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

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
750,000	750,000	893,160	+$143,160	+19.1%

Overview

The Office of Fossil Energy and Carbon Management (FECM) conducts research, development, demonstration, and deployment (RDD&D) that focuses on technologies to reduce carbon emissions and other environmental impacts of fossil fuel production and use, particularly the hardest-to-decarbonize applications in the electricity and industrial sectors. Furthermore, the program advances technologies that convert and durably store CO_2 into value-added products and technologies on carbon dioxide (CO_2) removal (CDR) to remove atmospheric and legacy emissions of CO_2.

To meet these challenges, the FECM Budget focuses on technology priority areas of point-source carbon capture, carbon transport and storage, carbon dioxide conversion, hydrogen with carbon management, methane emissions reduction, critical minerals (CM) production, and CDR. FECM recognizes that global decarbonization is essential to meeting climate goals—100% 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 conditions of communities impacted by the legacy of fossil fuel use and to supporting a healthy economic transition that accelerates the growth of good-paying jobs.

FECM is dedicated to implementing the principles of climate and clean energy and environmental justice in the planning, processes, and outcomes of its work in alignment with Executive Orders (EO) 14008, *Tackling the Climate Crisis at Home and Abroad,* and EO 13985, *Advancing Racial Equity and Support for Underserved Communities Through the Federal Government*. FECM focuses on: (1) the meaningful participation of communities, with special focus on disadvantaged communities; (2) a just distribution of benefits; and (3) emphasis on remediating legacy harms while also mitigating new impacts. These principles will be at the center of funding decisions, including implementation of the Justice40 Initiative, and partnership development.

The FY 2023 Budget Request for FECM will extend the impact of the Department of Energy's (DOE) RDD&D funding by leveraging creative funding mechanisms—such as prizes, competitions, technical assistance, and programs targeted to small businesses. The goal is to enable the commercialization of climate change and clean energy innovations that will activate job creation, expand other public impact outcomes, and yield a more geographically-diverse and impactful research portfolio. This request also includes funding for the basic operating costs of FECM and investment at the National Energy Technology Laboratory (NETL).

FECM's FY 2023 priorities follow:

- **Point-Source Carbon Capture:** Reduce the cost, increase the efficacy, and advance the deployment of commercial-scale point-source capture technologies in the power and industrial sectors, coupled to permanent storage.
- **Methane Mitigation:** Develop technologies and deploy regional initiatives to monitor and reduce methane emissions from fossil fuel infrastructure including coal, oil, and gas.
- **Carbon Dioxide Removal (CDR):** Invest in a diverse set of CDR approaches to support DOE's Carbon Negative Shot of just, sustainable, and scalable CDR at costs below $100/net metric ton of CO_2-equivalent (CO_2e).
- **Domestic Critical Minerals Production:** Support demonstrations for extraction and remediation to processing and refining for building a strong CM supply chain while creating good-paying jobs.
- **Reliable Carbon Storage and Transport:** Make advancements in storage technologies and transport mechanisms, provide technical assistance in Class VI well permitting, and support large-scale transport and storage facilities and regional hubs.
- **Carbon Dioxide Conversion:** Accelerate capabilities for large-scale conversion of CO_2 into products that advance net-zero and justice goals, facilitated by markets for CO_2 as a feedstock.

- **Hydrogen with Carbon Management:** Research, development, deployment, and demonstration (RDD&D) for hydrogen production coupled with carbon capture and storage (CCS) using sustainably sourced carbon-based feedstocks. Invest in the advancement and utility-scale demonstration of hydrogen storage, reversible solid oxide fuel cells, and 100 percent hydrogen fired turbines (with NOx mitigation), supporting DOE's Hydrogen Shot target.
- **Justice, Labor, and Domestic and International Collaboration:** Collaborate with domestic and international partners to create a sustainable energy infrastructure with equity and justice at the core of FECM's work.

Highlights and Major Changes in the 2023 Budget Request
Recognizing recent developments in the United States (U.S.) and global energy landscape, the FY 2023 FECM RDD&D Budget Request is adjusted relative to the FY 2021 Enacted Level:

- There is a need for the advancement of next-generation decarbonized technologies to achieve a net-zero carbon economy. This requires a deep investment and prioritization of carbon management, including point-source carbon capture, direct air capture (DAC), CO_2 conversion approaches, and dedicated and reliable CO_2 storage.
- There is growing importance for the U.S. to focus on zero-carbon and carbon-neutral hydrogen. In partnership with the Office of Energy Efficiency and Renewable Energy (EERE) Hydrogen and Fuel Cell Technologies Office (HFTO), DOE will invest in a wide array of hydrogen technologies to expedite the hydrogen energy economy.
- Methane is one of the most potent GHG. It is critical that we reduce methane leakage. To that end, FECM will invest in approaches that reduce methane emissions from the oil, gas (e.g., fugitive methane and flaring), and coal (methane emissions from active and abandoned mines and wells) industries toward the production of useful chemicals such as hydrogen and ammonia.
- The U.S. must become a leader in CM and rare earth elements (REE) supply. FECM will increase focus on the extraction of CM and REE from coal feedstocks and byproducts of the industry, which will also serve as an economic transition strategy in regions of the U.S. that are heavily dependent on this industry today.
- The FY 2023 Budget continues the process from FY 2022 of ensuring that its programs do not directly subsidize fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels while also investing in technologies to improve energy security and lower energy prices. The Budget focuses on other activities that support clean energy development and deployment (including carbon management), environmental benefits, and the creation of good-paying jobs that provide a free and fair chance to join a labor union.

For comparability, all discussions of funding changes that follow assume the FY 2023 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 ($478.905M)
The Office of Carbon Management (OCM) facilitates a just and environmentally sustainable transition toward a net-zero carbon economy by focusing on CO_2—its storage, permanent containment, and capture. OCM addresses emissions associated with the power and industrial sectors, as well as legacy 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 2023 Budget Request are as follows:

Hydrogen with Carbon Management ($74M)
The Hydrogen with Carbon Management (HCM) subprogram invests in RDD&D to evaluate carbon-based clean H_2 (i.e., coupled to CCS) as a fuel and support development of technologies to use clean H_2 from any source. The subprogram's efforts are an integral part of DOE's recently launched Hydrogen Shot, with a goal of clean H_2 costs of $1/kg within one decade (1-1-1) while expanding employment of the U.S. energy workforce. Seeking a cost-competitive decarbonized alternative to traditional fossil fuels, the subprogram has a research and development (R&D) portfolio consisting of a new generation of carbon neutral or net-negative GHG emissions technologies. Gasification, reversible solid oxide fuel cells (RSOFCs), technologies in H_2 turbines, and advanced materials, sensors and controls all support this goal.

The FY 2023 Budget Request for HCM of $74 million for these activities will provide research with a platform for developing the advanced systems of the future, while reducing emissions. In FY 2023, the subprogram will not fund RDD&D specific to traditional fossil power generation, but rather, will narrow the focus to work on H_2-fueled turbines, fuel cells, CCS-relevant technologies, and production of clean H_2 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 sector, especially regarding disadvantaged communities. As such, the subprogram is working to address local air quality issues associated with Nitrous Oxide emissions that could be produced as a byproduct Hydrogen combustion – and working to ensure that impacts to disadvantaged communities are robustly considered when siting new hydrogen infrastructure.

Carbon Transport and Storage ($122M)

The Carbon Transport and Storage (CTS) subprogram is uniquely positioned to support the U.S. as it develops a carbon transport and storage industry at the scale necessary to decarbonize the economy while considering environmental and social benefits and associated impacts these efforts may have. This RDD&D subprogram is making key investments in advanced technology RDD&D, large-scale transport scenarios, commercial-scale storage facilities, and regional hubs, all to support a foundation for carbon storage in support of both carbon mitigation and removal. Critical components that will help catalyze the growth of CCS deployment at-scale include, but are not limited to, strategies to develop the infrastructure for reliable carbon storage, RDD&D to improve performance and reduce costs, educational partnerships to grow the workforce, technology transfer, and technical assistance to stakeholders.

The FY 2023 Budget Request provides $122 million for the CTS subprogram and RDD&D activities that address the performance challenges of operating and monitoring commercial scale CO_2 storage sites. The RDD&D supported by the CTS subprogram will aim to improve storage and operational efficiency, improve understanding of overall cost and de-risking strategies to reduce it. 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 ($65M) and Carbon Dioxide Conversion ($50M)

The CDR subprogram advances a diverse set of CDR approaches in service of facilitating gigatonne-scale removal by mid-century. It emphasizes rigorous analysis of life cycle impacts and has a deep commitment to justice. The subprogram invests in CDR technologies, such as DAC and direct ocean capture (DOC) with durable storage; biomass with carbon removal and storage (BiCRS); and mineralization concepts to remove legacy emissions and address emissions from hard-to-abate sectors.

The Carbon Dioxide Conversion (CDC) subprogram invests in research, development, and demonstration (RD&D). It supports the ecosystem to deploy technologies that recycle CO_2 into value-added products. To create products such as CO_2-based building materials, fuels, and chemicals, the subprogram focuses on mineralization, catalytic conversion, and biological approaches. Through these investments, the CDC subprogram can help the U.S. achieve the goals of a net-zero carbon economy by 2050, while simultaneously developing the industries of the future in equitable and just ways.
In FY 2023, the Budget Request provides $65 million for CDR and $50 million in the CDC subprograms. CDR funding will support continued development of novel DAC and DOC materials and processes to help optimize and reduce the cost, R&D, and Front End Engineering and Design (FEED) studies for BiCRS, and novel approaches that can leverage industrial waste minerals and naturally occurring minerals that can capture atmospheric CO_2.

CO_2 conversion technologies for the CDC subprogram have the potential to develop additional markets for CO_2-based 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, polymers, and nutraceuticals; mineralization to building products; generation of solid carbon products; and algal systems designed to integrate 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 ($162.905M)

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 CO_2-emitting industrial sectors, such as cement, steel, and H_2 production are particular priorities. FY 2023 activities will focus on new capture technologies in

addition to the demonstration of more proven capture approaches. The FY 2023 Budget Request provides $162.905 million in the Point-Source Carbon Capture subprogram for pre- and post-combustion capture RDD&D on transformational gas separation technologies that can help achieve decarbonization goals.

Additionally, the Point-Source Carbon Capture subprogram will leverage its prior and current RDD&D experience on carbon capture technology development for application to industrial applications, specifically, cement, steel and H_2 production. RDD&D will focus on optimization of technologies for these applications to reduce cost and improve performance. A continued focus will be on decarbonization of natural-gas based systems for power generation.

Carbon Management – Policy and Analysis ($4M)
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 thoughtfully engaging with stakeholders, realistic scenarios can be crafted using market and technology-based information. The FY 2023 Budget Request for Policy and Analysis is $4 million.

Carbon Management – Justice and Engagement ($1M)
The FY 2023 Request of $1 million supports research, development, demonstration, and deployment (RDD&D) of carbon management technologies through engagement with key partners within the U.S. and globally. Funding will support domestic engagement and justice efforts as well as international collaboration with various partners through bi-lateral and multi-lateral agreements. The Office of Fossil Energy and Carbon Management (FECM) will focus on building capacity and working with interagency partners to ensure safe, effective, and efficient implementation of its RDD&D 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 ($182.694M)
The Resource Sustainability Office addresses critical issues associated with reducing the environmental impacts of the historical and continued use of fossil fuels. This includes conducting RDD&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 2023 Budget Request, which totals $182.694 million, are as follows:

Advanced Remediation Technologies ($12.964M) (New Control Point)
The Advanced Remediation Technologies program will focus on technologies that can be applied to the remediation and prevention of environmental impacts from fossil fuel extraction activities. This will include research to address wellbore integrity, induced seismicity, water use, produced water treatment, water management, and offshore safety and spill prevention. The program will leverage previous research, to include field laboratory efforts, to assess the viability of converting expended unconventional oil and gas wells to carbon storage sites.

Methane Mitigation Technologies ($100M) (New Control Point)
The Methane Mitigation Technologies program will develop technologies to reduce emissions from fossil fuel production, transmission, distribution, processing, and storage infrastructure. This program will also focus on developing technologies to detect, locate, and measure emissions, including the development and validation of measurement sensor technologies for the collection, dissemination, and analysis of emissions data which will inform efforts such as the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory, Life Cycle Analysis (LCA), and other remediation programs. 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. It will also conduct research to develop advanced materials, sensors, data management systems, and more efficient and flexible compressors.

Natural Gas Decarbonization and Hydrogen Technologies ($26M) (New Control Point)
The new Natural Gas Decarbonization and Hydrogen Technologies program will focus on technologies for carbon-neutral H_2 production as well as hydrogen (and ammonia) transportation, and geologic storage technologies that leverage existing natural gas infrastructure as well as supporting analytical tools and models. Hydrogen research will focus on improving natural gas steam methane reforming (SMR), blending H_2 with natural gas, and leveraging existing transportation and 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.

Mineral Sustainability ($44M)
The Mineral Sustainability program will support the sustainable economic, environmental, and geopolitical production of CM. The integration of extraction of carbon ore and CM is naturally part of the upstream process; therefore, the integration of the CM and Carbon Ore Processing activities will result in more efficient and economic technology development and deployment. 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, REE and carbon ore to products production.

The Carbon Ore Processing activity (formerly Advanced Coal Processing) is focused on utilizing materials to be recycled from previously mined resources outside of traditional thermal and metallurgical markets that can contribute to the U.S. gross domestic product. The 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. These transformational technologies have minimal emissions, superior product performance, and better lifecycle for new and existing products in the market.

Resource Sustainability – Policy and Analysis ($0)
These activities will be completed with available resources; no additional funding is requested in FY 2023. The Policy and Analysis Division supports all program areas in the Office of Resource Sustainability through the drafting of studies and reports, conducting economic and environmental analysis, and reviewing legislation, regulations, and executive orders.

Resource Sustainability – Justice and Engagement ($0)
These activities will be completed with available resources; no additional funding is requested in FY 2023. This Justice and Engagement Division conducts and provides support to leadership's engagement with a wide set of domestic and international stakeholders, to include frontline and disadvantaged communities, government agencies, non-government entities, non-profits, academia, and foreign governments.

Other FECM Program Activities
Repurposing Fossil Energy Assets ($6M)
The Repurposing Fossil Assets program will support leveraging and transforming fossil assets, including coal power plants, coal mines, and abandoned oil and gas wells, through repurposing them for clean energy and manufacturing. This is one of the best ways to unite private sector and energy community interests in places where employment and opportunity is on the decline. Many fossil asset sites can offer private sector actors looking to repurpose with access to 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 assets. 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. In turn, repurposing considerably addresses the potential resistance to the decommissioning of coal plants and ensures that historic energy communities have a path forward. For energy communities, repurposing fossil assets can provide a variety of both short-term and permanent family-wage jobs, 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 claim control of their own narratives and become active participants in the energy transition.

The FY 2023 Budget Request of $6 million will develop case studies of fossil assets across the U.S. that are being repurposed. The program will fund concept development followed by pre-FEED studies where the assets can be transformed to use other sources of clean energy such as solar, geothermal, wind, and nuclear sources and repurpose the

existing fossil asset. The case studies and the pre-FEED work will serve as powerful examples for other communities to emulate and transition in a phased and methodical manner to achieve the clean energy goals.

University Training and Research ($13M)
The request of $13 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 2023.

National Energy Technology Laboratory (NETL)

($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request
NETL Program Direction	27,780	27,780	29,900
NETL Infrastructure	55,000	55,000	55,000
NETL Research and Operation	83,000	83,000	83,000
Interagency Working Group	0	0	3,000
Subtotal, NETL	**165,780**	**165,780**	**170,900**
Special Recruitment	700	700	1,000
HQ Program Direction (includes Import/Export)	33,720	33,720	40,391
Subtotal, Remaining Programs	**34,420**	**34,420**	**41,391**

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 2023 Budget Request for NETL is $170.9M and an additional $41.4M 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 $70.291 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 2023 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, and for information technology (IT) development, modernization, and enhancement.
- **NETL Research and Operations:** The Request of $83 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 FY 2023 Budget Request of $3 million for the DOE-led Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization will support the IWG's capacity building activities conducted at NETL, including research and analysis to inform investment decisions and the coordination of interagency efforts to deliver Federal resources to those communities hard-hit by coal, oil and gas, and power plant closures. Capacity building activities will focus not only on promoting investments that support economic revitalization and job

creation in these communities but will also proactively promote investments in communities likely to be impacted by these closures in the near-term.

Cybersecurity: DOE is engaged in two categories of cyber-related activities: (1) safeguarding the DOE enterprise IT systems from a range of cyber threats that can adversely impact mission capabilities, and (2) enhancing the security of U.S. critical energy infrastructure to all hazards, mitigate the impacts of disruptive events and risk to the sector overall through preparedness and innovation, and respond to and facilitate recovery from energy disruptions in collaboration with other Federal agencies, the private sector, and State, local, tribal, and territory governments. FECM's IT cybersecurity efforts in FY 2023 targets critical cybersecurity needs across FECM enterprise, prioritizing cybersecurity enhancements, including: zero trust architecture implementation, transition to ongoing authorization, adoption of DOE Order 205.1C, establish a privacy continuous monitoring, cloud migration and security, support Federal Information Security Modernization Act (FISMA) remediation, establish security operations center, and DOE cyber retention incentive program.

Energy Storage Grand Challenge (ESGC): DOE is participating in the ESGC and provides $6 million of support relevant to that program from within FECM's Repurposing Fossil Energy Assets program.

FY 2023 Crosscuts ($K)

	Cybersecurity	Energy Storage Grand Challenge	Total
NETL Infrastructure	9,378	0	9,378
Program Direction	1,800	0	1,800
Repurposing Fossil Energy Assets	0	6,000	6,000
Total, Crosscuts	**11,178**	**6,000**	**17,178**

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

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Carbon Management Technologies					
Hydrogen with Carbon Management	122,300	122,300	74,000	-48,300	-39.5%
Carbon Transport and Storage	79,000	79,000	122,000	+43,000	+54.4%
Carbon Dioxide Removal	40,000	40,000	65,000	+25,000	+62.5%
Carbon Dioxide Conversion	23,000	23,000	50,000	+27,000	+117.4%
Point-Source Carbon Capture	86,300	86,300	162,905	+76,605	+88.8%
Carbon Management - Policy and Analysis	500	500	4,000	+3,500	+700.0%
Carbon Management - Justice and Engagement	650	650	1,000	+350	+53.8%
Transformational Coal Pilots	10,000	10,000	0	-10,000	-100.0%
Supercritical Transformational Electric Power (STEP)	14,500	14,500	0	-14,500	-100.0%
Subtotal, Carbon Management Technologies	**376,250**	**376,250**	**478,905**	**+102,655**	**+27.3%**
Resource Sustainability					
Advanced Remediation Technologies	44,500	44,500	12,964	-31,536	-70.9%
Methane Mitigation Technologies	20,000	20,000	100,000	+80,000	+400.0%
Natural Gas Decarbonization and Hydrogen Technologies	0	0	26,000	+26,000	N/A
Mineral Sustainability	53,000	53,000	44,000	-9,000	-17.0%
Subtotal, Resource Sustainability	**117,500**	**117,500**	**182,964**	**+ 65,464**	**+55.7%**
Unconventional Fossil Energy Technologies from Petroleum - Oil Technologies	**46,000**	**46,000**	**0**	**-46,000**	**-100.0%**
Repurposing Fossil Energy Assets	**5,000**	**5,000**	**6,000**	**+1,000**	**+20.0%**
University Training and Research	**5,050**	**5,050**	**13,000**	**+7,950**	**+157.4%**
Special Recruitment	**700**	**700**	**1,000**	**+300**	**+42.9%**
Program Direction	**61,500**	**61,500**	**70,291**	**+8,791**	**+14.3%**
NETL Infrastructure	**55,000**	**55,000**	**55,000**	**0**	**0%**
NETL Research and Operations	**83,000**	**83,000**	**83,000**	**0**	**0%**
Interagency Working Group	**0**	**0**	**3,000**	**+3,000**	**N/A**
Total, Fossil Energy and Carbon Management	**750,000**	**750,000**	**893,160**	**+143,160**	**+19.1%**
Federal FTEs	**679**	**679**	**719**	**40**	

SBIR/STTR:

- FY 2021 Enacted: SBIR $12,970; STTR: $2,256
- FY 2022 Annualized CR: SBIR $12,970; STTR: $2,256
- FY 2023 Request: SBIR $17,300; STTR: $2,433

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

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Carbon Management Technologies					
Hydrogen with Carbon Management	0	0	74,000	+74,000	N/A
Carbon Transport and Storage	0	0	122,000	+122,000	N/A
Carbon Dioxide Removal	0	0	65,000	+65,000	N/A
Carbon Dioxide Conversion	0	0	50,000	+50,000	N/A
Point-Source Carbon Capture	0	0	162,905	+162,905	N/A
Carbon Management - Policy and Analysis	0	0	4,000	+4,000	N/A
Carbon Management - Justice and Engagement	0	0	1,000	+1,000	N/A
Transformational Coal Pilots	0	0	0	0	N/A
Supercritical Transformational Electric Power (STEP)	0	0	0	0	N/A
Subtotal, Carbon Management Technologies	**0**	**0**	**478,905**	**+478,905**	N/A
Resource Sustainability					N/A
Advanced Remediation Technologies	0	0	12,964	+12,964	N/A
Methane Mitigation Technologies	0	0	100,000	+100,000	N/A
Natural Gas Decarbonization and Hydrogen Technologies	0	0	26,000	+26,000	N/A
Mineral Sustainability	0	0	44,000	+44,000	N/A
Subtotal, Resource Sustainability	**0**	**0**	**182,964**	**+182,964**	N/A
Unconventional Fossil Energy Technologies from Petroleum - Oil Technologies	0	0	**0**	**0**	N/A
Repurposing Fossil Energy Assets	0	0	**6,000**	**+6,000**	N/A
University Training and Research	0	0	**13,000**	**+13,000**	N/A
Special Recruitment	0	0	**1,000**	**+1,000**	N/A
Program Direction	0	0	**70,291**	**+70,291**	N/A
NETL Infrastructure	0	0	**55,000**	**+55,000**	N/A
NETL Research and Operations	0	0	**83,000**	**+83,000**	N/A
Interagency Working Group	0	0	**3,000**	**+3,000**	N/A
Total, Fossil Energy and Carbon Management	**0**	**0**	**893,160**	**+893,160**	N/A
Federal FTEs	**0**	**0**	**719**	**+719**	N/A

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
CCUS and Power Systems					
Carbon Capture	126,300	126,300	0	-126,300	-100.00%
Carbon Utilization	23,000	23,000	0	-23,000	-100.00%
Carbon Storage	79,000	79,000	0	-79,000	-100.00%
Advanced Energy Systems	122,000	122,000	0	-122,000	-100.00%
Cross Cutting Research	72,000	72,000	0	-72,000	-100.00%
Transformational Coal Pilots	10,000	10,000	0	-10,000	-100.00%
Supercritical Transformational Electric Power (STEP)	14,500	14,500	0	-14,500	-100.00%
Subtotal, CCUS and Power Systems	**446,800**	**446,800**	**0**	**-446,800**	**-100.00%**
Natural Gas Technologies	**51,000**	**57,000**	**0**	**-57,000**	**-100.00%**
Unconventional Fossil Energy Technologies from Petroleum - Oil Technologies	**46,000**	**46,000**	**0**	**-46,000**	**-100.00%**
Special Recruitment	**700**	**700**	**0**	**-700**	**-100.00%**
Program Direction	**61,500**	**61,500**	**0**	**-61,500**	**-100.00%**
NETL Infrastructure	**55,000**	**55,000**	**0**	**-55,000**	**-100.00%**
NETL Research and Operations	**83,000**	**83,000**	**0**	**-83,000**	**-100.00%**
Total, Fossil Energy and Carbon	**750,000**	**750,000**	**0**	**-750,000**	**-100.00%**
Federal FTEs	**679**	**679**	**0**	**-679**	**-100.00%**

Outyear Funding
($K)

	FY 2023 Request	FY 2024 Request	FY 2025 Request	FY 2026 Request	FY 2027 Request
Office of Fossil Energy and Carbon Management	893,160	913,703	934,718	955,282	976,298

Outyear Priorities and Assumptions

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2024 - FY 2027. The outyear funding levels use the growth rates in outyear account totals published in the FY 2023 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

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.

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

- **In consultation with other offices:**
  - **Regional Direct Air Capture Hubs (with OCED) –** The goal of this investment is to establish a program under which the Secretary shall provide funding for eligible projects that contribute to the development of 4 regional direct air capture hubs.
  - **Carbon Storage Validation and Testing (with OCED) –** 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.
  - **Carbon Dioxide Transportation Infrastructure Finance and Innovation (CIFIA) (with LPO)** – The goal of this investment is to provide flexible, low-interest loans for CO_2 transport infrastructure projects and grants for initial excess capacity on new infrastructure to facilitate future growth. Modeled after the existing TIFIA and 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 OCED)** – The goal of this investment is to demonstrate the feasibility of a full-scale integrated rare earth element 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 rare earth elements demonstration facility.

- **Managed by FECM:**
  - **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 research and development to improve the security of rare earth elements.
- **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 Utilization and Storage technologies.
- **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 pilot projects and demonstration projects and test carbon capture technologies. Prizes will be awarded to projects that demonstrate the technical and commercial viability of technologies to reduce carbon dioxide emissions released from coal electric generation facilities and natural gas electric generation facilities for commercial deployment.
- **Precommercial Direct Air Capture Technology Prize Competitions** – The goal of this investment is to advance research, development, demonstration, and commercial application of carbon capture technologies. Prizes will be awarded to projects that demonstrate the technical and commercial viability of technologies to reduce carbon dioxide emissions released from coal electric generation facilities and natural gas electric generation facilities for commercial deployment.
- **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.

Carbon Management Technologies (CMT)
($K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
376,250[1]	376,250	478,905	+102,655	+27.3%

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

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

- **Demonstrate and Deploy Point Source Carbon Capture:** Conduct RDD&D for CCUS in the power and industrial sectors to enable wider, strategic commercial deployment to meet goals of zero carbon pollution power by 2035 and net-zero emissions by 2050.
- **Accelerate Carbon-Neutral Hydrogen (H_2):** Conduct RDD&D to evaluate carbon-neutral hydrogen (i.e., coupled to carbon capture and storage (CCS)) as a fuel and support development of technologies to use carbon-neutral hydrogen from any source.
- **Develop Low-Carbon Supply Chains for Industries:** Develop novel approaches to recycle carbon oxide (CO) emissions, principally carbon dioxide, into value-added products such as cement, concrete, steel, chemicals, and fuels using systems-based carbon management approaches.
- **Advance Carbon Dioxide Removal (CDR) and Conversion:** Research, develop, demonstrate, and deploy CDR technologies and approaches by investing in direct air capture (DAC), direct ocean capture (DOC), biomass with carbon removal and storage (BiCRS), and mineral carbonation projects.
- **Invest in Thoughtful Transition Strategies:** Invest in technologies and approaches and deploy regional initiatives to help in the transition to a net-zero greenhouse gas economy, especially in fossil infrastructure host communities. These approaches such as co-firing fossil fuels with waste biomass, coupled to carbon capture, in addition to mineral and carbon extraction from coal using safe and sustainable technologies, will leverage both regional resources and existing labor forces to achieve a clean energy economy.
- **Increase Efficient Use of Big Data and Artificial Intelligence (AI):** Use AI, machine learning (ML), and data analysis to create learning algorithms within large datasets to help discover new materials, optimize processes, and run autonomous systems. Specifically, research passive sensor platforms, data management and systems, and tools that employ AI to help adapt varying pipeline conditions and additional fluids, and to optimize dedicated CO_2 storage. Partner with academic institutions and the Department of Energy (DOE) National Laboratories to focus on the application of AI and ML to improve infrastructure operations, technology testing, systems analysis, and technology transfer to industry.

Highlights of the FY 2023 Budget Request
The Carbon Management Technologies program will pursue the following major activities in FY 2023:

<u>Hydrogen with Carbon Management</u>
The FY 2023 Budget Request for the HCM program is $74 million. The program comprises six activities: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells (R-SOFCs), (4) Advanced Energy Materials, (5) Sensors, Controls,

[1] Does not include $70.55 million that was enacted in Advanced Energy Systems ($30 million) and Crosscutting Research ($40.55 million). This table is showing a comparable budget breakdown to the FY 2023 Congressional Budget Request ($7.5 million in Advanced Remediation Technologies, $53 million in Mineral Sustainability, $5 million in Repurposing Fossil Energy Assets, and $5.05 million in University Training and Research).

and Other Novel Concepts, and (6) Simulation-Based Engineering (SBE). In FY 2023, these activities will provide a research platform for developing future advanced systems while reducing emissions. In FY 2023, the HCM subprogram will primarily focus its work on hydrogen-fueled turbines, fuel cells, CCUS-relevant technologies, and production of clean hydrogen through waste/biomass gasification. Improvements to these technologies are also applicable to other energy systems. These sub-programs will align with the administration's priority to reduce the environmental impact of the power sector, especially regarding disadvantaged communities.

Carbon Transport and Storage

The FY 2023 Budget Request provides $122 million for the Carbon Transport and Storage Program addresses the performance challenges of operating and monitoring commercial scale CO_2 storage sites. The RDD&D activities in FY 2023 will aim to improve: (1) storage and operational efficiency; (2) understanding of overall cost; and (3) de-risking strategies. Achieving each of these elements is critical for enabling a CCUS and CDR industry that is safe, economically viable, and environmentally benign.

Carbon Dioxide Removal (New Control Point)

Many modeling scenarios to achieve economy-wide decarbonization suggest that CDR will be required in the future. CDR refers to approaches that remove CO_2 from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. The FY 2023 Budget Request for CDR is $65 million and includes: DAC, DOC, BiCRS, and mineralization concepts. It will focus on lab- and bench-scale development, pilot-scale tests, front-end engineering design (FEED) studies, and life cycle analysis (LCA) and techno-economic analysis (TEA) studies of these approaches.

Carbon Dioxide Conversion

In FY 2023, the Budget Request provides $50 million for the Carbon Dioxide Conversion subprogram for lab- and bench-scale CO_2 conversion technologies that have the potential to develop environmentally and socially responsible CO_2-based 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 to various bioproducts. Funding will support laboratory 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, and standardized benchmarking for catalytic conversion systems.

Point-Source Carbon Capture

The Point-Source Carbon Capture activity has completed its efforts in first-generation technology through successful demonstration projects. FY 2023 activities represent a focus on next-generation capture technologies in addition to the demonstration of more proven capture approaches. The FY 2023 Budget Request provides $163 million to the Point-Source Carbon Capture activity for pre- and post-combustion capture RDD&D on transformational gas separation technologies that can help achieve decarbonization goals. Specifically, the FY 2023 Budget Request provides funding for pre- and post-combustion capture RDD&D on transformational gas separation technologies capable of deep decarbonization (at least 95% purity of CO_2).

Carbon Management – Policy and Analysis

The Carbon Management - Policy and Analysis subprogram has a Budget Request of $4 million and evaluates potential economic, jobs, and environmental benefits and impacts from the deployment of carbon management and fossil technologies. This subprogram supports strategic planning by identifying major challenges and opportunities to improve efficiency, cost, and environmental performance for the deployment of carbon management applications.

Carbon Management – Justice and Engagement

The FY 2023 Request of $1 million will support domestic engagement and environmental justice efforts as well as international collaboration with various partners through existing and newly established bi-lateral and multi-lateral efforts. The Office of Fossil Energy and Carbon Management (FECM) will focus on building capacity across the federal government by working with interagency partners to ensure safe, effective, and efficient implementation of DOE's carbon management RDD&D 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. These efforts will prioritize activities and strategies to maximize the impact of FECM's research dollars and help ensure that the clean energy economy benefits all Americans.

Additional Areas of Focus

The FY 2023 Budget continues the process from FY 2022 of ensuring that its programs do not directly subsidize fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels while also investing in technologies to improve energy security and lower energy prices. The Budget focuses on other activities that support clean energy development and deployment (including carbon management), environmental benefits, and the creation of good-paying jobs that provide a free and fair chance to join a labor union.

Carbon Management Technologies
Funding by Congressional Control ($K)
(Comparable)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Carbon Management Technologies					
Hydrogen with Carbon Management					
Gasification Systems	19,000	19,000	26,000	7,000	36.8%
Advanced Turbines	27,000	27,000	27,000	0	0.0%
Reversible Solid Oxide Fuel Cells	30,000	30,000	5,000	(25,000)	-83.3%
Advanced Energy Materials	16,100	16,100	5,000	(11,100)	-68.9%
Sensors, Controls and Other Novel Concepts	8,000	8,000	5,000	(3,000)	-37.5%
Simulation-Based Engineering	6,200	6,200	6,000	(200)	-3.2%
Transformative Power Generation	16,000	16,000	0	-16,000	-100.0%
Subtotal Hydrogen with Carbon Management	**122,300**	**122,300**	**74,000**	**(48,300)**	**-39.5%**
Carbon Transport and Storage					
Storage Infrastructure	57,500	57,500	90,000	32,500	56.5%
Advanced Storage RDD&D	15,700	15,700	32,000	16,300	103.8%
Sub-disciplinary Storage RDD&D	5,800	5,800	0	(5,800)	-100.0%
Subtotal Carbon Transport and Storage	**79,000**	**79,000**	**122,000**	**43,000**	**54.4%**
Carbon Dioxide Removal	**40,000**	**40,000**	**65,000**	**25,000**	**62.5%**
Carbon Dioxide Conversion	**23,000**	**23,000**	**50,000**	**27,000**	**117.4%**
Point-Source Carbon Capture					
Post-Combustion Capture Systems	73,300	73,300	144,405	71,105	97.0%
Pre-Combustion Capture Systems	10,000	10,000	15,000	5,000	50.0%
Emissions Control	3,000	3,000	3,500	500	16.7%
Subtotal Point-Source Carbon Capture	**86,300**	**86,300**	**162,905**	**76,605**	**88.8%**
Carbon Management - Policy and Analysis	**500**	**500**	**4,000**	**3,500**	**700.0%**
Carbon Management - Justice and Engagement	**650**	**650**	**1,000**	**350**	**53.8%**
Transformational Coal Pilots	**10,000**	**10,000**	**0**	**(10,000)**	**-100.0%**
Supercritical Transformational Electric Power (STEP)	**14,500**	**14,500**	**0**	**(14,500)**	**-100.0%**
Total, Carbon Management Technologies	**376,250**[1]	**376,250**	**478,905**	**102,655**	**27.3%**

[1] Does not include $70.55 million that was enacted in Advanced Energy Systems ($30 million) and Crosscutting Research ($40.55 million). This table is showing a comparable budget breakdown to the FY 2023 Congressional Budget Request ($7.5 million in Advanced Remediation Technologies, $53 million in Mineral Sustainability, $5 million in Repurposing Fossil Energy Assets, and $5.05 million in University Training and Research).

SBIR/STTR:

- FY 2021 Enacted: SBIR $8,820; STTR: $1,535
- FY 2022 Annualized CR: SBIR $8,820; STTR: $1,535
- FY 2023 Request: SBIR $12,454; STTR: $1,751

Carbon Management Technologies
Funding by Congressional Control ($K)
(Non-Comparable)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
CARBON MANAGEMENT TECHNOLOGIES					
Hydrogen with Carbon Management					
Gasification Systems	0	0	26,000	26,000	N/A
Advanced Turbines	0	0	27,000	27,000	N/A
Reversible Solid Oxide Fuel Cells	0	0	5,000	5,000	N/A
Advanced Energy Materials	0	0	5,000	5,000	N/A
Sensors, Controls and Other Novel Concepts	0	0	5,000	5,000	N/A
Simulation-Based Engineering	0	0	6,000	6,000	N/A
Transformative Power Generation	0	0	0	0	N/A
Subtotal Hydrogen with Carbon Management	**0**	**0**	**74,000**	**74,000**	**N/A**
Carbon Transport and Storage					
Storage Infrastructure	0	0	90,000	90,000	N/A
Advanced Storage RDD&D	0	0	32,000	32,000	N/A
Sub-disciplinary Storage RDD&D	0	0	0	0	N/A
Subtotal Carbon Transport and Storage	**0**	**0**	**122,000**	**122,000**	**N/A**
Carbon Dioxide Removal	**0**	**0**	**65,000**	**65,000**	**N/A**
Carbon Dioxide Conversion	**0**	**0**	**50,000**	**50,000**	**N/A**
Point-Source Carbon Capture					
Post-Combustion Capture Systems	0	0	144,405	144,405	N/A
Pre-Combustion Capture Systems	0	0	15,000	15,000	N/A
Emissions Control	0	0	3,500	3,500	N/A
Subtotal Point-Source Carbon Capture	**0**	**0**	**162,905**	**162,905**	**N/A**
Carbon Management - Policy and Analysis	**0**	**0**	**4,000**	**4,000**	**N/A**
Carbon Management - Justice and Engagement	**0**	**0**	**1,000**	**1,000**	**N/A**
Transformational Coal Pilots	**0**	**0**	**0**	**0**	**N/A**
Supercritical Transformational Electric Power (STEP)	**0**	**0**	**0**	**0**	**N/A**
Total, CARBON MANAGEMENT TECHNOLOGIES	**0**	**0**	**478,905**	**478,905**	**N/A**

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
CCUS AND POWER SYSTEMS					
Carbon Capture					
Post-Combustion Capture Systems	108,300	108,300	0	-108,300	-100.00%
Pre-Combustion Capture Systems	15,000	15,000	0	-15,000	-100.00%
Emissions Control	3,000	3,000	0	-3,000	-100.00%
Total, Carbon Capture	**126,300**	**126,300**	**0**	**-126,300**	**-100.00%**
Carbon Utilization					
Carbon Use and Reuse	23,000	23,000	0	-23,000	-100.00%
Total, Carbon Utilization	**23,000**	**23,000**	**0**	**-23,000**	**-100.00%**
Carbon Storage					
Storage Infrastructure	57,500	57,500	0	-57,500	-100.00%
Advanced Storage RDD&D	15,700	15,700	0	-15,700	-100.00%
Sub-disciplinary Storage RDD&D (formerly Focus Area for Carbon Sequestration Science)	5,800	5,800	0	-5,800	-100.00%
Total. Carbon Storage	**79,000**	**79,000**	**0**	**-79,000**	**-100.00%**
Advanced Energy Systems					
Gasification Systems	19,000	19,000	0	-19,000	-100.00%
Advanced Turbines	27,000	27,000	0	-27,000	-100.00%
Reversible Solid Oxide Fuel Cells (formerly Solid Oxide Fuel Cells)	30,000	30,000	0	-30,000	-100.00%
Advanced Coal Processing (formerly Coal Beneficiation)	30,000	30,000	0	-30,000	-100.00%
Transformative Power Generation	16,000	16,000	0	-16,000	-100.00%
Total, Advanced Energy Systems	**122,000**	**122,000**	**0**	**-122,000**	**-100.00%**
Crosscutting Research					
Plant Optimization Technologies					
Sensors, Controls and Other Novel Concepts	*8,000*	*8,000*	*0*	*-8,000*	*-100.00%*
Cross-cutting Materials RDD&D	*16,100*	*16,100*	*0*	*-16,100*	*-100.00%*
Advanced Ultrasupercritical	*0*	*0*	*0*	*0*	*N/A*
Water Management RDD&D	*7,500*	*7,500*	*0*	*-7,500*	*-100.00%*
Subtotal, Plant Optimization Technologies	31,600	31,600	0	-31,600	-100.00%
Coal Utilization Science					
Simulation Based Engineering	*6,200*	*6,200*	*0*	*-6,200*	*-100.00%*
Subtotal, Coal Utilization Science	6,200	6,200	0	-6,200	-100.00%

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Energy Analyses					
Technical and Economic Analysis	*500*	*500*	*0*	*-500*	*-100.00%*
Subtotal, Energy Analyses	500	500	0	-500	-100.00%
University Training and Research					
University Coal Research	*3,000*	*3,000*	*0*	*-3,000*	*-100.00%*
HBCU's, Education, and Training	*2,050*	*2,050*	*0*	*-2,050*	*-100.00%*
Subtotal, University Training and Research	5,050	5,050	0	-5,050	-100.00%
International Activities					
International Program Support	*650*	*650*	*0*	*-650*	*-100.00%*
Subtotal International Activities	650	650	0	-650	-100.00%
Energy Storage Grand Challenge (formerly Advanced Energy Storage Initiative)	5,000	5,000	0	-5,000	-100.00%
Feasibility of Recovering Rare Earth Elements	23,000	23,000	0	-23,000	-100.00%
Total Cross Cutting Research	**72,000**	**72,000**	**0**	**-72,000**	**-100.00%**
Transformational Coal Pilots	**10,000**	**10,000**	**0**	**-10,000**	**-100.00%**
Supercritical Transformational Electric Power (STEP)	**14,500**	**14,500**	**0**	**-14,500**	**-100.00%**
TOTAL CCUS AND POWER SYSTEMS	**446,800**	**446,800**	**0**	**-446,800**	**-100.00%**

SBIR/STTR:

- FY 2021 Enacted: SBIR $8,820; STTR: $1,535
- FY 2022 Annualized CR: SBIR $8,820; STTR: $1,535
- FY 2023 Request: SBIR $12,454; STTR: $1,751

Carbon Management Technologies
Explanation of Major Changes ($K)

	FY 2023 Request vs FY 2021 Enacted
Hydrogen with Carbon Management: At the decreased level of funding, work will focus on: (1) developing modular systems for hydrogen production, advanced gas turbines for 100% hydrogen fired turbines, and high-efficiency natural gas turbines with CCS; (2) materials development for extreme conditions; and (3) reversible solid oxide fuel cell systems.	**-$48,300**
Carbon Transport and Storage: Funding prioritizes CarbonSAFE Phase II storage opportunities and CarbonSTORE field labs, continues the four Regional Initiative projects to provide technical assistance to their respective stakeholders, and supports priority RDD&D that enable AI/ML-based technologies and approaches for optimizing performance of commercial-scale storage operations.	**+$43,000**
Carbon Dioxide Removal: The increase in funding expands efforts on DOC, mineralization and enhanced weathering. The increase in funding also allows for field studies of BiCRS concepts.	**+$25,000**
Carbon Dioxide Conversion: The increase in funding allows continued development of at least one CO_2 utilization integrated system and allows for scale up and higher-TRL field testing of promising conversion technologies, such as that being performed at the National Carbon Capture Center (NCCC).	**+$27,000**
Point-Source Carbon Capture: The increase in funding supports expanding the carbon capture FEED studies to new industrial sources of CO_2 including H2 production and additional support for pilot testing at natural gas-fired electric utilities including both natural gas combined cycle (NGCC) systems and simple cycle power plants. The increase in funding is for FEED studies of pre-combustion carbon capture on Steam Methane Reformer (SMR) and Autothermal Reforming (ATR).	**+$76,605**
Carbon Management – Policy and Analysis: The increase in funding will expand the capabilities of the analysis division, allowing work on Hydrogen storage and infrastructure, CCUS, and general systems-based energy and carbon management modeling. The funding increase will also enable analysis of opportunities in the industrial sector for carbon management and will provide additional analysis to support multi-agency task forces as directed by Consolidated Appropriations Act of 2021**.**	**+$3,500**
Carbon Management – Justice and Engagement: Additional funding will support International Agreements supporting the Administration's de-carbonization priorities.	**+$350**
Transformational Coal Pilots: No funding is requested for FY 2023.	**-$10,000**
Supercritical Transformational Electric Power: No funding is requested for FY 2023.	**-$14,500**
Total, Carbon Management Technologies	**+$102,655**

Carbon Management Technologies
Hydrogen with Carbon Management

Introduction

The Hydrogen with Carbon Management (HCM) subprogram invests in research, development, demonstration, and deployment (RDD&D) to evaluate carbon-neutral hydrogen (i.e., coupled to carbon capture and storage (CCS)) as a fuel and also support 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) recently 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. They Hydrogen Shot establishes a framework and foundation for clean hydrogen deployment in the American Jobs Plan, which includes support for demonstration projects. Seeking a cost-competitive decarbonized alternative to traditional fossil fuels, the subprogram has a research and development portfolio consisting of a new generation of carbon neutral or net-negative greenhouse gas emissions technologies. The program 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 while reducing carbon dioxide (CO_2) and other emissions. 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 continued 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 HCM activity is presented below:

Gasification Systems

Gasification technologies can turn any carbonaceous feedstocks/mixtures into syngas and other chemical building blocks such as carbon-neutral hydrogen, liquid fuels, chemicals (e.g., ammonia), and carbon products. Additionally, feedstock blends that consist of legacy coal waste, waste plastics, and biomass may afford a carbon neutral emissions profile when used in combination with CCS. Gasification technology with integrated carbon capture is a strong path forward for rapid clean hydrogen rollout to meet ambitious goals including the Hydrogen Shot target. Also, flexible feedstock gasification technology can promote environmental justice by consuming various forms of environmental liability waste materials that other hydrogen production technologies cannot address. Strategic siting of new hydrogen production can improve economic conditions of marginalized communities by bringing steady, well-paying jobs in the clean energy sector.

The FY 2023 Budget Request provides $26 million for RDD&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:

- **Carbon-Neutral Hydrogen production**: Improve and advance the maturity of novel technologies capable of producing carbon-neutral hydrogen. The focus of this research element is systems for gasification of legacy coal wastes, mixed waste plastics, municipal solid waste, and biomass, the use of which accomplish remediation and reduction of legacy pollution.
- **Mapping of resources and infrastructure requirements for a decarbonized economy using waste streams**: An assessment of the available waste streams (opportunity waste products) to make electricity and useful products in a decarbonized economy.
- **Using microwaves for enhanced gasification**: Develop small-scale, fuel-flexible microwave reactor technologies that expand the capability of gasification to use non-traditional feedstocks like waste materials

such as waste plastics, municipal solid waste, legacy coal waste, and biomass. Incorporating microwave technology can bring operational resiliency and boost the efficiency of carbon-neutral hydrogen generation.

- **Gasification for supercritical CO_2 (sCO_2) power cycles:** The direct sCO_2 power cycle is ideal for carbon capture because it inherently co-produces high pressure CO_2 ready for storage. A special purpose, ultra-high-pressure gasifier would maximize the benefit of this innovative cycle. Such a special purpose gasifier could co-produce carbon-neutral hydrogen for pipeline export, and carbon monoxide as fuel input to a direct sCO_2 power cycle. Early-stage RDD&D is needed to enable ultra-high-pressure capability for the gasification front-end.

Advanced Turbines

The FY 2023 Budget Request provides $27 million in funding to develop gas turbine combustion systems to accommodate hydrogen and hydrogen-natural gas fuel blends while minimizing nitrogen oxide (NOx) emissions and maintaining machine efficiency. RDD&D investments will also support efficiency goals of 67% (lower heating value (LHV), natural gas (NG)) and 50% (LHV, NG) for combined cycle (CC) and simple cycle machines, respectively. The program will also invest in a long-term goal of a 70% efficient CC machine (LHV, NG).

Investments will be made in the application of advanced manufacturing and machine learning/artificial intelligence to attain efficiency goals. The activity will be executed in cost-shared collaboration with capital equipment manufacturers, the vast secondary market supporting turbine technology, U.S. universities, and the U.S. National Laboratory complex.

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 (PGC), (3) Modular Turbine-Based Hybrid Heat Engines, and (4) Supporting the University Turbine Systems Research (UTSR) program. DOE's RDD&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 (PGC) 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 PGC and is being explored in this program.
- **Modular Turbine-based Hybrid Heat Engine:** Projects seek to develop modular turbine-based hybrid heat engines that integrate with modular gasifiers, promote the clean use of stranded fuels, support energy storage cycles, make hydrogen generation more affordable, improve the efficiency and environmental performance of natural gas compression stations, and provide an affordable cost of electricity.
- **University Turbine Systems Research:** The Request also supports the UTSR sub-activity within the Advanced Turbines activity, which achieves the Department's and gas turbine industry goals by supporting research at U.S. universities. This cost shared activity, with industry endorsement, supports fundamental and applied RDD&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 SOFCs (R-SOFCs) use natural gas and up to 100% hydrogen to produce electricity, water and CO_2 when operating in a fuel cell mode. Solid Oxide Fuel Cells (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 SOFC into a Solid Oxide Electrolyzer Cell (SOEC). SOECs essentially function as an SOFC in reverse and optimize the use of these system to reduce overall costs. The 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 in a single system and can contribute to clean energy generation/storage when paired with a renewable fuel such as hydrogen (in SOFC mode) or renewable electricity (in SOEC 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 SOFCs/SOECs include:

- Field-testing of 10–25 kilowatt (kW) SOFC systems running on both natural gas and hydrogen in a real environment at third-party data center locations;
- Carbon neutral hydrogen production from SOEC systems;
- Developing and validating the materials proposed for improving the cost, performance, and reliability of R-SOFC systems; and
- RDD&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 basic RDD&D to mature 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 FECM 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 (A-USC) 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 included RDD&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 powerplant 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 2023 Request of $5 million will provide funding for supply chain RDD&D to develop ceramic matrix composite materials for turbine applications (thermal barrier coatings or turbine blade materials) and carbon management (CM) 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 provide funding for early-stage RDD&D efforts 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.

Advances in RDD&D 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.

RDD&D will focus on advanced data analytics and controls development for power plants 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; carbon-capture, utilization and storage; flexible-fuel boiler systems; and energy storage.

Focus areas include:

- **Real Time Monitoring & Diagnostics:** Early-stage RDD&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 RDD&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:** Consists of a range of project areas that focus on the protection of fossil-based power generation 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. It's 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 (SBE) activity includes computational software development, HPC, advanced optimization, TEA, and artificial intelligence (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 2023, the Budget Request for SBE provides $6 million to continue funding for DOE National Laboratory RDD&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.

HCM closely coordinates its hydrogen RDD&D 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 (SETT) 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 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Hydrogen with Carbon Management: **$122,300,000**	**$74,000,000**	**-$48,300,000**
Gasification Systems $19,000,000	**$26,000,000**	**+$7,000,000**
• Announced funding opportunity announcement (FOA) Enabling Gasification of Blended Coal, Biomass and Plastic Wastes to Produce Hydrogen with Potential for Net Negative Carbon Dioxide (CO_2) Emissions. • Research, development, demonstration, and deployment (RDD&D) focusing on early-stage research of carbon-neutral or carbon-negative transformational technologies (e.g., chemical looping, topping cycles, magnetohydrodynamic (MHD), etc.) that will allow the coal-fired fleet to evolve and maintain a viable source of clean and secure energy. • Innovate technologies to enable Ultra High Pressure (UHP) gasifier (up to 300 bar) suitable for use in a direct-supercritical carbon dioxide ((s)CO_2) power cycles.	• Develop robust, fuel-flexible, load-following modular gasification systems, specifically for community-scale gasification of legacy coal waste and opportunity feedstock. • 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).	• Additional funding will accelerate development gasification systems that utilize legacy coal waste, plastics, and waste biomass with carbon capture and storage (CCS) to reach negative emissions. • Development of materials for hydrogen and ammonia turbines. • Support hydrogen retrofit packages for existing turbines. • Support reversible solid oxide fuel cells (R-SOFC) systems capable of continuous operation.
Advanced Turbines $27,000,000	**$27,000,000**	**$0**
• Funding for hydrogen gas (H_2) front-end engineering design (FEED) studies and Critical Components. • University Turbine Systems Research (UTSR) FOA.	• Support new designs for hydrogen, ammonia, and gas with carbon capture turbine components, advanced cooling techniques, aerodynamics, sealing, combustion systems and materials. • Supports UTSR.	• The funding will be utilized for FOAs addressing topic areas in 100% hydrogen turbines. • Development of hydrogen combustion systems for retrofit applications and new gas turbines.

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Reversible Solid Oxide Fuel Cells $30,000,000	**$5,000,000**	**-$25,000,000**
• Integrated Energy Systems work with the Idaho National Laboratory (INL). • Funding for National Energy Technology Laboratory (NETL) and other National Labs for electrode engineering innovation, systems analysis on SOFC (solid oxide fuel cell)/SOEC (solid oxide electrolyzer cell)/R-SOFC as part of an energy system. • FOA on SOEC Technology Development for Hydrogen Production.	• 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 RDD&D on SOECs. • Focus on carbon neutral hydrogen production from SOECs.	• The decrease in funding will not impact ongoing RDD&D. Significant investment has been made with industry in previous fiscal years – results from this RDD&D will be known in FY 2023.
Advanced Energy Materials $16,100,000	**$5,000,000**	**-$11,100,000**
• Completed ComTEST R&D. • FOA on nickel (Ni) Alloy Cost & Cycling. • Appalachian Regional Commission Welding Workforce Training partnership**.**	• 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.	• Continue development of models critical to understanding hydrogen-related materials impacts to establish a new domestic supply chain of hydrogen resistant materials.
Sensors and Controls and other Novel Concepts $8,000,000	**$5,000,000**	**-$3,000,000**
• Development and deployment of wireless sensor systems. • RDD&D on optical fiber sensors, applied diagnostics, and quantum sensing.	• RDD&D on low-cost and reliable multi-sensing wired and wireless technologies. • Develop technologies that monitor power plant networks to identify abnormal behaviors because of operational issues or a malicious cybersecurity event.	• The decrease in funding is a result of less focus on advanced coal plants, however, FECM continues to maintain focus on the industrial sector and continue funding for NETL and other National Labs efforts in this area.
Simulation Based Engineering $6,200,000	**$6,000,000**	**-$200,000**
• Supports the development of interactive visualization technology and data communication optimization methods to improve the design and operation of advanced	• Supports the development of interactive visualization technology and data communication optimization methods to improve the design and operation of advanced	• Funding will allow the program to work directly with stakeholders of existing power generation units to validate the models and provide valuable information to make the models robust.

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
power systems with carbon capture and sequestration. • Provides first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes.	power systems with carbon capture and sequestration 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.	• The funding allows the application of these models to integrate the waste heat from heavy industries including steel and cement. • Continue supporting 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.
Transformative Power Generation $16,000,000	**$0**	**-$16,000,000**
• Selected four FEED studies to support the 21st Century Power Plant that includes the Critical Components FOA that is funded by relevant programs.	• No funding requested.	• Funds are re-allocated to higher priority activities.

Carbon Management Technologies
Carbon Transport and Storage

Description

The Carbon Transport and Storage (CTS) subprogram is focused on the development of infrastructure and carbon management technologies for the safe and secure transport and geologic storage of CO_2 captured from point sources and the air. Research, development, demonstration, and deployment (RDD&D) in this area is critical to validating and increasing confidence in the safety, affordability, and permanence of CO_2 injection and storage and the associated transport infrastructure necessary to connect source and storage resources. This area of research is in the national interest since it has long-term economic and environmental benefits for the U.S. and industry, and it contributes to the Administration's decarbonization goals. These benefits may be realized through financial incentives to store CO_2, such as the California Low Carbon Fuel Standard and changes to the Section 45Q tax credit as amended in the 2018 Bipartisan Budget Act. Further advancements in CO_2 transport and storage technology and performance will help ensure that industry has verifiable information to economically plan and monitor the necessary CO_2 transport infrastructure and safely assess and monitor long-term storage of CO_2 at commercial volumes and timeframes and ensure the viability of geologic carbon storage to enable CO_2 mitigation and removal that can be widely implemented. This includes supporting dedicated storage in saline formations, mineralization, depleted oil and gas fields, and existing natural deposits of CO_2 that could be repurposed for dedicated storage.

Carbon Transport and Storage

Carbon Capture, Utilization[1], and Storage (CCUS) is a critical component of the Administration's broad efforts to meet net-zero CO_2 emissions by 2050. Geological storage of CO_2 has been a natural process in the Earth's upper crust for hundreds of millions of years, and while this supports the concept that CO_2 can be securely and safely contained in the deep subsurface, having the technical means to identify suitable sites and monitor stored CO_2 to verify secure containment and regulatory compliance is vitally important. The U.S. Department of Energy (DOE) Office of Fossil Energy and Carbon Management (FECM) has supported a Carbon Transport and Storage RDD&D subprogram to develop the technologies and capabilities for widespread commercial deployment of geologic storage. FECM's investments have made DOE a world leader in CCUS technology development. Carbon transport is also a demonstrated industry in the United States with over 5,000 miles of operational CO_2 pipelines constructed over the past 50 years that today service the transport of about 60 million metric tons of CO_2 per year, currently associated primarily with Enhanced Oil Recovery (EOR). One of the challenges to broadly deploying CCUS and carbon dioxide removal (CDR) nation-wide to meet the Administration's decarbonization targets will be the need to construct a concomitant CO_2 transport system, primarily pipelines, designed to connect capture from sources of direct air capture to dedicated storage to eventual service injection rates of up to 1.5 billion metric tons of CO_2 per year by 2050.

CCUS projects supported by DOE and other organizations around the world, which injected more than 25 million metric tons of CO_2 in 2019, have demonstrated secure geologic storage of CO_2 in many different geologic formations with a diversity of depositional environments and shown to be safe to human health and the environment. Increasing years of experience and a preponderance of successful RDD&D projects will promote even further confidence in secure geological storage for operators, regulators, insurers, financial institutions, environmental groups, and the public. The Regional Carbon Sequestration Partnership (RCSP) Initiative has demonstrated the technical viability of secure geologic storage of CO_2 through their successful injection and validation of secure storage of over 11 million metric tons of CO_2 into a variety of reservoir types. The success of the RCSP initiatives has provided the lessons learned and technology validation for scaling up to commercial operations. This transition began in 2016 when FECM launched the multi-phase Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative. Additionally, the successors of the original seven RCSPs, now consolidated to four projects and referred to as the Regional Initiative projects, will continue to serve their broad stakeholder base with technical assistance and project development. These initiatives and other RDD&D activities are advancing storage security and performance and are driving the CTS subprogram forward to accelerate commercial CCUS deployment.

[1] Utilization refers to uses of CO_2 as a feedstock for developing products with market value, excluding CO_2-enhanced hydrocarbon recovery.

The Budget Request provides $122 million for RDD&D activities that address the performance challenges of operating and monitoring commercial scale CO_2 storage sites. The RDD&D supported by the CTS subprogram in FY 2023 will improve storage and operational efficiency, improve understanding of overall cost and de-risking strategies to reduce it. Achieving each of these elements is critical for enabling a CCUS industry that is safe, affordable, and environmentally benign.

Storage Infrastructure

The Storage Infrastructure activity is expected to make a substantial contribution toward meeting the Administration's decarbonization goals. The critical part of this contribution is investing in activities that will help expand the commercial on- and offshore CO_2 storage capacity as defined by the Society of Petroleum Engineers (SPE) CO_2 Storage Resources Management System (SRMS) that will serve as the storage sites and hubs for CO_2 captured from point sources and the air. In this effort, the Storage Infrastructure activity will focus primarily on broadening field activities that advance commercial-scale storage projects through the feasibility process of project development, which will include community engagement and environmental justice considerations. The sub-activities within the Storage Infrastructure activity will be designed to support and align with congressional direction on CCUS as outlined in the Bipartisan Infrastructure Law (BIL).

The CTS Budget Request includes $90 million for Storage Infrastructure that will leverage active field projects supported by prior year funding and conduct RDD&D as part of the multi-phase CarbonSAFE efforts to characterize, analyze and evaluate storage opportunities for onshore and offshore formations that will support the deployment of CCUS in the power, hydrogen, and hard-to-decarbonize industrial sectors, as well as CDR. The funding will also support the Regional Initiative to select additional technical assistance projects to develop hubs, regional characterization, and technical assistance to stakeholders in state governments that may be responsible for regulating or overseeing carbon transport and storage efforts. The Regional Initiative projects are playing an important role in providing technical, regulatory, and project development assistance to their respective regional stakeholders. Historically, FECM has funded field projects to conduct regional and site-specific characterization and validation; simulation and risk assessment; and applied monitoring, verification, accounting, and assessment technologies (MVAA) to various onshore and offshore storage reservoirs. These projects have been successful in improving our understanding of CO_2 injection, fluid and pressure migration, and geochemical and geomechanical impacts from CO_2 injection. In an effort to make further improvements in the cost and performance of applied monitoring technologies the Storage Infrastructure activity will competitively seek to award several Carbon Storage Technology and Operational Research (CarbonSTORE) facilities that will be linked with active commercial-scale CCUS projects and serve as field laboratories for testing new technologies and providing real-world data for program-wide RDD&D efforts. FY 2023 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 dedicated storage; impacts of financial incentive 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 developing the most efficient transport system.

Advanced Storage RDD&D

The Advanced Storage RDD&D activity is focused on developing and validating CO_2 storage technologies that lower cost and improve capabilities in plume detection, storage efficiency, secure storage verification, subsurface stress assessments, and legacy wellbore integrity assessment and repurposing in oil, gas, and natural CO_2 domes. Current CO_2 storage technologies have largely been developed and tested at the laboratory, pilot, and large field test scale. In anticipation that the Bipartisan Infrastructure Law (BIL) will accelerate the growth of commercial-scale carbon capture and storage (CCS) and DAC projects, the Advanced Storage RDD&D activity will focus primarily on the optimization of monitoring systems applied at commercial scale projects that reduce cost, improve performance, and enable more rapid decision making for storage operators.

The CTS Budget Request includes $32 million for the Advanced Storage RDD&D activity. Previous efforts in this activity have supported the development of new machine learning/artificial intelligence (ML/AI) tools and technologies through the Science-informed Machine learning to Accelerate Real-Time decisions for Carbon Storage (SMART-CS) initiative. FY 2023 funds for the Advanced Storage RDD&D activity will continue to support SMART-CS through the development of new or improved sensors, power and telemetry systems, and data analytics and integration methods that will generate data streams needed by SMART-CS ML-based algorithms. FY 2023 funds will also support priority RDD&D on site/hub

characterization tools and techniques for improved assessment of contingent and commercial storage capacity as defined by the CO_2 SRMS. Additional activities include RDD&D to advance fault/fracture networks characterization and associated stress state, fluid/pressure migration management, legacy wellbore assessment and repurposing or oil, gas, CO_2 production, and waste-water injection well; and intelligent systems for adaptive reservoir management. The program will also be supporting investment in the materials and retrofitting existing CO_2 transport systems that are currently used for other fluids such as methane. FY 2023 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.

Sub-disciplinary Storage RDD&D (formerly Carbon Sequestration Science)
All efforts from this control point are redirected towards Advanced Storage RDD&D.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Carbon Transport and Storage: $79,000,000	**$122,000,000**	**+$48,800,000**
Storage Infrastructure: $57,500,000	**$90,000,000**	**+$32,500,000**
• Support Phase III of the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative and the Regional Carbon Capture, Utilization, and Storage (CCUS) Deployment Initiative projects. • Perform infrastructure network studies and analyses for carbon dioxide (CO_2) source and Enhanced Oil Recovery/storage matching, and early-stage research, development, demonstration and deployment (RDD&D) for high priority activities.	• 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 Carbon Storage Technology and Operational Research (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 carbon capture and storage 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.	• Funding prioritizes CarbonSAFE Phase II storage opportunities and CarbonSTORE field labs that will have broad applicability to support the hydrogen, power, industry, and negative emission technology applications. • Funding also continues the Regional Initiative to provide technical assistance to their respective stakeholders to help facilitate CCUS deployment within their regions for projects and hubs.
Advanced Storage: RDD&D: $15,700,000	**$32,000,000**	**+$16,300,000**
• Supports RDD&D to advance sensing and data telemetry capabilities, and high priority studies on fault/fracture networks characterization, stress state, fluid/pressure migration, and wellbore	• Supports competitive selection of RDD&D projects on high priority topics including legacy well assessment, above-zone monitoring methods and	• The increase supports priority RDD&D that enable Artificial Intelligence/ML-based technologies and approaches for optimizing performance of commercial-scale storage operations. Increase also

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
integrity monitoring that advance adaptive reservoir management capabilities. • Continue support for National Risk Assessment Partnership (NRAP). • Continue machine learning (ML) RDD&D to advance forecasting capabilities and improve real-time operational performance.	tools, existing well and pipeline repurposing for CO_2 transport and storage. • Supports RDD&D on advance tools, sensors and monitoring systems that create data and data streams compatible with Science-informed Machine learning to Accelerate Real-Time's (SMART) 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 RDD&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 data curation and platform maintenance.	supports priority RDD&D on improving site/hub characterization tools and techniques critical for assessing contingent and commercial storage capacity as defined by the Special Petroleum Engineer's CO_2 Storage Resource Management System. Increase support for RDD&D on mineralization of CO_2 in geologic deposits.
Sub-disciplinary Storage R&D: $5,800,000	**$0**	**$0**
• The National Energy Technology Laboratory (NETL) and other National Laboratory funding for RDD&D activities on reservoir performance, applied monitoring, verification, accounting, and assessment technologies (MVAA), geomechanics, wellbore integrity, and risk assessment.	• No funding is requested for FY 2023.	• All efforts from this control point are redirected towards Advanced Storage RDD&D.

Carbon Management Technologies
Carbon Dioxide Removal

Description

Many modeling scenarios to achieve economy-wide decarbonization suggest that carbon dioxide (CO_2) removal (CDR) will be required in the future. CDR refers to activities that remove CO_2 from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. CDR activities include direct air capture (DAC), direct ocean capture (DOC), biomass with carbon removal and storage (BiCRS), mineralization, terrestrial carbon removal and sequestration (e.g., agricultural land management, afforestation, reforestation), and coastal blue carbon (e.g., 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 maximal emissions mitigation.
- NETs/CDR would likely need to play a large role on the order of gigaton removal assisting us in meeting our net-zero greenhouse gas emissions goal.

FECM has been working on carbon capture, utilization, and storage (CCUS) projects for almost 20 years and has invested heavily in the development of technologies to capture relatively high concentrations of CO_2 from power plants and industrial sources. More recently, the Department has been applying this technology development to various NETs, including BiCRS and DAC, which requires capture of extremely low concentration CO_2 from the atmosphere.

An objective of CDR is to advance technologies to make significant progress towards reaching DOE's Carbon Negative Shot target of less than $100/net metric ton CO_2 equivalent for both capture and durable storage. Investments in various CDR approaches—DAC, DOC, BiCRS, and mineralization—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 maintaining focus on ensuring future deployments are conducted in a manner that ensures social and environmental justice.

The FECM CDR subprogram was a new budget line in the FY 2022 Budget Request. The FY 2023 Budget Request is focused on DAC, DOC, BiCRS, and mineralization concepts. However, it builds upon past CCUS efforts, which have been funded through FECM's CCUS activities, such as past work on mineralization, co-firing of biomass, and capture technology development.

Activities to develop and commercialize DAC systems largely follow known chemical and physical methods (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 DAC systems compared to point sources. Subsequently, the power requirements to overcome the pressure drop in vertical packed tower configurations would contribute to both significant capital and operating costs. Therefore, designs based on conventional scrubbing technology are now recognized as not broadly applicable to DAC systems, motivating separate subprograms in point-source capture and CDR.

Concerted research, development, demonstration, and deployment (RDD&D) is needed to reduce costs and the energy penalty, and improve scalability, siting, and operations. Efforts will focus on conducting materials and components RDD&D, pilot-scale testing, front-end engineering and design (FEED) studies, and large-scale extended tests. It should be noted that first generation technologies will also continue to improve, and RDD&D conducted for transformational technologies may also improve the processes and components of first-generation technologies.

BiCRS offers an opportunity for near-term deployment of CDR technologies. Biomass can be used to produce various products—power, fuels, chemicals—similar to other carbon-containing feedstocks such as coal, oil, and natural gas. The

biomass consumes CO_2 from the atmosphere, through photosynthesis, during its growing phase 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 removed from the atmosphere.

The point-source 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, energy penalty, and integration are directly applicable in the case of power generation and gasification processes.

The NASEM report characterizes carbon mineralization as occurring at the surface (ex situ) as well as subsurface (in situ). 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.

In-situ mineralization is part of the Carbon Transport and Storage subprogram's activities where there has been an extensive RDD&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. In addition to this subsurface (i.e., in situ) RDD&D, FECM previously conducted various studies and experimental work on surface/ex situ 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 United States. 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 ensuring the viability of the various technologies to confirm the process is removing more CO_2 from the atmosphere than generated by the process over its lifecycle. While LCA is a common tool and approach in many industries and for many processes, it is currently evolving in the CDR area. Many technologies are relatively new, and the energy inputs required can significantly impact the LCA. Further RDD&D on the CDR approach is necessary to provide the fundamental scientific and technical basis for LCA tools and methodologies. Coupling together RDD&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.

[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 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Carbon Dioxide Removal: $40,000,000	**$65,000,000**	**+$25,000,000**
• Supported continued development of transformational direct air capture (DAC) materials and structural components, and initial feasibility studies of current DAC systems. • National Laboratory research, development, demonstration, and deployment (RDD&D) evaluated challenges and concepts for ex situ mineralization and enhanced weathering concepts. • Evaluated coal-biomass co-feeding concepts coupled with carbon capture, utilization, and storage at existing facilities.	• Continue development of transformational DAC materials and components, and feasibility studies of current DAC systems. • Continue RDD&D on mineralization and enhanced weathering concepts. • Evaluate biomass with carbon removal and storage (BiCRS) concepts at existing facilities.	• The increase in funding expands efforts on mineralization and enhanced weathering concepts. • The increase in funding allows for field testing of BiCRS concepts.

Carbon Management Technologies
Carbon Dioxide Conversion

Description

The Carbon Dioxide Conversion subprogram develops technologies to convert carbon dioxide (CO_2) into economically valuable products manufactured in a just and sustainable manner. Research, development, demonstration, and deployment (RDD&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. RDD&D in this area is critical to validating the emissions reduction of CO_2-based products, producing economically viable technologies, and supporting 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. These benefits may be realized by financial incentives to utilize or convert CO_2 such as the California Low Carbon Fuel Standard, regional procurement policies for lower-carbon or sustainably produced materials, and the incorporation of utilization pathways to the Section 45Q tax credit, as amended in the Bipartisan Budget Act of 2018. 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 CO_2-based products. In addition, the creation of widely implementable platform technologies for emissions solutions can capitalize on a variety of opportunities such as excess low-carbon electrons, industrial waste heat, and byproduct streams such as waste heat integration, wastewater reduction, flue gas contaminant reduction, and reduced energy demand.

Given the variety of challenges in CO_2 conversion technologies, there are many opportunities to improve systems. For example, RDD&D aims to 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 requires energy. The result is an energy penalty for the utilization system. 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 (CO_x) emissions, principally CO_2, 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 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 RDD&D.

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. This subprogram will work to address the need for enabling technologies including using carbon-neutral hydrogen (H_2) as a reactant in the synthesis of fuels and chemicals and maintaining an alkalinity source for mineralization. The efficiency of reaction conversion, amount of CO_2 stored in a product and energy use of these utilization processes also represent a critical challenge that the Office of Fossil Energy and Carbon Management (FECM) can address as it is uniquely positioned to efficiently assess and invest in the life cycles of these developing technologies.

The FY 2023 Budget Request provides $50 million for this subprogram and supports lab- and bench-scale CO_2 conversion technologies that have the potential to develop environmentally and socially responsible CO_2-based 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 to various bioproducts. The subprogram aims to continue investment activities from FY 2022, 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 CO_2 utilization 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 as well as continued support for carbon conversion test facilities at the National Carbon Capture Center (NCCC).

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request Level	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Carbon Dioxide Conversion: $23,000,000	**$50,000,000**	**+$27,000,000**
• Lab- and bench-scale technologies to convert carbon oxides (CO_x), principally carbon dioxide (CO_2) into valuable products such as chemicals, fuels, and building products. • Support development of at least one integrated CO_2 utilization system.	• 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.	• The increase in funding allows continued development of at least one CO_2 utilization integrated system. • The increase allows for 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

Description

Advancements in carbon capture technologies can support United States (U.S.) efforts to decarbonize power generation and industry. Carbon capture from power generation is a technology approach for mitigating carbon dioxide (CO_2) emissions, and for concentrating CO_2 for applications such as conversion to products. Transformational carbon capture technologies will advance U.S. leadership in low-emission generation and clean hydrogen (H_2) innovation, supporting its efforts in achieving a decarbonized power sector by 2035 and a decarbonized economy by 2050. CO_2 capture technologies can be applied to a wide variety of sources such as power plants, ethanol, ammonia, cement, steel, chemical facilities, and other sources. Research, development, demonstration, and deployment (RDD&D) is focused on adapting technologies to under-investigated applications like natural gas power and industry and making them robust enough to capture greater than 95% of the CO_2 emissions from a wide variety of sources. RDD&D is needed on both the materials and systems configurations to address challenges such as differences in pollution control systems, oxygen content, CO_2 concentrations, and unique integration issues.

RDD&D is needed to 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 (PSCC) subprogram is focused on RDD&D of carbon capture technologies that play a key role in decarbonizing committed emissions associated with the power sector and hard-to-decarbonize industries. The PSCC 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 PSCC subprogram has completed its efforts in 1st generation technology through successful demonstration projects. FY 2023 activities represent a focus on next-generation capture technologies to enable clean H_2 and allow for the integration of advanced carbon capture technologies with both power and diverse industrial emission sources. Specifically, the FY 2023 Budget Request provides $163 million to the PSCC activities for pre- and post-combustion capture RDD&D on transformational gas separation technologies capable of deep decarbonization (at least 95% of CO_2 at 95% purity). These investments can improve energy efficiency, reduce capital costs, and achieve high capture rates.

These transformational technologies will be designed to adapt to the operational demands of current and future power systems including the increasing need for thermal power plants to, at times, be load-following/demand-responsive electricity generators. The activity will investigate approaches to optimize the capture process for all point sources such as natural gas-based power systems including both natural gas combined cycle (NGCC) systems and simple cycle operations.

Additionally, the PSCC subprogram will leverage its prior and current RDD&D experience on carbon capture technology development for application to industrial applications. RDD&D will focus on optimization of technologies for these applications to reduce cost and improve performance.

Key RDD&D challenges for PSCC 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 PSCC subprogram will also 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 RDD&D and information to validate techno-economic studies and lifecycle analyses. The PSCC also supports FEED studies of highly efficient carbon capture technologies for natural gas and waste-to-energy powerplants. One 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.

Post-Combustion Capture Systems

Post-combustion capture refers to the capture and separation of CO_2 after fuel is combusted. The FY 2023 PSCC subprogram Budget Request includes $144.4 million for RDD&D in Post-Combustion Capture Systems, for transformational CO_2 capture RDD&D at both new and existing power plants, and industrial systems such as steel, cement, hydrogen production, and chemicals. Critical RDD&D milestones have been achieved since 2008 in laboratories through pilot-scale testing of 2nd generation CO_2 capture approaches through multiple small-scale (0.5-1 MWe) slipstream tests and several large-scale (13 MWe) tests on flue gases from different power systems and industrial sources. It is expected that government-industry partnerships will continue the development, adoption, and commercialization of these technologies.

Activities in FY 2023 will continue to focus on RDD&D for novel CO_2 capture technologies such as non-aqueous solvents, membranes, advanced sorbents, and cryogenic processes. 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. Funding will continue to support the National Carbon Capture Center (NCCC) to provide testing on actual flue gas.

Pre-Combustion Capture Systems

Pre-combustion capture refers to separation of CO_2 from the syngas (or other high-pressure streams) prior to its combustion for power production, or the separation of CO_2 to produce H_2 or other products.[1] Specifically, two systems can generate H_2 from natural gas—steam methane reformers (SMR) and autothermal reformers (ATR). SMRs remain the most economical and widespread way to produce H_2 and currently account for over 90% of the H_2 produced globally. Pre-combustion technologies can be used to lower the carbon intensity of H_2 from these systems. Discussion regarding new ATR construction is becoming increasingly more common as the inherent ATR process concentrates CO_2 and allows for deeper decarbonization using pre-combustion technologies at lower cost than SMRs.

DOE's pre-combustion PSCC activity is focused on pursuing transformational capture goals which require capture greater than 95%. Technologies for pre-combustion capture complement research that is ongoing in creating new fundamental knowledge of advanced gasification systems, including the 21st Century Power Plant, and could be applied to H_2 production and other industrial processes.

Emissions Control

The Emission Control subprogram, created in FY 2020, focuses on reducing the costs and emissions of non-CO_2 pollutants associated with the use and combustion of carbon-containing fuels. This effort would conduct systems analyses and technical assessments to identify and address issues associated with non-CO_2 emissions from power plants as well as industrial applications (i.e., trace and heavy metal emissions in solid, liquid, and gaseous effluents that are potential areas

[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.

of concern). 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.

Additionally, advanced concepts and new technologies will be developed to determine the environmental uses of combustion residuals from all ash residuals not just restricted to pure coal combustion residuals (CCR). Examples could include ash resulting from co-fire or biomass combustion activities. RDD&D will be directed at: (1) the fraction of combustion products that are not currently being recycled or beneficially reused at high levels such as non-gypsum, wet- and dry-flue gas desulfurization (FGD) materials and bottom ash; (2) materials used in current combustion residual facilities that may be impacted by new regulations; (3) improvements in the performance and cost of beneficiation/upgrading of technology associated with high-volume reuse materials (i.e., fly ash and synthetic gypsum); (4) advanced cost-effective approaches for removing, upgrading, and beneficially recycling combustion residuals from active and inactive storage impoundments will be developed; and (5) risk pathways via construction risk management frameworks will be developed as appropriate for ash management facilities.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Point-Source Carbon Capture[2] $86,300,000	**$162,905,000**	**+$76,605,000**
Post-Combustion Capture Systems $73,300,000	**$144,405,000**	**+$71,105,000**
• Supported up to four Small Scale and/or Bench Scale Carbon Capture Tests on Actual Flue Gases from coal and natural gas. • Implemented Congressional direction on industrial capture research, development, demonstration, and deployment (RDD&D) and front-end engineering design (FEED) studies. • National Carbon Capture Center (NCCC): Funded and operated the NCCC post combustion carbon capture test facility. • Supported 21st century power plant design and component testing.	• 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 RDD&D and pilot-scale carbon capture projects for industrial sources of carbon dioxide (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.	• The increase in funding supports expanding the carbon capture FEED studies to new industrial sources of CO_2 including hydrogen (H_2) production and additional support for pilot testing at natural gas-fired electric utilities including both natural gas combined cycle (NGCC) systems and simple cycle.
Pre-Combustion Capture Systems: $10,000,000	**$15,000,000**	**$5,000,000**
• Supported Lab, bench, pilot scale Transformational Carbon Capture. • Supported 21st century power plant design and component testing.	• Conduct transformational carbon capture RDD&D for H_2 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.	• The increase in funding is for FEED studies of carbon capture on steam methane reforming (SMR) and autothermal reforming (ATR).

[2] $40M for Negative Emissions Technologies described in the Carbon Dioxide Removal justification. Actual Carbon Capture Budget Request in FY 2021 was $126.3M.

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Emissions Control: $3,000,000	**$3,500,000**	**+$500,000**
• Conducted systems analyses and technical assessments to identify and address non-CO_2 emissions from coal-fired power plants (i.e., trace metals emissions in solid, liquid, and gaseous effluents that are potential areas of concern).	• Conduct RDD&D, systems analyses and technical/economic assessments to identify and address non-CO_2 emissions from power plants and industrial sources (i.e., 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.	• This increase in funding further expands efforts to address high-priority solid and liquid waste streams from coal combustion residuals (CCR). Efforts will be primarily focused on reducing potential environmental issues associated with geochemical and physical concerns of ash impoundments and landfills (legacy and active), as well as development of novel technologies to create environmentally-benign byproducts from combustion residuals with potential for reducing environmental impacts and/or avoided emissions. Definition of ash and combustion residuals also include ash resulting from comingled or biomass combustion activities.

CCarbon Management Technologies
Carbon Management - Policy and Analysis

Description

The Carbon Management - Policy and Analysis subprogram evaluates potential economic, employment, and socioenvironmental benefits and impacts from the deployment of carbon management technologies. This subprogram supports strategic planning by identifying major challenges and opportunities to improve efficiency, cost, and socioenvironmental performance for the deployment of carbon management applications.

The Office of Strategic Planning, Analysis and Engagement, within the Office of Carbon Management, supports high-impact, crosscutting, integrative activities through close coordination with the Office of Fossil Energy and Carbon Management (FECM) technology programs, other DOE offices, DOE's efforts to meet the Administration's climate and energy goals as well as the Justice40 Initiative and support for the transition of fossil host communities. This includes support for activities to inform key FECM audiences and stakeholders about FECM's work to transition the U.S. to a clean energy economy and fight the global climate crisis. Strategic Analysis provides evidence-based, portfolio-wide analysis for decision-makers. FECM will lead activities to provide 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. Strategic analysis and engagement efforts will help ensure that FECM maximizes the impact of its research dollars, tracks the impacts of FECM investments, and strives to ensure that the clean economy benefits all Americans.

Siting and permitting of carbon management projects will be critically important. The analysis and engagement efforts will evaluate key environmental and siting considerations through research to understand impacts to and engagement with communities and environments, development of technical solutions, and issues that cause permitting uncertainty and risks for the carbon management projects. FECM supports social science and socio-economic research to understand impacts of carbon management on communities and provide technical assistance to communities considering carbon management (e.g., DOE's Communities Local Energy Action Program (LEAP)). Activities will aid in proactive, place-based community engagement and planning processes that include consideration of carbon capture and storage (CCS) and carbon dioxide removal (CDR) development, in the context of broader decarbonization options, to both ensure that carbon management projects work for communities and to characterize siting processes for future development.

Analysis and engagement activities are described in more detail below:

Energy and Regulatory Analysis Support

- Performs economic and environmental impact 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 market dynamics.
- Informs Carbon Management's RDD&D strategic planning and decision-making by studying current and potential future market and regulatory conditions which might affect future viability. These studies seek to identify potential market driven opportunities which will aid in the deployment of carbon management technologies. It also seeks to identify gaps in decarbonization needs which can be addressed by RDD&D activities.
- Disseminates best practices and approaches for evaluating and analyzing carbon management technologies and strategies to external entities and stakeholders. Entities like the Environmental Protection Agency (EPA), EIA, and others depend on FECM systems analysis to drive their analyses into potential future decarbonization opportunities.
- Analyzes crosscutting issues which have the potential to affect the deployment of Carbon Management technologies like electric power grid integration, hard to decarbonize sectors, and competitiveness implications of changing energy and industrial markets as they transition to a net-zero greenhouse gas emission economy.
- Provides technical and policy analyses as part of intergovernmental support in areas of expertise (e.g., EPA, Internal Revenue Service (IRS) Section 45Q).

Carbon Management Technologies
Carbon Management - Policy and Analysis

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Carbon Management - Policy and Analysis: **$500,000**	**$4,000,000**	**+$3,500,000**
• Support for analysis efforts with potential economic, employment, and environmental benefits and impacts from the deployment of carbon management and fossil technologies.	• Support program strategic planning by identifying major challenges, technologies, and advanced concepts that have the potential to improve the efficiency, cost, and environmental performance of carbon management applications including hydrogen production and carbon removal. • Evaluate potential economic, jobs, and environmental benefits and impacts from the deployment of carbon management and fossil technologies.	• 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 enhancements to the National Energy Modeling System in order to analyze potential future deep decarbonization scenarios. • Funding increase will also enable analysis of opportunities in the industrial sector for carbon management. This will enable further inventory and systems analyses to highlight lower cost opportunities for decarbonization. • Increase will also be used to develop tools and methodologies to assist stakeholders in integrated planning of decarbonization strategies which leverage potential cross-sectorial contributions to greenhouse gas mitigation and removal from Carbon Management technologies. • Additional analysis to support multi-agency task forces as directed by Consolidated Appropriations Act of 2021.

Carbon Management Technologies
Carbon Management - Justice and Engagement

Description

Carbon Management - Justice and Engagement supports research, development, demonstration, and deployment (RDD&D) of carbon management technologies through engagement with key partners within the U.S. and globally. Funding will support domestic engagement and justice efforts as well as international collaboration with various partners through bi-lateral and multi-lateral agreements. The Office of Fossil Energy and Carbon Management (FECM) will focus on building capacity and working with interagency partners to ensure safe, effective, and efficient implementation of its RDD&D 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.

The FY 2023 Budget Request of $1 million is to prioritize RDD&D activities and strategies to maximize the impact of research dollars, track the impacts of FECM investments, and strive to ensure that the clean energy economy benefits all Americans. Efforts will be closely coordinated with the Department of Energy's (DOE) activities to meet the goals of the Justice40 Initiative, to work with states and local communities to deliver benefits from Federal investments in climate and clean energy to disadvantaged communities.

The Budget Request also supports social science and socioeconomic research to understand impacts of carbon management on communities and provide technical assistance to communities considering carbon management technologies such as carbon capture and storage (CCS), carbon dioxide (CO_2) conversion, and carbon dioxide removal (CDR). Research will aid in the understanding of impacts of carbon management on communities and allow for strategies that reduce impacts and increase environmental justice for carbon management development. The work will support deployed carbon management technologies, to ensure disadvantaged communities have access to objective information regarding the benefits and costs of carbon management technologies.

International

- Leverages decades of experience in working successfully with global governments, organizations, and stakeholders through a variety of bi-lateral and multi-lateral mechanisms to accelerate the advancement and responsible deployment of carbon management technologies 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 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 RDD&D with these willing partners.
- Makes targeted investments in international carbon management efforts with select countries that can accelerate technological development for climate mitigation, as well as prime major global markets for American technologies and services, to have the greatest value for potential emissions reductions and creating American jobs.

Domestic

- Works with stakeholders to build a foundation for expeditiously administering several new investments such as increases for CCS, CDR, and other carbon management deployment focused programs that will rely on new and existing relationships with American networks and communities.
- 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.
- 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.
- Works with other agencies to develop and improve accounting frameworks and tools to accurately measure carbon removal and sequestration methods and technologies. 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 – Justice and Engagement

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Carbon Management - Justice and Engagement: **$650,000**	**$1,000,000**	**+$350,000**
• Support for international efforts with various international partners through bilateral and multi-lateral agreements.	• Support Domestic and International justice and engagement Activities and Agreements, and other collaborative international efforts.	• Additional funding will support expanded domestic justice and engagement as well as new International Agreements supporting the administration's de-carbonization priorities.

Carbon Management Technologies
Transformational Coal Pilots

Overview

The Consolidated Appropriations Act of 2017, H.R. 244, provided $50 million "*to remain available until expended, shall be for the transformational coal technologies pilot program described in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act)*. Per the FY 2017 Congressional direction, funding is to support a new solicitation for two large-scale pilots that focus on transformational coal technologies representing a new way to convert energy that would enable a step change in performance, efficiency, and the cost of electricity compared to today's technologies. Such technologies include thermodynamic improvements in energy conversion and heat transfer, such as pressurized oxygen combustion and chemical looping, and improvements in carbon capture systems technology. In directing any ongoing activities, the Department of Energy (DOE) will prioritize activities that are consistent with this Administration's goal of 100% carbon-pollution-free electricity by 2035.

In accordance with this legislation, the solicitation was announced by DOE in August of 2017, with successful completion of Phase I (feasibility) and Phase II (design). Evaluation of the final applications for Phase III (construction/operations) is currently ongoing. Since FY 2017, a total of $140 million has been appropriated by Congress for the program, with approximately $23 million utilized for Phase I and Phase II. FY 2022 funds will be carried over into FY 2023.

Description

No funding is requested in the FY 2023 Budget. Prior year funding will be used to award up to 2 final Phase III projects.

Carbon Management Technologies
Transformational Coal Pilots

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Transformational Coal Pilots $10,000,000	**$0**	**-$10,000,000**
• Funding was utilized for Phase III downselect.	• No funding is requested.	• No funding is requested. Unobligated funds will be used for Phase III selections.

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 the Consolidated and Further Continuing Appropriations Act, 2015 (P.L. 113-235).

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 2023, 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 selected sCO_2 cycles. This effort includes the design, development, and fabrication of all components in the cycle (i.e., turbomachinery, recuperators, heat source integration, etc.). During operation, the test facility will validate operability of a sCO_2 Recompression Brayton Cycle at the 10 Mwe test facility in San Antonio, Texas.

No funding is requested for the STEP 10 Mwe pilot in the FY 2023 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 2023.

The FY 2023 Budget Request does not provide additional funds for this activity.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Supercritical Transformational Electric Power (STEP)		
$14,500,000	**$0**	**-$14,500,000**

• Funded Budget Period (BP) 2 of project:
  • Completed site construction and civil works.
  • Fabricated/Installed major equipment.
  • Simple Cycle commissioned and tested.
	• No funding is requested in FY 2023.	• Funding in the FY 2021 Enacted is sufficient to complete BP2.

Resource Sustainability
($K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
117,500	117,500	182,964	+65,464	+55.7%

Overview

Reducing the environmental impacts, especially methane leakage, associated with the production, transportation, and storage of oil, natural gas, and coal is critical to achieving net-zero emissions. Looking ahead, innovative technologies will provide alternative solutions for aspects of fossil fuel production, such as conversion of flared methane to high-value products and cleaning water produced from hydraulic fracturing operations for agriculture use.

The United States 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 the infrastructure is facing operational challenges including leaking 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 United States' historical and continued use of fossil fuels. Specifically, the Program's mission is to conduct research, development, demonstration, and deployment (RDD&D) that reduces environmental impact from the development, extraction, transportation, distribution, and storage of fossil fuels. The Program comprises four subprograms: Advanced Remediation Technologies, Methane Mitigation Technologies, Natural Gas Decarbonization and Hydrogen Research, and Mineral Sustainability.

The Advanced Remediation Technologies program will focus on developing solutions that address the environmental and social impacts of oil and natural gas exploration and production. The domestic production of oil and natural gas has contributed to America's economy and provides fuel for vehicles, heat for homes, industrial products, plastics, and other important products. Although there are many benefits from oil and natural gas, it comes with risks to the environment. 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 who are affected by the negative impacts of poor air quality, water contamination, oil spills or induced seismicity.

The Methane Mitigation Technologies program supports research, development, demonstration, and deployment (RDD&D) focused on innovative sensors, compressors, 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 develop innovative technologies to reduce flaring and venting of natural gas, during production and transportation, through conversion of the flared and vented natural gas to high-value, readily transportable products. Given the Nation's reliance on natural gas, it is critical to ensure the safety and reliability of related infrastructure. This program will also 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 the negative impacts, like ground water contamination, that plague communities.

The Natural Gas Decarbonization and Hydrogen Research 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 subprogram 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 FY 2023 Budget continues the process from FY 2022 of ensuring that its programs do not directly subsidize fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels while also investing in technologies to improve energy security and lower energy prices. The Budget focuses on other activities that support clean energy development and deployment (including carbon management), environmental benefits, and the creation of good-paying jobs that provide a free and fair chance to join a labor union.

Highlights of the FY 2023 Budget Request
The Resource Sustainability Program will pursue the following major activities in FY 2023:

Advanced Remediation Technologies
The Advanced Remediation Technologies activity will address wellbore integrity, induced seismicity, water use, produced water treatment, and offshore safety and spill prevention. The program will leverage previous research, to include field laboratory efforts, to assess the viability of converting expended unconventional oil and gas wells to carbon storage sites.

Methane Mitigation Technologies
The Methane Mitigation Technologies program is focused on developing next-generation natural gas technologies for detecting, quantifying and mitigating methane emissions, including enhancing both the cyber and physical security across the entire natural gas infrastructure system—from production through end use. FY 2023 supports the following activities:

- Develop technologies in advanced materials, sensors, data management tools, in-pipe inspection and repair technologies, and dynamic compressor research and development.
- 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.
- Develop advanced sensor technologies to detect and locate emissions from pipelines, storage facilities, and abandoned wells.
- Develop modular technologies, materials, and solutions to aid remediation of orphaned wells.
- Develop and validate emissions detection and measuring technologies.
- Collect, analyze, and distribute emissions data, information, and knowledge to inform efforts on orphaned well remediation, Life Cycle Analysis (LCA) studies, and the Environmental Protection Agency's (EPA) Greenhouse Gas (GHG) Inventory.

Natural Gas Decarbonization and Hydrogen Technologies
The Natural Gas Decarbonization and Hydrogen Technologies subprogram focus is on research, development and deployment (RD&D) of technologies to produce clean hydrogen from fossil feedstocks, the transport of hydrogen and hydrogen carriers (e.g., Ammonia) through natural gas infrastructure, and the geologic bulk storage of hydrogen and related technologies for subsurface storage evaluation.

FY 2023 activities include developing analytical tools and models that are able to evaluate potential advanced technologies, technology performance metrics, technoeconomic and LCA, and resource evaluations. The subprogram will also develop technologies for "carbon-neutral" hydrogen production, transportation (including advanced pipeline materials), and geologic storage technologies that leverage existing natural gas infrastructure.

Mineral Sustainability

The Mineral Sustainability program will support domestic supply chain networks required for the economically, environmentally, and geopolitically sustainable production 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 Carbon Ore Processing activity (formerly Advanced Coal Processing) is focused on utilizing materials to be recycled from previously mined resources outside of traditional thermal and metallurgical markets that can contribute to the U.S. gross domestic product.

Resource Sustainability – Policy and Analysis

These activities can be completed within already available resources and no additional funding is requested in FY 2023. The Policy and Analysis Division supports all program areas in the Office of Resource Sustainability through the drafting of studies and reports, conducting economic and environmental analysis, and reviewing legislation, regulations, and executive orders.

Resource Sustainability – Justice and Engagement

These activities can be completed within already available resources and no additional funding is requested in FY 2023. The Justice and Engagement Division conducts and provides support to leadership's engagement with a wide set of domestic and international stakeholders, to include frontline and disadvantaged communities, government agencies, non-government entities, non-profit, academia, and foreign governments.

Resource Sustainability
Funding ($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
RESOURCE SUSTAINABILITY					
Advanced Remediation Technologies					
Environmentally Prudent Stewardship	12,000	12,000	12,964	964	8.0%
Gas Hydrates	25,000	25,000	0	-25,000	-100.0%
Water Management Technologies	7,500	7,500	0	-7,500	-100.0%
Subtotal Advanced Remediation Technologies	**44,500**	**44,500**	**12,964**	**-31,536**	**-70.9%**
Methane Mitigation Technologies	**20,000**	**20,000**	**100,000**	**80,000**	**400.0%**
Natural Gas Decarbonization and Hydrogen Technologies	**0**	**0**	**26,000**	**26,000**	**N/A**
Mineral Sustainability					
Critical Minerals	23,000	23,000	40,000	17,000	73.9%
Carbon Ore Processing	30,000	30,000	4,000	-26,000	-86.7%
Subtotal Mineral Sustainability	**53,000**	**53,000**	**44,000**	**-9,000**	**-17.0%**
TOTAL, RESOURCE SUSTAINABILITY	**117,500**	**117,500**	**182,964**	**+65,464**	**+55.7%**

SBIR/STTR:

- FY 2021 Enacted: SBIR $2,905: STTR: $505
- FY 2022 Annualized CR: SBIR $2,905: STTR: $505
- FY 2023 Request: SBIR $4,664: STTR: $656

Resource Sustainability
Explanation of Major Changes ($K)

	FY 2023 Request vs FY 2021 Enacted
Resource Sustainability	
Methane Mitigation Technologies: Funding increase reflects research on advanced materials, data management tools, sensors, compressors, and analysis technologies for emissions reduction in oil and gas infrastructure; conversion technologies for stranded and vented gas; advanced remote detection technologies; and modular remediation materials. Funding increase also reflects development and validation of measurement sensor technologies for: the collection, dissemination, and analysis of emissions data; data collection and support to EPA's GHG Inventory; and data collection, analysis and support related to quantifying emissions from legacy infrastructure and orphan wells.	**+$80,000**
Natural Gas Decarbonization and Hydrogen Technologies: Funding increase reflects new research on developing and advancing technologies for the production, transportation, and storage of domestically produced Hydrogen.	**+$26,000**
Advanced Remediation Technologies: Overall funding decrease reflects the elimination of direct fossil fuel subsidies from the FY 2023 Budget, offset by a funding increase in Environmentally Prudent Stewardship to reflect research to develop solutions that address the environmental impacts of oil and natural gas development. These topics include wellbore integrity, oil spill prevention, and produced water treatment and reuse technologies.	**-$31,536**
Mineral Sustainability: Funding decrease reflects reduced funding for coal-based building composed of 51% 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 resource.	**-$9,000**
Total, Resource Sustainability	**+$65,464**

Resource Sustainability
Advanced Remediation Technologies

Overview

Fossil fuels have contributed to America's economy and have provided fuel for vehicles, heat for homes, industrial products, plastics, and other important products. Although there are many benefits from oil, natural gas, and coal, these benefits come with significant negative environmental impacts. The Advanced Remediation Technologies Program addresses these critical environmental and safety issues. The Program conducts research, development, demonstration and deployment (RDD&D) that reduces the environmental impact 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 and social impacts of fossil fuel development. Hydraulic fracturing requires the use of large amounts of water and chemicals, which needs to be cleaned and safely disposed of without inducing seismic events. Offshore oil development carries the risk of oil spills and contamination to important ecological environments. Many communities that rely on oil, natural gas, and coal development for jobs and economic activity are also the same communities who are affected by the negative impacts from air quality, water contamination, oil spills and/or induced seismicity.

There is no funding requested for the Gas Hydrates subprogram in FY 2023.

There is no funding requested for the Water Management Technologies subprogram in FY 2023.

Highlights of the FY 2023 Budget Request

The Environmentally Prudent Stewardship subprogram will conduct RDD&D technologies to address wellbore integrity, induced seismicity, water use, produced water treatment, and offshore safety and spill prevention.

Resource Sustainability
Advanced Remediations Technologies
Funding ($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Advanced Remediations Technologies					
Environmentally Prudent Stewardship	12,000	12,000	12,964	+964	+8.0%
Gas Hydrates	25,000	25,000	0	-25,000	-100%
Water Management Technologies	7,500	7,500	0	-7,500	-100%
Total, Advanced Remediations Technologies	**44,500**	**44,500**	**12,964**	**-31,536**	**-70.9%**

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

	FY 2023 Request vs FY 2021 Enacted
Advanced Remediation Technologies	
Environmentally Prudent Stewardship: Funding increase reflects research to develop solutions that address the environmental impacts of oil and natural gas development. These topics include wellbore integrity, oil spill prevention, and produced water treatment and reuse technologies	**+$964**
Gas Hydrates: No funding requested in FY 2023	**-$25,000**
Water Management Technologies: No funding requested in FY 2023	**-$7,500**
Total, Advanced Remediation Technologies	**-$31,536**

Resource Sustainability
Advanced Remediation Technologies

Description

Environmentally Prudent Stewardship

The Environmentally Prudent Stewardship subprogram will focus on addressing the environmental impacts from oil and natural gas development, to include unconventional development and offshore safety and spill prevention. The program will build on research conducted and data collected from the Department of Energy's (DOE) 17 National 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.

Produced water is a byproduct from the extraction of oil and natural gas using hydraulic fracturing techniques. Shale rock that contains oil and gas also holds water. As the oil and natural gas is produced, water is brought to the surface and will contain fracturing fluid mixed with the naturally-occurring water. This produced water will often contain sand, oils, salts, chemicals, bacteria, organic compounds, and even naturally-occurring radioactive materials. DOE is transforming produced water from a waste to a resource by developing treatment technologies that allow for its safe re-use in applications such as agriculture.

DOE's offshore safety and spill prevention research focuses on: 1) identifying and mitigating risks from ocean currents and seafloor hazards such landslides; 2) reducing risks associated with infrastructure used to deliver chemicals to the well and to bring produced fluids to the platform; and 3) 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.

Gas Hydrates

There is no funding requested for the Gas Hydrates subprogram in FY 2023.

Water Management Technologies

There is no funding requested for the Water Management Technologies subprogram in FY 2023.

Resource Sustainability
Advanced Remediation Technologies

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Advanced Remediation Technologies $44,500,000	**$12,964,000**	**-$31,536,000**
Environmentally Prudent Stewardship **$12,000,000**	**$12,964,000**	**+$964,000**
• Research on reducing the environmental footprint of unconventional oil and gas development.	• Funding will support research that address the environmental impacts of fossil fuel development. These topics include wellbore integrity, oil spill prevention, and produced water treatment and reuse technologies.	• Funding will support research that addresses the environmental impacts of fossil fuel development. These topics include wellbore integrity, oil spill prevention, and produced water treatment and reuse technologies.
Gas Hydrates $25,000,000	**$0**	**-$25,000,000**
• Conducted early-stage research such as numerical simulations, fundamental property characterization, and pore-scale visualization of hydrate bearing sediments. • Prepared for long-term reservoir flow test on the North Slope of Alaska. • Prepared for phase two expedition in the Gulf of Mexico.	• No funding is requested within the Advanced Remediation Technologies Budget Request.	• Funds are reallocated to higher Administration priorities.
Water Management Technologies $7,500,000	**$0**	**-$7,500,000**
• Awarded Funding Opportunity Announcement for Water Management for Thermal Power Generation. • Conducted tests at the Energy and Environmental Research Center Brine Extractions and Storage Test Site. • Funded the National Energy Technology Laboratory and other National Labs for research and development on impacts of water demand and water availability for power generation, Carbon Capture, Utilization, and Storage (CCUS), and hydrogen.	• No funding is requested within the Advanced Remediation Technologies Budget Request.	• Funds are reallocated to higher Administration priorities.

Resource Sustainability
Methane Mitigation Technologies

Overview

The Methane Mitigation Technologies Program addresses critical environmental and safety issues associated with the production and transmission of domestic oil and natural gas. Specifically, the Program's mission is to conduct research, development, demonstration, and deployment (RDD&D) of technologies and solutions that detect, quantify, reduce, and mitigate methane emissions.

The program supports RDD&D focused on innovative sensors, compressors, 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 develop innovative technologies to reduce flaring and venting of natural gas, during production and transportation, through conversion of the flared and vented natural gas to high-value, readily transportable products. The 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, is critical to reducing emissions and addressing the negative impacts, like ground water contamination, that plague communities.

Highlights of the FY 2023 Budget Request

The Methane Mitigation Technologies Program will pursue the following major activities in FY 2023:

- Developing technologies in advanced materials, sensors, data management tools, in-pipe inspection and repair technologies, and dynamic compressor research and development.
- Developing 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.
- Developing advanced sensor technologies to detect and locate emissions from production fields, pipelines, storage facilities, and abandoned wells.
- Developing and validating emissions detection and measuring technologies.
- Collecting, analyzing, and distributing emissions data, information, and knowledge to inform efforts on orphaned well remediation, Life Cycle Analysis studies, and the Environmental Protection Agency's (EPA) Greenhouse Gas (GHG) Inventory.

Resource Sustainability
Methane Mitigation Technologies
Funding ($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Methane Mitigation Technologies	20,000	20,000	100,000	+$80,000	+400%
Total, Methane Mitigation Technologies	**20,000**	**20,000**	**100,000**	**+$80,000**	**+400%**

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

	FY 2023 Request vs FY 2021 Enacted
Methane Mitigation Technologies:	
• Funding increase reflects research on advanced materials, data management tools, sensors, compressors, and analysis technologies for emissions reduction in oil and gas infrastructure; conversion technologies for stranded and vented gas; advanced remote detection technologies; and modular remediation materials. Additionally, funding reflects development and validation of measurement sensor technologies for the collection, dissemination, and analysis of emissions data; data collection and support to EPA's GHG Inventory; and data collection, analysis and support related to quantifying emissions from legacy infrastructure.	**+$80,000**
Total, Methane Mitigation Technologies	**+$80,000**

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 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 RDD&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 sensor technologies for the collection, dissemination, and analysis of emissions data; data collection and support to EPA's GHG Inventory; and data collection. This work will inform future research efforts and priorities; improve analytics, data collection and modeling; and inform mitigation and remediation efforts for natural gas pipelines, storage facilities, and legacy infrastructure.

Resource Sustainability
Methane Mitigation Technologies

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Methane Mitigation Technologies $20,000,000	**$100,000,000**	**+$80,000,000**
• 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. • Field scale methane emissions detection and quantification technology development and validation.	• 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 will support the development of direct and remote measurement sensor technologies for the collection, dissemination, and analysis of emissions data. • Research, data collection and analytics that support the Environmental Protection Agency's (EPA) Greenhouse Gas (GHG) Inventory.	• Increase in funding will support new advanced remote detection technologies for natural gas infrastructure and the development of modular remediation materials and solutions. • Increase in funding will expand research, development, demonstration and deployment (RDD&D) solutions for mitigating emissions throughout the natural gas supply chain, from reducing flaring in production fields to detecting and mitigating legacy infrastructure. • Increase in funding will support the development of advanced materials, data management tools, in-pipe inspection and repair technologies, and dynamic compressor research and development. • Increase in funding will support the development of direct and remote measurement sensor technologies for the collection, dissemination, and analysis of emissions data, including support to EPA's GHG Inventory.

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Overview

The new Natural Gas Decarbonization and Hydrogen Technologies program will focus on technologies for carbon-neutral hydrogen production as well as hydrogen (and ammonia) transportation, and geologic storage technologies that leverage existing natural gas infrastructure as well as supporting analytical tools and models. Hydrogen research will focus on cutting-edge conversion technologies (including pyrolysis, microwave or plasma assisted catalytic conversion and other potential future in-situ conversion processes), blending hydrogen with natural gas, and leveraging existing transportation and 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 (LCA), and resource evaluations.

Highlights of the FY 2023 Budget Request

The Natural Gas Decarbonization and Hydrogen Technologies Program will focus on technologies for "carbon-neutral" hydrogen production as well as hydrogen (and ammonia) transportation and geologic storage technologies that leverage existing natural gas infrastructure in coordination with the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Hydrogen and Fuel Cell Technologies Office (HFTO).

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

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Natural Gas Decarbonization and Hydrogen Technologies	0	0	26,000	+$26,000	N/A
Total, Natural Gas Decarbonization and Hydrogen Technologies	**0**	**0**	**26,000**	**+$26,000**	**N/A**

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

	FY 2023 Request vs FY 2021 Enacted
Natural Gas Decarbonization and Hydrogen Technologies:	
. The FY 2023 Budget Request reflects new research on developing and advancing technologies for the production, transportation, and storage of domestically produced, carbon-neutral Hydrogen.	**+$26,000**
Total, Natural Gas Decarbonization and Hydrogen Technologies	**+$26,000**

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Description

The United States (U.S.) is well positioned to transition to a hydrogen economy and DOE is committed to advancing technology solutions that utilize fossil energy to enable this transition. Steam methane reforming (SMR) is an advanced and mature production process that builds upon the existing natural gas pipeline delivery infrastructure. However, traditional SMR has a heavy carbon footprint. Hydrogen production research will focus on the development of novel technologies for more efficient conversion of methane to hydrogen. Hydrogen transportation research will focus on blending hydrogen with natural gas and leveraging existing transportation and storage infrastructure. Research will include materials compatibility, compressor and pneumatic controller suitability, separation technologies, and life cycle and techno-economic analysis (TEA). Storage research will include reservoir assessment and response tests, impacts on geochemistry, physics, and geological structure of existing reservoirs when used for hydrogen storage. The program will also develop analytical tools and models that are able to evaluate potential advanced technologies, technology performance metrics, TEA, LCA, and resource evaluations. This analysis will provide potential technology pathways and aid in predicting future market penetration of different development strategies.

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Natural Gas Decarbonization and Hydrogen Technologies $0	**$26,000,000**	**+$26,000,000**
• No FY 2021 enacted funding.	• 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.	• Increase reflects research on new natural gas hydrogen research program. • Research includes natural gas related research on carbon-neutral hydrogen production, transportation, and storage.

vefResource Sustainability
Mineral Sustainability

Overview

The Mineral Sustainability program will support domestic supply chain networks required for the economically, environmentally, and geopolitically sustainable production 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.

These unconventional resources are defined as coal waste and industrial by-products—coal refuse (mineral matter that is removed from coal), clay/sandstone over/under-burden materials, ash (coal combustion or gasification residuals), aqueous effluents such as Acid Mine Drainage (AMD), and associated solids and precipitates resulting from AMD treatment, as well as legacy, ponded, impoundment remediation/reclamation coal-based materials. In addition, CM extraction associated with produced water from the fossil fuel industry and industrial byproducts associated with steel, cement, and refining industries will also be considered.

It is imperative that the U.S. continue to invest in clean energy technologies. However, building these and other clean technologies will require ever larger quantities of minerals and metals than are currently being consumed. Unfortunately, the United States (U.S.) import dependency on many of the minerals and metals needed for clean energy technology—major stepping stones toward an improved climate quality—has continued to increase dramatically over the past 30 years.

The Mineral Sustainability subprogram activities in the Department of Energy's (DOE) Office of Fossil Energy and Carbon Management (FECM), along with complementary investments in DOE's Office of Energy Efficiency and Renewable Energy (EERE) 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.

Developing more domestic CM resources in the most sustainable manner for meeting current and future demand has become a national priority. Development of sustainable and resilient CM supply chains has the potential to address adverse environmental concerns, revitalize domestic manufacturing capabilities, and create good paying jobs with a free and fair chance to join a labor union. 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 these disadvantaged communities that are seeking opportunities to contribute to the transition to a clean energy economy.

Critical Minerals

The development of a domestic, economically competitive supply of CMs are needed to help fuel the Nation's economic growth; transition to clean energy technologies; secure energy independence by reducing reliance on foreign CM and REE sources; and increase U.S. national security. The CM subprogram focuses on the sustainable recovery of all CM, including REEs, throughout the upstream, midstream, and downstream supply chain by prioritizing the use of unconventional resources as the most environmentally sustainable primary feedstock resource for domestic production.

The CM 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 CM subprogram leverages the success of the former, fully integrated "Feasibility of Recovery of Rare Earth Element" research and development (R&D) project 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 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 (ML) and artificial intelligence, small- and large-scale pilot projects—including public-private partnerships, and existing basin partnerships developed through Carbon Ore Rare Earth-Critical Mineral Initiative (CORE-CM).

Since 2014, research, development, demonstration and deployment (RDD&D) activities have provided successful results from one Bench-scale REE-CM Separation facility at the University of North Dakota and three Pilot-Scale REE-CM Separation facilities at the University of Kentucky, West Virginia University and at Physical Sciences Inc. in Massachusetts, which have demonstrated the technical feasibility of extracting CMs and REEs from carbon ore and by-products in small quantities. These facilities were the first ever projects to demonstrate the capability to extract CMs/REEs from coal refuse, coal ash, and AMD. These small-scale projects were the foundation for the development of the large-scale pilots. Currently, pre-front end engineering and design (FEED) studies are underway and will be a pre-cursor to new FEED studies for the development of large-scale pilot facilities that will produce 1-3 tonnes/day mixed REEs and other CMs. In addition to this groundbreaking RDD&D, mineral characterization and analysis has been conducted on four to five thousand samples from fourteen coal-producing states, and 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. Results from this activity's laboratory characterization work of the samples has indicated REE presence in the materials in the form of conventional minerals, such as monazite and xenotime. However, the work has also 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 has 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.

There are four key focus areas in which RDD&D will be conducted:

- **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) at the Department of Interior and the Environmental Protection Agency.
- **Sustainable Resource Extraction and Beneficiation Technology Development** – Novel technology development and validation for sustainable 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 includes development of models to use as virtual test platforms to optimize process separation designs. This area also includes technology development of individual high-purity separation 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.
- **International Engagements, Standards, Supply Chain Development, and Characterization Technology Development**–Prioritize working with international allies to address sustainable practices throughout the world.

Highlights of the FY 2023 Budget Request

- Further advance facilities to produce large quantities of high purity, commercial grade REEs and other CMs, through FEED, 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 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. This work is coordinated with ongoing work in EERE.

- Support the maturation of transformational separation and extraction technologies, characterization of CMs/REEs, ML, and optimization modeling. Modeling and validation of models for optimization and efficiency improvements would improve process economics and are a necessary step in design and operation of larger scale facilities with continuous production.

Carbon Ore Processing

This Carbon Ore Processing subprogram (formally Advanced Coal Processing) is focused on utilizing materials to be recycled from previously mined resources outside of traditional thermal and metallurgical markets that can contribute to the U.S. gross domestic product. Activities in Carbon Ore Processing is focused on developing transformational technologies to enable domestic manufacturing of strategic materials and superior building products from carbon ore at competitive market prices. These transformational technologies have minimal emissions, superior product performance, and better lifecycle for new and existing products in the market.

RDD&D activities in the Carbon Ore Processing subprogram will further efforts for the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated predominantly from 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. Transformational technology development and validation will be conducted to enable future commercial industries in three areas:

- High-value carbon products, such as graphene, synthetic graphite, quantum dots, conductive inks, enhanced textiles, battery anodes, and supercapacitor materials from carbon ore;
- Universal infrastructure components, such as components for mass transit, sewers and tunnel, roads and bridges; and,
- Continuous industrial processes to reduce capital and operating costs for future carbon products.

The FY 2023 Budget Request of $4 million for Carbon Ore Processing combines basic chemistry and combustion science along with basic and fundamental research on thermo-physical properties, materials interactions, and heat transfer to improve how carbon ore and coal waste is processed and utilized to expand market opportunities. This work is coordinated with DOE's EERE. The funding will be used to:

- Develop new technologies for creating products such as supercapacitors and other electronic components, nanomaterials such as quantum dots, conductive specialty inks, as well as the production of synthetic graphite.
- Support new technologies for carbon fiber and nanomaterials, infrastructure such as foams, composites, building materials, and 3D printing materials.
- Support techno-economic characterization, life cycle analyses, and health and safety studies to assess the environmental impacts for coal waste-derived carbon products, composites, and 3D printing fluids in addition to continuing fundamental research in developing new advanced materials.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Mineral Sustainability $53,000,000	**$44,000,000**	**-$9,000,000**
Critical Minerals $23,000,000	**$40,000,000**	**+$17,000,000**
• Pre-front end engineering and design (FEED) Studies for large-scale pilot projects that will produce large quantities of high purity, commercial grade mixed rare earth elements (REE) and other critical minerals (CMs) including individual separation and metallization. • Research, Development, Demonstration, and Deployment (RDD&D) to enable Carbon Ore, Rare Earth, and Critical Mineral (CORE-CM) Initiative, supporting over 13 basins across the U.S. • Continued maturation of transformational separation and extraction technologies, characterization of CMs/REEs, machine learning and optimization modeling. • Funding opportunity announcement (FOA) on April 29, 2021 for Initiatives to Produce REEs and CMs.	• RDD&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.	• Support large-scale pilot development through FEED studies to produce large quantities of high purity, commercial grade REE and other CMs. • Additional support to maturation of transformational processing from unconventional resources.
Carbon Ore Processing $30,000,000	**$4,000,000**	**-$26,000,000**
• Develop existing and new technologies to turn coal waste and refuse into synthetic graphite and graphene. • RDD&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 waste to products work. • Continue to support additive manufacturing of products using coal refuse via 3D printing to reclaim abandoned coal mining land. • Continue to support RDD&D of high value carbon-based products such as quantum dots and memristor computer chips, using novel technologies.	• Reduced funding for coal-based building composed of 51% carbon ore. • Maintain partial funding to support the development of synthetic graphite, carbon-based battery anodes, nanomaterials, and graphene in addition to ORNL's CFTF.

NETL Infrastructure
($K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
55,000	**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 3-year lease of Joule, NETL's high-performance computer (HPC) at Morgantown, WV. The FY 2023 Budget Request includes $6.0 million for the continuation of a 3-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.

(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 August 31, 2021

	Morgantown	Pittsburgh	Albany	Total NETL
Buildings	42	30	35	**107**
Sq. Ft. of Building Space (000s)	445	431	243	**1,119**
Acres	136	57.4	43.9	**237.3**
NETL Federal Workforce	214	230	46	**493**[2]
NETL Contractor Workforce (FTEs)	324	399	90	**843**[3]
Assets Replacement Value	$292.8M	$243.9M	$180.8M	**$717.5M**

[1] Table 1 reflects on board employees as of February 28, 2022 and Table 2 reflects authorized and requested FTEs.

[2] Total NETL includes two employees located in Houston, TX and one located in Germantown, MD.

[3] Total NETL includes three contractors located in Houston, TX And 27 located offsite.

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

	FY 2021 Enacted	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted
NETL Program Direction	125	138	+13
NETL Research & Operations	430	440	+10
TOTAL, NETL	**555**	**578**	**+23**
FECM-HQ Program Direction	124	141	+17
TOTAL, FECM RDD&D	**679**	**719**	**+40**

Highlights of the FY 2023 Budget Request

The FY 2023 Budget Request for NETL Infrastructure is $55 million. This request includes $19 million for General Plant Projects (GPP), prioritizing research laboratory upgrades in key FECM areas such as Materials Characterization, Materials Engineering Manufacturing, 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.

FY 2023 Departmental Crosscuts ($K)

	Cybersecurity	
	2021 Enacted	**2023 Request**
NETL Infrastructure	4,772	9,178

The FY 2023 Budget Request supports one Departmental crosscut: Cybersecurity. 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, Credential, and Access Management (ICAM) Initiative. Within the FY 2023 Budget Request for NETL Infrastructure, $9.178 million will be used to support these crosscutting cyber activities. Cybersecurity is funded under the Safeguards and Security subprogram.

NETL Infrastructure
Funding ($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
NETL Infrastructure					
Super Computer	6,000	6,000	6,000	0	0%
Laboratory- & Site-Wide Facilities	39,500	39,000	39,000	-500	-1.2%
Safeguards and Security	7,500	8,000	8,000	+500	+6.7%
Environmental Restoration	2,000	2,000	2,000	0	0%
Total, NETL Infrastructure	**55,000**	**55,000**	**55,000**	**0**	**0%**

NETL Infrastructure
Explanation of Major Changes ($K)

	FY 2023 Request vs FY 2021 Enacted
NETL Infrastructure: No change from FY 2021 Enacted	**0**
Total, NETL Infrastructure	**0**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 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 3-year lease of Joule, National Energy Technology Laboratory's (NETL) high performance computer (HPC) at Morgantown, WV.	• Funding is for the 3-year lease of Joule, NETL's HPC at Morgantown, WV.	• No change.
Laboratory and Site wide Facilities $39,500,000	**$39,000,000**	**-$500,000**
• 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. Priorities for funding are established to ensure compliance with life safety standards, ensure critical laboratory research facilities and infrastructure and comply with HPSB goals. Funding also includes information technology (IT) development, modernization, and enhancement (DME) investment.	• The FY 2023 Budget Request includes a slight reduction in General Plant Projects. The request also includes $2.5 million for IT DME.
Safeguard and Securities $7,500,000	**$8,000,000**	**+$500,000**
• 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.	• Slight increase in security costs.
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 2021 Enacted	FY 2021 Actuals	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))						
Capital Equipment >$500K (including MIE)	n/a	0	0	0	0	0
Minor Construction Project (>$5M)	44,372	0	12,000	12,000	0	-12,000
Total, Capital Operating Expenses	**44,372**	**0**	**12,000**	**12,000**	**0**	**-12,000**
Capital Equipment > $500K (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 (>$5M)						
Computational Science & Engineering Center	19,372	0	12,000	12,000	0	-12,000
Direct Air Capture Center	25,000	0	0	0	0	0
Total, Minor Construction Projects	**44,372**	**0**	**12,000**	**12,000**	**0**	**-12,000**
Total, Capital Summary	**44,372**	**0**	**12,000**	**12,000**	**0**	**-12,000**

NETL Research and Operations
($K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
83,000	83,000	83,000	+$0	0%

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 structural 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 2023 Budget Request

The NETL Research and Operations Request is consistent with the FY 2021 Enacted level. Areas of increasing costs are offset by operational efficiencies. In addition to an increase in salary and benefit levels, increases include 10 additional research FTEs, consistent with NETL's special hiring authority to add up to 10 accepted service term appointments to enhance recruitment through the temporary infusion of highly talented individuals who can assist in meeting a specific project/research need and possess advanced scientific or engineering backgrounds or business backgrounds that can assist in specific technology-to-market needs. Additional increases allow NETL to reduce operational risk in site operations. Funding will be used to enhance: (1) cleaning and disinfecting services, site access screening, and other activities in response to the pandemic; (2) controls around engineering drafting and drawing, shipping and receiving, and industrial hygiene sampling; and (3) predictive and preventative maintenance. Offsetting these cost increases are reductions in contractor support in the areas of fleet and transportation management, warehouse and property management, and business integration support. Also, costs under an expiring Energy Savings Performance Contract (ESPC) discontinue after FY 2022.

NETL Research and Operations
Funding ($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
NETL Research and Operations					
Research, Development, Demonstration, and Deployment	51,000	51,000	54,000	+$3,000	+6%
Site Operations	21,000	21,000	18,000	-$3,000	-14%
Program Oversight	11,000	11,000	11,000	0	0%
TOTAL, NETL Research and Operations	**83,000**	**83,000**	**83,000**	**0**	**0%**
Federal FTEs	**430**	**430**	**440**	**+10**	**+2.3%**

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 2023 Request vs FY 2021 Enacted
NETL Research and Operations:	
• The FY 20203 Budget Request is the same as FY 2021 Enacted. Increases in Federal headcount and salary and benefit levels, along with increased costs for including pandemic response activities, enhancement of controls, and predictive and preventative maintenance are offset by contractor support cost savings and the expiration of an ESPC.	**$0**
Total, NETL Research and Operations	**$0**

NETL Research and Operations
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
NETL Research and Operations $83,000,000	**$83,000,000**	**+$0**
Research, Development, Demonstration, and Deployment $51,000,000	**$54,000,000**	**+$3,000,000**
• 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 an increase of 10 federal FTEs and a 2.7% salary and benefit increase for existing staff in 2022 and an additional 4.6% in 2023.
Site Operations $21,000,000	**$18,000,000**	**-$3,000,000**
• Site Operations funding supports variable costs of operating NETL's laboratories and research sites. Funding provides for operations personnel along with support contractors for building operations, grounds maintenance, etc.	• Site Operations funding supports variable costs of operating NETL's laboratories and research sites. Funding provides for operations personnel along with support contractors for building operations, grounds maintenance, etc.	• The net reduction reflects decreased contractor support in the areas of fleet and transportation management, warehouse and property management, and business integration support. The net reduction also reflects the expiration of

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
		an Energy Savings Performance Contract. These reductions are partially offset by increased costs for enhanced: (1) cleaning and disinfecting services, site access screening, and other activities in response to the pandemic; (2) controls around engineering drafting and drawing, shipping, and receiving, and industrial hygiene sampling; and (3) predictive and preventative maintenance.
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 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
0	0	3,000	+$3,000	N/A

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 to be co-chaired by the Director of the National Economic Council and the National Climate Advisor and 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 identified 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 2023 Budget Request

The FY 2023 Budget Request of $3 million for the DOE-led IWG on Coal and Power Plant Communities and Economic Revitalization will support targeted investments across the Federal government to help communities impacted by the climate crisis and shift to a clean energy economy. Other highlights include connecting targeted communities with funding from the following sources:

- Grant funding for infrastructure projects, including, roads, broadband, water and sewer system improvements, and local transportation—creating immediate good-paying union jobs and laying the foundation for economic development.
- Resources to deploy innovative low-carbon technologies on power plants and industrial facilities—capitalizing on technological advances to prepare traditional energy infrastructure for the clean energy economy.
- Financing and grant funding programs to remediate abandoned mine lands, orphaned oil and gas wells, mine-impacted water, and brownfields—restoring natural assets and curbing toxic emissions that pose serious safety hazards and contaminate air and water.
- Funding for small businesses, community development financial institutions, local non-profit organizations, and economic innovation hubs—supporting the local economic infrastructure necessary for economic revitalization.
- Grant funding for regional economic development-aligned workforce development—enabling energy communities to prepare workers for new markets and industries.

Interagency Working Group
Explanation of Major Changes ($K)

	FY 2023 Request vs FY 2021 Enacted
Interagency Working Group:	
• The FY 2023 Budget Request will support targeted investments across the Federal government to help affected communities impacted by the climate crisis and shift to a clean energy economy.	**+$3,000**
Total, Interagency Working Group	**+$3,000**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Interagency Working Group $0	**$3,000,000**	**+$3,000,000**
• Using available resources, the Interagency Working Group (IWG) conducted over 100 in-person and virtual workshops, webinars, and stakeholder meetings. • Developed a public-facing website (EnergyCommunities.Gov) to serve energy communities. • Developed a searchable clearinghouse of Federal funding opportunities available to energy communities.	• 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 IWG will support targeted investments across the Federal government to help affected communities impacted by the climate crisis and shift to a clean energy economy.

Special Recruitment Programs
($K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
700	700	1,000	+$300	+43%

Overview

The Office of Fossil Energy and Carbon Management (FECM) emphasizes educational programs to support an increase in the number of females and under-represented minorities entering science (including social science), technology, engineering, 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 (RD^3) initiatives within FECM and the challenges in providing clean, affordable energy for future generations. FECM also utilizes Departmental program 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 STEMS workforce. The Special Recruitment Programs aligns with the Administration's Justice40 Initiative and equity priorities.

Highlights of the FY 2023 Budget Request

In FY 2023, 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 research and development (R&D) projects under the mentorship of an FECM scientist, researcher, or program official.

Special Recruitment Programs
Funding ($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Special Recruitment Programs	700	700	1,000	+$300	+43%
Total, Special Recruitment Programs	**700**	**700**	**1,000**	**+$300**	**+43%**

Special Recruitment Programs
Explanation of Major Changes ($K)

	FY 2023 Request vs FY 2021 Enacted
Special Recruitment Programs:	**+$300**
• The FY 2023 Budget Request level supports administration of the MLEF, MEISPP, DOE Scholars, STP, or other educational programs.	
Total, Special Recruitment Programs	**+$300**

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Special Recruitment Programs $700,000	**$1,000,000**	**+$300,000**
• 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.	• The increased funding will provide for additional fellowships, increased financial support (i.e., higher stipends) to participants, and enhanced recruitment engagements with HBCUs and MSIs.

Program Direction
($K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
61,500	61,500	70,291	+$8,791	+14.3%

Overview

Program Direction provides for the Headquarters (HQ) workforce responsible for the oversight and administration of the Fossil Energy and Carbon Management (FECM) Research, Development, Demonstration, and Deployment (RDD&D) program. It also provides for 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.

Also included in Program Direction is 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 2023 Budget Request

The FY 2023 Budget Request is $70.291 million and reflects a $8.791 million increase from the FY 2021 Enacted level. This 14.3% increase is driven by a 2.7% pay increase in 2022 and a 4.6% pay increase for 2023, and a requested 19.1% increase in FECM funding. 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 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Washington Headquarters					
Salaries and Benefits	21,937	21,937	25,732	+3,795	+17.3%
Travel	394	394	400	+6	+1.5%
Support Services	546	546	2,911	+2365	+433.2%
Other Related Expenses	8,476	8,476	8,418	-58	-0.7%
Total, Washington Headquarters	**31,353**	**31,353**	**37,461**	**+6,108**	**+19.5%**
National Energy Technology Laboratory					
Salaries and Benefits	17,000	17,000	19,300	+2,300	+13.5%
Travel	400	400	400	0	0.0%
Support Services	7,280	7,280	7,100	-180	-2.5%
Other Related Expenses	3,100	3,100	3,100	0	0.0%
Total, National Energy Technology Laboratory	**27,780**	**27,780**	**29,900**	**+2,120**	**+7.6%**
Import/Export Authorization					
Salaries and Benefits	1,554	1,554	1,930	+376	+24.2%
Travel	18	18	20	+2	+11.1%
Support Services	231	231	450	+219	+94.8%
Other Related Expenses	564	564	530	-34	-6.0%
Total, Import/Export Authorization	**2,367**	**2,367**	**2,930**	**+563**	**+23.8%**
Total Program Direction					
Salaries and Benefits	40,491	40,491	46,962	+6,471	+16.0%
Travel	812	812	820	+8	+1.0%
Support Services	8,057	8,057	10,461	+2,404	+29.8%
Other Related Expenses	12,140	12,140	12,048	-92	-0.8%
Total Program Direction	**61,500**	**61,500**	**70,291**	**+8,791**	**+14.3%**

Program Direction Summary	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
Federal FTEs – HQ	**121**	**121**	**141**	**+20**	**+16.5%**
Federal FTEs – NETL[1]	**121**	**121**	**138**	**+17**	**+14.0%**
Federal FTEs – Total	**242**	**242**	**279**	**+37**	**+15.3%**
Support Services					
Technical Support					
Headquarters	546	546	2,911	+2,365	+433.2%
NETL	0	0	0	0	0.0%
Import/Export Authorization	231	231	450	+219	+94.8%
Total, Technical Support	**777**	**1,035**	**3,361**	**+2,584**	**+332.6%**
Management Support					
Headquarters	0	0	0	0	0.0%
NETL	7,280	7,280	7,100	-180	-2.5%
Import/Export Authorization	0	0	0	0	0.0%
Total Management Support	**7,280**	**7,280**	**7,100**	**-180**	**-2.5%**
Total, Support Services	**8,057**	**8,057**	**10,461**	**+2,404**	**+29.8%**
Other Related Expenses					
Headquarters	8,476	8,476	8,418	-58	-0.07%
NETL	3,100	3,100	3,100	0	0.00%
Import / Export Authorization	564	564	530	-34	-6.0%
Total, Other Related Expenses	**12,140**	**12,140**	**12,048**	**-92**	**-0.8%**

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

Program Direction
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Program Direction $61,500,000	**$70,291,000**	**+$8,791,000**
Salaries and Benefits $40,491,000	**$46,962,000**	**+$6,471,000**
• 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 addition of 20 full-time equivalents (FTE) to support FECM's mission as well as a 4.6% pay raise for federal staff in 2023, the Federal Employees Retirement System (FERS) increase, and awards pool funding increase in FY 2022. • NETL increase reflects the addition of 17 FTEs to support FECM's mission as well as a 2.7% pay raise for federal staff in 2022 and a 4.6% pay raise, FERS increase, and awards pool funding increase in FY 2023.
Travel $812,000	**$820,000**	**+$8,000**
• Travel includes funding for management meetings, training, etc.	• Travel includes funding for management meetings, training, etc.	• Travel increase is a minimal addition.
Support Services $8,057,000	**$10,461,000**	**+$2,404,000**
• 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 HQ request is a slight increase over the FY 2021 Request. • The NETL decrease of $0.68 million reflects a shift of 5 FTEs from contractor staff to federal staff; these positions represent permanent needs (rather than cyclical) in direction-setting roles appropriately staffed with Federal employees. Reduction also reflects efficiencies gained through continuous process improvement and automation.

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Other Related Expenses $12,140,000	**$12,048,000**	**-$92,000**
• 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 a decrease due to re-prioritization.

Repurposing Fossil Energy Assets
($K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted ($)	FY 2023 Request vs FY 2021 Enacted (%)
5,000	5,000	6,000	+$1,000	+20%

Description
Over the next few decades, the United States (U.S.) and the world will need to dramatically reduce greenhouse gas (GHG) emissions to avoid the worst effects of climate change. This imperative implies an unprecedented transition in the energy system away from GHG-emitting fuels (unabated coal, oil, and natural gas) and toward clean energy sources, such as wind, solar, and nuclear, along with emerging technologies, such as large-scale energy storage and carbon capture, use, and storage. This transition will be challenging for a variety of technical, political, and socio-economic reasons.

In the U.S., fossil resources (coal, natural gas, and oil) play a major role in meeting energy needs. Yet, accelerated penetration of renewable energy-based generation into the energy grids has resulted in a decline in fossil-based generation over the past decade. Coal communities have faced major challenges in recent years. 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.

Coal-unit retirements, driven by changing economics, may leave valuable features of communities on the table, such as a skilled workforce, community relationships, transmission and distribution infrastructure, electrical interconnect equipment, and site and permitting licenses. As the Nation alters its carbon footprint, repurposing fossil energy assets, such as coal and natural gas plants and oil and gas wells, may address potential resistance to decommissioning coal plants and allow newer technologies to replace them. Repurposing fossil energy assets also allows communities to be active participants in the current and coming energy transition. Benefits are very clear since projects that transition fossil assets may utilize the local skilled workforce, keep sites economically active, leverage the value of infrastructure, and provide grid stability benefits (such as rotational inertia) as retiring assets are repurposed.

Energy storage is critical to advance a flexible and resilient electric grid. Achieving net-zero carbon emissions by 2050 in the U.S. will rely primarily on renewables for the electricity sector, but some fossil fuels coupled with carbon capture and reliable storage as well as strategic storage that includes hydrogen or ammonia will likely be required for near-term baseload applications. FECM will leverage its expertise in the geologic storage of carbon dioxide (CO_2) to explore and invest in approaches to store hydrogen and ammonia in significant quantities required for grid demand. This subprogram takes a technology agnostic approach to long-duration energy storage that is scalable from small applications to full-scale commercial power plants. The subprogram focuses on the integration of long-duration energy storage technologies with a variety of fossil assets, including large-scale coal and gas power plants as well as smaller assets like single-cycle peaking gas turbines and microgrid applications. Co-locating energy storage with fossil assets provides many benefits including improved asset flexibility and efficiency, improved grid reliability, and reduced GHG emissions. Additionally, energy storage enables many heavily decarbonized use cases; for example, the integration of a hydrogen energy storage system with hydrogen turbine power production. Analytical results and stakeholder input suggest this activity will emphasize energy storage technologies that are thermal, chemical (including hydrogen/ammonia), mechanical, or long-duration electrochemical (e.g., flow battery) in nature. FECM's activities are coordinated with the Department of Energy's crosscut activities across the Office of Electricity (OE), Energy Efficiency and Renewable Energy (EERE), Nuclear Energy (NE), Advanced Research Projects Agency -Energy (ARPA-E), and Office Technology Transitions (OTT). FECM's energy storage activities are documented in the Energy Storage Grand Challenge (ESGC) roadmap and regularly communicated among the Department's participating offices.

This request provides $6 million to develop case studies that leverage the Use Cases indicated in the ESGC Roadmap and their associated metrics and to support feasibility studies of co-located energy storage technologies with fossil assets.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Repurposing Fossil Energy Assets $5,000,000	**$6,000,000**	**+$1,000,000**
• Research and development is focused on DOE's efforts to take a broad, more holistic view of energy storage as a set of capabilities that enable temporal flexibility in the conversion of energy resources to useful energy services.	• Develop early-stage concepts with some pre-front end engineering design (FEED) studies to integrate technologies (e.g., chemical, thermal, mechanical and electrochemical) with fossil assets as they transition to meet decarbonization goals.	• The increased funding will help to move some of the selected pre-FEED work to prepare case studies including the initial assessment of technologies at potential fossil sites.

Fossil Energy and Carbon Management Workforce Development
University Training and Research

Description

As part of President Biden's commitment to advance environment justice and spur economic opportunity for disadvantaged communities, the Administration established the Justice40 Initiative. The Department of Energy's (DOE) FY 2023 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, technology, engineering, and mathematics (STEM), and humanities (including social and behavioral) 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 Administration's goals and the inseparability of the humanities and human element in new technology deployment. The FY 2023 Budget will provide $13 million for 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) $5M:** 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 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) $8M**: 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's commitment to fossil energy and carbon management and further Administration equity priorities.

Fossil Energy and Carbon Management Workforce Development
University Training and Research

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
University Training and Research $5,050,000	**$13,000,000**	**+$7,950,000**
University Carbon Research $3,000,000	**$5,000,000**	**+$2,000,000**
• 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 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.
HBCUs, Education, and Training $2,050,000	**$8,000,000**	**+$5,950,000**
• 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.

Fossil Energy and Carbon Management
Excess Facilities

Excess Facilities are facilities no longer required to support the Department's needs, present or future missions or functions, or the discharge of its responsibilities. 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.

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 2021 Enacted	FY 2021 Actuals	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))						
Capital Equipment >$500K (including MIE)	n/a	0	0	0	0	0
Minor Construction Project (>$5M)	44,372	0	12,000	12,000	0	-12,000
Total, Capital Operating Expenses	**44,372**	**0**	**12,000**	**12,000**	**0**	**-12,000**
Capital Equipment > $500K (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 (>$5M)						
Computational Science & Engineering Center	19,372	0	12,000	12,000	0	-12,000
Direct Air Capture Center	25,000	0	0	0	0	0
Total, Minor Construction Projects	**44,372**	**0**	**12,000**	**12,000**	**0**	**-12,000**
Total, Capital Summary	**44,372**	**0**	**12,000**	**12,000**	**0**	**-12,000**

Fossil Energy and Carbon Management
Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR)
($K)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request/ Projected Transfer	FY 2023 Request vs FY 2021 Enacted ($)
Carbon Management Technologies				
SBIR	8,820	8,820	12,454	+3,634
STTR	1,535	1,535	1,751	+216
Resource Sustainability				
SBIR	2,905	2,905	4,664	+1,759
STTR	505	505	656	+151
Unconventional FE Technologies				
SBIR	1,116	1,116	0	-1,116
STTR	194	194	0	-194
Repurposing Fossil Energy Assets (RFEA)[1]				
SBIR	129	129	182	+53
STTR	22	22	26	+4
Total, SBIR/STTR	**15,226**	**15,226**	**19,733**	**+4,507**

[1] SBIR and STTR is shown here for the new FECM control point. RFEA CJ does not have a funding table.