Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Program Direction $70,000,000	**$92,475,000**	**+$22,475,000**
Salaries and Benefits $46,962,000	**$57,969,000**	**+$11,007,000**
• The funding supports Headquarters (HQ) Federal staff who provide monitoring (oversight and audit) activities for the Office of Fossil Energy and Carbon Management (FECM) research, development, demonstration, and deployment (RDD&D) portfolio. • The funding supports the technical Federal staff at the National Energy Technology Laboratory (NETL). The staff covered in this area provide for management of the Lab, communications, legal, acquisition and finance activities.	• The funding supports HQ Federal staff who provide monitoring (oversight and audit) activities for the FECM RDD&D portfolio. • The funding supports the technical Federal staff at NETL. The staff covered in this area provide for management of the Lab, communications, legal, acquisition and finance activities.	• The HQ increase reflects the additions to full-time equivalents (FTE) to support FECM's mission as well as a 5.2% pay raise for federal staff in 2024, the Federal Employees Retirement System (FERS) increase, and awards pool funding increase in FY 2024.
Travel $820,000	**$2,115,000**	**+$1,295,000**
• 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	**$13,479,000**	**+$3,309,000**
• Support Services at HQ includes technical support, information technology (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, administrative support. • Support services at NETL include management and communications support, as well as finance and acquisition technicians.	• The $3.3M increase over FY 2023 Enacted Budget for Import/Export Program Direction support services is to cover anticipated studies and environmental reviews, Fossil Energy Regulatory Gas Activity System (FERGAS), and 5.2% adjustment for cost-of-living increase. • As FTEs increase, cost categories such as WCF, training, supplies, rent (outside of WCF), equipment, and IT expenses increase as well. • NETL Support Services projected obligations are flat.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Other Related Expenses $12,048,000	**$18,912,000**	**+$6,864,000**
• The activities supported by this line item include E-Government initiatives, Working Capital Fund (WCF), computer systems and support, contractual services for HQ and environmental, security, safety, and health 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 environmental, security, safety, and health 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 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
5,000	6,000	6,000	0	N/A

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. This transition will be challenging for a variety of technical, political, and socio-economic reasons.

In the U.S., fossil resources (coal/natural gas/oil) play a major role in meeting energy needs. Coal generation has declined over the past decade, leading to challenges in host communities. In parts of Appalachia, coal-related employment has declined for decades due to increased automation and reduced demand. In the Powder River Basin, the largest source of U.S. coal, production began declining in 2008 and has fallen more sharply in recent years.

Fossil asset retirements can mean that transmission and distribution infrastructure, electrical interconnection equipment, site and permitting licenses, and other infrastructure become available for alternative uses. As the Nation reduces its carbon footprint and deploys new technology and infrastructure, productively repurposing 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 that come with productively leveraging existing assets for new uses. 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 leveraging and transforming decommissioned and retiring energy assets, including coal power plants, coal mines, and abandoned oil and gas wells, through repurposing them for clean energy and manufacturing, including through technical assistance, financial assistance, and developing publicly available tools and resources. The program will also conduct stakeholder outreach and fund studies on how existing energy assets can safely and reliably support energy service provision as decarbonization proceeds. Many fossil energy asset sites host a skilled workforce with knowledge of industrial operations, livelihoods, 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, and potentially even site and permitting licenses among other assets.

The FY 2024 Budget Request of $6M will support energy asset transformation efforts across the U.S., through both direct assistance (e.g., funding an ongoing project in a community hosting an asset undergoing transition, through mechanisms like prizes, competitive solicitations, and Partnership Intermediary Agreements (PIAs)) and paper case studies (e.g., through supporting work at headquarters, the National Labs, or contractor funding). It will also continue to support place-based interagency efforts related to energy transition and energy asset transformation, including by contributing to DOE's funding of the Rapid Response Teams associated with the Interagency Working Group on Coal and Power Plant Communities. The program will fund concept development through prizes or a competitive solicitation to repurpose the existing asset, with the intent of supporting transformation efforts in seeking additional support for FEED studies and other work. The program will also support 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. Success will be measured by number of applications (an indicator of need) and number of projects funded (an indicator of project quality). Where appropriate, success will also be measured by projects' impacts on their host communities (e.g., through indicators like those developed under Justice40) and contribution to further funding applications (e.g., for FEED or demonstration funding, or loan support).

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy Asset Transformation $6,000,000	**$6,000,000**	**+$0**
• Funding supports both direct assistance to energy asset host communities (through mechanisms like prizes, Partnership Intermediary Agreements, 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 Rapid Response Teams and other place-based initiatives focused on energy transitions.	• Funding will continue to support engagement by the Rapid Response Teams • Funding will be used for direct assistance to energy asset host communities, including through prizes, technical assistance, and PIAs. • Funding will be used to support transformation activities and develop early-stage concepts through prizes, competitive solicitation, and technical assistance, potentially leading to some pre-front end engineering design (FEED) for asset repurposing and adaptive use given new and challenging operational constraints.	• The program is not seeking additional funding for FY 2024 versus FY 2023.

Fossil Energy and Carbon Management Workforce Development
University Training and Research

($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
13,000	13,000	19,000	+6,000	+46.2%

Overview

The Department of Energy's (DOE) FY 2024 Budget Request proposes historic increases in funding for foundational research and development (R&D) to train the next generation of students at Historically Black Colleges and Universities (HBCU) and Minority-Serving Institutions (MSI) majoring in science (including social science), technology, engineering, and mathematics (STEM), and humanities disciplines to strengthen the workforce. The University Training and Research (UTR) subprogram focuses on introducing students to the diversity of research topics pursued in support of the Fossil Energy and Carbon Management mission and goals. The FY 2024 Budget funds a new competitive funding opportunity announcements (FOA) for U.S. academic institutions of higher learning to support fundamental research that cuts across the Office of Fossil Energy and Carbon Management's (FECM) research focus areas, including exploration and education of the integration of cultural sensitivities, design and esthetics, and other community issues, into the development and deployment of new technology. The funding aims to sustain a national university program of research in energy, environmental, science, social science, engineering, and humanities that focuses on innovative and fundamental investigations pertinent to advancing the Administration's research, development, demonstration, and deployment (RDD&D) and equity goals.

The UTR subprogram comprises of two areas, which are competitively funded on an annual basis to encourage broad participation:

- **University Carbon Research (UCR) $5 million:** This sub-activity provides funding to colleges and universities to support early-stage research and education into societal and human impacts of new technology development and deployment consistent with the program's goals including Advancing Carbon Dioxide Removal, Accelerating Clean Hydrogen, Demonstrating and Deploying Point-Source Carbon Capture, and Advancing Critical Minerals (CM), Rare Earth Elements (REEs), Coal and Coal Waste to Products, and Mine Remediation. This sub-activity provides a threefold benefit: (1) conducting directed energy research in an innovative environment; (2) expanding the research capabilities and education of students in STEM and humanities disciplines; and (3) developing research-based solutions to support Administration RDD&D and equity goals.
- **Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI) $14 million**: This sub-activity also supports early-stage mission-focused research and investigations and education into the societal and human impacts of new technology deployment related to the FECM mission. Grants awarded under this program are intended to maintain and upgrade the educational, training, and research capabilities of HBCUs/MSIs in the fields of STEM and humanities with project results being used to further DOE and the Administration's commitment to equity and to advancing carbon management, critical minerals, and environmental remediation priorities.

Fossil Energy and Carbon Management Workforce Development
University Training and Research

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
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 Office of Fossil Energy and Carbon Management's (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.	• Support curriculum design, research on successful recruitment and retention methods, development of outreach or mentorship programs, fellowships, and building science, engineering research, and education capacity.
HBCU, MSI, Education, and Training $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 request level significantly increases historical funding levels, in part, to accommodate the Administration's Justice40 Initiative. • Support curriculum design, research on successful recruitment and retention methods, development of outreach or mentorship programs, fellowships, and building science, engineering research, and education capacity.

Fossil Energy and Carbon Management
Facilities Maintenance and Repair

The Department's 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 2021 Actual Cost	FY 2021 Planned Cost	FY 2022 Planned Cost	FY 2023 Planned Cost
National Energy Technology Laboratory	19,282	10,915	19,780	19,780
Total, Direct-Funded Maintenance and Repair	**19,282**	**10,915**	**19,780**	**19,780**

Report on FY 2021 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 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 2021 to the amount planned for FY 2021, including Congressionally directed changes.

Total Costs for Maintenance and Repair ($K)

	FY 2021 Actual Cost	FY 2021 Planned Cost
National Energy Technology Laboratory	19,282	10,915
Total, Direct-Funded Maintenance and Repair	**19,282**	**10,915**

In review of the planned vs actual costs for FY 2021, the primary reason for higher than planned costs is pandemic-related delays in project execution. Certain costs originally planned for FY 2019 and FY 2020 were not incurred until FY 2021. Larger dollar projects that were delayed included NETL's sensitive compartmented information facility and water line replacement at the Pittsburgh site. A fire at the Albany site also contributed to higher actual FY 2021 maintenance and repair costs.

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. In this table, report 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.

Fossil Energy and Carbon Management
Excess Facilities

Costs for Direct-Funded Excess Facilities ($K)

	FY 2021 Actual Cost	FY 2021 Planned Cost	FY 2022 Planned Cost	FY 2023 Planned Cost
National Energy Technology Laboratory (All)	54	45	40	40
NA	0	0	0	0
Total, Direct-Funded Excess Facilities	54	45	40	40

Fossil Energy and Carbon Management
Capital Summary ($K)

	Total	Prior Years	FY 2022 Enacted	FY 2022 Actuals	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))							
Capital Equipment >$500,000 (including MIE)	n/a	0	0	0	0	0	0
Minor Construction Project (>$5 million)	32,000	0	32,000	32,000	0	0	0
Total, Capital Operating Expenses	**32,000**	**0**	**32,000**	**32,000**	**0**	**0**	**0**
Capital Equipment > $500,000 (including MIE)							
Total Non-MIE Capital Equipment	n/a	0	0	0	0	0	0
Total, Capital Equipment (including MIE)	**n/a**	**0**	**0**	**0**	**0**	**0**	**0**
Minor Construction Projects (>$5 million)							
Computational Science & Engineering Center	12,000	0	12,000	12,000	0	0	0
Direct Air Capture Center	20,000	0	20,000	20,000	0	0	0
Total, Minor Construction Projects	**32,000**	**0**	**32,000**	**32,000**	**0**	**0**	**0**
Total, Capital Summary	**32,000**	**0**	**32,000**	**32,000**	**0**	**0**	**0**

Fossil Energy and Carbon Management
Safeguards and Security ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Protective Forces	3,164	3,164	4,325	+1,161	36.7%
Physical Security Systems	171	171	150	-21	-12.3%
Information Security	156	163	3,239	+3,076	1,887.1%
Cybersecurity*	4,416	4,416	7,398	+2,982	67.5%
Personnel Security	346	358	383	+25	7.0%
Material Control and Accountability	0	0	0	0	N/A
Research, Development, Demonstration, and Deployment (RDD&D)	0	0	0	0	N/A
Program Management	316	320	337	+17	5.3%
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	**8,569**	**8,592**	15,832	+7,240	**84.3%**

*Does not include Fossil Energy and Carbon Management (FECM) RDD&D-funded HQ cybersecurity (FY 2022, $1.3 million; FY 2023, $1.8 million; FY 2024, $2.3 million)

National Energy Technology Laboratory (NETL) - Funding will support continued 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 FECM 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.