DOE/CF-0174
Volume 3 Part 2

Department of Energy
FY 2022 Congressional Budget Request

Nuclear Energy
Fossil Energy and Carbon Management
Indian Energy Policy and Programs
Advanced Tech. Vehicles Manufacturing Loan Program
Title 17—Innovative Tech. Loan Guarantee Program
Tribal Energy Loan Guarantee Program
Energy Information Administration
Advanced Research Projects Agency - Energy
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Clean Energy Demonstrations

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FY 2022 Congressional Budget

Request Volume 3 Part 2

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DEPARTMENT OF ENERGY
Appropriation Summary
(dollars in thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 vs. FY 2021 $	FY 2022 vs. FY 2021 %
Department of Energy					
Energy Efficiency and Renewable Energy	2,777,277	2,861,760	4,732,000	1,870,240	65.35%
Electricity	190,000	211,720	327,000	115,280	54.45%
Cybersecurity, Energy Security, and Emergency Response	156,000	156,000	201,000	45,000	28.85%
Strategic Petroleum Reserves	195,000	188,000	197,000	9,000	4.79%
SPR - Petroleum Account	10,000	1,000	7,350	6,350	635.00%
Naval Petroleum & Oil Shale Reserves	14,000	13,006	13,650	644	4.95%
Northeast Home Heating Oil Reserves	10,000	6,500	0	-6,500	-100.00%
Total, CESER and Petroleum Reserve Accounts	385,000	364,506	419,000	54,494	14.95%
Nuclear Energy	1,340,000	1,357,800	1,680,700	322,900	23.78%
Nuclear Waste Disposal		27,500	27,500	0	0.00%
Fossil Energy and Carbon Management	750,000	750,000	890,000	140,000	18.67%
Uranium Enrichment Decontamination and Decommissioning Fund (UED&D)	881,000	841,000	831,340	-9,660	-1.15%
Energy Information Administration	126,800	126,800	126,800	0	0.00%
Non-Defense Environmental Cleanup	319,200	319,200	338,860	19,660	6.16%
Science	7,000,000	7,026,000	7,440,000	414,000	5.89%
Advanced Research Project Agency-Energy	425,000	427,000	500,000	73,000	17.10%
Advanced Research Project Agency-Climate			200,000	200,000	N/A
Office of Clean Energy Demonstrations			400,000	400,000	N/A
Office of Technology Transitions			19,470	19,470	N/A
Departmental Administration	161,000	166,000	321,760	155,760	93.83%
Indian Energy Policy & Programs	22,000	22,000	122,000	100,000	454.55%
Office of Inspector General	54,215	57,739	78,000	20,261	35.09%
Title 17 - Innovative Technology Loan Guarantee Program	29,000	-363,000	179,000	542,000	-149.31%
Advanced Technology Vehicles Manufacturing Loan Program	5,000	-1,903,000	5,000	1,908,000	-100.26%
Tribal Energy Loan Guarantee Program	2,000	2,000	2,000	0	0.00%
Total, Credit Programs	36,000	-2,264,000	186,000	2,450,000	-108.22%
Total, Energy Programs	14,467,492	12,295,025	18,640,430	6,345,405	51.61%
Weapons Activities	12,457,097	15,345,000	15,484,295	139,295	0.91%
Defense Nuclear Nonproliferation	2,164,400	2,260,000	1,934,000	-326,000	-14.42%
Naval Reactors	1,648,396	1,684,000	1,860,705	176,705	10.49%
Federal Salaries and Expenses	434,699	443,200	464,000	20,800	4.69%
Total, National Nuclear Security Administration	16,704,592	19,732,200	19,743,000	10,800	0.05%
Defense Environmental Cleanup	6,255,000	6,426,000	6,841,670	415,670	6.47%
Other Defense Activities	906,000	920,000	1,170,000	250,000	27.17%
Total, Environmental and Other Defense Activities	7,161,000	7,346,000	8,011,670	665,670	9.06%
Nuclear Energy (050)	153,408	149,800	149,800	0	0.00%
Power Marketing Administrations	58,324	78,600	80,000	1,400	1.78%
Federal Energy Regulatory Commission	0	0	0	0	N/A
UED&D Discretionary Payments			-415,670	-415,670	N/A
Title XVII Loan Guar. Prog Section 1703 Negative Credit Subsidy Receipts	-15,000	0	-10,800	-10,800	N/A
Excess Fees and Recoveries, FERC	-16,000	0	-9,000	-9,000	N/A
Colorado River Basin Fund		2,000	0	-2,000	-100.00%
Total, Receipts	-31,000	2,000	-435,470	-437,470	-21873.50%
Total, Department of Energy	**38,513,816**	**39,603,625**	**46,189,430**	**6,585,805**	**16.63%**

DOE Budget Function					
NNSA Defense (050) Total	16,704,592	19,732,200	19,743,000	10,800	0.05%
Non-NNSA Defense Total	7,314,408	7,495,800	8,161,470	665,670	8.88%
Defense (050)	**24,019,000**	**27,228,000**	**27,904,470**	**676,470**	**2.48%**
Science (250)	7,000,000	7,026,000	7,440,000	414,000	5.89%
Energy (270)	7,506,239	5,349,625	10,844,960	5,495,335	102.72%
Non-Defense (Non-050)	**14,506,239**	**12,375,625**	**18,284,960**	**5,909,335**	**47.75%**

Nuclear Energy

Nuclear Energy

Nuclear Energy

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Nuclear Energy

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for nuclear energy activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, *$1,850,500,000* remain available until expended: *Provided*, That of such amount, *$85,000,000* shall be available until September 30, *2023*, for program direction.

(EnergyandWaterDevelopment and Related Agencies Appropriations Act, 2021.)

Nuclear Energy
($K)

FY 2020 Enacted[1,2]	FY 2021 Enacted[1,3]	FY 2022 Request
1,493,408	1,507,600	1,850,500

Overview

Nuclear energy is a key element of the President's plan to put the United States (U.S.) on a path to net-zero emissions by 2050. America's nuclear energy sector provides approximately 55 percent of the nation's annual clean electricity production and generates about 20 percent of U.S. electricity from a fleet of 94 operating units in 28 states. America's nuclear energy sector also plays key national security and global strategic roles for the U.S. including nuclear nonproliferation.

The U.S. pioneered the development and peaceful use of nuclear power to produce around-the-clock, emission-free baseload electricity generation as well as the development of the civilian nuclear fuel cycle. The Office of Nuclear Energy (NE) is now leading the effort to move new and innovative advanced reactors, small modular reactors, and microreactors from the conceptual and development stages into the commercial energy sector. NE executes its mission through investments in research and development efforts with the national laboratories, U.S. universities, and industry technical organizations, as well as through partnerships with the U.S. industry and commercial stakeholders to develop and demonstrate advanced reactor technologies and designs.

The FY 2022 request helps to advance U.S. leadership in critical technologies, invest in our workforce, create good paying jobs and provide the free and fair choice to join a union, combat climate change, and upgrade America's research infrastructure. U.S. leadership in crosscutting and advanced nuclear technologies is critical to both our future economic competitiveness and our national security.

The Office of Nuclear Energy (NE) focuses on three major mission areas: the nation's existing nuclear fleet, the development of advanced nuclear reactor concepts, and fuel cycle technologies. Investments in these areas leverage the tremendous innovation capacity of the United States' National Laboratories, universities, and advanced reactor developers to transform America's power sector. NE is also responsible for ensuring the operation and securing the availability of the Idaho National Laboratory as a national asset supporting a broad range of civilian and national security research.

NE FY 2022 Budget Request will extend the impact of our Research, Development, Demonstration & Deployment (RDD&D) funding by leveraging a variety of funding mechanisms - such as competitive awards, technical assistance, and programs targeted to small businesses. The goal is to enable the commercialization of clean energy innovations that will help tackle the climate change crisis, activate job creation, expand other public impact outcomes, and yield a more geographically diverse and impactful research portfolio that supports equity, diversity, and environmental justice. NE, through its robust RDD&D programs invests in innovative clean energy solutions and assists in helping to achieve a carbon-pollution free electricity sector by 2035 and net-zero emissions, economy-wide, by no later than 2050.

[1] Funding does not reflect the transfer of SBIR/STTR to the Office of Science.
[2] Funding does not reflect the mandatory transfer of $88.5M from Naval Reactors for operation of the Advanced Test Reactor.
[3] Funding does not reflect the mandatory transfer of $91.0M from Naval Reactors for operation of the Advanced Test Reactor.

Highlights and Major Changes in the FY 2022 Budget Request

Supporting the President's commitment to put America on a path to achieve net-zero emissions economy-wide no later than 2050 by investing in resilience, clean energy innovation and U.S. competitiveness, the NE budget request provides a $342.9M increase (+23%) above the FY 2021 appropriation. These investments will leverage the tremendous innovation capacity of the National Laboratories, universities, and advanced reactor developers to transform America's power sector.

- The **Advanced Reactor Demonstration Program** is requesting $370.4M to execute cost-shared cooperative agreements with domestic nuclear industry partners to develop, license, construct, and operate two advanced demonstration reactors, and to continue support for risk reduction R&D through partnerships with five less-mature advanced reactor designs with potential for commercial deployment, regulatory development efforts, and facilitating capacity building and private sector technology developers' access to the strategic infrastructure and assets of the national laboratories ..
- $145M is requested for preliminary design and other activities for the Versatile Test Reactor (VTR). The VTR will provide a critical research infrastructure capability needed to support the development of advanced reactor technologies (1) through accelerated testing of new fuels and materials and development of advanced instruments and sensors and (2) essential for meeting U.S. clean energy goals and rebuilding U.S. economic prosperity and global economic competitiveness. A new subprogram, **High-Assay, Low Enriched Uranium (HALEU) Availability**, is initiated in FY 2022 with a request of $33M to support HALEU availability by making available small quantities of HALEU from limited DOE uranium inventories and HALEU production in the short term and working with the private sector in its design and build out of commercial HALEU production capability in the U.S. for the long term
- At least $20M is allocated to support the development and implementation of an interim storage program that employs consent-based siting to address the near-term requirements for storage of commercial used fuel. These funds are included within the Integrated Waste Management System subprogram within the Fuel Cycle R&D Program. In FY 2021, funding for related activities was appropriated within the Interim Storage and Nuclear Waste Fund Oversight program (Nuclear Waste Disposal account).
- Acknowledging the tremendous recent advances that have been made in microreactor research and development, the **Transformational Challenge Reactor** effort ended in FY 2021. The associated crosscutting research, particularly in areas such as advanced manufacturing, are integrated into the base NE R&D programs.
- **International Nuclear Energy Cooperation** is restored as a standalone program. FY 2021 and FY 2022 efforts are focused on preparing for the U.S. hosted 2022 International Atomic Energy Agency (IAEA) Nuclear Power Ministerial meeting.
- Over the last several years NE's federal staffing levels have declined while the size of NE's programs has doubled. The FY 2022 request of $85M for Program Direction will support a multiyear effort to restore staffing levels to the 2016 level.
- Within its **Infrastructure Program**, NE is requesting $300M for Idaho National Laboratory (INL) Facilities Operations and Maintenance (IFM) subprogram. The request will focus on maintaining mission critical facilities to support technical advancements in existing nuclear fleet, reactors, and nuclear fuel cycle. It will also focus on investing in the Advanced Test Reactor (ATR) Complex and the Materials and Fuels Complex to improve reliability and modernize capabilities in support of nuclear energy research and development objectives. Additionally, within the Construction subprogram, NE is requesting $41M for the Sample Preparation Laboratory (SPL) at INL, which will provide world-class capability to conduct post-irradiation examinations at micro and nano scale of existing and advanced nuclear fuels and materials.

Nuclear Energy
Funding by Congressional Control ($K)

	FY 2020 Current[1,2]	FY 2021 Enacted[1,3]	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Integrated University Program	**5,000**	**5,000**	**6,000**	**+1,000**	**+20%**
STEP Research & Development (R&D)	**5,000**	**5,000**	**0**	**-5,000**	**-100%**
Reactor Concepts Research, Development & Demonstration (RD&D)					
Advanced SMR RD&D	100,000	115,000	115,000	0	0%
Light Water Reactor Sustainability	47,000	47,000	60,000	+13,000	+28%
Advanced Reactor Technologies	55,000	46,000	65,000	+19,000	+41%
Versatile Advanced Test Reactor	65,000	0	0	0	+0%
Reactor Concepts RD&D	**267,000**	**208,000**	**240,000**	**+32,000**	**+15%**
Fuel Cycle Research and Development					
Mining, Conversion and Transportation	2,000	2,000	2,000	0	0%
Civil Nuclear Enrichment	40,000	40,000	0	-40,000	-100%
Materials Recovery and Waste Form Development	30,000	25,000	35,000	+10,000	+40%
Accident Tolerant Fuels	95,600	105,800	115,000	+9,200	+9%
TRISO and Graphite Qualification	30,000	36,000	36,000	0	+0%
Fuel Cycle Core R&D	20,000	20,000	46,925	+26,925	+135%
High Assay Low Enriched Uranium Availability	0	0	33,075	+33,075	+100%
Used Nuclear Fuel Disposition R&D	62,500	62,500	62,500	0	0%
Integrated Waste Management System	25,000	18,000	38,000	+20,000	+111%
Fuel Cycle R&D	**305,100**	**309,300**	**368,500**	**+59,200**	**+19%**

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	FY 2020 Current[1,2]	FY 2021 Enacted[1,3]	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Nuclear Energy Enabling Technologies					
Crosscutting Technology Development	25,000	28,000	47,000	+19,000	+68%
Joint Modeling and Simulation Program	35,000	35,000	35,000	0	0%
Nuclear Science User Facilities	30,000	30,000	42,000	+12,000	+40%
Transformational Challenge Reactor	23,450	29,869	0	-29,869	-100%
Nuclear Energy Enabling Technologies	**113,450**	**122,869**	**124,000**	**+1,131**	**+1%**
Advanced Reactor Demonstration Program					
National Reactor Innovation Center	20,000	30,000	55,000	+25,000	+83%
Demonstration 1	80,000	80,000	108,700	+28,700	+36%
Demonstration 2	80,000	80,000	136,650	+56,650	+71%
Risk Reduction for Future Demonstrations	30,000	40,000	50,000	+10,000	+25%
Regulatory Development	15,000	15,000	15,000	0	0%
Advanced Reactor Safeguards	5,000	5,000	5,000	0	0%
Subtotal, Advanced Reactors Demonstration Program	**230,000**	**250,000**	**370,350**	**+120,350**	**+48%**
Versatile Test Reactor Project					
Other Project Costs	0	43,000	55,000	+12,000	+28%
21-E-200, Versatile Test Reactor	0	2,000	90,000	+88,000	+4,400%
Versatile Test Reactor Project	**0**	**45,000**	**145,000**	**+100,000**	**+222%**
Infrastructure					
INL Facilities Operations & Maintenance	280,000	280,000	300,000	+20,000	+7%
ORNL Infrastructure Facilities O&M	20,000	20,000	0	-20,000	-100%
Research Reactor Infrastructure	9,000	11,500	15,000	+3,500	+30%
Construction					
16-E-200, Sample Preparation Laboratory	25,450	26,000	41,850	+15,850	+61%
Subtotal, Infrastructure	**334,450**	**337,500**	**356,850**	**+19,350**	**+6%**

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[3] Funding does not reflect the mandatory transfer of $91.0M from Naval Reactors for operation of the Advanced Test Reactor.

	FY 2020 Current[1,2]	FY 2021 Enacted[1,3]	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Idaho Sitewide Safeguards and Security	**153,408**	**149,408**	**149,800**	**0**	**0%**
International Nuclear Energy Cooperation	**0**	**0**	**5,000**	**+5,000**	**+100%**
Program Direction	**80,000**	**75,131**	**85,000**	**+9,869**	**+13%**
Total, Nuclear Energy R&D	**1,496,408**	**1,507,600**	**1,850,500**	**+342,900**	**+23%**
Federal FTEs	275	272	298	+26	+9%

SBIR/STTR:

- FY 2020 Transferred: SBIR $19,538; STTR $2,747
- FY 2021 Projected: SBIR $16,093; STTR $2,800
- FY 2022 Request: SBIR $19;243; STTR $2,712

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[3] Funding does not reflect the mandatory transfer of $91.0M from Naval Reactors for operation of the Advanced Test Reactor.

Integrated University Program

Overview

The Office of Nuclear Energy (NE) Integrated University Program (IUP) supports the next generation of the nuclear energy workforce. The program provides important educational support to bolster scientific discovery and innovation in nuclear science and engineering (NS&E) programs at United States (U.S.) universities and colleges.

NE's IUP program objective is to sustain future domestic NS&E workforce needs and to attract qualified students to nuclear energy professions by providing single-year undergraduate scholarships and multi-year graduate fellowships. Scholarships are awarded for undergraduate study at two- and four-year institutions leading to a major or minor degree or certificate and fellowships are awarded for graduate level work leading to a masters or doctoral degree in the fields or disciplines of NS&E relevant to the NE mission. NS&E disciplines of interest include nuclear engineering, mechanical engineering, electrical engineering, chemistry, health physics, nuclear materials science, radiochemistry, applied nuclear physics, nuclear policy, radiation protection technology, nuclear power technology, nuclear maintenance technology, and nuclear engineering technology.

NE has awarded more than $55 million for 929 nuclear energy-related scholarships and fellowships at 75 universities and colleges—including 11 minority-serving institutions (MSIs) and two Historically Black Colleges and Universities (HBCUs)—in 32 states since IUP was authorized by Congress in 2009. Currently, scholarships are $7,500 for one year. The maximum award for a fellowship is $52,000 per year for three years, with an additional one-time $5,000 allotment to fund a minimum 10-week internship at Department of Energy (DOE), a DOE national laboratory, or other designated facility.

All scholarship and fellowship awards are competitively awarded to students attending U.S. institutions of higher education offering NS&E educational programs, including MSIs and HBCUs. Moving forward, emphasis will be placed on increasing the involvement of HBCUs/MSIs, resulting in direct and meaningful investments in the areas of clean energy training and workforce development in support of the administration's Justice40 Initiative.

Specifically, in fiscal year (FY) 2022, NE will support a new scholarship opportunity targeting 2-year applied technical degree programs focused on nuclear energy-related topics, with priority funding set-aside specifically to support HBCUs, MSIs, and institutions in disadvantaged communities. In direct support of the administration's efforts to focus on workforce development, this scholarship will not only strengthen the ability of HBCUs and MSIs to compete in future opportunities, but will also prepare individuals for clean energy union jobs centered around nuclear energy-related technicians and similar trades, including nuclear operations, mechanical and electrical maintenance, chemistry, health physics, etc. The program will be a student-focused, one-year scholarship program supporting students at technical and community colleges in communities across the U.S., including those in close geographic proximity to locations where nuclear-related skillsets would be valuable, e.g., nuclear power plants, new builds, fuel cycle facilities, national laboratories, etc. This opportunity would support the existing reactor fleet and the emerging advanced reactor developers. Additionally, this program may provide an opportunity for students to continue their education and pursue a four-year degree bachelors program in a nuclear-related field.

This new opportunity will be closely coordinated with the IUP elements executed by the Nuclear Regulatory Commission and the National Nuclear Security Administration to avoid redundancy and overlap of activities.

To promote this scholarship opportunity and to generate program interest, NE will support outreach activities targeted at technical and community colleges, including those that (1) are in close geographic proximity to energy communities and/or (2) serve traditionally disadvantaged communities. Such activities will include university visits, promotion of the opportunity at conferences, and the enhancement of NE's IUP website to provide program resources for interested parties.
All Department awards are fully funded in the year funding is received. As a result, multi-year student research fellowships do not require support by out-year funds after the appropriation year.

Integrated University Program
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Integrated University Program					
Integrated University Program	5,000	5,000	6,000	+1,000	+20%
Total, Integrated University Program	**5,000**	**5,000**	**6,000**	**+1,000**	**+20%**

Integrated University Program
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Integrated University Program:	
The increase from $5,000,000 to $6,000,000 at the FY 2022 Request level reflects fully funding single-year scholarships and multi-year fellowships and maintaining or increasing the number of such awards via the Integrated University Program (IUP), as well as initiating a new scholarship opportunity that targets two-year applied technical degree programs focused on nuclear energy related topics, all with an increased emphasis on capacity-building and education at HBCUs, MSIs, and institutions in disadvantaged communities.	-+1,000
Total, Integrated University Program	**+1,000**

Integrated University Program

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Integrated University Program $5,000,000	**$6,000,000**	**+$1,000,000**
• Support nuclear science and engineering study and research by fully funding approximately 30 multi-year student fellowships and approximately 45 single-year scholarships in the nuclear energy field of study.	• Support nuclear science and engineering study and research by fully funding approximately 30 or more multi-year student fellowships and 45 or more single-year scholarships in the nuclear energy field of study. • Support a new scholarship program opportunity that targets two-year applied technical degree programs focused on nuclear energy-related topics, all with an increased emphasis on capacity-building and education at HBCUs, MSIs, and institutions in disadvantaged communities. This opportunity will focus on workforce development for nuclear relevant technician training, including nuclear operations, mechanical maintenance, electrical maintenance, chemistry, health physics and other nuclear energy-related topics. • Bolster outreach efforts focused on increasing HBCU/MSI involvement to include website resources, conference promotion, and university visits.	• The increase from $5,000,000 to $6,000,000 reflects fully funding single-year scholarships and multi-year fellowships and maintaining or increasing the number of such awards via the Integrated University Program (IUP) and initiating a new scholarship opportunity that targets two-year applied technical degree programs focused on nuclear energy related topics, all with an increased emphasis on capacity-building and education at HBCUs, MSIs, and institutions in disadvantaged communities.

Supercritical Transformational Electric Power Research and Development

Overview

The Supercritical Transformational Electric Power Research and Development (STEP R&D) initiative was a collaborative Department of Energy (DOE) project to develop and scale-up advanced Supercritical Carbon Dioxide (sCO_2) Brayton cycle energy conversion technology to facilitate commercial development. As a result of the successful program efforts, the underlying technology is ready for industry to complete the final development and scale-up for commercial application. Given this transition of final commercial development to industry, the Office of Nuclear Energy does not plan to support the STEP R&D program in FY 2022.

The sCO_2 Brayton technology has the potential to significantly reduce costs of energy production by improving the efficiency of converting thermal energy to electrical energy compared to using traditional steam-Rankine cycle systems, which are currently used for roughly 80% of the world's electricity generation. The sCO_2 Brayton cycle technology utilizes smaller equipment and will be simpler to operate compared to Rankine cycle technology, resulting in lower capital and operating costs. These improvements could make advanced nuclear energy technologies more cost competitive. Extensive systems testing has significantly lowered the technical risk for this technology and any remaining commercialization efforts should be left to industry to resolve.

Any remaining early-stage research required to address Brayton cycle energy conversion technology issues specific to advanced nuclear energy applications could be continued within the Reactor Concepts, Research, Development and Demonstration (RD&D) program.

Highlights of the FY 2022 Budget Request

No funding is requested for the STEP R&D initiative, consistent with the Department's decision to shift scale-up of the technology to the private sector.

Supercritical Transformational Electric Power Research and Development
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Supercritical Transformational Electric Power Research and Development					
Supercritical Transformational Electric Power Research and Development	5,000	5,000	0	-5,000	-100%
Total, Supercritical Transformational Electric Power Research and Development	**5,000**	**5,000**	**0**	**-5,000**	**-100%**

SBIR/STTR:

- FY 2020 Transferred: SBIR $160; STTR $22
- FY 2021 Projected: SBIR $155; STTR $27
- FY 2022 Request: SBIR $0; STTR $0

Supercritical Transformational Electric Power Research and Development
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Supercritical Transformational Electric Power Research and Development: No funding is requested in the FY 2022 Budget.	-5,000
Total, Supercritical Transformational Electric Power Research and Development	**-5,000**

Supercritical Transformational Electric Power Research and Development

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Supercritical Transformational Electric Power Research and Development $5,000,000	**$0**	**-$5,000,000**
• Through engagement with national laboratories and industry partners, develop test capabilities and validate grid compatible sCO_2 Brayton cycle systems. • Demonstrate power electronics designs to control sCO2 Brayton cycle and reject power to the grid for simple cycle configuration. • Demonstrate dynamic testing of sCO_2 seals and statically tested dry gas lift off seals. • Operate sCO_2 core design for 150+ hours on single set of bearings.	• No funding is being requested.	• No funding is requested in the FY 2022 Request. This technology is sufficiently mature for industry to adopt and further develop.

Reactor Concepts Research, Development and Demonstration

Overview

The Reactor Concepts Research, Development and Demonstration (RD&D) program supports conducting RD&D on existing and advanced reactor designs and technologies to enable industry to address technical and regulatory challenges associated with maintaining the existing fleet of nuclear reactors, promote the development of a robust pipeline of advanced reactor designs and technologies and associated supply chains, and progress these advanced reactor designs and technologies towards demonstration when deemed appropriate. Program activities are focused on addressing technical, economic, safety, and security enhancement challenges associated with the existing commercial light water reactor fleet and advanced reactor technologies, covering large, small, and micro-sized designs and an array of reactor types including fast reactors using liquid metal coolants and high temperature reactors using gas or molten salt coolants.

In maximizing the benefits of nuclear power, work must be done to address the following challenges:

- Improving affordability of nuclear energy technologies;
- Enhancing safety and reducing technical and regulatory risk;
- Minimizing proliferation risks of nuclear materials; and
- Improving the economic outlook for the United States (U.S.) nuclear industry.

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

The Reactor Concepts RD&D program continues to support RD&D efforts focused on SMRs in FY 2022. The Advanced SMR R&D subprogram supports cost-shared R&D activities for the purpose of accelerating the development of U.S. SMR technologies for domestic and international markets, including countries that have expressed interest in near-term SMR deployment. In FY 2022, the program will continue to support funding competitive awards to multiple recipients to encourage domestic SMR technology development and to produce results that are widely applicable across the spectrum of emerging reactor concepts.

The Light Water Reactor Sustainability (LWRS) subprogram conducts research in support of light water reactor (LWR) technologies so that LWR-based commercial nuclear power plants can continue to provide safe, clean, and reliable energy. The goal is to enable industry to enhance the efficient and economic performance of current nuclear power plants while enabling their extended operation. The primary focus of the subprogram is on cost-shared, private-public partnerships to help industry resolve its highest priority and highest uncertainty technical issues where U.S. government partnership is appropriate. Examples of such partnerships are the R&D on methods of control room and plant modernization to address aging and obsolescence of existing analog instrumentation and controls to improve plant efficiency and increasing revenue opportunities through the demonstration of non-electric applications such as hydrogen production.

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

Highlights of the FY 2022 Budget Request

The Reactor Concepts Research, Development & Demonstration (RD&D) program will continue to conduct RD&D activities to address technical, cost, safety, and security enhancement challenges associated with the existing commercial light water reactor fleet and advanced reactor technologies.

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

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Reactor Concepts Research, Development and Demonstration					
Advanced Small Modular Reactor R&D	100,000	115,000	115,000	0	0%
Light Water Reactor Sustainability	47,000	47,000	60,000	+13,000	+28%
Advanced Reactor Technologies	55,000	46,000	65,000	+19,000	+41%
Versatile Advanced Test Reactor R&D	65,000	0	0	0	0%
Total, Reactor Concepts Research, Development and Demonstration	**267,000**	**208,000**	**240,000**	**+32,000**	**+15%**

SBIR/STTR:

- FY 2020 Transferred: SBIR $6,464; STTR $909
- FY 2021 Enacted: SBIR $2,814; STTR $490
- FY 2022 Request: SBIR $4,480; STTR $630

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

	FY 2022 Request vs FY 2021 Enacted
Advanced Small Modular Reactor RD&D: There are no changes to the budget.	**0**
Light Water Reactor Sustainability: The increase from $47,000,000 to $60,000,000 reflects a greater emphasis on cost-shared, industry-led projects to address highest priority technical challenges associated with plant modernization, physical security enhancements, non-electric products, and thermal energy storage activities, and demonstration of non-electric applications.	**+13,000**
Advanced Reactor Technologies: The increase from $46,000,000 to $65,000,000 reflects a greater emphasis on essential research and development activities to address high priority technical challenges and reduce the technical risks associated with advanced reactor technologies and systems.	**+19,000**
Total, Reactor Concepts Research, Development & Demonstration	**+32,000**

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

Description

The Advanced Small Modular Reactor (SMR) Research, Development and Demonstration (RD&D) subprogram supports enabling industry to reverse the downward market trajectory of our nation's nuclear energy sector, reestablish U.S. leadership in the nuclear technology development arena, and meet our nation's climate change and clean energy goals. A range of significant technological challenges remain in developing advanced SMR designs. By continuing this effort in FY 2022, the Department intends to continue to leverage its appropriate federal role and notable expertise to facilitate industry's development and demonstration of advanced SMR designs that have the potential to provide safe, clean, and affordable energy generation options. The Department acknowledges the need to help enable industry's acceleration of innovative reactor designs into the domestic and international markets.

The Advanced SMR RD&D subprogram will support R&D to assist in maturing concepts toward commercial readiness. Results are generally intended to be widely applicable and adopted by domestic nuclear reactor vendors for the purpose of accelerating the development of their technologies. In so doing, the Advanced SMR RD&D subprogram will help address the climate crisis and achieve 100% carbon-free electricity by 2035. Funding will support ongoing and new, competitively-selected awards to multiple recipients, and this subprogram will seek to maximize leveraging of ongoing and planned R&D activities supported by the related Advanced Reactor Technologies subprogram.

The subprogram will support industry and university awards that have high potential to accelerate the development of both emerging and more mature SMR designs.

Advanced Small Modular Reactor RD&D

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Advanced Small Modular Reactor RD&D **$115,000,000**	**$115,000,000**	**0**
• Support targeted research and development (R&D) to further advance small modular reactors (SMR). • Award projects under the Industry Funding Opportunity Announcement (Industry FOA) to support the development of SMRs of various technology types, with an emphasis on innovative reactor component construction techniques that have broad applicability to demonstration of advanced SMR technologies. • Provide funding to support the NuScale SMR design development project that was originally selected competitively.	• Support cost-shared industry partnership awards that have high potential to accelerate the development of both emerging and more mature SMR designs. • Support targeted R&D to further advance SMRs via competitively-selected awards to universities, with an emphasis on supporting historically black colleges and universities (HBCU) and other minority serving institutions (MSI), and institutions in historically disadvantaged communities.	• No increase.

Reactor Concepts Research, Development and Demonstration
Light Water Reactor Sustainability

Description

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

With the initial success of the lead plants' Subsequent License Renewal submittals in FY 2018, the focus for sustaining the existing fleet has shifted from enabling industry's effort to extend their operational licenses to conducting R&D to address technical questions that affect the industry's economic challenges leading to premature shutdowns. LWRS will continue to collaborate with nuclear power plant owner-operators, vendors, suppliers, industry support organizations, other research organizations, and the Nuclear Regulatory Commission (NRC) to closely coordinate research that both supports industry needs and maximizes taxpayer benefit.

Currently, the LWRS subprogram consists of the following primary technical areas of R&D:

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

In FY 2022, the LWRS subprogram continues to leverage cost-shared, private-public partnerships and our national laboratory system to conduct R&D to resolve industry's highest priority and highest uncertainty challenges where U.S. government partnership is appropriate. These high priority areas include providing science and technology-based solutions to improve the current business model and associated practices of the current fleet and develop the scientific bases for managing the aging of SSCs to allow existing nuclear power plants to continue to operate safely and cost-effectively.

Light Water Reactor Sustainability

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Light Water Reactor Sustainability $47,000,000	**$60,000,000**	**+$13,000,000**
• Materials Research – Complete environmental fatigue assessment of stainless steel and dissimilar metal weldments under relevant light water reactor conditions. Continue development of a predictive model for cable degradation. • Risk-Informed Systems Analysis – Complete human-reliability analysis to credit Diverse and Flexible Coping Strategies (FLEX) in accident management and perform risk-informed analysis of a passive-cooling design. Develop the strategy to extend the implementation of fire Probabilistic Risk Assessment (PRA) tools for the existing fleet. • Plant Modernization – Complete development of asset risk models that will be applicable to a variety of existing reactor designs and will be made widely available to the industry to enable adoption of predictive maintenance strategies to replace time-based maintenance activities of plant equipment. Conduct targeted research and development (R&D) on technologies that can enable online monitoring of plant equipment to replace labor-based approaches to equipment condition assessment at commercial nuclear power plants to reduce operating costs and improve equipment availability and reliability. • Flexible Plant Operations and Generation – Working with other applied energy offices, fund competitively selected industry-led projects for grid-integration with hydrogen technologies to enhance the stability of the power grid through	• Materials Research – Complete analysis of the Zion reactor pressure vessel materials, benchmark performance models, and evaluate safety margins. • Risk-Informed Systems Analysis – Complete application for the prediction of component health by creating data-driven reliability models for components. • Plant Modernization – Develop a concept for integrating the instrumentation and controls architecture into a seamless digital environment that enables wide-spread automation and process efficiencies across plant support functions. • Flexible Plant Operations and Generation – Produce an investor-grade report to support the production of zero or net-zero carbon synthetic fuels using hydrogen and CO_2 resources from air, ethanol production or natural gas at an operating nuclear power plant, addressing chemical plant cost, economic, and environmental benefits. • Physical Security – Create guidance using lessons learned during pilot projects for systematically evaluating current physical-security postures with advanced modeling and simulation tools to identify potential cost savings.	• The increase reflects a greater emphasis on cost-shared, industry-led projects to address industry's highest priority challenges in plant modernization upgrades, physical security enhancements, and non-electric applications.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
responsive load and energy storage, in support of H2@Scale. • Physical Security – Develop the technical basis for potential future, industry-funded pilots of remote operated weaponry, increasing the operating fleet's security posture and allowing for the first implementation of automated weapons at an operating commercial nuclear power plant.		

Reactor Concepts Research, Development and Demonstration
Advanced Reactor Technologies

Description

The Advanced Reactor Technologies (ART) subprogram conducts essential research and development (R&D) activities to reduce technical risks associated with advanced reactor technologies and systems. The subprogram R&D scope reflects input from advanced reactor stakeholders with a goal of enabling industry to mature and ultimately demonstrate advanced reactor technologies by the 2030s. Innovative advanced reactor concepts have the potential to offer significant benefits versus existing technologies, including possible lower costs, enhanced safety and security, greater resource utilization, and simpler operating regimes. Such advantages could allow nuclear energy to increase its contributions to United States (U.S.) clean and resilient energy sources and to support the growth of high-paying U.S. jobs. The ART subprogram conducts R&D that can help reduce long-term technical barriers for multiple reactor technology concepts with a focus on innovative technologies. This subprogram will address the full range of high-value research and development to enable advancement of innovative technologies that benefit multiple advanced reactor concepts, including emerging microreactor designs, and stimulation of new ideas for transformational future concepts.

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

Industry-led, innovative cost-shared R&D activities are supported through competitive industry awards to reduce technical and regulatory risks associated with advanced reactor designs. Specifically, in FY2021, DOE announced the selection of three awards to support the development of designs that could have significant impact on the energy market in the mid-2030s or later. The three concepts selected for award were:

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

Advanced Reactor Technologies

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Advanced Reactor Technologies $46,000,000	**$65,000,000**	**+$19,000,000**

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Fast Reactor Technologies – Maintain Mechanisms Engineering Test Loop (METL) facility operational readiness to support industry-identified fast reactor component experiments. Continue in-sodium testing of industry-identified fast reactor component experiments that may yield results that can be useful to multiple reactor developers. Qualify historical fast reactor data sets targeted by U.S. vendors using the Nuclear Regulatory Commission (NRC)-approved Quality Assurance (QA) methodology. Continue the American Society of Mechanical Engineers (ASME) material qualification efforts. Additional activities include: ○ Develop benchmarks to validate U.S. fast reactor code suites. ○ Qualify Grade 91 sodium in support of NRC licensing by fast reactor developers. ○ Support development of hydrogen sensors for near-term sodium fast reactor applications. • Gas Reactor Technologies – Perform experimental validation of normal operation and transient conditions and support modeling and simulation using the water-based reactor cavity cooling system at the Natural Convection Shutdown Heat Removal Test Facility (NSTF) at the Argonne National Laboratory (ANL). Continue American Society of Mechanical Engineers (ASME) code qualification of Alloy 617 and resolve issues necessary to achieve endorsement by Nuclear Regulatory Commission (NRC). • Molten Salt Reactor Technologies – Continue development of chemical monitoring requirements, methods, and instrumentation. Continue modeling framework for salt characterization. Continue to collect and analyze fundamental data to understand fission product behavior in chloride salt-fueled systems. Continue to develop advanced instrumentation for monitoring fissile material inventory. Additional activities include:	• Fast Reactor Technologies – Maintain METL facility operational readiness to support industry identified fast reactor component experiments. Commission Gear Test Article for METL to perform experimental validation under normal and transient conditions. Initiate testing of the Thermal Hydraulic Experiment Test Article in sodium to generate data for fast reactor design and safety code validation. Additional activities include: ○ Close legacy fast reactor database and software QA gaps to support fast reactor licensing activities. ○ Design and test the in-sodium hydrogen sensor and verify its operability. ○ Develop an acoustic flow sensor which can be utilized for measuring flow on larger diameter liquid metal pipes. • Gas Reactor Technologies – Continue experimental validation of normal operation and transient conditions and support modeling and simulation activities. Initiate ASME committee approval process for high temperature alloy to enable more efficient designs by increasing the allowable number of design cycles of gas-cooled reactor components. • Molten Salt Reactor (MSR) Technologies – Provide thermophysical and thermochemical updates to the databases being developed to aid in the design and licensing of Molten Salt Reactors (MSRs). Investigate tritium transport properties and the development of tritium control systems for MSRs. Generate a benchmark based on the Molten Salt Reactor Experiment (MSRE) to serve as a common source for validating software performance and making code-to-code comparisons. • Microreactor Technologies - Continue development of the MARVEL test platform. Additional activities include:	• The increase reflects a greater emphasis on essential research to address the highest priority industry-identified challenges associated with advanced reactor technologies and systems, including a ramp-up in testing at the METL facility, increased research activities to reduce the technical risks associated with MSRs, increased activities to support development of MARVEL, increased support for materials development, and increased efforts for experimentally validating advanced reactor modeling and simulation capabilities.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
○ Validate chemical control strategies for controlled plating techniques and filtering methods. ○ Fabricate replacement parts for a test loop using advanced manufacturing methods as a demonstration for future molten salt reactor component builds. • Microreactor Technologies – Continue nonnuclear testing and validation of high priority components. Begin nonnuclear integrated testing and validation of microreactor systems and operational regimes, e.g., load following, process heat, semi-autonomous operation. Continue advanced dynamic analysis of microreactor concepts to support potential demonstration designs. Continue qualification and irradiation testing of high temperature materials that have the broadest potential application for microreactor applications. Additional activities include: ○ Continue code case development for Grade 91 steel as an improved structural material for microreactors. ○ Complete detailed engineering design to support construction of the Microreactor Applications, Research, Validation and Evaluation (MARVEL) test platform (nuclear microreactor test platform for validating autonomous operation regimes and demonstrating integration of commercial end-user applications). • Cross-Cutting Technologies – Continue cross-cutting research and development for advanced reactor designs. Continue work on printed circuit heat exchangers, intermediate heat exchanger alloys and Brayton cycle plant analysis codes. • Industry Awards – Support innovation and competitiveness of the U.S. nuclear industry through cost-shared research and development. Select U.S. based teams to receive funding through the Advanced Reactor Concepts (ARC)–20 program. Finalize the work-scopes and milestones to be supported	○ Insert prototypical non-nuclear microreactor test article with embedded sensor technology into Microreactor Agile Non-nuclear Experimental Testbed (MAGNET) facility (non-nuclear electrically heated prototypical test bed supporting industry-identified microreactor integrated system validation testing) and complete initial testing to evaluate and validate remote health monitoring regimes under consideration by microreactor developers. ○ Perform power cycling tests in MAGNET to evaluate and validate microreactor load-following capabilities under prototypical operating conditions. ○ Demonstrate a compact heat exchanger for coupling near-term microreactor designs to end-user applications in MAGNET. ○ Complete qualification of legacy metallic fuel data applicable to microreactor core designs. ○ Continue qualification testing of advanced molybdenum alloys, graphite, and other advanced materials being considered for emerging microreactor technologies. • Industry awards - Continue execution of project activities funded through cost-shared awards.	

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
through the ARC-20 program and initiate execution of project activities.		

Fuel Cycle Research and Development

Overview

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

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

The program prioritizes R&D and evaluation of spent fuel and high-level waste disposition pathways, covering storage, transportation, and disposal technologies. The program also supports R&D on multiple advanced fuel technologies that hold promise for reduced risks and improved economics or are an important element in the development of the next generation of reactor designs; exploring the feasibility of reprocessing highly-enriched uranium to produce high-assay, low-enriched uranium (HALEU); and providing fuel to support demonstration of advanced reactor technologies. These activities provide valuable information that will inform industry's decisions on the commercialization and deployment of advanced reactors, including micro reactors.

Highlights of the FY 2022 Budget Request

Initiate a HALEU Availability subprogram to support civilian domestic demonstration and commercial use. This subprogram will work to make available small quantities of HALEU from limited DOE uranium inventories and HALEU production in the short term and will work with the private sector in its design and build out of commercial HALEU production capability in the U.S. in the long term.

Within the Fuel Cycle Core R&D subprogram, a new metallic fuel qualification effort is initiated, building upon recent R&D on accelerated testing and qualification of new fuels to support advanced reactor developers. Also, an innovative process control program is initiated to accelerate fuel preparation and treatment using molten salt technologies.

FY 2021 is the final year of funding for Civil Nuclear Enrichment; as such no additional funding for this subprogram is requested in FY 2022. This initiative will be completed on June 1, 2022.

The Integrated Waste Management System FY 2022 Budget Request is expanded to include working collaboratively with the public, communities, stakeholders, and governments at the tribal, state, and local levels to lay the groundwork for effective implementation of consolidated interim storage for the nation's nuclear waste. In FY 2021 funding for related activities was appropriated within the Interim Storage and Nuclear Waste Fund Oversight program (Nuclear Waste Disposal account).

Fuel Cycle Research and Development
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Fuel Cycle Research and Development					
Material Recovery and Waste Form Development	30,000	25,000	35,000	+10,000	+40%
Mining, Conversion, and Transportation	2,000	2,000	2,000	0	0%
Civil Nuclear Enrichment	40,000	40,000	0	-40,000	-100%
Accident Tolerant Fuels	95,600	105,800	115,000	+9,200	+9%
TRISO Fuel and Graphite Qualification	30,000	36,000	36,000	0	0%
Fuel Cycle Core R&D	20,000	20,000	46,925	+26,925	+135%
High-Assay, Low-Enriched Uranium Availability	0	0	33,075	+33,075	+100%
Used Nuclear Fuel Disposition R&D	62,500	62,500	62,500	0	0%
Integrated Waste Management System	25,000	18,000	38,000	+20,000	+111%
Total, Fuel Cycle Research and Development	**305,100**	**309,300**	**368,500**	**+59,200**	**+19%**

SBIR/STTR:

- FY 2020 Enacted: SBIR $7,683; STTR $1,080
- FY 2021 Request: SBIR $7,034; STTR $1,224
- FY 2022 Request: SBIR $8,115; STTR $1,141

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

	FY 2022 Request vs FY 2021 Enacted
Material Recovery and Waste Form Development: Funding increased from $25,000 to $35,000 reflects increased staffing needs and facility operation costs associated with accelerating Experimental Breeder Reactor-II (EBR-II) activities from 7 days/week, 12 hours/day to 7 days/week, 24 hours/day and the establishment of a new polishing process for the hybrid ZIRCEX activity.	**+10,000**
Civil Nuclear Enrichment Funding decrease from $40,000 to $0 reflects that FY 2021 is the final year of funding for this initiative and the effort will be completed on June 1, 2022.	**-40,000**
Accident Tolerant Fuels: Funding increase from $105,800 to $115,000 reflects the expansion of test capabilities at Idaho National Laboratory and increased R&D by the fuel vendors to support their near-term ATF concepts with higher burnup and enrichment.	**+9,200**
Fuel Cycle Core R&D: Funding increase from $20,000 to $46,925 reflects the initiation of a metallic fuel qualification program that supports advanced reactor developers using metallic fuel and continuing advances in accelerated fuel qualification for advanced reactor fuel. The increase reflects the initiation of an innovative process control program to accelerate the fuel preparation and treatment using molten salt technologies as well as investment in molten salt fuels development capabilities at the national laboratories that are critical for molten salt reactor development.	**+26,925**
High-Assay, Low-Enriched Uranium Availability Funding increase from $0 to $33,075 to initiate a HALEU availability program to make available small quantities of HALEU from limited DOE uranium inventories and HALEU production in the short term and support the private sector in its design and build out of commercial HALEU production capability in the U.S. in the long term.	**+33,075**
Integrated Waste Management System Funding increase from $18,000 to $38,000 working collaboratively with the public, communities, stakeholders, and governments at the tribal, state, and local levels to lay the groundwork for effective implementation of consolidated interim storage for the nation's nuclear waste.	**+20,000**
Total, Fuel Cycle R&D	**+59,200**

Fuel Cycle Research and Development
Material Recovery and Waste Form Development

Description

The Material Recovery and Waste Form Development (MRWFD) subprogram conducts applied research and development on advanced fuel cycle technologies that have the potential to improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk. The subprogram focuses on developing advanced fuel cycle technologies and addressing fundamental materials separation and recovery challenges that present significant degrees of technical risks and uncertainties making them unlikely for the private sector to invest.

MRWFD subprogram evaluates the feasibility of different technologies providing a limited supply of high-assay low enriched uranium (HALEU) to support fuel-fabrication research and development (R&D) needs for potential future demonstration of advanced reactor concepts. HALEU can be recovered from feedstock that contains highly-enriched uranium (HEU) by using the molten salt and hybrid ZIRCEX processes. A ¼-scale ZIRCEX pilot facility, using unirradiated materials (cold tests), was built at the Idaho National Laboratory to evaluate the feasibility of using recycled HEU fuel for HALEU production and evaluate this technology as a used fuel recycling head end de-cladding alternative. In FY22, the hybrid ZIRCEX activity will expand technical capabilities to establish a new back-end polishing process. This process is also capable of treating HALEU materials obtained from the Experimental Breeder Reactor-II (EBR-II) fuels treatment.

MRWFD applies the unique expertise and technical capabilities to a broad range of applications such as a fundamental understanding of various chemical challenges related to civil nuclear applications. It funds molten salt chemistry research to support advanced nuclear technologies using molten salts as electrolytes, fuel solvent and coolants. It also funds research on integrated advanced technologies encompassing R&D on off gas capture, waste form development. The subprogram employs a science-based approach to foster innovative and transformational technology solutions to achieve this objective.

Key subprogram activities in FY22 include:

1. Supporting the accelerated treatment of irradiated EBR-II fuel to produce limited quantity of HALEU materials for advanced reactor fuels fabrication and testing. In anticipation of expanding the runtime in FY 2024 from 7 days a week, 12 hours a day to 7 days a week, 24 hrs a day, activities will start in FY22 for training of qualified workers for hot cell and facility operations;
2. Developing advanced fuel cycle technologies targeting high-value used fuels (e.g., containing HEU and/or HALEU); and,
3. Supporting fundamental nuclear fuel cycle aqueous process chemistry and molten salt chemistry to develop innovative recycling technologies and maintain critical R&D core competencies in addressing various chemical challenges related to civil nuclear applications.

Material Recovery and Waste Form Development
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Material Recovery and Waste Form Development **$25,000,000**	**$35,000,000**	**+$10,000,000**
• Continued the acceleration of Experimental Breeder Reactor-II (EBR-II) used fuel treatment. • Continued Joint Fuel Cycle Study (JFCS) for its 10th and final year of collaboration with South Korea. • Continued hybrid ZIRCEX process focusing on cold pilot plant studies. • Supported fundamental aqueous and molten salt separation chemistries to address chemical challenges related to civil nuclear energy applications. • Explored next generation fuel cycle technologies targeting high-value used fuels.	• Continue the acceleration of EBR-II used fuel treatment and fund the increased staffing and facility operations costs associated with an anticipated expansion of fuel treatment operations from 7 days a week, 12 hours a day to 7 days a week, 24 hours a day in FY22. • Continue hybrid ZIRCEX process focusing on cold pilot plant studies and uranium polishing process. • Develop next generation fuel cycle technologies targeting high-value used fuels. • Support fundamental aqueous and molten salt separation chemistries to address chemical challenges related to civil nuclear energy applications.	• The increase reflects the increased staffing and facilities costs associated with the anticipated expansion of EBR-II fuel treatment facility operation from 7 X 12 to 7 X 24 mode in FY24. • The increase reflects efforts needed to establish a new polishing process for the hybrid ZIRCEX activity.

Fuel Cycle Research and Development
Mining, Conversion, and Transportation

Description

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

In FY 2021, DOE released a public funding opportunity announcement (FOA) to request proposals for R&D that reduces water usage and/or improves the extraction efficiency associated with uranium production. DOE anticipates making one or two awards under this FOA in FY 2021. Mining sites are often located in underserved communities and locations with limited water resources. Improvements to mining technology spurred by R&D may enable local economic opportunities and include environmental justice equities while reducing the amount of water used during uranium production.

In FY 2022, this subprogram will continue to fund cost-shared R&D for uranium mining and processing technologies that reduce water usage and/or improve extraction efficiency and resource utilization for uranium production.

Mining, Conversion, and Transportation
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Mining, Conversion, and Transportation $2,000,000	**$2,000,000**	**$0**
• Supported research and Development (R&D) for uranium mining and processing technologies that reduce water usage and/or improve extraction efficiency and resource utilization for uranium production.	• Continue R&D for uranium mining and processing technologies that reduce water usage and/or improve extraction efficiency and resource utilization for uranium production.	• No funding change.

Fuel Cycle Research and Development
Civil Nuclear Enrichment

Description

This subprogram executes a three-year, limited scope, demonstration of a U.S. origin, enrichment technology for producing high-assay, low enriched uranium (HALEU). FY 2021 is the final year of funding for this initiative and the demonstration will conclude on June 1, 2022.

Natural uranium consists almost exclusively of two types of uranium isotopes, mostly uranium-238 (99.3 percent) and a smaller fraction (0.7 percent) of the fissionable isotope uranium-235 (U-235). Many advanced reactor concepts are anticipated to require HALEU, which contains a uranium concentrated or enriched to levels between 5 and 20% in the U-235 isotope. Currently, there is no enrichment facility in the United States (U.S.) to produce HALEU for industry's advanced reactor demonstration and deployment.

In FY 2021, the Civil Nuclear Enrichment subprogram will complete cascade design work, install support equipment such as the inventory withdrawal station, restore the Piketon facility for handling classified material/information, install centrifuge machinery, condition the system for operation, calibrate operations and operate a cost-shared lead cascade of centrifuges with the goal to produce domestic HALEU in FY 2022. The Federal Government's cumulative cost share contribution over this three-year project, will not exceed $115 million. The lead cascade will include only a small number of centrifuges for demonstration purposes only. Work under this subprogram will take place during three years: May 31, 2019, to June 1, 2022. Early production of HALEU will permit vendors to ensure that reactor developers will have sufficient time to test new advanced fuels containing HALEU prior to seeking qualification of these fuels from the U.S. Nuclear Regulatory Commission. Data from this effort is shared with the National Nuclear Security Administration's Domestic Uranium Enrichment program, which is exploring options to meet certain long-term Departmental uranium needs.

The HALEU enrichment demonstration program is incurring additional costs due to the COVID pandemic, on the order of $2-3 million. Funding for these additional costs is requested in the HALEU Availability subprogram as that new subprogram support is focused on HALEU-related activities and funding for this Civil Nuclear Enrichment subprogram ended in FY 2021. State COVID related work restrictions initially led to unanticipated costs. In addition, suppliers have been unable to deliver equipment and materials causing alternative suppliers to be sought resulting in additional hours for contract activities, redesign, and additional nuclear criticality safety analyses. Additional activities included onsite health screenings and thorough industrial hygiene measures.

In FY22 the HALEU Availability subprogram will investigate options for working with industry to provide the quantities of HALEU needed to support the research, development, demonstration and commercial use from a variety of sources. In order to maintain a full suite of possible options and assist in enabling the availability of HALEU for near-term needs, this includes continuing to support the 16 centrifuges in Piketon.

Civil Nuclear Enrichment
Funding

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Civil Nuclear Enrichment $40,000,000	**$0**	**-$40,000,000**
• Completed cascade design work, install support equipment such as the inventory withdrawal station, restore the Piketon, OH facility for handling classified material/information, install centrifuge machinery, condition the system for operation, calibrate operations and operate a lead cascade of centrifuges. • Continued regulatory support related to demonstrating the production of high-assay, low-enriched uranium. • Produced material in the demonstration will be withdrawn in FY 2022 using funding from FY 2021.	• FY 2021 is the final year of funding for this initiative and the effort will be completed on June 1, 2022.	• FY 2021 is the final year of funding for this initiative and the effort will be completed on June 1, 2022.

Fuel Cycle Research and Development
Accident Tolerant Fuels

Description

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

Following the accident at Fukushima, Advanced Fuels initiated a program to explore advanced LWR fuel with enhanced accident tolerance to benefit existing U.S. commercial nuclear power reactors. After five years of feasibility studies and assessments of potential fuel concepts, the program identified promising concepts that have the potential to significantly enhance accident tolerance.

The U.S. fuel suppliers are developing accident tolerant fuel concepts that the owner/operators of commercial U.S. reactors believe will provide substantial performance improvements during accidents and under normal operations. The greatest improvements will come with using the robust nature of the accident tolerant fuel to enable the fuel to operate for a longer period of time in the reactor. This would allow reactors to operate for a longer time between refueling outages. Many reactors would be able to increase their cycle lengths from 18 to 24 months and less fuel would be needed to generate the same amount of electricity resulting in substantially reduced spent nuclear fuel storage and disposal requirements.

This subprogram supports the industry's objective to install the first reload quantities of accident tolerant fuel in pilot plants by the mid-2020s and qualify the fuel for use at higher burnup levels. In FY22 this will involve cost-shared testing and examination of fuel and cladding material performance to generate data that can be used by industry partners to support their NRC licensing efforts, research and development of pilot fuel pellet and cladding manufacturing equipment, analysis and redesign of fuel fabrication processes, and revising fuel performance codes and methods.

This subprogram is using the experimental and analytical capabilities only found at the Department of Energy (DOE) National laboratories to provide the U.S. nuclear industry with the data needed to qualify the accident tolerant fuel concepts for use at higher burn up levels and to demonstrate the performance of the fuel to take advantage of the safety and economic benefits that come with these more robust fuel designs. In FY 2022, this includes continuing the modifications at Idaho National Laboratory to expand its experimental capabilities. This involves: (1) the design, fabrication, and testing of experimental capsules to house irradiated fuel samples to simulate loss of coolant accident conditions in the transient test reactor (TREAT) and (2) the design and installation of a new test loop in the Advanced Test Reactor (ATR) to provide experimental capabilities lost from the Halden test reactor in Norway. These capabilities are boiling water reactor conditions, highly-instrumented test trains, ramp testing, and dry out testing. Also, in FY 2022, the partnership with industry to implement the test plans needed to develop the data needed to qualify the Accident Tolerant Fuel concepts for higher burn up will continue.

Several years ago, all three U.S. fuel suppliers (Framatome, General Electric and Westinghouse), the U.S. Nuclear Regulatory Commission, and the DOE National laboratories were conducting experiments in the Halden test reactor in Norway. The Norwegian Government shut down that reactor and the world's fuel development community lost a critical experimental capability to study fuel performance. The Department acted quickly to restore the lost capabilities at the Idaho National Laboratory. These include fuel rod re-fabrication and re-instrumentation, reliable in-reactor instrumentation, and irradiation testing capabilities for boiling water reactor conditions, ramp testing, and test to fuel failure.

Accident Tolerant Fuels
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Accident Tolerant Fuels $105,800,000	**$115,000,000**	**+$9,200,000**
• Continued irradiations of fuel rodlets in the central water loop of the Advanced Test Reactor (ATR). • In the Transient Reactor Test Facility (TREAT), performed reactivity insertion accident tests on irradiated fuel in static water capsules. • Continued investment in fuel development capabilities at the Department of Energy (DOE) National laboratories that are critical for accident tolerant fuel development. • Continued to advance the accident tolerant fuel concepts under development by the three fuel vendor teams under cooperative agreements with the Department.	• Continue irradiations of fuel rodlets in the central water loop of the ATR. • Continue investment in fuel development capabilities at the national laboratories that are critical for accident tolerant fuel development. • Fabricate and install equipment at ATR to expand the test capabilities. • Continue in partnership with industry to support the Fuel Performance and Testing Technical Experts Group for burn up extension. This includes Minifuel irradiations in High Flux Isotope Reactor (HFIR), re-irradiation of test samples in ATR, and loss of coolant tests in TREAT. • Continue to advance the accident tolerant fuel concepts under development by the three fuel vendor teams under cooperative agreements with the Department. This involves cost-shared testing and examination of fuel and cladding material performance, research and development of pilot fuel pellet and cladding manufacturing equipment, analysis and redesign of fuel fabrication processes, and revising fuel performance codes and methods.	• The increase reflects the expansion of test capabilities at Idaho National Laboratory and increased R&D by the fuel vendors to support their near-term Accident Tolerant Fuel concepts with higher burnup and enrichment.

Fuel Cycle Research and Development
TRISO Fuel and Graphite Qualification

Description

The Tristructural-isotropic (TRISO)-coated particle fuel and graphite subprogram includes activities for fuel and material irradiation, post-irradiation examination (PIE) and safety testing, fuel performance modeling, and fission product transport and source term research.

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

The graphite development and qualification efforts provide data to support the use of graphite in high temperature reactor environments. Since historical grades of graphite used in previous high temperature reactors are no longer available, graphite development includes efforts to characterize and irradiate new grades of graphite. These efforts provide non-irradiated and irradiated properties so that the thermomechanical design of the structural graphite in advanced high temperature reactors can be validated. The irradiation experiments span the proposed temperature and dose envelope for a prismatic high temperature gas reactor and is also applicable to pebble-bed and possibly molten salt-cooled high temperature reactors.

TRISO Fuel and Graphite Qualification
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
TRISO Fuel and Graphite Qualification $36,000,000	**$36,000,000**	**$0**
• Began post-irradiation examination (PIE) of the Advanced Gas Reactor (AGR)-5/6/7 Tristructural-isotropic (TRISO) fuel experiments at the Idaho National Laboratory (INL) and Oak Ridge National Laboratory (ORNL). • Performed safety testing of TRISO fuel in elevated temperatures. • Continued PIE efforts on irradiated TRISO fuel from AGR 3/4 experiments. • Began High Dose Graphite (HDG)-1 experiment irradiation in INL's Advanced Test Reactor (ATR). • Continued characterization and PIE of graphite specimens. • Began PIE of graphite specimens from the Advanced Graphite Creep (AGC)-4 experiment. • Continued to pursue addition of graphite to the American Society of Mechanical Engineers (ASME) code for use in high temperature reactors. • Supported development of a second TRISO fuel fabrication facility to enable transition to a multiple-producer TRISO fuel market and ensure that more than one industry source will be available to potential commercial and government markets.	• Continue PIE of the AGR-3/4 and AGR-5/6/7 TRISO fuel experiments. • Complete AGR 5/6/7 Disassembly and Metrology Report. • Continue safety testing of TRISO fuel in elevated temperatures. • Commission the air and moisture ingress furnace to understand TRISO fuel performance in a transient scenario resulting in air or moisture ingress. • Continue high dose graphite experiment irradiation in INL's ATR. • Continue characterization and PIE of graphite specimens. • Continue to pursue addition of graphite to the American Society of Mechanical Engineers (ASME) code for use in high temperature reactors.	• Funds will continue to support TRISO fuel and graphite qualification for use in high temperature gas reactors until PIE and data collection is completed..

Fuel Cycle Research and Development
Fuel Cycle Core R&D

Description

This subprogram supports innovative research activities that advance the knowledge base for nuclear fuel cycles and provide transformative changes to accelerate development of civil nuclear technologies, including consideration of fuel cycle impacts from the potential deployment of advanced reactor technologies. It also includes activities in Materials Protection, Accounting and Control Technology (MPACT), Systems Analysis and Integration (SAI), innovative fuel cycle process control capabilities and advanced reactor fuels research and development (R&D).

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

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

Innovative fuel cycle process controls include the development of advanced on-line real-time monitoring technologies to enhance process controllability and to enable predictive modeling capability of separation systems.

Advanced reactor fuels activities include continued advances in accelerated fuel qualification activities to support advanced reactor development. Conventional fuel qualification takes more than 20 years and costs hundreds of millions of dollars. Recent advances in modeling, examination and analysis techniques, irradiation testing techniques, and even artificial intelligence and machine learning can significantly reduce the time and expense of fuel qualification. In FY 2022 we propose to build upon the advanced irradiation testing techniques recently developed at the national labs. Those techniques are the Fission Accelerated Steady-State Testing (FAST) approach at INL and MiniFuel separate effects testing at ORNL. Both techniques allow for much shorter irradiation times to gather meaningful data on fuel performance. Also, in FY 2022 we propose to initiate a metallic fuel qualification program that supports advanced reactor developers using metallic fuel. Many advanced reactor developers are proposing metallic fuel for their reactors. Metallic fuel is a mature and may become a key strategic U.S. developed and owned technology. This program would establish a reference fuel performance baseline using legacy data and analyses, improve performance modeling capability in the BISON fuel performance code, and prepare for transient experiments in Transient Reactor Test Facility (TREAT) on legacy Experimental Breeder Reactor-II (EBR-II) reactor fuel.

Fuel Cycle Core Research & Development
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Fuel Cycle R&D $20,000,000	**$46,925,000**	**+$26,925,000**
• Continued the development of innovative technologies, analysis tools, and advanced integration methods for aqueous and molten salt separation process controls and nuclear materials management, and other limited fuel cycle research and development activities. • Developed innovative on-line process monitoring capabilities for advanced reactors fuel recycling. • Developed advanced solvent extractants and complexation agents to improve the separation processes controllability. • Developed and maintained leading-edge analysis capabilities to ensure world-class analysis of complete nuclear energy systems. • Performed scenario analysis studies of fuel cycle facilities for promising advanced reactor technologies. • Supported advanced reactor developers with innovative fuel irradiation experiments that accelerate the qualification of fuel for their reactor concepts. • Collaborated with Japan on transient testing of advanced fuel concepts.	• Continue lab research efforts to develop and demonstrate innovative technologies, analysis tools, and advanced integration methods for advanced material control and accounting applications. • Develop predictive process control modeling capability to enable tailoring of aqueous and molten salt separation systems. • Continue innovative on-line process monitoring capabilities for advanced reactors fuel recycling. • Continue to conduct performance assessments and economic and market analyses of promising advanced nuclear energy systems. • Continue experiments in the Advanced Test Reactor using the Fission Accelerated Steady-State Testing (FAST) approach. This irradiates a large number of miniature fuel rods for short time periods. • Continue experiments in the High Flux Isotope Reactor using MiniFuel separate effects testing. This irradiates BB-sized spherical fuel samples in high capacity cartridge holders for short time periods. • Continue transient testing of advanced fuel concepts with Japan. • Initiate a metallic fuel qualification program that supports advanced reactor developers using metallic fuel. This includes establishing a reference fuel baseline, improving performance modeling capability, and preparing for future transient experiments. • Initiate molten salt fuels development capabilities	• The increase reflects the initiation of a metallic fuel qualification program that supports advanced reactor developers using metallic fuel and continuing advances in accelerated fuel qualification for advanced reactor fuel. • The increase reflects the initiation of an innovative process control program to accelerate the fuel preparation and treatment using molten salt technologies. • The increase reflects investment in molten salt fuels development capabilities at the national laboratories that are critical for molten salt reactor development.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	at the national laboratories that are critical for molten salt reactor development.	

Fuel Cycle Research and Development
High Assay, Low-Enriched Uranium Availability

Description

Advanced reactors are being developed for flexible baseload power generation, providing U.S. leadership in nuclear technology, enabling new markets for export, and reducing greenhouse gas emissions. Many of these reactors are expected to require high-assay, low-enriched uranium (HALEU) fuel. HALEU is uranium with the fissionable isotope U-235 enriched to between greater than 5 and less than 20 percent. Current commercial light water reactors use uranium enriched to up to 5 percent U-235. There are no commercial suppliers of HALEU in the U.S. and advanced reactor developers will need small quantities of HALEU in the near term to support the qualification of their fuel for use and larger quantities for the first demonstration reactors. Much larger quantities of HALEU would be needed to if advanced reactors requiring HALEU fuel are commercialized. The Energy Policy Act of 2020 authorized DOE to begin working to address HALEU availability issues.[1]

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

In FY 2021, the Department will issue a request for information (RFI) that will inform the Department of the activities that should be initiated in FY 2022. The RFI may request information regarding: the establishment of a HALEU consortium, technical and regulatory barriers to licensing fuel cycle facilities, cost-sharing approaches or contracting vehicles, transportation capabilities, conversion capabilities, market-related barriers, financing, human resources, and/or other topics.

In FY 2022, subprogram activities would include activities to initiate the recovery and down-blending of limited excess quantities of DOE uranium inventories to HALEU: continue to staff and operate the HALEU enrichment demonstration facility in a cost share agreement with industry, ; take action to support industry in the transportation of HALEU; and work with industry on critical aspects of commercializing a long-term HALEU supply. To meet the long-term needs of stakeholders and federal partners, the FY 2021 RFI will inform the Department on further licensing and construction efforts to demonstrate production of HALEU.

The HALEU enrichment demonstration program is incurring additional costs due to the COVID pandemic, on the order of $2-3 million. Funding for these additional costs are requested in this HALEU Availability subprogram as this is a new subprogram supports HALEU-related activities and funding for the Civil Nuclear Enrichment subprogram ended in FY 2021. State COVID related work restrictions initially led to unanticipated costs. In addition, suppliers have been unable to deliver equipment and materials causing alternative suppliers to be sought resulting in additional hours for contract activities, redesign and additional nuclear criticality safety analyses. Additional activities included onsite health screenings and thorough industrial hygiene measures.

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1 The Energy Act of 2020 authorized a HALEU availability program, which authorized the Department perform activities regarding developing criticality benchmark data, supporting design and licensing of transportation packages, considering options for acquiring or providing HALEU to advanced reactor developers, surveying stakeholders, and establishing a HALEU consortium. The Act also directs DOE to be prepared to supply HALEU to commercial industry by January 1, 2026 and requires DOE to develop an associated cost recovery process.

High-Assay, Low-Enriched Uranium Availability
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
HALEU for R&D $0	**$33,075,000**	**+$33,075,000**
• Funding was not provided in FY 2021.	• Work with the National Nuclear Security Administration on the recovery and down-blending of limited quantities of highly enriched uranium to high-assay, low-enriched uranium (HALEU). • Continue to operate the 16-centrifuge cascade in Piketon to provide a limited amount of HALEU while working on efforts to commercialize the technology. • Develop criticality benchmark data to support the design and licensing of transportation packages. • Acquire transportation packages for Department of Energy-owned HALEU. • Work in partnership with industry to understand and help enable commercialization of long-term private-sector HALEU production. • Provide additional support to HALEU enrichment demonstration contractor for impacts related to COVID, such as supplier issues and contractual impacts.	• Initiate a HALEU availability program as authorized by the Energy Act of 2020 in order to support the private sector in developing advanced reactors that use HALEU fuel.

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

Description

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

Research and Development

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

Storage and Transportation R&D – In addition to the Full-Scale Storage Cask project, DOE will continue to support other lab testing, field studies, and modeling R&D related to the storage and transport of high-burnup fuel to include: testing of cladding response with hydride reorientation and embrittlement; the effects of atmospheric corrosion on storage welds; measuring the embrittlement of elastomer seals; determining thermomechanical degradation of bolts, welds, seals and poisons; analyzing thermal profiles of stored fuels; determining the stress profiles of fuels and casks; evaluating cask drying processes; laboratory post-irradiation examination and testing of the fuel from the cask demonstration project at the North Anna Generating Station in Mineral, Virginia; and the development of sensors for internal and external cask monitoring. R&D will focus on contributing to the technical knowledge to support long-term storage and eventual transportation of high-burn-up fuels. As the DOE continues to make progress on the accident tolerant fuels, research will be done to ensure that data are gathered on the new/modified cladding and fuel materials to ensure that they can be stored and transported in the future. Current work also indicates that burnup rates for accident tolerant fuels could go up to 75 to 80 GWD/MTU for which very little if any data exists, so additional R&D will be done to address this gap

Disposal R&D – Activities continue to further the understanding of long-term performance of disposal systems in three main geologic rock types: clay/shale, salt, and crystalline rock. These activities include collaborations with international partners to leverage and integrate applicable R&D being conducted by other countries into the U.S. disposal R&D portfolio. Also, evaluations will continue to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository.

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

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Used Nuclear Fuel Disposition Research & Development $62,500,000	**$62,500,000**	**$0**
• Completed non-destructive testing and continue destructive testing of fuel rods that were pulled from a commercial power station to establish the performance baseline of the stored used fuel. • Characterized external loadings on fuel rods during normal conditions of transport. • Developed an understanding of material degradation phenomena in safety components associated with long term storage and transportation systems. This work will support licensing applications for extended dry storage and subsequent retrieval and transport of high burnup used nuclear fuel. • Evaluated integration and implementation methodologies of process-level models with performance assessment tools relating to argillite and crystalline media disposal. Integrate developed modeling tools with analysis software for uncertainty quantification and sensitivity analysis. • Continued science and engineering technical basis for the disposal of heat generating waste in salt. • Continued research and development (R&D) activities associated with exploring potential disposal options for various waste and spent nuclear fuel forms, including collaboration with international partners to leverage R&D being conducted in various geologic media.	• Continue destructive testing on the 25 spent nuclear fuel rods that will be used to determine the performance baseline at the time of loading. • Test and evaluate the storage, transportation and disposal performance characteristics of the new accident tolerant fuels. • Evaluate the use of coatings such as metal cold spray, epoxy paints, polymer-based coatings and other methods to primarily prevent and possibly remediate stainless-steel corrosion of storage canisters. • Continue to monitor, measure and evaluate the data gathered from the High Burnup Nuclear Fuel Demonstration Project at North Anna Generating Station. • Continue the development of remote self-powered miniature sensors that can be placed inside a canister to monitor and measure: pressure, temperature, oxygen, hydrogen and moisture to determine the internal canister health. • Characterize high priority activities associated with the external loadings on fuel rods during normal conditions of transport. • Work with San Onofre Nuclear Generating Station (SONGS) in California, to implement full scale testing of salt deposition and corrosion of stainless-steel canisters.	• No Funding Change.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Issued evaluation of the technical feasibility of direct disposal of dual-purpose canisters to potentially eliminate the need for repackaging these canisters for disposal. • Begin testing and evaluation of the storage, transportation and disposal performance characteristics of the new accident tolerant fuels.	• Continue high-priority R&D activities associated with exploring potential disposal options for various waste and spent nuclear fuel forms, including collaboration with international partners to leverage R&D being conducted in various geologic media. • Continue evaluation of the technical feasibility of direct disposal of dual-purpose canisters to potentially eliminate the need for repackaging these canisters for disposal. • Continue science and engineering technical basis for the disposal of heat generating waste in salt, including in-situ testing at the Waste Isolation Pilot Project in New Mexico.	

Fuel Cycle Research and Development
Integrated Waste Management System

Description

The Nuclear Waste Policy Act of 1982 (NWPA) assigns the Department of Energy (DOE) the responsibility for disposition of the United States' (U.S.) spent nuclear fuel and high-level radioactive waste, and the Department remains committed to fulfilling the Federal Government's legal obligations to properly manage and dispose of that material. The Integrated Waste Management System subprogram supports efforts develop and implement a consent-based interim storage program as part of an overarching waste management system, as well as storage, transportation, and system development and analysis activities. The actions of this subprogram include working with communities, stakeholders, and governmental entities where spent nuclear fuel and high-level radioactive waste is currently stored at numerous sites in nearly 40 states across the nation.

The Integrated Waste Management System subprogram's FY 2022 Budget Request funds critical, foundational planning and development actions required to lay the groundwork for effective implementation of consolidated interim storage of the nation's nuclear waste. As part of its efforts, the Department will work collaboratively with the public, communities, stakeholders, and governments at the tribal, state, and local levels. The Department will support a consent- based siting approach working with potential host communities. These activities include:

- Issuing a Request for Information that will focus on factors to be considered for the implementation of a consent-based process for siting a federal interim storage facility,
- Soliciting feedback from stakeholders, including but not limited to congressional, state, and local delegations, organizations, officials, communities, and tribal nations,
- Engaging with stakeholders who were engaged during the previous consent-based siting initiative to determine whether their stances have changed and allow them the opportunity to discuss any additional considerations,
- Developing a waste management system that incorporates social equity and environmental justice,
- Evaluating the costs and benefits of federal and private interim storage facility approaches,
- Developing preliminary design concepts,
- Analyzing regulatory environment considerations for various designs and locations,
- Analyzing and updating critical data on identifying quantities of and collecting detailed information on relevant nuclear waste inventories to inform options analyses and transportation planning,
- Continuing efforts to establish system capabilities and infrastructure needs for large scale transportation.

As part of the subprogram, storage facility design options and operations are explored and evaluated including investigation into methods to mitigate the possibility of stress corrosion cracking and advanced manufacturing techniques for spent fuel containers. Evaluations of storage system design alternatives conducted in this subprogram inform an understanding which helps to guide future approaches and the development of system interface requirements.

Preparations for large-scale transportation of spent nuclear fuel and high-level radioactive waste include development of purpose-built railcar equipment, assessment of transportation infrastructure and transport options at nuclear power plant sites, employing state-of-the-science data and software tools to support decision-making and communications, thorough analysis of the future transportation system elements and dependencies, active engagement with State and Tribal government representatives through Department of Energy's (DOE) National Transportation Stakeholders Forum and associated working groups, and coordination with appropriate federal agencies on safety and security considerations. These efforts build on successes and lessons learned from prior DOE radioactive materials transportation programs and campaigns as identified through knowledge management activities.

Waste management system analysis capabilities will be maintained and enhanced as part of the IWMS subprogram. These analytical tools and database systems provide the ability to model various system architectures and configurations including options involving interim storage of spent nuclear fuel. Using these models and analytical tools, different system scenarios can be evaluated and the effect of varying input assumptions examined including facility receipt rate and capacities. Other analytical tools provide the capability to explore spent fuel storage, transport and disposal considerations. In FY 2022, these waste management system tools will be used to conduct analyses using the latest nuclear fuel data survey results from the Energy Information Administration (EIA). IWMS subprogram funding also supports streamlining integration of future EIA data with Office of Nuclear Energy waste management system analysis tools via a web-based application under development for which pilot testing is planned in FY 2022.

Integrated Waste Management System
Funding

Activities and Explanation of Changes

<table>
<tr><th>FY 2021 Enacted</th><th>FY 2022 Request</th><th>Explanation of Changes
FY 2021 Request vs FY 2020 Enacted</th></tr>
<tr><td>Integrated Waste Management System $18,000,000</td><td>$38,000,000</td><td>+$20,000,000</td></tr>
<tr><td>• Pursued possible storage approaches and solutions using advanced methods and techniques.
• Continue development of computational systems analysis tools to support facility licensing analyses and operational planning.
• Issued an updated report on evaluations of transportation infrastructure at nuclear power plant sites.
• Maintained spent nuclear fuel inventory data and system analysis modeling tools by importing latest spent fuel survey data and incorporating enhancements into software.
• Supported development of a prototype web-based application which can streamline future collection, processing, and analysis of spent nuclear fuel data from U.S. nuclear power plants.
• Continued testing and demonstration of the Atlas railcar consist.
• Received approval for the Fortis railcar design and began procurement for a prototype Fortis railcar.</td><td>• Developing the elements of a consent-based siting process by working with State, Tribal and local governments and other affected federal agencies to understand and consider concerns, challenges, options, and opportunities,
• Evaluating the costs and benefits of federal and private interim storage facility approaches,
• Developing preliminary design concepts,
• Analyzing regulatory environment considerations for various designs and locations,
• Analyzing and updating critical data on identifying quantities of and collecting detailed information on relevant nuclear waste inventories to inform options analyses and transportation planning,
• Continuing efforts to establish system capabilities and infrastructure need for large scale transportation.
• Continue to develop possible storage approaches and solutions which take advantage of recent advances in technologies.
• Continue development of computational systems analysis tools to support facility licensing analyses and operational planning.
• Evaluate transportation infrastructure at two or more nuclear power plant sites.
• Conduct integrated waste management system analyses using the latest imported spent nuclear fuel dataset to support the evaluation of options which include interim storage.</td><td>• Funding increase supports additional work-scope on interim storage-related activities.</td></tr>
</table>

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2021 Request vs FY 2020 Enacted
	• Support preparing the advanced web-based application tool for pilot testing prior to potential future use in U.S. nuclear fuel data surveys. • Continue testing and demonstration of the Atlas railcar consist, including one Atlas cask railcar, two buffer railcars, and one Rail Escort Vehicle. • Begin the design and fabrication of the Integrated Security and Safety Monitoring System, which will be necessary for any large-scale program of rail transportation. This system will be integrated into and monitored by the existing DOE Transportation Tracking and Communications System.	

Nuclear Energy Enabling Technologies

Overview

The Nuclear Energy Enabling Technologies (NEET) program conducts research and development (R&D) and makes strategic investments in research capabilities to develop innovative and crosscutting nuclear energy technologies to resolve nuclear technology development issues. The Crosscutting Technology Development (CTD) subprogram focuses on innovative research that directly supports the existing fleet of nuclear reactors and enables the development of advanced reactors and fuel cycle technologies, including topical areas such as advanced sensors and instrumentation; nuclear cybersecurity; innovative materials and manufacturing technologies; and integrated energy systems. Also, NEET invests in modeling and simulation tools for existing and advanced reactors and fuel system technologies. The program also provides industry, universities, and national laboratories with access to unique nuclear energy research capabilities through the Nuclear Science User Facilities (NSUF) subprogram. Collectively, NEET-sponsored activities support the Department's priorities to combat the climate crisis, create clean energy jobs with the free and fair chance to join a union and bargain collectively, and promote equity and environmental justice by delivering innovative clean energy and advanced manufacturing technologies for nuclear energy systems. NEET also makes these technology advancements accessible to the U.S. industry through the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative and private-public partnerships.

Highlights of the FY 2022 Budget Request

Additive manufacturing (AM) and artificial intelligence (AI) research to deliver enabling technologies for advanced reactors, initiated under the Transformational Challenge reactor in FY 2021, as well as the Nuclear Materials Discovery and Qualification initiative and Advanced Methods for Manufacturing topic area will all be incorporated into the CTD Advanced Materials and Manufacturing Technologies (AMMT) program to consolidate all relevant technologies under one program.

The Joint Modeling and Simulation subprogram, implemented as the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program, will continue the development of an initial set of tools for full system modeling capability for fast reactors under steady-state conditions that can support vendor license applications or regulatory reviews.

The NSUF program will include the High Performance Computing (HPC) nuclear energy computation system that provides scientific computing capabilities to NE's R&D programs, universities, industry, national laboratories, and federal agencies to support their research and development efforts

The FY 2022 Budget Request includes $5 million for research that supports Departmental crosscuts in Harsh Environment Materials, Advanced Manufacturing, Advanced Energy Storage, Critical Minerals, and Cybersecurity.

Nuclear Energy Enabling Technologies
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Nuclear Energy Enabling Technologies					
Crosscutting Technology Development	25,000	28,000	47,000	+19,000	+68%
Joint Modeling and Simulation	35,000	35,000	35,000	0	0%
Nuclear Science User Facilities	30,000	30,000	42,000	+12,000	+40%
Transformational Challenge Reactor	23,450	29,869	0	-29,869	-100%
Total, Nuclear Energy Enabling Technologies	**113,450**	**122,869**	**124,000**	**+1,131**	**+1%**

SBIR/STTR:

- FY 2020 Transferred: SBIR $3,631; STTR $511
- FY 2021 Enacted: SBIR $3,758; STTR $654
- FY 2022 Request: SBIR $3,968; STTR $558

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

	FY 2022 Request vs FY 2021 Enacted
Crosscutting Technology Development: The increase from $28,000,000 to $47,000,000 reflects support for the Advanced Materials and Manufacturing Technologies (AMMT) activity, which consolidates efforts from the Nuclear Materials Discovery and Qualification initiative, the crosscutting research previously conducted under the Transformational Challenge Reactor subprogram, and the Advanced Methods for Manufacturing area. This increase also provides support for the Integrated Energy Systems activity and additional support for research and development (R&D) in the areas of advanced sensors and instrumentation and cybersecurity.	**+19,000**
Joint Modeling and Simulation: There are no changes to the budget.	**0**
Nuclear Science User Facilities: The increase from $30,000,000 to $42,000,000 reflects additional support for industry, universities, and national laboratories access to unique nuclear energy research facilities and continued support for Idaho National Laboratory's High Performance Computing capability.	**+12,000**
Transformational Challenge Reactor: The decrease from $29,869,000 to $0 reflects the subprogram's transition to an R&D effort to be managed under the Crosscutting Technology Development (CTD) subprogram with other relevant R&D.	**-29,869**
Total, Nuclear Energy Enabling Technologies	**+1,131**

Crosscutting Technology Development

Description

The Crosscutting Technology Development (CTD) subprogram develops innovative solutions to crosscutting nuclear energy technology challenges, largely through competitively awarded research and development (R&D) projects with United States (U.S.) industry, universities, and national laboratory partners. The CTD subprogram focuses on foundational research that addresses technical gaps in order to support and enable new state-of-the-art transformative technologies needed to maintain the current fleet of nuclear reactors and support the development of advanced reactors (including large, small, and micro-sized designs) and advanced fuels. CTD is closely coordinated with the Office of Nuclear Energy's other R&D programs to ensure that developed technologies and capabilities are part of an integrated investment strategy aimed at improving reliability and economics of U.S. nuclear technologies.

Characteristics of the activities within this subprogram include:

- developing new capabilities needed by the domestic nuclear energy R&D enterprise, with focus on U.S. industry gaps;
- conducting high-risk research that could overcome current technological limitations;
- developing enabling materials and manufacturing technologies that have applicability across multiple technical areas; and
- conducting leading-edge R&D to improve the economics, quality, security, and efficiencies of nuclear technologies.

The principal focus areas for FY 2022 include advanced sensors and instrumentation, nuclear cybersecurity research, advanced materials and manufacturing technologies, and integrated energy systems as follows:

- Advanced Sensors and Instrumentation supports R&D of unique sensor and instrumentation technologies needed to monitor and control existing and advanced reactors and support fuel cycle development;
- Nuclear Cybersecurity supports innovative cybersecurity capability development to address cyber threats to the U.S. nuclear power infrastructure, in coordination with the Department's Cybersecurity, Energy Security, and Emergency Response office, and supports secure implementation of advanced technologies such as wireless control and remote or autonomous operations;
- Advanced Materials and Manufacturing Technologies supports the development of technology-based solutions for advanced materials and manufacturing technologies for use in the deployment of advanced nuclear reactors and sustainment of the existing fleet. This consolidated focus area integrates the cutting-edge research previously pursued through the Advanced Methods for Manufacturing topic area, the Nuclear Materials Discovery and Qualification Initiative, and the crosscutting research previously performed under the Transformational Challenge Reactor subprogram; and
- Integrated Energy Systems supports the expansion of nuclear energy's role beyond just supplying electricity to the grid such that nuclear energy can also support various industrial, transportation, and energy storage applications. The successful integration of energy systems would allow the electric grid to continue to rely on clean nuclear baseload electricity, while offering economic benefits to nuclear energy operators. These integrated systems would also expand the availability of clean, affordable nuclear energy to applications currently relying on other energy sources.

Crosscutting Technology Development

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Crosscutting Technology Development $28,000,000	**$47,000,000**	**+$19,000,000**
• Conduct research on advanced sensors and instrumentation and competitively award new fully-funded research and development (R&D) projects in areas applicable to advanced reactors and fuel cycle technologies. • Conduct research on nuclear cybersecurity to address cyber threats to the U.S. nuclear power infrastructure and to continue the development of standards for reducing supply chain risks and integrating nuclear safety risk management with cybersecurity risk management. • Initiate the Advanced Materials and Manufacturing Technologies (AMMT) program to consolidate materials and manufacturing technologies development to support the existing reactor fleet as well as the deployment of advanced reactors. • Research additional crosscutting research areas such as critical minerals (non-uranium) and advanced energy storage. • Conduct research on integrated energy systems to better understand how systems with multiple energy inputs, energy users, and mass energy storage could allow the electric grid to rely on optimized baseload electricity, while offering economic benefits to energy producers in concert with needed grid flexibility.	• Conduct research on advanced sensors and instrumentation and competitively award new fully-funded R&D projects in areas applicable to advanced reactors and fuel cycle technologies. • Conduct research to support the development of standards for reducing nuclear power plant supply chain risks and for integrating nuclear safety risk management with cybersecurity risk management, to support improved economic and security performance at existing and future plants. • Conduct R&D on secure implementation approaches for advanced control systems and remote or autonomous operations. • Continue the consolidation of R&D efforts in the areas of materials and supply chain development under AMMT to focus on the highest priorities needed to propel advanced reactor technology developers towards commercialization. Identify approaches and candidate tool sets that could accelerate the use of new materials and production technologies in nuclear systems—both for the case of future reactors and for improvements to the existing fleet. Develop advanced materials and manufacturing technologies that enhance the economics and performance of the existing reactor fleet and advanced reactor concepts. • Enable the integration of thermal storage and chemical plants with nuclear plants, to expand the role of nuclear energy beyond just supplying baseload electricity to the grid to include various industrial applications, transportation fuels, and	• The increase reflects support for the Integrated Energy Systems subprogram and the Advanced Materials and Manufacturing Technologies (AMMT) subprogram initiated in FY 2021, which consolidates efforts from the Nuclear Materials Discovery and Qualification initiative, the crosscutting research previously conducted under the Transformational Challenge Reactor subprogram, and the Advanced Methods for Manufacturing area. This increase also provides additional support for R&D in the areas of advanced sensors and instrumentation and cybersecurity.

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
	energy storage to provide flexible generation capacity from nuclear plants.	

Joint Modeling and Simulation

Description
The Joint Modeling and Simulation subprogram, as implemented through the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program within the Department of Energy, develops and deploys a set of predictive modeling and simulation tools to support and, in some cases, enable improved operation of the current fleet and the development and deployment of advanced reactors. NEAMS engages scientists and engineers in developing state-of-the-art, multi-scale models of physics and chemistry that drive advanced computational methods for simulations of advanced nuclear energy systems. NEAMS empowers researchers and designers to gain fundamental insights that are unattainable through experiment alone and inform experiment selection and design to minimize cost of research and development. Advanced modeling and simulation capabilities also support the Office of Nuclear Energy (NE) program priorities, such as the development of fuels with enhanced accident tolerance.

The NEAMS program has developed a set of analytic modeling and simulation tools that is flexible and able to accommodate different reactor types and designs. In addition, the Energy Innovation Hub for Modeling and Simulation (Hub) developed and deployed a reactor simulation tool set called the Virtual Environment for Reactor Applications (VERA), which focuses on light water reactor (LWR) technologies for an improved understanding of important operational and safety issues in existing commercial reactors. The Hub fully met its objectives and was brought to closure on June 30, 2020. The development of LWR capabilities is now performed under the NEAMS program making maximum use of capabilities developed by the Hub.

Through an enhanced programmatic framework, NEAMS tools support NE's mission priority areas: continued operation of the existing fleet of U.S. nuclear reactors; enable deployment of advanced nuclear reactors; develop advanced nuclear fuel cycles; and maintain U.S. leadership in nuclear energy technology.

For the existing fleet, NEAMS tools address core performance optimization issues and accelerate development of fuels with enhanced accident tolerance to help assure the long-term availability and market competitiveness of nuclear energy.

For advanced reactor technologies, these tools help industry accelerate advanced reactor development and meet otherwise cost-prohibitive data needs and will support Nuclear Regulatory Commission efforts to address its confirmatory analysis needs.

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

Joint Modeling and Simulation

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Joint Modeling and Simulation $35,000,000	**$35,000,000**	**$0**
• Enable and accelerate industry's advanced reactor deployment efforts through advanced multiscale and multiphysics modeling and simulation approaches. – Demonstrate fast reactor multiphysics modeling capability for core radial expansion as an important reactivity feedback mechanism taking structural and irradiation impacts into consideration. – Fully incorporate and update existing tristructural-isotropic (TRISO) fuel models into fuels modeling capability and perform validation against historical and Advanced Reactor Technologies Advanced Gas Reactor tests. – Simulate key molten salt properties and validate them with selected measured data. • Perform initial validation of advanced modeling tools consistent with Nuclear Regulatory Commission-specified priorities for specific validation experiments and reactor types. • Complete development and validate fuel performance and cladding models for Accident Tolerant Fuels (ATF). Update verification and validation plan with completed Advanced Test Reactor and Transient Reactor Test Facility experiments. • Transition the VERA Users Group to a self-sustaining model where the user community manages and funds development and maintenance of the VERA software. • Continue and update quality assurance (QA) assessments and documentation to meet	• Establish capability for High Temperature Gas Reactor system analysis for a range of anticipated operating and accident scenarios including normal operation, load following, pressurized loss of forced cooling, depressurized loss of forced cooling and air ingress, and steam generator tube break. • Steady-state and transient TRISO fuel performance as a function of temperature, fuel burnup to determine integrity of fuel and retention of fission products. • Initial demonstration of salt chemistry modeling capability in support of liquid-fuel Molten Salt Reactor development. • Complete initial microreactor structural analysis and material modeling to understand stress, creep, and geometry changes of key structural components. • Complete development of Light Water Reactor fuel performance and cladding models for ATF that include extending fuel to higher burnups. • Complete the development of an initial set of tools for full system modeling capability for fast reactors under steady-state conditions that can support vendor license applications or regulatory reviews.	• There are no changes to the budget.

stakeholder requirements, such as Nuclear QA-1 research level.

Nuclear Science User Facilities

Description

The Nuclear Science User Facilities (NSUF) subprogram is the Nation's designated program to gain access to user facilities for nuclear energy research. As a consortium of partner facilities, the NSUF connects a broad range of nuclear research capabilities, expert mentors, and experimenters. The NSUF represents a "prototype laboratory for the future," promoting the use of unique nuclear research facilities located at multiple sites across the Nation and encouraging active university, industry, and laboratory collaboration in relevant nuclear science research. The NSUF, through competitive solicitations, provides a mechanism for research organizations to collaborate, conduct experiments and post-experiment analysis, and utilize high performance computing at facilities not normally accessible to these organizations. On an annual basis, researchers propose projects to be conducted at these unique facilities, with timelines ranging from a few months to several years. When projects are awarded, the NSUF subprogram pays for experiment support and laboratory services at the partner user facilities. In this manner, researchers benefit from the introduction to new techniques, equipment, and personnel. Moving forward, emphasis will be placed on increasing the involvement of Historically Black Colleges and Universities, Minority Serving Institutions, and institutions in underserved communities, resulting in direct and meaningful investments through project selection and NSUF partnership agreements in support of the Administration's Justice40 Initiative.

The principal focus areas for FY 2022 include High Performance Computing and the NSUF Base program as follows:

- High Performance Computing (HPC) supports INL scientific computing capabilities to support efforts in advanced modeling and simulation. These resources support a wide range of research activities, including performance of materials in harsh environments (such as the effects of irradiation and high temperatures), performance of existing light water and advanced nuclear reactors, and multiscale multiphysics analysis of nuclear fuel performance. HPC capabilities are available to industry, universities, national laboratories, and federal agencies to support research and development. Three HPC supercomputers are currently in operation at the Idaho National Laboratory: Sawtooth, Falcon and Lemhi.
- The NSUF Base program supports all pertinent activities needed to provide researchers access to unique nuclear research facilities, including competitive solicitations, access to research reactors, hot cells, beam-line capabilities, irradiation capabilities, and irradiation experiment design and fabrication support, expert support, and communication and community outreach.

Nuclear Science User Facilities

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Nuclear Science User Facilities $30,000,000	**$42,000,000**	**+12,000,000**
• Competitively solicit and award new fully-funded facility access awards. • Award approximately 20 new fully-funded Rapid Turnaround Experiment awards through one competitive proposal process. • Optimize the capabilities available through partnerships with universities, industry, and national laboratories to offer unparalleled research opportunities in a highly cost-effective manner by leveraging capabilities and investments at partner institutions. • Enhance the research tools provided to the Nuclear Science User Facilities (NSUF) user community. These on-line tools include the Nuclear Energy Infrastructure Database, the Nuclear Fuels and Materials Library, and Combined Materials Experiment Toolkit which, in concert, provide access to information on scientific equipment, previously irradiated materials, irradiation dose predictions and subject matter experts. • Invest in select domestic scientific infrastructure capabilities to support the advancement of applied research and development (R&D) in support of the Office of Nuclear Energy (NE) mission. • Conduct a workshop on the current capability gaps in performing materials research on irradiated materials.	• Competitively solicit and award new fully-funded facility access awards. • Award more than 100 Rapid Turnaround Experiment awards through three competitive proposal periods. • Continue NSUF partnership agreements with universities, industry, and national laboratories to support ongoing irradiation experiments ranging from neutron, gamma and ion irradiation to post-irradiation examination and incorporate new irradiation capabilities as needs are identified. • Invest in select domestic scientific infrastructure capabilities to support the advancement of applied R&D in support of the NE mission. • Enhance the Nuclear Fuels and Materials Library through the addition of irradiated fuels and materials. • Operate three supercomputers totaling more than 155,000 processor cores and 8 Petaflops of computational performance. Support more than 800 users by providing training, user support, and code optimization. Ensure effective cybersecurity and user access controls. • Continue to enhance the High Performance Computing (HPC) science gateway to enable new users. Deploy an updated backup solution to protect user and project files.	• The increase reflects support for High Performance Computing activities and additional access for industry, universities, and national laboratories to unique nuclear energy research facilities and a restoration of three Rapid Turnaround Experiment award cycles.

Transformational Challenge Reactor

Description

The Transformational Challenge Reactor (TCR) subprogram provided a revolutionary platform to help demonstrate the ability to reduce the deployment costs and timelines for nuclear energy systems and enhanced the development of breakthrough technologies that provided the ability to manufacture small/micro advanced reactor components using additive manufacturing techniques. A central goal of the TCR subprogram was to demonstrate the ability to exploit advanced manufacturing techniques and digital predictive analysis capabilities to deliver a new approach to nuclear design and qualification for advanced reactor technologies. TCR combined advanced manufacturing with materials and computational sciences to predict optimal performance of components to enable faster innovation and certification.

Highlights of the FY 2022 Budget Request

No funding is requested in the FY 2022 Budget for the Transformational Challenge Reactor subprogram. In FY 2022, crosscutting research initiated under the TCR subprogram will continue under the Crosscutting Technology Development subprogram to consolidate all relevant technologies under one program.

Transformational Challenge Reactor

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Transformational Challenge Reactor $29,869,000	**$0**	**-$29,869,000**
• Demonstrate application of Artificial Intelligence (AI) to perform multi-physics optimization of additively manufactured component and provide benchmark test data to verify the framework. • Demonstrate predictive capability of the Digital Platform to assess nuclear component quality with Software Quality Assurance. • Perform irradiation testing of additively manufactured structures with embedded sensors and collect in situ data. • Publish handbook of properties for additively manufactured ceramic and metal materials including neutron irradiation data.	• No funding is requested to continue this program in FY 2022. Crosscutting research will continue under Crosscutting Technology Development (CTD).	• No funding is requested to continue this program in FY 2022.

Advanced Reactor Demonstration Program

Overview

The Advanced Reactor Demonstration Program (ARDP) focuses Departmental and non-federal resources on the construction of demonstration reactors in the near- and mid-term that are safe and affordable to build and operate.

In the FY 2020 Further Consolidated Appropriations Act, Congress established ARDP to demonstrate multiple advanced reactor designs. To support this goal, the program has five major elements:

- National Reactor Innovation Center (NRIC) – Supports testing, demonstration, and performance assessment to accelerate deployment of advanced reactors through development of advanced nuclear energy technologies by utilizing the unique DOE national laboratory facilities and capabilities;
- Advanced Reactor Demonstrations – Support the establishment of cost-shared (up to 50% government, not less than 50% industry) to build two advanced demonstration reactors with significant improvements compared to the current generation of operational reactors;
- Risk Reduction for Future Demonstrations – Supports the establishment of cost-shared (up to 80% government, not less than 20% industry) partnerships with United States (U.S.)-based teams to address technical, operational, and regulatory challenges to enable development of a diverse set of advanced nuclear reactor designs for future demonstration;
- Regulatory Development – Coordinates activities with the Nuclear Regulatory Commission (NRC) to address and resolve key regulatory framework and licensing technical issues that directly impact the “critical path” to advanced reactor demonstration and deployment; and
- Advanced Reactor Safeguards – Evaluates safeguards and security issues that are unique to advanced reactors to help reduce roadblocks by solving regulatory challenges, reducing safeguards and security costs, and utilizing the latest technologies and approaches for plant monitoring and protection.

In FY 2022, the Department, using current and prior year funds, focuses on the execution of the Demonstration and Risk Reduction projects selected in FY 2020 and FY 2021, respectively. For the Demonstration projects, funding will support two domestic advanced reactor development partners in the design development, engineering, safety analysis, and licensing activities that are required to submit construction permits and license applications to the NRC. For the Risk Reduction projects, funding will support five domestic advanced reactor development partners in resolving technical, operational, and regulatory challenges to enable future demonstration of their concepts. Efforts initiated under the NRIC, Regulatory Development and Advanced Reactor Safeguards subprograms will continue in FY 2022.

The ongoing ARDP demonstration projects, and the risk reduction projects working to overcome barriers to future demonstrations, have the potential to create substantial numbers of new short and long-term domestic jobs. For example, in the early stages of design development and licensing, the reactor demonstration vendors are adding many technical and professional employees to address design, engineering, testing, procurement, and licensing requirements. The construction phase is expected to result in hundreds of short-term construction jobs, many of which are expected to be union filled. The eventual operation of these reactors will require the creation of additional long-term operations, maintenance, and security positions with the utility owners. Overall, the deployment and operation of these reactors, and potentially subsequent demonstrations are expected to have significant positive, long-term economic impacts on the communities in which they are operated.

Highlights of the FY 2022 Budget Request

The primary focus of the FY2022 budget will be on supporting the continued development of the advanced reactor Demonstration projects. Additional funding is requested to continue ongoing activities under the Risk Reduction projects selected in FY2021, and the NRIC, Regulatory Development, and Advanced Reactor Safeguards subprogram areas.

Advanced Reactor Demonstration Program
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 + ($)	FY 2022 Request FY 2021 Enacted (%)
Advanced Reactor Demonstration Program					
National Reactor Innovation Center	20,000	30,000	55,000	+25,000	+83%
Demonstration 1	80,000	80,000	108,700	+28,700	+36%
Demonstration 2	80,000	80,000	136,650	+56,650	+71%
Risk Reduction for Future Demonstrations	30,000	40,000	50,000	+10,000	+25%
Regulatory Development	15,000	15,000	15,000	0	0%
Advanced Reactor Safeguards	5,000	5,000	5,000	0	0%
Total, Advanced Reactor Demonstration Program	**230,000**	**250,000**	**370,350**	**+120,350**	**+48%**

SBIR/STTR:

- FY 2020 Transferred: SBIR $1,600; STTR $225
- FY 2021 Enacted: SBIR $2,332; STTR $406
- FY 2022 Request: SBIR $4,000; STTR $563

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

	FY 2022 Request vs FY 2021 Enacted
National Reactor Innovation Center: The increase from $30,000,000 to $55,000,000 reflects a ramp-up in activities to support industry in developing and demonstrating advanced reactor designs, including increased support for development of demonstration test beds and advanced construction technologies.	**+25,000**
Demonstration 1: The increase from $80,000,000 to $108,700,000 reflects the ramp-up of the X-energy Xe-100 reactor demonstration project activities in the areas of design development, plant engineering, licensing, component prototyping and procurement as the projects proceed to construction and operation in the near term .	**+28,700**
Demonstration 2: The increase from $80,000,000 to $136,650,000 reflects the ramp-up of the TerraPower Natrium reactor demonstration project activities in the areas of design development, plant engineering, licensing, component prototyping and procurement as the projects proceed to construction and operation in the near term.	**+56,650**
Risk Reduction for Future Demonstration: The increase from $40,000,000 to $50,000,000 reflects an increase in project activities to support the Risk Reduction awards selected in FY2021.	**+10,000**
Regulatory Development: There are no changes to the budget.	**0**
Advanced Reactor Safeguards: There are no changes to the budget.	**0**
Total, Advanced Reactor Demonstration Program	**+120,350**

National Reactor Innovation Center

Description

The National Reactor Innovation Center (NRIC) mission is to enable and accelerate the testing and demonstration of advanced reactors by utilizing the unique capabilities of U.S. national laboratories. NRIC provides private sector technology developers with access to the strategic infrastructure and assets of the national laboratories to enable physical validation of advanced nuclear reactor concepts, resolve technical uncertainties, and generate data relevant to safety, resilience, security, and functionality of advanced nuclear reactor concepts. NRIC works closely with R&D programs within the Office of Nuclear Energy to avoid duplication. NRIC does not conduct R&D, it facilitates information sharing and connectivity necessary to enable the demonstration of selected nuclear reactor designs.

The NRIC subprogram activities includes interactions with reactor developers who are considering options for demonstrating their reactor technologies as well as investigation and development of national laboratory capabilities for hosting advanced reactor demonstrations. Subprogram activities will also include continuing design and pre-construction activities to support the development of infrastructure for the testing and demonstration of multiple advanced reactor concepts. While NRIC is led by the Idaho National Laboratory (INL) with significant activities at the INL Site, resources at other national laboratories and potential nuclear reactor demonstration sites will play an important role in achieving NRIC's objectives.

NRIC is expected to help accelerate technology readiness from proof of concept through proof of operations. Key support to be provided by NRIC includes:

- Well-characterized locations to site reactors for demonstrations to prove performance and to provide a pathway to commercialization;
- Facilitating industry access to key resources, such as materials needed for nuclear reactor fuel, facilities for fabrication of fuel for demonstrations, test reactors such as the Advanced Test Reactor and Transient Reactor Test Facility at the INL and High Flux Isotope Reactor at the Oak Ridge National Laboratory, characterization capabilities such as INL's Irradiated Materials Characterization Laboratory, and access to advanced modeling and simulation codes and high performance computers through the INL Collaborative Computing Center;
- Access to national laboratory experts to support technology development;
- Development and demonstration of complementary technologies, in conjunction with relevant Nuclear Energy R&D programs, such as application of digital engineering philosophies and development and demonstration of advanced construction technologies, to reduce the cost and schedule risks associated with the deployment of advanced reactors;
- Assistance with National Environmental Policy Act (NEPA) evaluations, Nuclear Regulatory Commission (NRC) licensing, and DOE authorization for nuclear facility operations related to selected demonstrations;
- Development of a resource network of sites, facilities, and capabilities suitable for performing key R&D, experiments, tests, or fabrications, and for hosting advanced reactor demonstrations; and
- Identifying and facilitating resolution of experimental capability gaps which are vital to advanced reactor development and demonstration.

National Reactor Innovation Center

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
National Reactor Innovation Center $30,000,000	**$55,000,000**	**+$25,000,000**
• Initiate siting and regulatory preparation for advanced reactors and identifying siting strategies that are scalable and incorporate environmental justice principles. • Engage with other Office of Nuclear Energy programs to provide access to integrated energy systems testing platforms to demonstrate advanced applications of nuclear heat and electricity. • Establish a formal agreement with the Nuclear Regulatory Commission (NRC) to facilitate the sharing of technical expertise and knowledge on advanced nuclear reactor technologies and nuclear energy innovation, including reactor concept demonstrations. • Continue activities to reduce the regulatory risks and costs associated with advanced reactor demonstration, including development of a plant parameter envelope approach for advanced reactors. • Commence design activities to inform future decisions about the implementation of demonstration test beds and ensure that project management best practices are applied to these activities. • Procure equipment and designing laboratory spaces to close vital experimental gaps. • Initiate design, development and testing of advanced construction technologies that may reduce the cost and schedule risk associated with construction of advanced reactors. • Support Environmental Assessment (EA) activities and	• Help make available infrastructure, sites, materials, and expertise to support advanced reactor demonstration. • Continue activities to help enable private sector entities to develop and demonstrate advanced construction technologies to reduce the cost and schedule risks associated with advanced reactor construction. • Continue support for the design and build of the Molten Salt Thermophysical Examination Capability (MSTEC) at Idaho National Laboratory (INL). • Continue engagement with key stakeholders such as the NRC, advanced reactor developers, and potential end-users. • Continue evaluating capabilities and gaps and working with R&D programs to facilitate coordinated actions to address critical needs. • Continue engagement with other Office of Nuclear Energy programs to provide access to integrated energy systems testing platforms to demonstrate advanced applications of nuclear heat and electricity. • Provide support to advanced reactor developers to enable successful execution of ARDP project activities, as appropriate.	• The increase reflects a ramp-up in activities to support industry in developing and demonstrating advanced reactor designs, including increased support for, the design and build of MSTEC to enable operation in 2023 and providing access to existing integrated energy systems testing platforms. .

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
• Provide support to advanced reactor developers to enable successful execution of ARDP project activities, as appropriate.		

Demonstration 1 and Demonstration 2

Description

These subprograms will begin to focus efforts on the execution of cost-shared projects for the eventual construction of two advanced reactor demonstrations, including design development, engineering, safety analysis, and licensing activities that are required to submit construction permits and licensing applications to the Nuclear Regulatory Commission (NRC). DOE focus will be establishing the Demonstrations as multi-year projects, identifying and incorporating appropriate project management requirements, principles, and identifying important information, including formally-established and monitored milestones, schedules and cost profiles.

In FY 2020, DOE announced awards to X-energy and TerraPower LLC to design, license, construct, and start up two advanced nuclear reactors that can be operational within seven years. The awards are cost-shared partnerships with industry that will deliver two first-of-a-kind advanced reactors to be licensed for commercial operations. Industry partners will cover at least 50 percent the costs of this program.

X-energy will deliver a commercial four-unit nuclear power plant based on its Xe-100 reactor design. The Xe-100 is a high temperature gas-cooled reactor that is ideally suited to provide flexible electricity output, as well as process heat for a wide range of industrial heat applications, such as desalination and hydrogen production. The project will also deliver a commercial scale TRi-structural ISOtropic particle fuel (TRISO) fuel fabrication facility, leveraging DOE's substantial past investment in development of this highly robust fuel form.

TerraPower will demonstrate the Natrium reactor, a sodium-cooled fast reactor that leverages decades of development and design work undertaken by TerraPower and its partner, General Electric-Hitachi (GE-H). The high-operating temperature of the Natrium reactor, coupled with thermal energy storage, will allow the plant to provide flexible electricity output that complements variable renewable generation such as wind a solar. In addition, this project will establish a new metal fuel fabrication facility that is scaled to meet the needs of this demonstration program.

Both Demonstration projects intend to pursue a 10 CFR Part 50 NRC licensing pathway that will involve development and submittal of a Construction Permit, and a subsequent Operating License which will require applications to be approved by NRC in advance of any significant construction activities. FY 2022 activities will focus heavily on completing licensing work.

In FY 2022, funding requests for the Demonstrations are submitted to support the unique funding needs and pace of activities for each project. In addition to the licensing activities, the Demonstration projects will begin to focus on safety analysis and testing requirements, fuel facility design, simulator design and development, reactor primary system component design and environmental testing, long-lead component procurement, and site preparation.

Demonstration 1 and Demonstration 2

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Demonstration 1 $80,000,000	**$108,700,000**	**$28,700**
Demonstration 2 $80,000,000	**$136,650,000**	**$56,650**
• DOE completed award negotiations and formalized cooperative agreements with two advanced reactor vendor organizations. • Demonstration reactor partners completed and submitted several early-stage project deliverables to DOE for milestones consistent with their project applications in areas such as: o Establishing project management structure and execution planning. o Development of licensing applications. o Reactor systems design development. o Procurement planning. o Fuel fabrication facility design and licensing per 10 CFR Part 70. o Site selection or site preparation activities. • Continued to execute project scope for both Demonstration projects per established project plans using current and prior year carryover funds.	• Demonstration reactor partners to complete and submit mid-stage project deliverables to DOE for project milestones consistent with their project applications in areas such as: o Completion and submittal of Construction Permits to the NRC. o Initiate fuel fabrication facility construction. o Completion of site selection (TerraPower only). o Completion of control room designs. o Completing detailed plant cost estimates (Class 3-4). o Initiating long-lead equipment procurement activities. • Continue to execute project scope for both Demonstration projects per established project plans using current and prior year carryover funds, such as: o Efforts to complete Operating License Applications. o Final design development. o Prototype equipment design and testing. o Non-nuclear construction on selected sites.	• FY 2022 funding request is consistent with the ramp-up in project activities required to accelerate the design and licensing application development that will support the aggressive construction and operation schedules for the Demonstration projects in the near term .

Risk Reduction for Future Demonstrations

Description

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

In FY 2021, DOE announced the selection of five projects to aid advanced reactor developers in resolving technical, operational, and regulatory challenges to enable future demonstration of a diverse set of advanced reactor designs. The Risk Reduction projects support the development of safe and affordable advanced reactor technologies that can be licensed and deployed over the next 10 to 14 years. Industry partners will provide at least 20 percent in matching funds for their cost share of the program.

The five projects selected for award are:

- Kairos Power, LLC (Alameda, CA) will work to design, construct, and operate its Hermes reduced-scale test reactor. Hermes is intended to lead to the development of Kairos Power's commercial-scale fluoride salt-cooled high temperature reactor (FHR), a novel advanced nuclear reactor technology that leverages TRI-structural ISOtropic particle fuel (TRISO) fuel in pebble form combined with a low-pressure fluoride salt coolant;
- Westinghouse Electric Company, LLC (Cranberry Township, PA) will advance the design of a heat pipe-cooled microreactor to support a nuclear demonstration unit by 2024;
- BWXT Advanced Technologies, LLC (Lynchburg, VA) will mature a commercially viable transportable microreactor conceptual design focused on using TRISO fuel particles to achieve higher uranium loading and an improved core design using a silicon carbide (SiC) matrix;
- Holtec Government Services, LLC (Camden, NJ) is receiving funding for early-stage design, engineering, and licensing activities to accelerate the development of its light water-cooled small modular reactor (SMR); and
- Southern Company Services Inc. (Birmingham, AL) will lead a project to design, construct, and operate the Molten Chloride Reactor Experiment (MCRE), a critical nuclear test bed supporting molten salt reactor systems and components demonstrations.

Risk Reduction for Future Demonstrations

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Risk Reduction for Future Demonstrations $40,000,000	**$50,000,000**	**+$10,000,000**
• Finalize Risk Reduction project selections through a competitive merit review process. • Finalize scope and milestones for Risk Reduction projects. • Initiate execution of project activities.	• Pending the finalization of scope and milestones, continue to execute project scope for Risk Reduction projects per established project plans using current and prior year carryover funds, such as: o Continuing design activities o Continuing interactions with the NRC on high impact regulatory related topics o Continuing activities to resolve technical, operational and regulatory challenges to prepare for future demonstration opportunities o Develop plans for establishing infrastructure and support capabilities to enable execution of Risk Reduction projects and future commercialization activities	• The increase reflects a ramp-up in project activities to support the Risk Reduction awards selected in FY 2021

Regulatory Development

Description

The Regulatory Development subprogram coordinates with the Nuclear Regulatory Commission (NRC) and industry to address and resolve key regulatory framework issues that directly impact the "critical path" to advanced reactor demonstration and deployment. Part of the subprogram focuses on regulatory modernization activities such as developing adaptations of light water reactor (LWR) based regulations for non-LWR advanced reactors, finalizing the establishment of risk-informed and performance-based license application guidance, and establishing clear expectations for license application content and review criteria. Other regulatory development activities include resolving the technical basis to support NRC endorsement of codes and standards important for the manufacture of advanced reactor components, and expanding access to priority material property data to be used in safety codes and models in support of licensing. Design-specific regulatory gaps for advanced reactors, including fast reactors, gas-cooled reactors, and molten salt reactors, are also addressed.

Regulatory Development

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Regulatory Development $15,000,000	**$15,000,000**	**$0**
• Continue coordination with industry and the Nuclear Regulatory Commission (NRC) to identify technology gaps and high impact challenges regarding advanced reactor regulation. • Execute priority technical and regulatory risk reduction projects. • Continue efforts to establish a risk-informed, advanced reactor regulatory framework. • Develop and submit an industry-driven proposal to NRC for risk-informed and "right-sized" license application content for advanced reactors to reduce regulatory uncertainty and support near-term demonstrations and deployments. • Perform a broad scope phenomena, identification, and ranking table (PIRT) exercise on liquid-fueled molten salt reactors (MSR) to identify key licensing and research and development (R&D) needs for demonstration and deployment. • Through industry and NRC engagement, continue efforts to resolve remaining high impact NRC regulatory policy issues impacting advanced reactor licensing.	• Execute FY 2022 limited early-stage research and development aimed at producing broadly applicable results that can be used by an array of private sector companies to inform their regulatory requirements. • Continue support of industry and NRC interactions that are establishing the advanced non-light water reactor regulatory framework. • Continue conducting targeted development and R&D to help address design-specific regulatory gaps including understanding radionuclide transport, understanding reactor behavior during anticipated transients, and experimentally validating methods for licensing support. • Facilitate NRC's formal approval of the license application content proposal developed and submitted in FY 2021. • Address priority MSR needs identified in the FY 2021 PIRT effort. • Continue development and testing to support inclusion of Alloy 709 (alloy with increased materials performance in high temperature advanced reactor operating environments) in the American Society of Mechanical Engineers (ASME) Code.	• No change.

Advanced Reactor Safeguards

Description

The Advanced Reactor Safeguards subprogram evaluates safeguards and security issues that are unique to advanced reactor designs. Project activities inform and improve advanced reactor designs by addressing issues such as diversion of advanced fuel forms, protection of remotely operated plants, and other proliferation and security concerns. This subprogram also helps to reduce security costs by utilizing the latest technologies and approaches for plant monitoring and protection. Coordination with the Nuclear Regulatory Commission (NRC), National Nuclear Security Administration (NNSA), and industry ensures duplication is avoided, existing expertise is leveraged, and synergies are maximized.

Advanced Reactor Safeguards

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Change FY 2022 Request vs FY 2021 Enacted
Advanced Reactor Safeguards $5,000,000	**$5,000,000**	**$0**
• Execute FY 2021 activities identified during Advanced Reactor Safeguards development planning and subprogram execution initiated during FY 2020. • Provide physical protection system design alternatives that significantly reduce cost or need for on-site responders for advanced reactors. • Provide recommendations to advanced reactor vendors on material control and accountancy approaches. • Design, analyze, and prove plant protection system generic design alternatives that significantly reduce or eliminate the need for on-site responders.	• Develop the technical basis to implement Nuclear Regulatory Commission (NRC) new rulemaking for the physical protection of advanced reactors that will allow the vendors to take credit for enhanced safety systems. • Establish material control and accountability approaches for pebble bed reactors, molten salt reactors, and microreactors to address gaps in specific monitoring systems. • Determine recommendations to address the physical protection and material control and accountability requirements for high-assay low-enriched uranium (HALEU).	• No change.

Versatile Test Reactor Project

Overview

To tackle the climate crisis, jumpstart clean energy manufacturing, and reestablish the United States (U.S.) as a global leader in nuclear science and innovation, a fast spectrum test reactor will be a pivotal experimental tool. Sustaining the existing fleet and the development of advanced reactors are key in providing a diverse portfolio of carbon pollution-free energy. Advancements in the area of testing of advanced fuels, materials and instruments and sensors in extreme environments, can further facilitate their development. Due to the very high neutron flux provided by such a fast test reactor, the irradiation time for testing of new materials can be reduced by an order of magnitude compared to that for a standard thermal test reactor such as the Advanced Test Reactor at Idaho National Laboratory.

The Versatile Test Reactor (VTR) supports reviving and expanding the nuclear sector in the U.S. Specifically, the VTR will support the modernization of the U.S. infrastructure for early stage research and development (R&D). It also aligns with the prioritization of test beds in the Department of Energy's FY 2022 Budget Request, to better enable private sector demonstration and deployment of energy technologies. Advancements in nuclear energy, particularly in the area of testing of advanced fuels, materials and instruments and sensors in extreme environments, is necessary for the advanced reactor community in the U.S. to achieve its goals. The VTR would help the U.S. to regain and strengthen its global technical leadership role in the development of the next generation of advanced reactors, and would contribute to the creation of high-paying jobs and economic prosperity, and train the next generation of scientists and engineers needed for the future viability of our nuclear sector.

The Department will execute this project in accordance with the rigorous methodology established by Department of Energy Order (DOE O) 413.3B, Program and Project Management for the Acquisition of Capital Assets. In parallel, the Department has begun preparation of an Environmental Impact Statement in accordance with National Environmental Policy Act requirements to ensure that all environmental factors are considered before the Department makes a final decision to move forward with the project.

In February 2019, the VTR Project was formally initiated with Critical Decision (CD)-0, Approve Mission Need, in accordance with DOE O 413.3B requirements. This decision formally evaluated the mission responsibilities and infrastructure capabilities and determined that the Department does not possess the capabilities to perform the needed accelerated testing and qualification of advanced nuclear fuels, materials, instrumentation, and sensors.

Following establishment of the VTR Project, subsequent FY 2019 and FY 2020 activities completed prerequisites for CD-1, Approve Alternative Selection and Cost Range, including completing the analyses of alternatives, completing a conceptual design and associated safety basis, and developing refined cost and schedule estimates. CD-1 was approved on September 11, 2020. Other FY 2020 activities included formulation of an acquisition strategy, development of cost estimates for fuel source and fuel fabrication, examination of critical component supply chain capabilities, and the signing of a memorandum of understanding with the Department's National Nuclear Safety Administration (NNSA) that establishes the terms and conditions governing cooperation on the transfer of feedstock material for alloying with uranium and zirconium for VTR's metal driver fuel.

The VTR will leverage synergies from TerraPower's Natrium project, a sodium-cooled fast reactor demonstration project selected under the Advanced Reactor Demonstration Program (ARDP), by sequencing the design and construction schedule of the VTR to follow Natrium and take full advantage of commonalities in the two designs, component development and testing, supply chain development, and construction activities. This will allow optimized use of otherwise limited human resources/expertise, optimized use of limited testing facilities, reduction in the overall development and testing costs for components that have similar features, and reduction in cost and schedule risk and uncertainty.

Highlights of the FY 2022 Budget Request

In FY 2022, activities will focus on preliminary design and safety basis development, fuel design and production capabilities, and risk reduction. Prototyping and testing will be performed to decrease project risk by proving the supply chain and ensuring performance of potentially challenging components. FY 2022 activities will also include establishment of the baseline and full implementation of the Earned Value Management System. Finally, funding will be used to support development of the CD-2 package, Approve Performance Baseline/Approve Start of Construction, anticipated for the 4Q FY 2027.

Versatile Test Reactor Project
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Versatile Test Reactor Project					
Versatile Test Reactor – Other Project Costs	0	43,000	55,000	+12,000	+28%
21-E-200 VTR Project	0	2,000	90,000	+88,000	+4,400%
Total, Versatile Test Reactor Project	**0**	**45,000**	**145,000**	**+100,000**	**+222%**

Versatile Test Reactor Project
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Versatile Test Reactor – Other Project Costs:	
The increase from $43,000,000 to $55,000,000 reflects the advancement of fuel and experimental test vehicle fabrication capabilities, and advancement of the safety basis consistent with the stage of design.	**+12,000**
21-E-200 VTR Project	
The increase from $2,000,000 to $90,000,000 reflects efforts needed to initiate preliminary design.	**+88,000**
Total, Versatile Test Reactor Project	**+100,0000**

Versatile Test Reactor – Other Project Costs

Description

In February 2019, the Versatile Test Reactor (VTR) Project was formally initiated with Critical Decision (CD)-0, Approve Mission Need, in accordance with Department of Energy Order 413.3B requirements. CD-1, Approve Alternative Selection and Cost Range, was approved on September 11, 2020. Approval of CD-1 reinforced the need for this nuclear energy infrastructure capability and established the construction of a sodium-cooled fast spectrum test reactor as the preferred strategy for meeting this critical mission. The Department will make a final decision on the design, technology selection and location for VTR following the completion of the VTR Environmental Impact Statement and issuance of a Record of Decision, which is expected in late 2021.

This budget line, Versatile Test Reactor – Other Project Costs (VTROPC), will be used to fund VTR costs that are not included in the Versatile Test Reactor - Design and Construction (VTRDC), such as supporting research and development, pre-authorization costs prior to start of preliminary design, plant support costs during design, construction, activation, and startup. VTROPC will also include funding of those activities necessary to comply with National Environmental Policy Act requirements. Specific activities to be accomplished in FY 2022 are in the Activities and Explanation of Changes section.

Versatile Test Reactor – Operating

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Versatile Test Reactor – Operating $43,000,000	**$55,000,000**	**+$12,000,000**
• Manage VTR Project in accordance with Department of Energy Order 413.3B. • Complete National Environmental Policy Act required Environmental Impact Statement and issue Record of Decision. • Commence design and prototype development of VTR nuclear fuel fabrication processes. • Continue development of the safety basis documentation, including Preliminary Safety Design Report, Transient Analysis, and Probabilistic Risk Assessment.	• Manage VTR Project in accordance with Department of Energy Order 413.3B. • Continue to mature cost estimate. • Initiate assembly of Driver Fuel Subassembly, using fuel simulants. • Plan heavy metal shipments to support feedstock preparation for first driver fuel core. • Initiate fabrication of first Experiment Cartridge prototype.	• The increase reflects the establishment of fuel and experimental test vehicle fabrication capabilities, and initiation of operations training. • Reflects increased safety basis activities consistent with the level of design.

21-E-200 VTR Project

Description

In February 2019, the Versatile Test Reactor (VTR) Project was formally initiated with Critical Decision (CD)-0, Approve Mission Need, in accordance with Department of Energy Order 413.3B requirements. CD-1, Approve Alternative Selection and Cost Range, was approved on September 11, 2020. Approval of CD-1 reinforced the need for this nuclear energy infrastructure capability and established the construction of a sodium-cooled fast spectrum test reactor with an estimated cost range of $2.6 to $5.8 billion as the preferred strategy for meeting this critical mission. The Department will make a final decision on the design, technology selection and location for VTR following the completion of the VTR Environmental Impact Statement and issuance of a Record of Decision, which is expected in late 2021.

This budget line, Versatile Test Reactor – Design and Construction (VTRDC), will be used to fund VTR costs that are not included in the Versatile Test Reactor – Other Project Costs, such as all engineering design costs (preliminary and final design), facility construction costs, and other costs specifically related to those construction and the procurement of VTR components and hardware. As a part of the project's overall risk reduction efforts, digital requirements management and digital design control techniques are being utilized to maximize design process efficiency and to help achieve the goal of finalizing the design prior to the start of construction. VTR will also include funding of project and construction management during preliminary and final design and construction, and funds to provide for contingency and economic escalation. Specific activities to be accomplished in FY 2022 are in the Activities and Explanation of Changes section.

Versatile Test Reactor – Design and Construction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
21-E-200 VTR Project $2,000,000	**$90,000,000**	**+$88,000,000**
• Manage VTR Project in accordance with Department of Energy Order 413.3B. • Initiate preliminary design on civil and structural disciplines.	• Manage VTR Project in accordance with Department of Energy Order 413.3B. • Continue preliminary design and expand to all mechanical, electrical, instrumentation and controls, and civil and structural disciplines. • Initiate prototype & testing for key equipment. • Initiate all design documentation.	• The increase reflects efforts needed to advance the preliminary design, continue long-lead activities, and initiate prototype and testing for high-risk equipment.

21-E-200, Versatile Test Reactor
Project is for Design and Construction

Summary, Significant Changes, and Schedule and Cost History

Summary

In accordance with DOE Order 413.3B (DOE O 413.3B), Critical Decision (CD) 0 was approved on February 22, 2019, and formally marked the start of the Versatile Test Reactor (VTR) project by confirming the Department's Mission Need for the VTR. Following establishment of the VTR Project, during subsequent FY 2019 and FY 2020 activities, the Office of Nuclear Energy (NE) completed prerequisites for CD-1, Approve Alternative Selection and Cost Range, including completing the analyses of alternatives, completing a conceptual design and associated safety basis, and developing refined cost and schedule estimates. CD-1 was approved by the Deputy Secretary of Energy on September 11, 2020. Approval of CD-1 reinforced the need for this nuclear energy infrastructure capability and established the construction of a sodium-cooled fast spectrum test reactor as the preferred strategy for meeting this critical mission.

The Department has begun preparation of an Environmental Impact Statement in accordance with National Environmental Policy Act (NEPA) requirements to ensure that all environmental factors are considered before the Department makes a final decision to move forward with the project. The Department will make a final decision on the design, technology selection and location for VTR following the completion of the VTR Environmental Impact Statement and issuance of a Record of Decision, which is expected in late 2021.

Funds requested in FY 2022 are for 1) execution of Preliminary Design ($90 million), including mechanical discipline drawings, electrical discipline drawings, instrument and control (I&C) discipline drawings, civil/structural/site discipline drawings, development of supporting preliminary design documentation and the continuation of prototyping and testing for key equipment; and 2) operating funds ($55 million) to initiate assembly of driver fuel subassembly, using fuel simulants, plan heavy metal shipments to support feedstock preparation for first driver fuel, develop the Preliminary Safety Design Report, and initiate first experiment cartridge detailed design.

The fast neutron testing capability provided through the VTR project will help the United States (U.S.) meet its goal for advanced nuclear reactor technology development. The VTR project will provide leading edge capability for accelerated testing of advanced nuclear fuels, materials, instrumentation, and sensors. It will allow DOE to modernize its nuclear energy infrastructure, and conduct advanced technology and materials testing within the U.S. in a safe, efficient and timely way. In addition to testing new high-performance fuels needed for advanced reactors (especially for fast reactors), the proposed VTR project could provide accelerated neutron damage rates ~10 times greater than current water-cooled test reactors. These higher damage rates are needed within the U.S. to accelerate the testing of innovative materials needed by scientist and developers of transformational reactor technologies to sustain long term continuous innovation for all reactors and enable new types of reactors, which are tailored to different regional markets, and are not ready for demonstration today.

CD-0 was approved with an estimated cost range of $3.0B to $6.0B and an estimated schedule completion range of 2026 to 2030. CD-1 was approved with a revised estimated cost range of $2.6 to $5.8 billion and estimated schedule completion range of 2026 to 2031 including cost and schedule uncertainty.

All scope, schedule, and cost information in this data sheet are pre-decisional, and therefore does not reflect an approved baseline.

Significant Changes

- The project completed the conceptual design for CD-1 on January 10, 2020.
- This Project Data Sheet reflects approval of CD-1, Approve Alternative Selection and Cost Range, by the Deputy Secretary on September 11, 2020.
- A draft VTR Environmental Impact Statement was issued on December 21, 2020 with anticipation of issuing a Record of Decision in late 2021 concluding the NEPA activities.

Critical Milestone History

Fiscal Quarter or Date

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	D&D Complete	CD-4
FY 2021	2Q FY2019	TBD	TBD	TBD	TBD	TBD	N/A	TBD
FY 2022	02/22/2019	01/10/2020	09/11/2020	TBD	TBD	TBD	N/A	TBD

CD-0 – Approve Mission Need
Conceptual Design Complete – Actual date the conceptual design was completed (if applicable)
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
Final Design Complete – Estimated/Actual date the project design will be/was complete (d)
CD-3 – Approve Start of Construction
D&D Complete – Completion of D&D work
CD-4 – Approve Start of Operations or Project Completion (CD-1 approved with Schedule Range of September 2026 to August 2031)

Fiscal Quarter or Date

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2021	2Q FY2023	4Q FY2021	N/A
FY 2022	TBD	TBD	N/A

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

Project Cost History

($ in 1,000)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, D&D	OPC, Total	TPC
FY 2021	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2022	TBD	TBD	TBD	TBD	TBD	TBD	TBD

1. Project Scope and Justification

Scope

The capability gap identified in the Mission Need Statement for the project can be addressed with a new fast neutron spectrum test facility based on sodium-cooled fast reactor (SFR) technology. With this approach, the new facility could be designed and built using mature SFR technology informed by more than a hundred cumulative years of SFR operating experience and associated lessons learned. This proposed approach is representative of the alternatives that could provide a test facility with versatile operational capabilities and maximum mission flexibility.

A number of important considerations will be addressed by this project:

- Availability and accessibility of pre-and post-irradiation preparation and examination facilities is required, and those facilities already exist within the national laboratory system. The availability of existing experiment manufacturing, fuels and materials characterization, and post-irradiation examination capabilities provides for optimized benefit of the new capability.

- The facility will be authorized and regulated by DOE consistent with other test reactors in the DOE Complex.
- Teaming with industry to identify and develop mitigations for supply chain challenges is essential to minimize the well-recognized issues associated with new nuclear facility builds and support re-energization and revitalization of the U.S. nuclear industry.

Funds appropriated under this data sheet will be used to establish VTR's driver fuel manufacturing capability and may be used to provide independent assessments related to project planning and execution.

Justification

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

The U.S. has been an international leader in the development and testing of nuclear reactor technologies since the advent of nuclear power generation. The Department of Energy (DOE) and its predecessor organizations appropriately provided nuclear fuels and materials development capabilities and large-scale testing facilities in support of all currently deployed nuclear reactor technologies. However, the U.S. has not maintained a domestic fast neutron spectrum testing capability for over two decades. This gap in testing capability is hindering the U.S. ability to move forward in the development of next-generation nuclear reactors that will be commercially competitive in the long-term – many of which require a fast neutron spectrum for operation – and equally impacts the U.S. ability to regain and sustain technology leadership in this arena. Accelerated materials testing for all types of reactors (including the existing fleet) is an added advantage associated with a versatile fast spectrum testing capability.

Common to advanced nuclear reactor technology development is the need for accelerated testing and qualification of advanced nuclear fuels, materials instrumentation and sensors.

This testing capability is essential for the U.S. to modernize its nuclear energy research and development (R&D) infrastructure for developing transformational nuclear energy technologies. The light water reactor (LWR) and advanced reactor communities, which are supported by several DOE program areas (e.g., small modular reactor technology development and licensing, LWR sustainability, advanced nuclear technology development) are key to providing a flexible portfolio of carbon pollution-free energy.

The Office of Nuclear Energy's (NE) mission is to advance nuclear power to meet the nation's energy, environmental, and national security needs. To accomplish this mission, NE has established research objectives to resolve barriers in technical, cost, safety, and proliferation resistance through early-stage research, development and demonstration to:

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

In support of these research objectives, the Versatile Test Reactor will provide leading edge capability for accelerated testing and qualification of advanced fuels and materials, enabling the U.S. to regain and sustain technology leadership in the area of advanced reactor systems.

Key Performance Parameters (KPPs)

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

The KPPs will be finalized as part of the performance baseline at CD-2/3.

Performance Measure	Preliminary Threshold	Preliminary Objective
Provide a high neutron flux (neutron energy > 0.1 MeV)	≥ 4×10^{15} n/cm^2-s	≥ 4×10^{15} n/cm^2-s
Provide high neutron dose rate for materials testing, quantified as displacements per atom (dpa)	> 30 dpa/year	> 30 dpa/year
Provide an irradiation length that is typical of fast reactor designs	0.6 m ≤ L ≤ 1 m	0.6 m ≤ L ≤ 1 m
Provide a large irradiation volume within the core region	≥7 L per test position ≥ 10 test position	≥7 L per test position ≥ 10 test position
Provide experiment capability to support experimental mission for a range of reactor technologies	Provide capability for experiment vehicle (including cartridge loops with different coolants) design, construction, transport, storage, insertion to and removal from reactor, and support services, for fuels, materials, sensors, and instrumentation	Provide capability for experiment vehicle (including cartridge loops with different coolants) design, construction, transport, storage, insertion to and removal from reactor, and support services, for fuels, materials, sensors, and instrumentation
Provide life cycle management for the reactor driver fuel	Fuel is available for startup and a pathway for spent fuel management is established.	Fuel is available for startup and a pathway for spent fuel management is established.

2. Project Cost and Schedule

Financial Schedule

(Dollars in Thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2019	--	--	--
FY 2020	--	--	--
FY 2021	2,000	2,000	1,600
FY 2022	90,000	90,000	72,400
Outyears	TBD	TBD	TBD
Construction			
Outyear	TBD	TBD	TBD
Total Estimated Costs (TEC)			
FY 2019	--	--	
FY 2020	--	--	

	Budget Authority (Appropriations)	Obligations	Costs
FY 2021	2,000	2,000	1,600
FY 2022	90,000	90,000	72,400
Outyears	TBD	TBD	TBD
Total TEC	**TBD**	**TBD**	**TBD**
Other Project Costs (OPC)			
FY 2019	65,000	65,000	42,000
FY 2020	65,000	65,000	68,000
FY 2021	43,000	43,000	63,000
FY 2022	55,000	55,000	44,000
Outyears	TBD	TBD	TBD
Total OPC	**TBD**	**TBD**	**TBD**
Total Project Costs (TPC)			
FY 2019	65,000	65,000	42,000
FY 2020	65,000	65,000	68,000
FY 2021	45,000	45,000	64,600
FY 2022	145,000	145,000	116,400
Outyears	TBD	TBD	TBD
Grand Total	**TBD**	**TBD**	**TBD**

3. Details of Project Cost Estimate

(Budget Authority in Thousands of Dollars)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	TBD	--	--
Contingency	TBD	--	--
Total, Design	TBD	--	--
Construction			
Site Work	TBD	--	--
Equipment	TBD	--	--

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction	TBD	--	--
Other, as needed	TBD	--	--
Contingency	TBD	--	--
Total, Construction	TBD	--	--
Other TEC (if any)			
Cold Startup	--	--	--
Contingency	--	--	--
Total, Other TEC	--	--	--
Total Estimated Cost	TBD	--	--
Contingency, TEC	TBD	--	--
Other Project Cost (OPC)			
OPC except D&D			
R&D	--	--	--
Conceptual Planning	--	--	--
Conceptual Design	TBD	--	--
Other OPC Costs	TBD	--	--
Contingency	TBD	--	--
Total, OPC	TBD	--	--
Contingency, OPC	TBD	--	--
Total Project Cost	TBD	--	--
Total Contingency (TEC+OPC)	TBD	--	--

5. Schedule of Appropriations Requests

(Dollars in Thousands)

Request Year	**Type**	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022**	**Outyears**	**Total**
FY 2021	TEC	--	--	262,000	-	-	TBD

	OPC	65,000	100,000	33,000	-	-	TBD
	TPC	65,000	100,000	295,000	-	-	TBD
FY 2022	TEC	--	--	2,000	90,000	TBD	TBD
	OPC	65,000	65,000	43,000	55,000	TBD	TBD
	TPC	65,000	65,000	45,000	145,000	TBD	TBD

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	TBD
Expected Useful Life (number of years)	TBD
Expected Future Start of D&D of this capital asset (fiscal quarter)	TBD

Related Funding Requirements

(Budget Authority in Millions of Dollars)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations and Maintenance	--	TBD	--	TBD

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at selected DOE laboratory	up to 325,000
Area of D&D in this project at selected DOE laboratory	0
Area at selected DOE laboratory to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Area of D&D in this project at other sites	0
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Total area eliminated	0

8. Acquisition Approach

The Versatile Test Reactor (VTR) is a Hazard Category 1 nuclear facility and design and construction must be integrated with ongoing nuclear operation activities at a designated national laboratory. Design and construction must also be coordinated/integrated with nuclear research and development programs to ensure mission objectives are met. The VTR is anticipated to follow a design-build project delivery method utilizing a cost-plus incentive fee contract, with the incentives contingent upon successfully meeting project deliverables.

Infrastructure

Overview

Infrastructure consists of the Idaho National Laboratory (INL) Facilities Operations and Maintenance (IFM), ORNL Nuclear Facilities O&M, the Research Reactor Infrastructure (RRI), and Construction subprograms.

The mission of the IFM subprogram is to manage the planning, acquisition, operation, maintenance, and disposition of the Office of Nuclear Energy (NE) owned multi-program nuclear facilities and capabilities along with its supporting infrastructure at INL. The IFM subprogram maintains Department of Energy (DOE) mission-supporting facilities and capabilities at the INL in a safe, compliant status (with DOE Orders, federal laws and regulations, and state agreements) to enable technological advancement in the existing nuclear fleet, advanced reactor pipeline, and fuel cycle mission areas. The availability of these key facilities and capabilities to support NE research and development (R&D) is critical to the ongoing effort to revitalize nuclear energy in the United States (U.S.). INL facilities and capabilities also support testing of naval reactor fuels and reactor core components and a diverse range of national security technology programs that support the National Nuclear Security Administration (NNSA) and other federal agencies such as the Department of Homeland Security (DHS) in the areas of critical infrastructure protection, nuclear nonproliferation, and incident response. The IFM subprogram integrates and closely coordinates with research programs to ensure proper alignment and prioritization of infrastructure investments, as well as infrastructure availability for programmatic work.

In FY 2021, INL continued to address climate risks and vulnerabilities per the Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, such as deployed, where applicable, low carbon use technologies for legacy equipment, LED lighting to reduce energy usage, transportation-fuels efficiency. INL is also following the Guiding Principles for Sustainable Federal Buildings by prioritizing the use of efficient, low-carbon technologies for new construction including installing water meters on all new buildings to monitor and trend water consumption and savings.

The RRI subprogram supports the continued operation of U.S. university research reactors by providing university research reactor fuel services, as well as maintenance of, and safety upgrades to, supporting fuel fabrication equipment and facilities.

The Construction subprogram plays a critical role in revitalizing the NE infrastructure. The subprogram focuses on addressing identified gaps created by either deteriorating critical infrastructure or evolving NE missions.

Highlights of the FY 2022 Budget Request

The focus of IFM subprogram activities remains on the safe and compliant operation of the INL's nuclear research reactor and non-reactor nuclear and radiological research facilities while continuing to realize improvements in the condition of aging INL infrastructure. In FY 2022, the increase in IFM subprogram budget supports:

- Reliability improvements to keep facilities at INL operational to support NE's research and advanced fuel development missions. This includes infrastructure investments in the ATR Complex and MFC facilities including the Transient Reactor Test (TREAT) facility.
- Resuming ATR operations following completion of the ATR Core Internals Change-out (CIC) with a goal of 161 irradiation days in FY 2022. The CIC is an extended, six to nine months, outage which occurs every 10 to 20 years to replace components within the high-flux region of the reactor core including the Beryllium reflectors, and to complete maintenance on critical balance of plant equipment.

In FY 2022, the Research Reactor Infrastructure (RRI) subprogram provides project management, technical support, quality engineering and inspection, and nuclear material support to 25 research reactors located at 24 U.S. universities. Major program deliverables include:

- procuring new plate fuel elements and shipping them to select universities;
- transporting used fuels from U.S. universities to a DOE site (e.g., Fuel used at the University of Texas at Austin and at Pennsylvania State University is placed into storage at those universities);
- procuring High Assay Low Enriched Uranium (HALEU) feedstock and shipping it to the Training, Research, Isotopes, General Atomics (TRIGA) Fuel Fabrication Facility (TFFF) in Romans, France, which completed major equipment and safety process upgrades to the TFFF in FY 2021 required by French safety authority to support commencement of commercial production in FY 2022;
- applying $3.5 million of FY 2022 funds to TRIGA fresh fuel orders to meet the increased fresh fuel requests from the 12 TRIGA research reactors located at U.S. universities and to take advantage of the significant fuel cost discount provided to the Department of Energy (DOE); and
- shipping used plate and TRIGA reactor fuel elements from supported universities to DOE used fuel receipt facilities while also reusing lightly-irradiated TRIGA fuel currently in the DOE inventory and evaluating additional alternative sources

In FY 2022, the Construction subprogram funds the continuation of the Sample Preparation Laboratory (SPL) project consistent with the approved project baseline. FY 2022 is the peak year of SPL construction activities and the Budget Request reflects the completion of the exterior building structure and initiation of major building system installations, such as HVAC, hot cell, glove boxes, and cranes. The Budget Request also supports procurement and receipt of scientific equipment including X-ray Photoelectron Instrument, Focused Ion Beam, dual arm Robot for Mechanical Properties Test Cell, digital microscopes and other specialized scientific equipment.

Infrastructure
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Infrastructure					
INL Facilities Operations and Maintenance[1]	280,000	280,000	300,000	+20,000	+7%
ORNL Nuclear Facilities O&M	20,000	20,000	0	-20,000	-100%
Research Reactor Infrastructure	9,000	11,500	15,000	+3,500	+30%
Construction: Sample Preparation Laboratory	25,450	26,000	41,850	+15,850	+61%
Total, Infrastructure	**334,450**	**337,500**	**356,850**	**+19,350**	**+6%**

[1] Funding does not reflect the transfer of approximately $88.5M in FY 2020 and $91M in FY 2021 from Naval Reactors for maintenance and operation of the Advanced Test Reactor.

Infrastructure
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
INL Facilities Operations and Maintenance:	
The increase from $280,000,000 to $300,000,000 reflects full support for the ongoing efforts to improve the reliability and availability of the Advanced Test Reactor (ATR) and key Materials and Fuels Complex (MFC) nuclear facilities through risk-based investments in equipment and infrastructure, such as canal bulkhead replacement, primary coolant system check valves replacement, low pressure air system replacement, hot cell window replacements, manipulator upgrades, and HVAC replacements.	**+20,000**
ORNL Nuclear Facilities O&M:	
The decrease from $20,000,000 to $0 reflects completion of one-time congressionally directed nuclear infrastructure activities.	**-20,000**
Research Reactor Infrastructure:	
The increase from $11,500,000 to $15,000,000 reflects additional Training, Research, Isotopes, General Atomics (TRIGA) fresh fuel orders to ensure a maximum number of fuel elements per year can be purchased, resulting in the lowest average price per element to obtain the 668 fuel elements within 10 years, representing the identified lifetime need for the 12 U.S. university TRIGA research reactors.	**+3,500**
Construction:	
The increase from $26,000,000 to $41,850,000 reflects the continuation of Sample Preparation Laboratory (SPL) project consistent with approved baselines. The Budget Request provides for the completion of the exterior building structure and initiation of major building system installations such as HVAC, hot cell, glove boxes, and cranes. The Budget Request also supports procurement and receipt of scientific equipment including X-ray Photoelectron Instrument, Focused Ion Beam, dual arm Robot for Mechanical Properties Test Cell and digital microscopes.	**+15,850**
Total, Infrastructure	**+19,350**

INL Facilities Operations and Maintenance

Description

INL Nuclear Research Reactor Operations and Maintenance

This subcategory supports nuclear research reactor operations and maintenance at the Advanced Test Reactor (ATR) Complex and the Materials and Fuels Complex (MFC) for the Idaho National Laboratory (INL), including the ATR, the ATR Critical Facility (ATRC), the Transient Reactor Test Facility (TREAT), and the Neutron Radiography Reactor (NRAD).

The ATR is the primary research reactor at the INL. The ATR supports the majority of the Office of Nuclear Energy (NE) research and development (R&D) programs, as well as Naval Reactors (NR) Program in support of the U.S. Navy nuclear fleet and National Nuclear Security Administration (NNSA) programs. The ATR is also used by universities, laboratories, and industry, and is the primary scientific capability of the Nuclear Science User Facilities (NSUF). R&D demand for thermal neutron irradiation at ATRC and neutron radiography and small component test irradiation at NRAD continues to be significant. The TREAT reactor, an air-cooled thermal spectrum test facility, continues to address technical challenges for reactor fuels related to nuclear-fuel performance and qualification. All programmatic work is funded by the sponsoring federal programs. The cost to other users is determined in accordance with the Department of Energy (DOE) regulations and depends upon the demands on the reactor and the nature of the user.

To satisfy the irradiation needs of ATR users, efforts will continue in FY 2022 to improve the availability and reliability of the ATR. The condition of ATR is expected to improve after the completion of the ATR Core Internals Change-out (CIC) in FY 2022, but continued investments are needed to sustain these gains and achieve predictable performance each year. In FY 2020, strategic investments led the ATR to achieve 167 irradiation days of a total planned 192 days, resulting in a cumulative operating efficiency of 87%, above the performance measure target of 80%. ATR investment scope is reanalyzed annually using a risk-informed approach to prioritize the necessary plant, equipment, and experimental loop replacements and refurbishments. In FY 2020 and FY 2021, ATR made significant progress in implementing the ATR Plant Health Investment Strategy. Accomplishments included replacement of ATRC Magnet Cans and Actuators, initiation of a multi-year cable management plan, refurbishment of Deep Well #3 spare motor, replacement of the diesel fuel oil distribution system, replacement of Neutron level Channel A and Wide Range Neutron Level Channels A & C, refurbishment and installation of the M-9 Primary Control Pump motor, replacement of lower Emergency Firewater Injection System (EFIS) check valves and upper EFIS level control valves, replacement of 30-ton crane, replacement of M-10 emergency cooling pump, and upgrade of Digital Radiation Monitoring System. The ATR CIC, started in FY 2021, will complete in FY 2022.

Transient testing operations at TREAT will continue in FY 2022 supporting a wide range of customers including NE R&D programs, commercial industry, and other Federal Agencies. FY 2020 and FY 2021 accomplishments include performing transient testing for a range of users, such as Accident Tolerant Fuels testing; and replacement and modernization of the automatic reactor control system.

INL Non-Reactor Nuclear Research Facility Operations and Maintenance

This subcategory provides funding for operations, maintenance, and support for non-reactor nuclear and radiological research facilities primarily located at the Materials and Fuels Complex (MFC). Activities within this category support sustainment of unique nuclear and radiological capabilities that are required to support essential research and development (R&D) programs of NE. Work scope focuses on maintaining a safe operating envelope by conducting maintenance (preventative and corrective) and refurbishments to sustain or improve core infrastructure capabilities. The non-reactor nuclear research facilities support core programmatic research capabilities including:

- Post-Irradiation Examination (PIE) and Fresh Fuel Characterization – Receipt of irradiated fuels and materials, non-destructive examinations, destructive examinations and analyses, and mechanical testing of highly radioactive materials.

- Experimental Fuel Fabrication – Glovebox lines, fume hoods, and hot cell capabilities; unique fabrication capabilities; and instrumentation and testing equipment that supports research and development (R&D) on multiple fuel types and hazard levels.
- Advanced Separation and Waste Forms – Separation and pre-treatment technology development and electrochemical separation and waste form development (engineering scale).

Funding is provided to ensure facility availability and equipment reliability at Materials and Fuels Complex (MFC) is as high as feasible to enable research and development activities. In FY 2020, in part due to addressing legacy equipment and facility issues, cumulative facility availability for the MFC was 89%, achieving the performance measure target of 80%. In FY 2021, investments continued in the MFC facilities and equipment to ensure achievement of facility performance target.

In FY 2022, MFC Plant Health investments will continue to focus on improving availability and throughput in MFC mission facilities. FY 2020 and FY 2021 accomplishments included replacing or upgrading the heating, ventilation and air-conditioning systems (HVAC) at Analytical Laboratory (AL) and Advanced Fuels Facility; renovating AL interior laboratory space; continuing campaigns to replace manipulators in the Hot Fuels Examination Facility (HFEF), Fuel Conditioning Facility (FCF) and AL; replacing the HFEF diesel generators; fabricating a manipulator repair enclosure for the Irradiated Materials Characterization Laboratory (IMCL); continuing electro-mechanical manipulator refurbishment in the HFEF and FCF; and continuing campaigns to replace hot cell windows in HFEF.

This subprogram also provides funding for the management of NE-owned special nuclear material (SNM), operation and maintenance of the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility and Radioactive Waste Scrap Facility (RSWF), and Other Project Costs (OPCs) for the Sample Preparation Laboratory (SPL) Project.

<u>INL Engineering and Support Facility Operations and Maintenance</u>

This subcategory provides funds for the community and technical support activities including support for the Shoshone-Bannock Tribes, Idaho Department of Environment Quality, and Nuclear Regulatory Commission cask certifications. This subcategory also funds Payment in Lieu of Taxes (PILT), Institute of Nuclear Power Operations, and other Departmental cross-cutting infrastructure reporting requirements.

DOE has had a formal relationship via an Agreement in Principle (AIP) with the Shoshone-Bannock Tribes since 1992 in recognition of the Tribes' connection and vested interest in the land upon which INL is located. Support is provided to the Tribes to participate in the review of Environmental Impact Statement and Environmental Assessments, cultural resource surveys and protection, environmental surveillance, and emergency response and preparedness.

<u>INL Regulatory Compliance</u>

This subcategory supports activities for continual compliance with the State and Federal environmental laws and other regulations that are under the purview of the Office of Nuclear Energy (NE). Compliance activities focus on air, soil, and water monitoring and waste disposal consistent with Federal and State permit requirements and agreements such as the Idaho National Laboratory (INL) Site Treatment Plan. Regulatory activities also include efforts that support compliance with the 1995 Settlement Agreement with the State of Idaho, which governs management and disposition of spent nuclear fuel and transuranic wastes at the INL. In November 2019, the Department of Energy (DOE) and the State of Idaho signed a Supplemental Agreement to the 1995 Idaho Settlement Agreement that reaffirms DOE's and Idaho's commitment to remove Cold War legacy waste and special nuclear materials from Idaho. The FY 2022 Budget Request provides increased support for activities associated with meeting the schedules and milestones under the Idaho Settlement Agreement. This subprogram also supports environmental surveillance and monitoring activities in accordance with State and Federal regulations; material stabilization; and legacy material packaging consistent with approved plans. FY 2020 and FY 2021 accomplishments included receipt of shipments of Experimental Breeder Reactor II (EBR-II) material at the Fuel Conditioning Facility (FCF) (9 shipments in FY 2020 and 12 in FY 2021) and processing of EBR-II material in the Mark IV electro-refiner (6 batches in FY 2021 and 7 batches in FY 2022).

INL Facilities Operations and Maintenance

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
INL Nuclear Research Reactor Operations and Maintenance $116,900,000	**$120,537,000**	**+$3,637,000**
• Maintain an Advanced Test Reactor (ATR) availability greater than 80% with a target of 60 irradiation days prior to beginning the core internals change-out (CIC). • Continue investments to improve ATR availability and reliability through refurbishments and replacements of reactor systems and components such as 670-E-80 motor control center replacement, M-10 Emergency Cooling Pump replacement, and the Digital Radiation Monitoring System upgrade. • Initiate the ATR CIC to replace major internal components including the Beryllium reflectors. • Complete major ATR reactor inspections including the reactor vessel weld and tank chain. • Continue transient testing base operations at the Transient Reactor Test Facility (TREAT). • Continue operations of the Neutron Radiography Reactor (NRAD).	• Maintain an ATR availability greater than 80% with a target of 161 irradiation days following the completion of the CIC. • Continue investments to improve ATR availability and reliability through refurbishments and replacements of reactor systems and components such as 670-E-28 M-11 Emergency Cooling Pump motor controller replacement and canal bulkhead replacements. • Complete the ATR CIC to replace major internal components including the Beryllium reflectors and resume regular ATR operations. • Continue inspections of underground piping systems. • Continue transient testing operations at the TREAT facility. • Continue operations of the NRAD.	• The increase supports full funding for ongoing efforts to improve the reliability and availability of the ATR through a risk-based prioritization of plant, equipment, and experimental loop investments, such as replacement of canal short bulkheads, primary coolant system check valves and low air pressure system, and inspections of underground piping systems.
INL Non-Reactor Nuclear Research Facility Operations and Maintenance $145,845,041	**$161,243,000**	**+$15,397,959**
• Operate and maintain Materials and Fuels Complex (MFC) infrastructure, facilities, and equipment to support facility operations and programmatic work activities. • Perform maintenance and refurbishment activities within the MFC nuclear facilities and infrastructure consistent with the approved safety basis. • Perform maintenance and refurbishment on the radiological and balance-of-plant facilities	• Operate and maintain MFC infrastructure, facilities, and equipment to support facility operations and programmatic work activities. • Perform maintenance and refurbishment activities within the MFC nuclear facilities and infrastructure consistent with the approved safety basis. • Perform maintenance and refurbishment on the radiological and balance-of-plant facilities	• The increase supports full funding for improving the reliability and availability of key MFC nuclear facilities through a risk-based prioritization of plant and equipment investments, such as replacement of manipulators and windows at Hot Fuels Examination Facility (HFEF), Fuel Conditioning Facility (FCF), and Analytical Laboratory (AL), replacement of hot cell HEPA filters and

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
necessary to support the Materials and Fuels Complex (MFC) nuclear facilities and core missions. • Continue off-site disposition of surplus Nuclear Energy (NE)-owned special nuclear material (SNM) consistent with programmatic needs and approved nuclear material allotment forecasts. • Operate and maintain the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility to provide legacy and new-generated waste disposal capability. • Conduct construction oversight activities for the Sample Preparation Laboratory (SPL) Project.	necessary to support the MFC nuclear facilities and core missions. • Continue off-site disposition of surplus NE-owned SNM consistent with programmatic needs and approved nuclear material allotment forecasts. • Operate and maintain the RHLLW Disposal Facility to provide legacy and newly - generated waste disposal capability. • Conduct construction oversight activities for the SPL Project. • Continue MFC infrastructure investments to improve reliability and availability of key facilities, such as hot cell window and manipulator replacements at Hot Fuels Examination Facility (HFEF), Fuel Conditioning Facility (FCF), and Analytical Laboratory (AL).	chiller at HFEF, and replacement of HVAC throughout MFC.
INL Engineering and Support Facility Operations and Maintenance $7,579,959	**$5,000,000**	**-$2,579,959**
• Continue to support activities to maintain operations at Idaho National Laboratory (INL) such as Nuclear Regulatory Commission (NRC) certificates for casks, Payment in Lieu of Taxes (PILT), and environmental monitoring to support State requirements.	• Continue to support activities to maintain operations at the INL such as NRC certificates for casks, PILT, and community support activities for local Shoshone-Bannock Tribes including review of Environmental Impact Statement and Environmental Assessments, cultural resource surveys and protection, environmental surveillance, and emergency response and preparedness. • Continue to support various Departmental cross-cutting infrastructure reporting requirements.	• The decrease reflects the transition of environmental surveillance and monitoring activities from federal contracts to Idaho National Laboratory (INL) under INL Regulatory Compliance.
INL Regulatory Compliance $9,675,000	**$13,220,000**	**+$3,545,000**
• Continue regulatory compliance program management. • Meet Idaho National Laboratory (INL) Site Treatment Plan milestones for treatment of two cubic meters of Mixed Low-Level Waste (MLLW) annually based on a three-year rolling average.	• Continue regulatory compliance program management. • Meet INL Site Treatment Plan milestones for treatment of two cubic meters of MLLW annually based on a three-year rolling average.	• The increase reflects funding for environmental surveillance and monitoring activities in accordance with State and Federal regulations, and increased support for activities associated with meeting the schedules and milestones under the Idaho Settlement Agreement.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Complete a minimum of 12 transfers of used nuclear fuel from wet storage in accordance with the 1995 Idaho Settlement Agreement and consistent with material requirements for the treatment of Experimental Breeder Reactor II (EBR-II) used nuclear fuel. • Process a minimum of 7 treatment batches of EBR-II fuel through the Fuel Conditioning Facility's pyro-processing equipment. • Continue to coordinate activities and operations for the direct shipment of EBR-II fuel from the Idaho Nuclear Technology and Engineering Center to the Materials and Fuels Complex.	• Complete a minimum of 12 transfers of used nuclear fuel from wet storage in accordance with the 1995 Idaho Settlement Agreement and consistent with material requirements for the treatment of EBR-II used nuclear fuel. • Process a minimum of 8 treatment batches of EBR-II fuel through Fuel Conditioning Facility (FCF) pyro-processing. • Continue to coordinate activities and operations for the direct shipment of EBR-II fuel from the Idaho Nuclear Technology and Engineering Center to the Materials and Fuels Complex. • Conduct environmental surveillance and monitoring activities.	

ORNL Nuclear Facilities O&M

Description

Consistent with congressional direction, this program provided funds in FY 2020 and FY 2021 to support Oak Ridge National Laboratory (ORNL) hot cells. In FY 2022, the Office of Nuclear Energy use of these ORNL facilities is fully funded through associated program budgets.

ORNL Nuclear Facilities O&M

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Oak Ridge Nuclear Infrastructure $20,000,000	**$0**	**-$20,000,000**
• Maintain/replace critical hot cell equipment and infrastructure to assure the Oak Ridge National Laboratory (ORNL) facilities continue to meet safety standards. • Manage hot cell infrastructure to applicable regulations, DOE Orders and Directives, including documented safety analyses, nuclear criticality safety analyses, nuclear material inventory management, radiological protection and industrial safety, waste disposal, staff training, and integrated safety management. • Perform preventative and corrective maintenance and repair of infrastructure, equipment, and components.	• No funding is requested.	• Funding is allocated through facility use charges applied to NE R&D programs utilizing ORNL hot cell capabilities.

Research Reactor Infrastructure

Description

The Research Reactor Infrastructure (RRI) subprogram provides fresh reactor fuel to, and removes used fuel from, 25 operating university research reactors to support their continued operation. This provides continued research and training reactor capability to U.S. universities to ensure their continued ability to support U.S. nuclear energy initiatives in the areas of research, development, and educational opportunities.

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

The RRI subprogram provides project management, technical support, quality engineering and inspection, and nuclear material support to 25 research reactors located at 24 U.S. universities. Major program deliverables include procuring new plate fuel elements and shipping them to select universities; transporting used fuels from U.S. universities to a DOE site; procuring High Assay Low Enriched Uranium (HALEU) and shipping it to the Training, Research, Isotopes, General Atomics (TRIGA) Fuel Fabrication Facility (TFFF) in Romans, France, for fabrication of TRIGA fuel and procuring new TRIGA fuel elements from the TFFF; and reusing lightly-irradiated TRIGA fuel currently in inventory at INL by retrieving, inspecting and shipping it to universities with the most urgent need. Major equipment and safety process upgrades to the TFFF, required by French safety authority, were completed in FY 2021 and commercial production will start in FY 2022. To meet the increased fresh fuel requests from the 12 TRIGA research reactors located at U.S. universities, and to take advantage of the significant fuel cost discount provided to the Department, the RRI program applies $3.5 million in FY 2022 to TRIGA fresh fuel orders. The RRI subprogram also ships used plate and TRIGA reactor fuel elements from supported universities to DOE used fuel receipt facilities. The Department will continue its policy, initiated in FY 2017, of reusing lightly-irradiated TRIGA fuel in the DOE inventory and evaluate additional alternative sources.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Request
Research Reactor Infrastructure $11,500,000	**$15,000,000**	**+$3,500,000**
• Procure 40 and deliver between 33 and 36 plate fuel elements required annually by University of Missouri (MURR) and Massachusetts Institute of Technology (MIT) as determined by need and fuel availability. • As needed, ship up to two cask loads of lightly-irradiated 8.5 wt% standard Training, Reactor, Isotope, General Atomics (TRIGA) fuel elements from the Irradiated Fuel Storage Facility at Idaho National Laboratory (INL) to select U.S. university research reactor facilities. • Procure and ship high assay low enriched uranium (HALEU) metal to the TRIGA International fuel fabrication facility (TFFF) in Romans, France to support procurement of up to 65 TRIGA fuel elements upon resumption of operations, and ship fuel elements to TRIGA reactor facilities as determined by need and fuel availability. • Complete up to 5 used fuel shipments to Savannah River Site (SRS) and the INL, pending resolution of moratorium on such shipments to the INL. • Continue Research Reactor Infrastructure (RRI) project management, quality assurance, nuclear material accountability, and transportation cask maintenance.	• Procure 40 and deliver between 33 and 36 plate fuel elements required annually by MURR and MIT as determined by need and fuel availability. • As needed, ship up to two cask loads of lightly-irradiated 8.5 wt% standard TRIGA fuel elements from the Irradiated Fuel Storage Facility at INL to select U.S. university research reactor facilities. • Procure up to 90 TRIGA fuel elements annually after the first year from TFFF. Due to COVID, there were delays in completing upgrades to the TFFF, gathering documentation from vendors to support the French regulator review, and significant increased time for the French regulator to complete their review. Therefore, fuel procurement will start in late FY 2021 or early FY 2022. • As needed, procure and ship HALEU metal to the TFFF in Romans, France, to support procurement of TRIGA fuel elements, and ship fuel elements to TRIGA reactor facilities as determined by need and fuel availability. • Complete up to 5 used fuel shipments to SRS and the INL, pending resolution of moratorium on such shipments to the INL. • Continue RRI project management, quality assurance, nuclear material accountability, and transportation cask maintenance.	• Reflects additional TRIGA fresh fuel orders to ensure a maximum number of fuel elements per year can be purchased, resulting in the lowest average price per element to obtain the 668 fuel elements identified as the lifetime required fuel supply for the 12 U.S. university TRIGA research reactors within 10 years.

Construction

Description

Line-item capital projects are sometimes required at the Idaho National Laboratory (INL) to maintain its ability to support mission goals. These projects help achieve the Department's and the Office of Nuclear Energy's (NE) strategic objectives by maintaining site services and providing critical information for future decisions. This activity is focused on two primary objectives: (1) identification, planning, and prioritization of projects required to meet NE program objectives, and (2) development and execution of these projects within approved cost and schedule baselines as such projects are deemed necessary. While the Department's acquisition management process does not guarantee that a project will be completed once the initial information gathering and preliminary design phase are complete, it does provide an important decision-making framework that, when well executed, allows only the most critically necessary, cost-effective projects to proceed to construction.

The Sample Preparation Laboratory (SPL) project is a line item capital project that will provide the capability for sample preparation to support micro-/nano-scale structural, chemical, mechanical, and thermal properties analyses. This capability will augment non-destructive examination, elemental analysis, and radiological capabilities already present or being developed at INL. The SPL will, when coupled with existing facilities and recapitalization efforts, fulfill near-term capabilities for conducting the advanced post-irradiation examination needed to improve understanding of nuclear fuels and material performance at the micro-, nano-, and atomic scales.

The most recent SPL Department of Energy Order (DOE O) 413.3B Critical Decision (CD), CD-1R/2/3 (Reaffirm Alternative Selection Process, Approve Performance Baseline, and Approve Start of Construction), was approved on January 31, 2020 with a Total Project Cost (TPC) of $166,000,000 and CD-4, Approve Project Completion, in FY 2027.

The FY 2022 Budget Request for the SPL project is $41,850,000. FY 2022 is the peak year of SPL construction activities and the Budget Request reflects the completion of the exterior building structure and initiation of major building system installations such as HVAC, hot cell, glove boxes, and cranes. The Budget Request also supports procurement and receipt of scientific equipment including X-ray Photoelectron Instrument, Focused Ion Beam, dual arm Robot for Mechanical Properties Test Cell, digital microscopes and other specialized scientific equipment.

Construction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Construction $26,000,000	**$41,850,000**	**+$15,850,000**
Sample Preparation Laboratory (16-E-200) ($26,000,000) • Funding continues Sample Preparation Laboratory (SPL) construction activities, such as: equipment and hardware procurement; hot cell liner fabrication; concrete stair and elevator core construction; concrete shear wall construction; and hot cell window delivery.	*Sample Preparation Laboratory (16-E-200) ($41,850,000)* • Continue SPL construction activities consistent with approved baseline. The Budget Request reflects the completion of the exterior building structure and initiation of major building system installations, such as HVAC, hot cell, glove boxes, and cranes. The Budget Request also supports procurement and receipt of scientific equipment including X-ray Photoelectron Instrument, Focused Ion Beam, dual arm Robot for Mechanical Properties Test Cell and digital microscopes.	*Sample Preparation Laboratory (16-E-200) (+$15,850,000)* • The increase is to meet established baseline funding requirements consistent with the Project Data Sheet.

Infrastructure
Construction Projects Summary ($K)

	Total	Prior Years	FY 2020 Enacted	FY 2020 Actuals	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
16-E-200, Sample Preparation Laboratory, INL							
Total Estimated Cost (TEC)	144,600	44,000	25,450	25,450	26,000	41,850	+15,850
Other Project Costs (OPC)	21,400	4,647	0	0	500	2,500	+2,000
Total Project Cost (TPC) Project Number 16-E-200	**166,000**	**48,647**	**25,450**	**25,450**	**26,500**	**44,350**	**+17,850**
Total All Construction Projects							
Total Estimated Cost (TEC)	144,600	44,000	25,450	25,450	26,000	41,850	+15,850
Total Other Project Costs (OPC)	21,400	4,647	0	0	500	2,500	+2,000
Total Project Cost (TPC) All Construction Projects	**166,000**	**48,647**	**25,450**	**25,450**	**26,500**	**44,350**	**+17,850**

16-E-200, Sample Preparation Laboratory
Idaho National Laboratory
Project is for Design and Construction

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

Summary
The FY 2022 Budget Request for the Sample Preparation Laboratory (SPL) project is $41,850,000. The most recent Department of Energy Order (DOE O) 413.3 B Critical Decision (CD), CD-1R/2/3 (Reaffirm Alternative Selection Process, Approve Performance Baseline, and Approve Start of Construction), was approved on January 31, 2020 with a Total Project Cost (TPC) of $166,000,000 and CD-4, Approve Project Completion, in FY 2027.

Capital funding requested in FY 2022 continues project construction activities including completion of the exterior building structure and initiation of major building system installations, such as HVAC, hot cell, gloveboxes, and facility cranes. FY 2022 funding will also support procurement and receipt of scientific facility equipment including X-ray Photoelectron Instrument, Focused Ion Beam, dual arm Robot for Mechanical Properties Test Cell, and digital microscopes.

A Level II Federal Project Director (FPD) has been assigned to this project, and their Level III certification is in progress.

Significant Changes
This Construction Project Data Sheet (CPDS) is an update of the FY 2021 CPDS and does not include a new start for FY 2022.

Critical Milestone History

(Fiscal Quarter or Date)

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	Final Design Complete	CD-1R/2/3	D&D Complete	CD-4
FY 2016	1/31/2011	4Q FY2014	3Q FY2015	TBD	TBD	TBD	TBD
FY 2017	6/18/2015	1Q FY2016	1Q FY2016	TBD	TBD	N/A	TBD
FY 2018	6/18/2015	8/31/2016	9/30/2016	TBD	TBD	N/A	TBD
FY 2019	6/18/2015	8/31/2016	9/30/2016	TBD	TBD	N/A	TBD
FY 2020	6/18/2015	8/31/2016	9/30/2016	TBD	TBD	N/A	TBD
FY 2021	6/18/2015	8/31/2016	9/30/2016	10/24/2018	1/31/2020	N/A	11/30/2026
FY 2022	6/18/2015	8/31/2016	9/30/2016	10/24/2018	1/31/2020	N/A	11/30/2026

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

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2016	N/A	N/A	N/A
FY 2017	N/A	N/A	N/A
FY 2018	N/A	N/A	N/A
FY 2019	N/A	N/A	N/A
FY 2020	N/A	TBD	TBD
FY 2021	1/31/2020	N/A	N/A
FY 2022	1/31/2020	N/A	N/A

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

Project Cost History

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, D&D	OPC, Total	TPC
FY 2016	10,000	68,000	78,000	17,000	0	17,000	95,000
FY 2017	10,000	73,000	83,000	12,000	0	12,000	95,000
FY 2018	13,385	72,615	86,000	12,200	0	12,200	98,200
FY 2019	13,385	72,615	86,000	12,200	0	12,200	98,200
FY 2020	13,385	72,615	86,000	12,200	0	12,200	98,200
FY 2021	9,998	134,602	144,600	21,400	0	21,400	166,000
FY 2022	9,998	134,602	144,600	21,400	0	21,400	166,000

2. Project Scope and Justification

Scope

The Sample Preparation Laboratory (SPL) will receive irradiated materials and prepare samples for micro-/nano-scale structural, chemical, mechanical, and thermal properties analyses. The improved sample preparation and analytical capabilities provided by SPL will enhance non-destructive examination, elemental, and radiological capabilities already present at the Materials and Fuels Complex (MFC).

SPL will provide the required capabilities to allow high hazard materials to be routinely prepared and tested in a safe, secure, and environmentally-controlled environment. To meet this objective, SPL was designed and will be constructed to include the following specific capabilities and characteristics:

- The facility will be a Hazard Category 3, non-reactor nuclear facility designed to meet Seismic Design Category 2, Limit State B requirements. The facility has been designed to meet stringent vibration, electrical and magnetic field, acoustic, and temperature fluctuation requirements for advanced analytical equipment with the ability to support development and deployment of equipment, instruments, and models to meet future nuclear fuel development R&D needs over a 40-year period.
- The facility will be a three-story structure encompassing approximately 49,000 ft^2, comprised of two main areas: the nuclear portion (typically referred to as the hot cell gallery) and the office/support area, constituting 35,000 ft^2 and 14,000 ft^2, respectively.
- The facility will provide a source material receiving and storage area to receive and store experiment subassemblies with lengths up to 48 inches and weighs up to 20 pounds; other source material with a diameter of less than 5 inches and weighs up to 20 pounds will be accommodated.
- The facility will include a library or prepared sample storage area with the capacity to store up to 1,800 samples.

- The facility will include a shielded cell for mechanical properties testing. The initial complement of mechanical properties testing equipment will include a mechanical properties testing load frame, a Charpy impact tester, a hardness tester, and a digital microscope.
- The facility design allocated space for eight separate instrument enclosures for deployment of advanced post-irradiation examination instruments; three of which will be shielded enclosures constructed as part of the initial facility buildout. The remaining five enclosure spaces are designated for future expansion, should there be a future decision to do so; one shielded enclosure and four non-shielded enclosures for contact-handled materials. The shielded enclosures are designed for regular manned access when radioactive samples are not present. The shielded enclosures will be flexible and reconfigurable to accommodate operational requirements for use with modern characterization instruments. The minimum initial complement of shielded examination instruments will include a scanning electron microscope, a surface science instrument, and an x-ray diffraction instrument. Additional scientific capability will be considered as risk is retired during construction.
- The facility will include space for research expansion, allowing future installation of non-shielded instrument enclosures and instruments, if a future decision is made to do so.

The initial complement of scientific instruments will be procured, modified to operate remotely through hot cell walls via telemanipulators or robotics, and tested as part of the project prior to installation in the facility. The initial complement of scientific instruments includes a scanning electron microscope, a surface science instrument (such as x-ray photoelectron spectroscopy), and micro x-ray diffraction.

The Sample Preparation Laboratory (SPL) Facility will be operated to preclude or limit introduction of alpha-emitting radioisotopes. Limitation of alpha-emitting radioisotopes will be accomplished through limitation of the types of materials that will be studied. The SPL is a separate structure, limited to receiving, processing, handling, examining, testing, storing, and packaging irradiated beta-gamma emitting materials with limited amounts of alpha contamination. In some cases, very small quantities of alpha-emitting material (i.e., fuels) may be received in the form of metallurgical mounts for examination, using unique SPL examination instruments. The sectioning and mounting of these metallurgical mounts would be performed elsewhere. The SPL will operate in conjunction with the Hot Fuel Examination Facility (HFEF), Analytical Laboratory, and Irradiated Materials Characterization Laboratory (IMCL), and offsite facilities to provide the overall capability to analyze and characterize irradiated and non-irradiated nuclear material samples. The SPL facility will not replace these facilities; it will function synergistically with them. Having most of these facilities located within a single security-protected site (i.e., MFC) supports efficient nuclear material control, security, and management.

Facility operations will include cask receipt and unloading, experiment decontamination, sample preparation (e.g., machining, grinding, and polishing), sample storage, waste packaging, and various micro-structure and thermal examinations. Majority of these operations will take place within shielded cells and enclosures due to the radioactivity of the materials handled. These include the Sample Preparation Line, the Mechanical Properties Test Cell (MPTC), and the shielded instrument rooms.

Nuclear materials and samples will be handled in containers ranging from the Battelle Energy Alliance, LLC (BEA) research reactor cask to shielded/non-shielded 55-gallon drums, incorporating a truck lock for cask and related container handling. The principal feature of the SPL design is the shielded sample preparation hot cells that include four cells with five additional stations supporting experiment handling, sizing, and grinding (two stations), decontamination/waste handling, and sample storage. Materials will be transferred to the testing and examination areas throughout the facility using a pneumatic transfer system (PTS). Samples will also be transferred within the facility and to other facilities via small shielded pigs or casks that mate to the outside of the hot cells. Samples will be appropriately shielded and confined to protect workers, equipment, and the facility.

The MPTC will be attached to the hot cells on the first floor. Material handling operations within the MPTC and enclosures will be done through robotics, rather than using traditional telemanipulators and shielded windows similar to the sample preparation line.

The remaining space on the first floor will consist of office and support areas. The second-floor design provides for an auxiliary equipment area to support the scientific instruments on the first floor. Additional research space and office areas comprise the remainder of the floor. The third floor will include the bulk of the facility service and support areas including rooms associated with equipment and instrument repair.

Key Performance Parameters (KPPs)

KPPs are defined as a vital characteristic, function, requirement, or design basis that, if changed, would have a major impact on the facility or system performance, scope, schedule, cost, risk, or the ability of an interfacing project to meet its mission requirements. The threshold KPPs represent the minimum acceptable scope for successful delivery of SPL. Achievement of KPPs will be a prerequisite for approval of CD-4. The project has identified Objective KPPs that will provide expanded capabilities to meet R&D objectives, if needed. If project performance warrants, management reserve and/or contingency funds can be allocated to Objective KPP scope or infrastructure enhancements to improve facility performance. As the project progresses, project status will be assessed, and recommendations made to the FPD regarding the potential execution of objective KPP scope. Such recommendations will consider remaining project risks and will include detailed cost and schedule performance information.

Threshold and Objective KPPs

Performance Measure	Threshold	Objective*
Construct a Hazard Category-3, non-reactor nuclear laboratory facility	Minimum of 40,000 gross square feet of laboratory/support space	N/A
Provide a shielded sample preparation capability designated for beta/gamma emitting irradiated materials	Shielded hot cell with five workstations/windows and associated equipment that support cask receipt, material handling, gross source material sizing, storage, decontamination, and fine sample preparation	N/A
Provide advanced post-irradiation examination capabilities for beta/gamma emitting irradiated materials	Three shielded scientific instrument enclosures Three advanced scientific instruments that support interior (crystal) phase characterization, fracture surface analysis, and surface science	Up to five additional advanced scientific instruments and associated facility infrastructure
Provide mechanical properties testing capabilities for beta/gamma emitting irradiated materials	Mechanical Properties Test Cell with capabilities for hardness, tensile strength, and impact testing	N/A
* SPL will be baselined to the Threshold Measure. Objective KPPs will be executed if funding is available after Threshold KPPs are achieved.		

The SPL facility will be constructed using sustainable building considerations per Department of Energy Guide 413.3-6B, dated 4-5-2020, “High Performance Sustainable Buildings.” The facility design includes provisions for meeting the 2016 and 2020 Guiding Principles for Sustainable Federal Buildings. Design, construction, and documentation of the 2016 Guiding Principles ensure compliance with DOE Order 436.1, Departmental Sustainability.

Funds appropriated under this data sheet may be used to provide independent assessments related to project planning and execution.

Justification

The behavior of fuels and materials in a nuclear reactor irradiation environment is the limiting factor in nuclear plant safety, longevity, efficiency, and economics. During the last 15 years, nano-scale (i.e., 10^{-9} meter) characterization of nonnuclear materials has become routine, with capabilities for sub-angstrom (i.e., 10^{-10}meter) investigation becoming increasingly available to researchers in other fields. An understanding of nuclear fuel and material performance in the nuclear reactor internal environment at this scale is critical to development of the innovative fuels and materials required for tomorrow’s nuclear energy systems.

Existing post-irradiation examination (PIE) and thermal and mechanical properties testing capabilities at U.S. Department of Energy (DOE) laboratories, universities, and in the private sector are widely dispersed. Current PIE capabilities serve basic needs for fuel examination, material handling, and waste disposal, but are limited in their ability to function on the micro, nano, and atomic scale. Advanced characterization of radioactive samples at nano-scale to micro-scale length resolutions will support development of modern computer codes that could enable order-of-magnitude improvements in the time and cost of developing new fuels.

The SPL facility will support a variety of programs and users by receiving irradiated nuclear materials and by preparing samples for micro-/nano-scale structural, chemical, mechanical, and thermal properties analyses. This improved sample preparation capability will enhance non-destructive examination, elemental, and radiological capabilities already present at the Materials and Fuels Complex (MFC). The SPL may also provide source material and sample storage capability. The laboratory will, when coupled with existing facilities and recapitalization efforts, fulfill near-term advanced post-irradiation capabilities necessary for conducting the advanced post-irradiation examination needed to improve understanding of nuclear fuels and materials performance at the micro-, nano-, and atomic scales. This new understanding will allow for the development of innovative fuels and materials that can be used by the nuclear energy community. Irradiation-driven phenomena can only be understood through conducting a scientific program that includes experimental irradiation testing and post-irradiation examination, materials characterization, and testing coupled with modeling and simulation.

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

3. Financial Schedule

(Dollars in Thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
Prior Years	13,385	13,385	6,517
FY 2019	0	0	3,471
FY 2020	0	0	0
FY 2021	0	0	0
FY 2022	0	0	0
Outyears	0	0	0
Construction			
Prior Years	615	615	0
FY 2019	30,000	30,000	0
FY 2020	25,450	25,450	19,277
FY 2021	26,000	26,000	38,396
FY 2022	41,850	41,850	53,130
Outyears	TBD	TBD	TBD
Total Estimated Costs (TEC)			
Prior Years	14,000	14,000	6,517

	Budget Authority (Appropriations)	Obligations	Costs
FY 2019	30,000	30,000	3,471
FY 2020	25,450	25,450	19,277
FY 2021	26,000	26,000	38,396
FY 2022	41,850	41,850	53,130
Outyears	TBD	TBD	TBD
Total TEC	**144,600**	**144,600**	**144,600**

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Costs			
Prior Years	4,647	4,647	2,756
FY 2019	0	0	1,139
FY 2020	0	0	740
FY 2021	500	500	512
FY 2022	2,500	2,500	2,464
Outyears	TBD	TBD	TBD
Total OPC	21,400	21,400	21,400
Total Project Costs (TPC)			
Prior Years	18,647	18,647	9,273
FY 2019	30,000	30,000	4,610
FY 2020	25,450	25,450	20,017
FY 2021	26,500	26,500	38,908
FY 2022	44,350	44,350	55,594
Outyears	TBD	TBD	TBD
Grand Total	**166,000**	**166,000**	**166,000**

4. Details of Project Cost Estimate

(Budget Authority in Thousands of Dollars)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	9,998	10,785	9,998
Contingency	0	2,600	0
Total, Design	9,998	13,385	9,998
Construction			
Site Work	2,505	2,230	2,505
Equipment	17,878	8,545	17,878
Construction	94,237	56,840	94,237
Other, as needed	--	--	--
Contingency	19,982	5,000	19,982

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, Construction	134,602	72,615	134,602
Other TEC (if any)			
Cold Startup	--	--	--
Contingency	--	--	--
Total, Other TEC	--	--	--
Total **Estimated Cost**	144,600	86,000	144,600
Contingency, TEC	19,982	7,600	19,982
Other Project Cost (OPC)			
OPC except D&D			
R&D	0	4,220	0
Conceptual Planning	1,310	1,310	1,310
Conceptual Design	821	821	821
Other OPC Costs	15,743	4,549	15,743
Contingency	3,526	1,300	3,526
Total, OPC	21,400	12,200	21,400
Contingency, OPC	3,526	1,300	3,526
Total Project Cost	166,000	98,200	166,000
Total Contingency (TEC+OPC)	23,508	8,900	23,508

5. Schedule of Appropriation Requests

(Dollars in Thousands)

Request Year	Type	Prior Years	FY 2019	FY 2020	FY 2021	FY 2022	Outyears	Total
FY 2016	TEC	2,000	TBD	TBD	TBD	0	0	78,000
	OPC	1,847	TBD	TBD	TBD	0	0	17,000
	TPC	3,847	TBD	TBD	TBD	0	0	95,000
FY 2017	TEC	8,000	TBD	TBD	TBD	TBD	TBD	83,000
	OPC	4,647	TBD	TBD	TBD	TBD	TBD	12,000
	TPC	12,647	TBD	TBD	TBD	TBD	TBD	95,000
FY 2018	TEC	14,000	TBD	TBD	TBD	TBD	TBD	86,000
	OPC	4,647	TBD	TBD	TBD	TBD	TBD	12,200
	TPC	18,647	TBD	TBD	TBD	TBD	TBD	98,200
FY 2019	TEC	14,000	TBD	TBD	TBD	TBD	TBD	86,000
	OPC	4,647	TBD	TBD	TBD	TBD	TBD	12,200
	TPC	18,647	TBD	TBD	TBD	TBD	TBD	98,200
FY 2020	TEC	14,000	30,000	5,242	TBD	TBD	TBD	86,000
	OPC	4,647	0	0	TBD	TBD	TBD	12,200

Request Year	Type	Prior Years	FY 2019	FY 2020	FY 2021	FY 2022	Outyears	Total
	TPC	18,647	30,000	5,242	TBD	TBD	TBD	98,200
FY 2021	TEC	14,000	30,000	25,450	18,000	41,850	TBD	144,600
	OPC	4,647	0	0	2,403	2,500	TBD	21,400
	TPC	18,647	30,000	25,450	20,403	44,350	TBD	166,000
FY 2022	TEC	14,000	30,000	25,450	26,000	41,850	7,300	144,600
	OPC	4,647	0	0	500	2,500	TBD	21,400
	TPC	18,647	30,000	25,450	26,500	44,350	TBD	166,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	1Q FY 2027
Expected Useful Life (number of years)	40
Expected Future Start of D&D of this capital asset (fiscal quarter)	1Q FY 2067

Related Funding Requirements
(Budget Authority in Thousands of Dollars)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations and Maintenance	9,926	9,926	1,675,000	1,675,000

Life-cycle operations and maintenance costs include annual escalation.

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at Idaho National Laboratory	49,000
Area of D&D in this project at Idaho National Laboratory	0
Area at Idaho National Laboratory to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Area of D&D in this project at other sites	0
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Total area eliminated	0

Site location, building name or numbers, and square footages of existing facilities to be replaced: N/A

As a new Laboratory facility, the proposed SPL is not subject to Freeze the Footprint (>50% lab space).

8. Acquisition Approach

As a Hazard Category 3 nuclear facility, design and construction of the Sample Preparation Laboratory (SPL) must be integrated with ongoing nuclear operations activities. Design and construction must also be coordinated/integrated with nuclear research and development programs. A design-bid-build project delivery method managed by the Idaho National Laboratory management and operating contractor was used for the design and construction of the SPL. The SPL construction subcontract is a firm, fixed-price contract.

Idaho Sitewide Safeguards and Security

Overview

The Idaho Sitewide Safeguards and Security (S&S) program supports the Idaho National Laboratory (INL) complex nuclear facility infrastructure and enables the Office of Nuclear Energy (NE) to conduct research and development (R&D) in support of multiple program missions. The S&S program benefits the site infrastructure and users by providing the safeguards and security functions required at Department of Energy (DOE) sites to enable R&D utilizing nuclear materials and protected information. In addition to NE R&D activities, S&S enables a range of national security programs that support the National Nuclear Security Administration (NNSA) and other Federal agencies including the Department of Homeland Security (DHS) in the areas of critical infrastructure protection, nuclear nonproliferation and incident response. Safeguards and security functions, through the INL S&S program, also enable the Department of the Army, the Department of the Navy, and NNSA Naval Reactors mission activities.

The FY 2022 Budget Request provides direct funding for the INL S&S base program. Strategic Partnership Projects (SPP) will continue to fund an allocable share of the S&S program via full cost recovery. Extraordinary security requirements, such as dedicated security for special projects or exercises, will be a direct charge to DOE and SPP customers.

Highlights of the FY 2022 Budget Request

In FY 2022, the S&S program will sustain program functionality at the level necessary to assure high confidence in the protection of INL assets and a high degree of customer service by maintaining effective staffing levels, proactive preventative and corrective maintenance programs, and a robust cybersecurity program. The FY 2022 Budget Request will focus on continued implementation of physical security infrastructure investments, capital improvements, emerging security technology investments, and enhanced cybersecurity program capabilities to adequately secure site wide assets, including:

- Completing critical physical security infrastructure investments and maintaining protective force staff levels required to maintain an effective S&S program consistent with evolving Departmental requirements, including related analyses and modifications to enhance physical security infrastructure across several INL complexes;
- Supporting physical security systems life-cycle replacement including preventative and corrective maintenance on critical security systems, subsystems, and components;
- Supporting implementation of the Design Basis Threat, Departmental Orders and force-on-force exercises and equipment required to analyze and validate changes to security models that provide data for risk-informed decision making and directly test the efficacy of the protection methodology and security posture; and
- Maintaining an effective cybersecurity program through the addition of lifecycle hardware/software upgrades and replacements including continuous monitoring, maintaining Industrial Control Systems, essential cybersecurity positions and associated training.

Idaho Sitewide Safeguards and Security
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Idaho Sitewide Safeguards and Security					
Protective Forces	79,450	80,812	85,356	+4,544	+5.6%
Security Systems	10,075	10,075	11,575	+1,500	+14.9%
Security Infrastructure	21,588	16,618	5,618	-11,000	-66.2%
Information Security	4,674	4,674	6,174	+1,500	+32.1%
Personnel Security	7,714	7,714	4,714	-3,000	-38.9%
Material Control & Accountability	4,876	4,876	6,376	+1,500	+30.8%
Program Management	8,175	8,175	10,175	+2,000	+24.5%
Cybersecurity	16,856	16,856	19,812	+2,956	+17.5%
Total, Idaho Sitewide Safeguards and Security	**153,408**	**149,800**	**149,800**	**0**	**0%**

Idaho Sitewide Safeguards and Security
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Protective Forces: The increase from $80,812,000 to $85,356,000 includes costs to maintain the protective force personnel staffing consistent with Departmental protection requirements and existing labor wage agreements. Funding also supports protective force equipment, training, facilities, and management consistent with Departmental requirements and the site-wide protection strategy.	**+4,544**
Security Systems: The increase from $10,075,000 to $11,575,000 ensures the Idaho National Laboratory's (INL) ability to maintain and conduct end-of-life equipment replacements to ensure the efficacy of the site-wide security posture.	**+1,500**
Security Infrastructure: The decrease from $16,618,000 to $5,618,000 reflects the required project funds for Phase IIB offset by the completion of the consolidated training facility at the Central Facilities Area.	**-11,000**
Information Security: The increase from $4,674,000 to $6,174,000 reflects an increase to ensure compliance with newly established requirements for the management and protection of Controlled Unclassified Information (CUI) and Operations Security (OPSEC) training requirements.	**+1,500**
Personnel Security: The decrease from $7,714,000 to $4,714,000 reflects the implementation of full cost recovery for security clearance activities by requesting program organizations.	**-3,000**
Material Control & Accountability: The increase from $4,876,000 to $6,376,000 reflects investments in Material Control & Accountability (MC&A) program measuring and tracking equipment to effectively manage increases in material handling activities across the INL.	**+1,500**
Program Management: The increase from $8,175,000 to $10,175,000 reflects funding necessary to evaluate the impact of departmental security policy updates, the conduct of required vulnerability analysis that identify and evaluate potential risks, and the development of required site security operational documents.	**+2,000**

	FY 2022 Request vs FY 2021 Enacted
Cybersecurity: The increase from $16,856,000 to $19,812,000 reflects funds necessary to add additional Idaho National Laboratory (INL) staff and to provide network tools to identify, mitigate, and remediate the increasing number and sophistication of cyber-attacks on INL data and infrastructure.	+2,956
Total, Idaho Sitewide Safeguards and Security	**0**

Idaho Sitewide Safeguards and Security

Description

The Idaho Sitewide Safeguards and Security (S&S) program funds Office of Nuclear Energy (NE) base physical and cybersecurity activities for the Idaho National Laboratory (INL), providing protection of the Department of Energy's (DOE) nuclear materials, classified and unclassified matter, government property, personnel and other vital assets from theft, diversion, sabotage, espionage, unauthorized access, compromise, and other hostile acts that may cause adverse impacts on our national security; program continuity; or the health and safety of employees, the public, or the environment.

Protective Forces

Protective Forces provides security police officers (SPO's) and other specialized personnel, equipment, training, and management needed during normal and security emergency conditions for the adequate protection of site assets consistent with site security plans. Protective force personnel are deployed 24 hours a day, 7 days a week, across 890 square miles to deter, detect, delay, and respond to adversarial threats.

Security Systems

Physical Security Systems provides preventative and corrective maintenance and performance testing of intrusion detection and assessment systems, entry and search control equipment, barriers, secure storage, lighting, sensors, entry/access control devices, locks, explosives detection, and tamper-safe monitoring. Ensures 24 hours a day, 7 days a week operation of approximately 4,600 security alarms and 6,100 security locks at multiple security areas.

Security Infrastructure

Security Infrastructure provides critical security infrastructure investments and protection enhancements necessary to ensure adequate protection of assets consistent with Departmental requirements. These include, but are not limited to: upgrades, refurbishments or replacement of protective force training and muster facilities; physical security systems or equipment required by Departmental Orders, such as perimeter intrusion detection and assessment systems, closed-circuit televisions, central and/or secondary alarm stations; and other similar activities.

Information Security

Information Security provides for the protection and control of classified and sensitive matter that is generated, received, transmitted, used, stored, reproduced, and/or destroyed. The Classified Matter Protection and Control Program and Operations Security Program ensure that classified and sensitive unclassified matter is appropriately managed and adequately protected and controlled to prevent access by unauthorized individuals and that those individuals that do have access are trained to handle classified matter. Information Security executes the Technical Security Countermeasures (TSCM) program and conducts TSCM surveys.

Personnel Security

Personnel Security provides access to classified and sensitive information and assignment of personnel in sensitive positions through the clearance program, adjudication, security awareness and education, U.S. citizen and foreign visitor control, Human Reliability Program, psychological/medical assessments, and administrative review costs.

Materials Control and Accountability

Material Control & Accountability (MC&A) provides the personnel, equipment, and services required to account for and control special nuclear materials (SNM) from diversion. MC&A is accomplished through the administration of a robust formal inventory process that allows security personnel to locate and track specific quantities of SNM in real time, state of the art measurement equipment, non-destructive analysis, and a robust tamper indicating device program.

Program Management

Program Management includes policy oversight, development, and update of site security plans; vulnerability assessments and performance testing to ensure adequate protection of SNM; investigations into incidents of security concern; and issuance of security infractions. Program management also ensures activities are conducted to analyze and identify the impacts of changes to Departmental policies and requirements on the site-wide safeguards and security program. The activities completed within Program Management allow for risk-informed decision making, support a performance-based S&S program, and directly test the efficacy of the protection methodology/posture.

Cybersecurity

Cybersecurity maintains the staffing, computing infrastructure, and network security configuration necessary to support classified and unclassified information and electronic operations. Cybersecurity uses a graduated risk approach based on data sensitivity and impact of loss/compromise to ensure that electronic or computer information systems are protected in a manner consistent with upholding key priorities; including importance to national security, support of DOE missions and programs, vulnerability to threats, and the magnitude of harm that would result from an information system and industrial control systems compromise.

Idaho Sitewide Safeguards and Security

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Protective Forces $80,812,000	**$85,356,000**	**+$4,544,000**
• Provide funds for additional protective force staff to continue security infrastructure Phase IIA Implementation Plan activities consistent with the Site Security Plan, approved site labor wage agreement, and Idaho National Laboratory (INL) cost model, including associated training activities and facilities required to maintain protective force qualifications. • Provide funding to purchase Protective Force equipment such as ammunition, weapons, protective gear and vehicles.	• Provides funds for protective force staff, including support to initiate security enhancement Phase IIB Implementation Plan protective force staffing requirements consistent with the Site Security Plan, approved site labor wage agreement, and INL cost model, including associated training activities and facilities required to maintain protective force qualifications. • Provides funding to purchase Protective Force equipment such as ammunition, weapons, protective gear and vehicles.	• Increase reflects funds to support for security enhancement Phase IIB Implementation Plan protective force staffing requirements consistent with the approved strategy to implement Departmental security requirements.
Security Systems $10,075,000	**$11,575,000**	**+$1,500,000**
• Provide full funding for staff and equipment to plan and conduct preventative and corrective maintenance on physical security systems across multiple security areas. • Support the operation of the INL central alarm stations, development and modification of security alarm systems and life cycle replacement of systems.	• Provides full funding for staff and equipment to plan and conduct preventative and corrective maintenance on physical security systems across multiple security areas. • Supports the operation of INL central alarm stations, development and modification of security alarm systems and life cycle replacement of systems.	• The increase reflects funds to ensure the INL's continued ability to respond to changes in departmental directives and to maintain the efficacy of the site-wide security posture.
Security Infrastructure $16,618,000	**$5,618,000**	**-$11,000,000**
• Provide funds to initiate planning activities in support of Implementation Plan Phase IIB activities including the performance of design work, construction, and related analyses required by Departmental Orders. These modifications are in support of the multi-year effort to enhance physical security infrastructure across several INL complexes, as approved by the Department. • Provide funds for internet pipeline infrastructure upgrades required to maintain security controls on the increased capacity and meet protection requirements.	• Supports continued work on Implementation Plan Phase IIB activities including the performance of design work, construction, and related analyses required by Departmental Orders. These modifications are in support of the multi-year effort to enhance physical security infrastructure across several INL complexes, as approved by the Department.	• Reflects completion of the consolidated training facility at the Central Facilities Area offset by Phase IIB project requirements.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Information Security $4,674,000	**$6,174,000**	**+$1,500,000**
• Provide funds to implement information security activities to protect classified and sensitive unclassified matter including Classified Matter Protection and Control, Technical Surveillance Countermeasures, Classification/Declassification, and Operations Security programs.	• Provides funds to implement information security activities to protect classified and sensitive unclassified matter including Classified Matter Protection and Control, Technical Surveillance Countermeasures, Classification/Declassification, and Operations Security programs.	• The increase reflects funds that are necessary to ensure compliance with newly established requirements for the management and protection of Controlled Unclassified Information (CUI) to includes Operations Security (OPSEC) training requirements.
Personnel Security $7,714,000	**$4,714,000**	**-$3,000,000**
• Provide funding for federal and contractor personnel security programs including processing, tracking and adjudication of security investigations, including monitoring ongoing efforts to that will help to reduce case backlogs, Homeland Security Presidential Directive-12 (HSPD-12) badging and smart card administration/issuance, foreign visits and assignments, and management of the human reliability program including medical examinations. • Support personnel security services for Nuclear Energy (NE) headquarters staff.	• Provides funding for contractor personnel security programs including processing, tracking and adjudication of security investigations, including the monitoring of ongoing efforts that will help reduce case backlogs, HSPD-12 badging and smart card administration/issuance, foreign visits and assignments, and management of the human reliability program including medical examinations. Funding also covers clearances for federal personnel	• The decrease reflects funds that were transferred to the programs in response to clearance costs being moved to the respective programs. Starting in FY22, full cost recovery will be obtained by requiring programs to pay for their security clearances.
Material Control & Accountability (MC&A) $4,876,000	**$6,376,000**	**+$1,500,000**
• Provide funds to maintain the site's special nuclear material (SNM) database and tracking systems, coordinate on-and off-site material movements, and to conduct SNM inventories.	• Provides funds to maintain the site's SNM database and tracking systems, coordinate on- and off-site material movements, and to conduct SNM inventories.	• The increase reflects funds which are necessary to ensure that the MC&A program is equipped to effectively manage the personnel, systems, equipment, and services required to account for and control special nuclear materials (SNM) from diversion.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Management $8,175,000	**$10,175,000**	**+$2,000,000**
• Provide funding to monitor and improve program management functions, including the development and maintenance of adequate security program documentation vulnerability and risk assessments and to conduct performance testing to assure program effectiveness in the implementation of Departmental Orders. • Provide funds to support force-on-force exercises which directly test the efficacy of the protection methodology and posture and allow for risk-informed decision making.	• Provides funding to monitor and improve program management functions, including the development, and maintenance of adequate program documentation, vulnerability and risk assessments and to conduct performance testing to assure program effectiveness in the implementation of Departmental Orders. • Provides funds to support force-on-force exercises which directly test the efficacy of the protection methodology and posture and allow for risk-informed decision making. • Provides funding to assess the impact of Departmental policy changes and requirements on the site-wide safeguards and security program.	• The increase reflects funding necessary to manage the site-wide security program and the process of evaluating the impact of departmental security policy updates which includes the conduct of required vulnerability analysis that identify risks and feed into site-wide implementation requirements and the development of required security planning documents.
Cybersecurity $16,856,000	**$19,812,000**	**+$2,956,000**
• Provide funding to maintain an effective cybersecurity program, consistent with the Department's measured risk management and vulnerability and incident management strategies. • Provide funding for staffing, training, tools, hardware and software lifecycle replacement, and certification and accreditation for classified and unclassified systems. • Maintain 24/7 intrusion detection and prevention monitoring, ensuring that incidents and breaches were discovered and remediated. • Improve cyber threat detection and response capabilities, developed hunt teams and improved network traffic monitoring capabilities by detecting and isolating advanced threats. • Perform penetration testing on the Idaho National Laboratory (INL) Industrial Control Systems (ICS) cybersecurity program and initiate integrating ICS activities into the Security Operations Center and Vulnerability Management program.	• Provides funding to maintain an effective cybersecurity program, consistent with the Department's measured risk management and vulnerability and incident management strategies. • Maintain 24/7 intrusion detection and prevention monitoring, in order to ensure incidents and breaches are discovered and remediated. • Provides funding for staffing, training, tools, hardware and software lifecycle replacement, and certification and accreditation for classified and unclassified systems. • Continue to improve cyber threat detection and response capabilities, develop additional hunt teams and improve network traffic monitoring capabilities by detecting and isolating advanced threats.	• The increase reflects funds necessary to add additional staff to the cybersecurity program at the INL to maintain the ability to identify, mitigate, and remediate the increasing number and sophistication of cyber-attacks on INL data and infrastructure.

Idaho Sitewide Safeguards and Security
Capital Summary ($K)

	Total	Prior Years	FY 2020 Enacted	FY 2020 Actuals	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Capital Operating Expenses Summary (including Major Items of Equipment)								
Minor Construction	n/a	4,789	21,588	21,588	16,618	5,618	-11,000	-66.2%
Total, Capital Operating Expenses	**n/a**	**4,789**	**21,588**	**21,588**	**16,618**	**5,618**	**-11,000**	**-66.2%**
Minor Construction Projects								
Internet Pipeline Monitoring Infrastructure	1,800	0	0	0	1,800	0	-1,800	-100%
Security Infrastructure Phase III	20,000	0	0	0	0	0	0	0%
Materials and Fuels Complex Protective Forces Building	15,600	0	15,600	15,600	0	0	0	0%
Security Infrastructure Phase IIB	18,000	0	5,477	5,477	2,818	5,618	+2,800	+99.4%
Security Infrastructure Phase IIA project 2	5,300	4,789	511	511	0	0	0	0%
Consolidated training facility at the Central Facilities Area	12,000	0	0	0	12,000	0	-12,000	-100%
Total, Minor Construction Projects	**76,400**	**4,789**	**21,588**	**21,588**	**16,618**	**5,618**	**-11,000**	**-66.2%**
Total, Capital Summary	**n/a**	**4,789**	**21,588**	**21,588**	**16,618**	**5,618**	**-11,000**	**-66.2%**

International Nuclear Energy Cooperation

Overview

The International Nuclear Energy Cooperation (INEC) program leads the Department's international engagement for civil nuclear energy, including analysis, development, coordination, and implementation of U.S. civil nuclear energy policy integrated with the Office of Nuclear Energy's (NE) international nuclear technical activities. INEC works closely with the Department's Office of International Affairs to ensure appropriate involvement, information sharing, and coordination on international issues. INEC contributes to bilateral and multilateral civil nuclear research and development (R&D) with countries that have advanced nuclear programs, while providing the expertise to better inform emerging countries on safety and security issues that should be considered before developing a civilian nuclear program.

INEC also contributes technical expertise to international organizations, including the Nuclear Energy Agency (NEA), International Framework for Nuclear Energy Cooperation (IFNEC), the Clean Energy Ministerial (CEM) and the International Atomic Energy Agency (IAEA) and its International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). INEC employs a suite of tools, including workshops and other expert-based exchanges to engage industry, stakeholders and foreign governments on issues such as nuclear energy as an integral part of a climate change strategy, infrastructure development, financing for nuclear builds, nuclear safety and multinational cooperation on the back end of the nuclear fuel cycle, including disposal.

INEC also works to connect commercial opportunities for the U.S. nuclear industry with international needs. INEC actively works with industry and international partners to consider how advanced U.S. reactor designs, including traditional large reactor designs and small and micro-sized reactors, might be incorporated into established and growing energy grids. INEC's efforts contribute to increased nuclear exports which support U.S. leadership in the global nuclear market and expand U.S. job creation.

In conclusion, INEC enables the Department to effectively engage with international partners on civil nuclear policy, research, development, and demonstration (RD&D) and advancing U.S. technology exports. INEC's bilateral and multilateral engagement addresses broader U.S. strategic interests that support U.S. nuclear industry in the safe and secure deployment of nuclear energy worldwide while remaining sensitive to nonproliferation policy. INEC executes its international mission in close coordination with the Office of International Affairs, National Nuclear Security Administration; the National Security Council; the Department of State; the Department of Commerce; and the Nuclear Regulatory Commission to better support U.S. nuclear energy RD&D, civil nuclear policy, and U.S. commercial interests internationally.

Highlights of the FY 2022 Budget Request

In FY2022 the INEC budget will be transferred from the NE Program Direction Budget Request to a program level activity within the overall NE Congressional Budget Request. This change will enable the Office of Nuclear Energy to better focus financial and personnel resources toward international priorities while providing improved transparency to Congress. The transfer will also facilitate NE's ability to ensure the successful planning, organization and execution of the 2022 IAEA Nuclear Power Ministerial.

A major focus of INEC in FY 2022 will be planning, organizing and hosting the 2022 IAEA Nuclear Power Ministerial, a major summit occurring every four years. The United States was selected by the IAEA to host the FY 2022 Ministerial in Washington, DC with participants invited from over 170 IAEA member countries. Three of the four previous hosts are major competitors of the United States, including France, Russia and China. The Ministerial will accordingly provide the United States a high-profile opportunity to shape the international conversation on nuclear energy, including its role in global efforts to address the threat of climate change, and showcase our nuclear industry, with the potential to expand the application of U.S. nuclear technology to new markets around the world.

International Nuclear Energy Cooperation
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
International Nuclear Energy Cooperation				
International Nuclear Energy Cooperation	0	0	$5,000	+$5,000
Total, International Nuclear Energy Cooperation	**0**	**0**	**$5,000**	**+$5,000**

International Nuclear Energy Cooperation
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
International Nuclear Energy Cooperation:	
• The increase from $0 to $5,000,000 reflects INEC's transfer from NE Program Direction to a program level activity within the FY 2022 NE Congressional Budget Request. • This request includes $3,000,000 to support INEC's core mission and a one-time request for $2,000,000 to plan and organize the 2022 IAEA Nuclear Power Ministerial.	+5,000
Total, International Nuclear Energy Cooperation	**+5,000**

International Nuclear Energy Cooperation

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs. FY 2021 Enacted
International Nuclear Energy Cooperation $0	**$5,000,000**	**+$5,000,000**
• In FY 2021, INEC was funded within the NE Program Direction budget.	• Plan, organize and host 2022 IAEA Nuclear Power Ministerial, including coordination with IAEA, NEA co-sponsors. • Support the Secretary of Energy and NE leadership in all international nuclear events, including participation in bilateral meetings and multilateral events such as the IAEA General Conference and Clean Energy Ministerial. • Expand collaboration with small and emerging nuclear states through internships, educational exchanges, professional technical exchanges and training, and feasibility studies. • Continue bilateral coordination of technical cooperation with France, India, and the United Kingdom through mechanisms such as R&D Agreements, implementing arrangements and Action Plans. • Coordinate Fukushima Forensics activities that support improved operation and safety of U.S. domestic nuclear power plants. • Coordinate with U.S. interagency to support increased U.S. civil nuclear exports. • Manage International Nuclear Research Initiatives (INERI) collaborative partnerships on RD&D projects with the EURATOM and Republic of Korea focusing on advanced nuclear technologies to improve cost, safety, and proliferation-resistance.	• Transfer from PD. • Actual program changes from FY21.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs. FY 2021 Enacted
	• Leverage U.S. strategic policy goals in multilateral organizations by providing staff to support the mission of these agencies. • Leverage role of Chair of IFNEC to better promote the use of nuclear energy for peaceful purposes while ensuring the highest standards for safety, security, and nonproliferation. • Continue to support infrastructure development and safety culture in Armenia and Ukraine.	

Program Direction

Overview

Program Direction provides the federal staffing resources and associated costs required to support the overall direction and execution of the Office of Nuclear Energy (NE) programs. NE has staff strategically located in multiple locations: Washington, D.C. Headquarters, Nevada Field Office, and the Idaho Operations Office. Activities within the site offices support inherently federal functions that facilitate the efficient execution of Department of Energy (DOE) programs or directly execute DOE mandated safety, security, business functions, and public outreach. In addition to NE federal personnel, Program Direction supports select federal staff and support for the Office of Human Capital Service Center.

The Support Services subprogram allows the Department to cost-effectively hire the best available industry experts to support federal staff in managing the nuclear programs and complex activities. The ability to acquire expertise quickly and on an “as needed basis” provides flexibility in team composition as the needs of NE evolve. Program Direction also includes the Other Related Expenses subprogram, which provides NE’s directed funding contribution to the Department’s Working Capital Fund (WCF). The WCF supports specific Departmental services and activities that are shared across DOE including: employee health and testing services, and consolidated training and recruitment initiatives; all established in previous fiscal years and supported in FY 2022.

In addition to appropriated funds, NE also manages approximately $200 million annually from other activities including: Strategic Partnerships Program and reimbursable funding from the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD).

Over the last several years NE’s program direction funding has remained level and overall federal staffing levels have declined by more than a quarter. Over the same period the size of NE’s programs have doubled. NE is now at a critical moment where it must replace retiring staff, flexibly increase staffing in areas of priority, and support career enhancing opportunities that allow NE to attract and retain new staff. As such the FY 2022 request reflects the first funding increase for program direction in 8 years to support a multiyear effort, started in FY 2021, to restore staffing levels to the 2016 level.

The FY 2022 Program Direction Budget Request reflects NE’s continued effort to optimize support for its federal programs through continued efficiency and cost-effectiveness; and to ensure a measured and effective oversight of NE mission activities. Federal staff supported by the Program Direction account are responsible for ensuring the appropriate planning, oversight, and execution of all activities within NE. NE's hiring efforts will prioritize the diversity and equity goals outlined by the Administration. Continued efforts will enable graduates from Historically Black Colleges and Universities, Minority Serving Institutions, and other underserved communities to be fairly and equitably represented within our office.

Highlights of the FY 2022 Budget Request

The FY 2022 Program Direction Budget Request includes a transfer of the INEC program within the NE Program Direction Budget Request to a program level activity within the overall NE Congressional Budget Request. The federal staff designated to support the Interim Storage Program, which consists of 8 FTEs, will be transferred within NE Program Direction beginning in FY 2022.

The Request also includes funding to support an additional 26 federal staffing positions to be allocated across NE’s site office locations as appropriate. This increase will allow NE to rebuild its workforce to levels consistent with our FY 2017 profile, which is necessary to execute the robust Research and Development, and Infrastructure activities that NE is responsible for overseeing.

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Program Direction				
Salaries and Benefits	51,606	48,812	56,995	8,183
Travel	357	725	1,625	900
Support Services	12,973	7,655	9,960	2,305
Other Related Expenses	12,664	13,939	16,420	2,481
International Nuclear Energy Cooperation	2,400	4,000	0	-4,000
Total, Program Direction	**80,000**	**75,131**	**85,000**	**9,869**

Program Direction
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Salaries and Benefits: The increase from $48,812 to $56,995 reflects the funds necessary to support salaries and benefits for onboard staff and the additional 26 new FTEs planned across the Headquarters and Idaho Operations Offices in FY 2022.	**8,183**
Travel: The increase from $725 to $1,625 reflects a return to normal travel spending levels post COVID-19 restrictions.	**900**
Support Services: The increase from $7,655 to $9,960 reflects additional funding allocated for contractual support as needed to aid and support the increased federal workforce responsible for executing NE's requirements.	**2,305**
Other Related Expenses: The increase from $13,939 to $16,420 reflects funding to support other expenses related to the increase of NE's workforce that occurred in FY 2021 and planned hires in FY 2022.	**2,481**
International Nuclear Energy Cooperation The decrease from $4,000 to $0 reflects the International Nuclear Energy Cooperation's transfer from Nuclear Energy (NE) Program Direction to a program level activity within the FY 2022 NE Congressional Budget Request.	**-4,000**
Total, Program Direction	**9,869**

Program Direction
Funding ($K)

	FY 2021 Enacted	FY 2022 Request	FY 2021 Enacted vs FY 2022 Request
Program Direction Summary			
Washington Headquarters			
Salaries and Benefits	23,760	29,601	5,841
Travel	300	1,200	900
Support Services	6,525	8,496	1,971
Other Related Expenses	5,191	7,672	2,481
International Nuclear Energy Cooperation	4,000	0	-4,000
Total, Washington Headquarters	**39,776**	**46,969**	**7,193**
Oak Ridge Operations Office			
Salaries and Benefits	38	0	-38
Travel	0	0	X
Support Services	200	0	-200
Other Related Expenses	0	0	X
Total, Oak Ridge Operations Office	**238**	**0**	**-238**
Nevada Field Office			
Salaries and Benefits	1,457	1,267	-190
Travel	0	0	0
Support Services	0	0	0
Other Related Expenses	103	103	0
Total, Nevada Field Office	**1,560**	**1,370**	**-190**
Idaho Operations Office			
Salaries and Benefits	23,558	26,127	2,569
Travel	425	425	0
Support Services	930	1,463	533
Other Related Expenses	8,645	8,645	0
Total, Idaho Operations Office	**33,558**	**36,660**	**3,102**

	FY 2021 Enacted	FY 2022 Request	FY 2021 Enacted vs FY 2022 Request
Total Program Direction			
Salaries and Benefits	48,812	56,995	8,182
Travel	725	1,625	900
Support Services	7,655	9,960	2,305
Other Related Expenses	13,939	16,420	2,481
International Nuclear Energy Cooperation	4,000	0	-4,000
Total, Program Direction	**75,131**	**85,000**	**9,869**
Federal FTEs	**272**	**298**	**26**
Support Services			
Technical Support			
Mission Related	775	896	121
Advisory and Assistance	1,810	2,092	282
Total, Technical Support	2,585	2,988	403
Management Support			
Administrative	2,658	4,183	1,525
IT	2,412	2,789	377
Total Management Support	5,070	6,972	1,902
Total, Support Services	**7,655**	**9,960**	**2,305**
Other Related Expenses			
Working Capital Fund	6,000	6,500	500
Training	100	100	0
Miscellaneous	5,634	7,415	1,781
Rents and Utilities	2,205	2,405	200
Total, Other Related Expenses	**13,939**	**16,420**	**2,481**

Program Direction
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $75,131,000	**$85,000,000**	**$9,869,000**
Salaries and Benefits $48,811,628	**$56,994,810**	**$8,183,182**
• Provides salaries and benefits for 272 FTEs.	• Provides salaries and benefits for 298 FTEs.	• The increase reflects additional approximately 26 FTE count during FY 2022 as well as a full FY cycle of costs for the approximately 30 new hires to be onboarded in FY 2021. Of the 35 additional staff, 8 are in support of the Interim Storage Program.
Travel $725,000	**$1,625,000**	**$900,000**
• Provides for travel of the federal staff including any necessary permanent change of duty status costs.	• Provides for travel of the federal staff including any necessary permanent change of duty status costs.	• The increase reflects a normalization of federal travel activities post COVID-19 restrictions.
Support Services $7,655,016	**$9,959,657**	**$2,304,641**
• Provides for technical and administrative support services for the Nuclear Energy (NE) federal staff.	• Provides for technical and administrative support services, such as administrative support for front office, contracts for international medical insurance, contracts to support clearance appeals process, public outreach contracts, technical support service contractors for needed experts, for the NE federal staff.	• The increase reflects additional funding allocated for contractual support as needed to aid and support the increased federal workforce responsible for executing NE's requirements.
Other Related Expenses $13,939,356	**$16,420,533**	**$2,481,177**
• Provides for NE's share of goods and services procured through the Department's Working Capital Fund (WCF); rents and utilities associated with the Idaho Operations Office; federal training expenses; and other miscellaneous expenses.	• Provides for NE's share of goods and services procured through the Department's WCF; rents and utilities associated with the Idaho Operations Office; federal training expenses; and other miscellaneous expenses.	• The increase reflects funding to support other expenses related to the increase of NE's workforce that occurred in FY 2021 and planned hires in FY 2022.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
International Nuclear Energy Cooperation (INEC) $4,000,000	**$0**	**-$4,000,000**
• Plan and organize 2022 IAEA Nuclear Power Ministerial, including venue reservation, primary contractor selection and coordination between primary contractor, venue and IAEA, NEA co-sponsors. • Support the Secretary of Energy and NE leadership in all international nuclear events, including participation in bilateral meetings and multilateral events such as the IAEA General Conference and Clean Energy Ministerial. • Expand collaboration with small and emerging nuclear states through internships, educational exchanges, professional technical exchanges and training, and feasibility studies. • Continue bilateral coordination of technical cooperation with France, India, and the United Kingdom through mechanisms such as R&D Agreements, implementing arrangements and Action Plans. • Coordinate Fukushima Forensics activities that support improved operation and safety of U.S. domestic nuclear power plants. • Coordinate with U.S. interagency to support increased U.S. civil nuclear exports. • Manage International Nuclear Research Initiatives (INERI) collaborative partnerships on RD&D projects with the EURATOM and Republic of Korea focusing on advanced nuclear technologies to improve cost, safety and proliferation-resistance. • Leverage U.S. strategic policy goals in multilateral organizations by providing staff to support the mission of these agencies.	• This activity will be reestablished as it's own program within the FY 2022 Congressional Budget Request.	• The decrease reflects INEC's transfer from Nuclear Energy (NE) Program Direction to a program level activity within the FY 2022 NE Congressional Budget Request

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Leverage role of Chair of IFNEC to better promote the use of nuclear energy for peaceful purposes while ensuring the highest standards for safety, security and nonproliferation. • Continue to support infrastructure development and safety culture in Armenia and Ukraine		

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

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
STEP R&D			
SBIR	160	155	0
STTR	22	27	0
Reactor Concepts RD&D			
SBIR	6,464	2,814	3,840
STTR	909	489	540
Fuel Cycle R&D			
SBIR	7,683	7,034	8,115
STTR	1,080	1,224	1,141
Nuclear Energy Enabling Technologies			
SBIR	3,631	3,758	3,968
STTR	511	654	558
Advanced Reactors Demonstration Program			
SBIR	1,600	2,332	3,360
STTR	225	406	473
Total, SBIR	**19,538**	**16,093**	**19,283**
Total, STTR	**2,747**	**2,800**	**2,712**
Total, SBIR/STTR	**22,285**	**18,893**	**21,995**

Nuclear Energy
Research and Development ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
Basic	0	0	0
Applied	735,684	791,239	953,075
Development	359,895	265,806	209,461
Subtotal, R&D	**1,095,579**	**1,057,045**	**1,162,536**
Equipment	0	0	0
Construction	65,000	11,000	98,400
Total, R&D	**1,160,579**	**1,068,045**	**1,260,936**

Nuclear Energy
Safeguards and Security($K)

	FY 2020 Enacted	FY 2021 Request	FY 2022 Request
Idaho Sitewide Safeguards and Security			
Protective Forces	79,450	80,812	85,356
Security Systems	10,075	10,075	11,575
Security Infrastructure	21,588	16,618	5,618
Information Security	4,674	4,674	6,174
Personnel Security	7,714	7,714	4,714
Material Control & Accountability	4,876	4,876	6,376
Program Management	8,175	8,175	10,175
Cybersecurity	16,856	16,856	19,812
Total, Idaho Sitewide Safeguards and Security	**153,408**	**149,800**	**149,800**

Nuclear Energy
Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget and displayed below are intended to halt asset condition degradation. This excludes maintenance of excess facilities (including high-risk excess facilities) necessary to minimize the risk posed by those facilities prior to disposition.

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

	FY 2020 Actual Cost	FY 2020 Planned Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
Idaho National Laboratory	30,081	22,120	23,743	24,396
Total, Direct-Funded Maintenance and Repair	30,081	22,120	23,743	24,396

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

	FY 2020 Actual Cost	FY 2020 Planned Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
Idaho National Laboratory	22,072	21,082	21,607	22,147
Total, Indirect-Funded Maintenance and Repair	22,072	21,082	21,607	22,147

Report on FY 2019 Expenditures for Maintenance and Repair

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

Nuclear Energy
Total Costs for Maintenance and Repair ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost
Idaho National Laboratory	52,153	43,202
Total, Maintenance and Repair	**52,153**	**43,202**

Each year, the "Planned Cost" for maintenance and repair is a minimum target amount. The Nuclear Energy (NE) program met its planned minimum target in FY 2020. The NE program exceeded the minimum target amount due to strategic investments at the Advanced Test Reactor and Materials and Fuels Complex at the Idaho National Laboratory.

Nuclear Energy
Excess Facilities

Costs for Direct-Funded Excess Facilities ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
Idaho National Laboratory	905	0	0	0
Total, Direct-Funded Excess Facilities	905	0	0	0

Costs for Indirect-Funded Excess Facilities ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
Idaho National Laboratory	40	500	660	836
Total, Indirect-Funded Excess Facilities	40	500	660	836

In FY 2020, INL:

- Demolished two Fuel Oil Storage Tanks (TRA-727A, TRA-727B), two Diesel Oil Storage Tanks (TRA-727C, TRA-727D), Fuel Oil Pumphouse (TRA-627), Effluent Discharge System (IF-705A), 1714-T-1 (Transformer Pad, TRA-1714), ATR Pumphouse Transformer Pad (TRA-711), Diesel Oil Storage Tank (TRA-775), and the Radioactive Material Area (TRA-1716).

In FY 2021, INL remains on schedule and within budget to:

- Declare as excess the Information Operations & Research Center (IF-608);
- Begin legacy underground storage tank (UST) removals and abandoned well closures; and
- Demolish Waste Storage Pad (TRA-1706) and Fuel Pump Island (NRF-764).

In FY 2022, INL plants to:

- Demolish Dosimetry Calibration Lab (CF-638), Firewater Pump House (TAN-610), Deepwell Pump House (TAN-613), and Diesel Tank for 793 (TAN-792).

Nuclear Waste Disposal
Appropriation Language

For Department of Energy expenses necessary for activities to carry out the purposes of the Nuclear Waste Policy Act of 1982, Public Law 97-425, as amended, $7,500,000, to remain available until expended, to be derived from the Nuclear Waste Fund.

Nuclear Waste Fund Oversight
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
0	27,500	7,500	-20,000	-72%

Overview

The Nuclear Waste Fund Oversight element supports the Department's responsibilities for managing the Nuclear Waste Fund, administering the Standard Contract, and maintaining the security of the Yucca Mountain site.

Highlights of the FY 2022 Budget Request

The Nuclear Waste Fund Oversight program's FY 2022 Budget Request activities include:

- Implementation of an appropriate investment strategy and the prudent management of the Nuclear Waste Fund (NWF) investment portfolio,
- Administer the Standard Contract,
- Maintain physical security requirements, under DOE Order 473.3A for the Yucca Mountain site, as well as maintenance and environmental requirements,
- Support associated federal staff and support.

The Interim Storage program's FY 2022 Budget Request is included in the Office of Nuclear Energy's Fuel Cycle Research and Development program, Integrated Waste Management System subprogram.

These funds are inclusive of program direction activities and management and technical costs necessary to carry out the mission.

Nuclear Waste Fund Oversight

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These funds are inclusive of program direction activities and management and technical costs necessary to carry out the mission.

Nuclear Waste Fund Oversight
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Nuclear Waste Fund Oversight					
Interim Storage (FY 2022 requested in Nuclear Energy R&D)	0	20,000	0	-20,000	-100%
Nuclear Waste Fund Oversight	0	7,500	7,500	+0	+0%
Total	0	27,500	7,500	+0	+0%
FTEs	0	26	24	-2	-7%

Explanation of Major Changes
Funding ($K)

	FY 2022 Request vs FY 2021 Enacted
Interim Storage and Nuclear Waste Fund Oversight:	
Interim Storage scope and funding is being requested within the Nuclear Energy Research and Development account.	**-20,000**
Total, Interim Storage and Nuclear Waste Fund Oversight	**-20,000**

Nuclear Waste Fund Oversight

Description

The United States (U.S.) utilizes nuclear technology for national defense, research and development, and electric power generation. These activities produced and continue to create large quantities of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) that require safe storage and eventual disposal. Commercial electricity generation, the largest generator of SNF accounts for approximately 80,000 metric tons of uranium (MTU) of SNF with the potential to produce an additional 60,000 MTU (total of 140,000 MTU) with the current reactor fleet. Nearly all existing commercial SNF is stored at the reactor sites where it was generated. Of the 74 commercial reactor sites, 17 sites no longer have an operating reactor. The U.S. inventory of HLW includes commercial HLW stored in one state and defense HLW stored in three states. Under current law, the federal government, and specifically DOE, is responsible for the disposal of SNF and HLW. The Oversight program will ensure implementation of an appropriate investment strategy and the prudent management of the Nuclear Waste Fund investment portfolio are essential to fulfilling the program's fiduciary responsibility under the Nuclear Waste Policy Act (NWPA), and the administration of the Standard Contract.

Requirements for the management and operation of DOE’s physical security under the Protection Program Operations Directive (DOE Order 473.3A) at the Yucca Mountain site will continue.

Nuclear Waste Fund Oversight
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Nuclear Waste Fund Oversight **$27,500,000**	**$7,500,000**	**$ -20,000,000**
• Initiating processes to identify potential sites. • Developing an integrated program plan. • Developing preliminary design concepts. • Conduct analyses, leverage expertise from other programs, and work with stakeholders as appropriate to develop, evaluate, and acquire Monitored Retrievable Storage capabilities and associated transportation. • Maintain engagement with regional, state, and tribal transportation authorities to prepare for future spent nuclear fuel (SNF) and high-level radioactive waste (HLW) shipments. • Maintain support for logistical requirements, packaging and transportation hardware and analytical capabilities. • Implementation of an appropriate investment strategy and the prudent management of the Nuclear Waste Fund (NWF) investment portfolio. • Administer the Standard Contract. • Maintain physical security requirements, under Department of Energy (DOE) Order 473.3A for the Yucca Mountain site, as well as maintenance and environmental requirements. • Support associated federal staff and support.	• Implementation of an appropriate investment strategy and the prudent management of the Nuclear Waste Fund (NWF) investment portfolio. • Administer the Standard Contract. • Maintain physical security requirements, under DOE Order 473.3A for the Yucca Mountain site, as well as maintenance and environmental requirements. • Support associated federal staff and support.	• Interim Storage activities will now be funded through Nuclear Energy Research and Development.

Fossil Energy and Carbon Management

Fossil Energy and Carbon Management

Fossil Energy and Carbon Management

Table of Contents

Fossil Energy and Carbon Management
Research, Development,
Demonstration, and Deployment
(FECM RDD&D)
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
750,000	750,000	890,000	+140,000

Overview

The Fossil Energy and Carbon Management (FECM) Research, Development, Demonstration, and Deployment (RDD&D) program conducts research that focuses on early-stage technologies that help to ensure clean and affordable energy for all Americans, facilitate the transition towards a carbon-pollution-free economy, rebuild a U.S critical minerals (CM) supply chain, and retain and create good paying jobs with a free and fair chance to join a union and collectively bargain. To meet these challenges, the Budget re-focuses funding from traditional fossil combustion-centric activities (e.g. Advanced Energy Systems and Cross-cutting Research) to climate-centric activities (e.g. Carbon Capture, Utilization, and Storage (CCUS)). These reallocations will enable near-term work to develop and deploy carbon solutions for the power and industrial sectors. Immediate action will be taken to locate and mitigate methane leaks, one of the most potent greenhouse gases (GHG) – coupled with longer term R&D to expedite the clean hydrogen (H_2) energy economy. These investments will be critical to meet 100% clean electricity by 2035. Carbon dioxide removal (CDR) will be an important tool to achieve economy-wide net-zero emissions and industrial decarbonization by 2050. FECM is investing in direct air capture (DAC), carbon capture and storage (CCS) coupled to the conversion of biomass waste to energy, and accelerated weathering through mineral carbonation to assist in meeting our climate goals.

The FY 2022 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 2022 RDD&D priorities follow:

- **Reduce Methane Emissions:** Develop technologies and deploy regional initiatives to monitor and reduce methane emissions across the fossil fuel infrastructure including coal, oil, and gas. Specifically, develop advanced sensor technologies to detect and locate emissions from pipelines, storage facilities, and abandoned mines and wells; novel technologies in advanced materials, sensors, data management tools, in-pipe inspection and repair, and dynamic compressors; and, add RDD&D for advanced modular technologies to beneficially utilize otherwise flared, vented, or stranded natural gas.
- **Accelerate Carbon-Neutral Hydrogen (H_2):** Develop technologies that leverage the natural gas infrastructure for H_2 production, transportation, storage, and use coupled to carbon management. Hydrogen offers an emissions-free fuel for power generation, industrial applications, and the transportation sector.
- **Develop Low-Carbon Supply Chains for Industries:** Develop novel approaches to recycle carbon oxide emissions, principally carbon dioxide (CO_2), into value-added products such as cement, concrete, steel, chemicals, and fuels using systems-based carbon management approaches.
- **Advance Carbon Dioxide Removal:** Research, develop, and demonstrate CDR technologies and approaches by investing in DAC and mineral carbonation projects.
- **Invest in Thoughtful Transition Strategies:** Invest in technologies and approaches and deploy regional initiative to help in the transition to a net-zero carbon economy in coal and fossil-based power plant 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.
- **Demonstrate and Deploy Point Source Carbon Capture and Storage:** RDD&D for CCS in the power and industrial sectors to enable wider, strategic commercial deployment to meet net-zero emissions goals by 2050.

- **Advance CM, Rare Earth Elements (REE), Coal Waste to Products and Mine Remediation:** Develop technologies that enable the sustainable recovery of CM, including REE from multiple feed stocks, throughout the upstream, midstream, and downstream supply chain from carbon and other ores, mining by-products, abandoned mines and wells and other valuable sources. Specifically, develop technologies that improve REE separation/recovery technologies to manufacture products from carbon ore and to address current market and process economics. Develop technologies and validation approaches- including machine learning and artificial intelligence, small- and large-scale pilot projects, and public-private partnerships as well as existing basin partnerships developed through Carbon Ore Rare Earth-Critical Mineral Initiative (CORE-CM).
- **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 hydrogen pipeline conditions, optimize dedicated CO_2 storage, and apply remediation technologies to detect and fix methane leakage from fossil infrastructure. Partner with academic institutions and DOE National Laboratories to focus on the application of AI and ML to improve plant operations, technology testing, systems analysis, and technology transfer to industry.
- **Address the Energy Water Nexus:** Improve the Department's efficient use of scarce water resources and focus on environmental benefits related to advance water remediation technologies associated with produced or displaced water associated with oil, gas, and coal industries, in addition to that associated with dedicated CO_2 storage.

Highlights and Major Changes in the 2022 Budget Request

Recognizing recent developments in the U.S. and global energy landscape, the FY 2022 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, 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 REE supply. FECM will increase focus in the extraction of CM and REE from coal feedstocks and byproducts of the industry, which also serve as a transition strategy in regions of the U.S. that are heavily dependent on this industry today.
- NETL continues to make important contributions within the National Laboratory system. To further strengthen NETL's capabilities, the FY 2022 Budget Request for NETL Infrastructure represents a $23 million (+41.8%) increase over the FY 2021 Enacted Level, which a specific focus on the development of a testing center for DAC.
- The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. FECM will ensure that its programs are not directly subsidizing fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels. 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 union.

For comparability, all discussions of funding changes that follow assume the FY 2022 proposed budget structure. Funding crosswalks in the Budget Structure Crosswalks chapter of this narrative provide details of the proposed changes.

<u>Carbon Capture, Utilization and Storage and Power Systems ($531.5M)</u>

Descriptions of major funding and programmatic changes and highlights within the CCUS and Power Systems program for the FY 2022 Budget Request are as follows:

Carbon Capture ($150M)
The Carbon Capture activity has completed its efforts in first-generation technology through successful demonstration projects. FY 2022 activities represent a focus on new capture technologies in addition to the demonstration of more proven capture approaches. The FY 2022 Budget Request provides $150 million in the Carbon Capture subprogram for pre- and post-combustion capture RDD&D on transformational gas separation technologies that can help achieve decarbonization goals.

Additionally, the Carbon Capture 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.

Carbon Utilization ($38M)
In FY 2022, the Budget Request provides $38 million in the Carbon Utilization subprogram for early-stage CO_2 utilization technologies that 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. Funding will support the development of at least one, fully integrated field-test system as well as continued support for carbon utilization test facilities at the National Carbon Capture Center, located in Wilsonville, Alabama.

Carbon Storage ($117M)
The FY 2022 Budget Request provides $117 million for the Carbon Storage 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 Carbon Storage 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 is critical for enabling a CCUS industry that is safe, economically viable, and environmentally benign.

Advanced Energy and Hydrogen Systems ($82M)
The Advanced Energy and Hydrogen Systems subprogram comprises of four activities: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells (R-SOFCs); and (4) Advanced Energy Materials. In FY 2022, these activities will provide research a platform for developing the advanced systems of the future while reducing emissions.
In FY 2022, the program will not fund R&D specific to traditional fossil power generation, but rather, will narrow the focus to work on hydrogen-fueled turbines, fuel cells, CCUS-relevant technologies, and production of clean hydrogen through gasification. Improvements to these technologies are also applicable to other energy systems. These improvements to new and existing plants will also make them less carbon intensive and allow these assets to provide continued low-cost baseload power and resilient flexible grid services. This subprogram aligns with the Administration's priority to reduce the environmental impact of the power sector, especially regarding disadvantaged communities.

Note: Funding for Gasification Systems to enable hydrogen production is increasing by $29 million (+152.6%) to $48 million. Decreases in this program are for R-SOFCs), where significant work has already taken place, and Transformative Power Generation, which was focused on fossil fuel promotion that are no longer in line with the Administration's goals. There is additional work on hydrogen in the Natural Gas Technologies program

Crosscutting Research ($36.5M)
The Crosscutting Research subprogram supports innovative early stage RDD&D for improving reliability, availability, efficiency, and environmental performance. In FY 2022, the program will not fund RDD&D specific to traditional fossil combustion. Rather, the program will narrow focus to technologies that aid in minimizing the environmental impact of the U.S.'s high dependence on fossil fuels, which includes both power and industrial sectors. The subprogram bridges basic and applied research by targeting concepts with the greatest potential for transformational breakthroughs. Research is focused on seven activities: 1) Sensors, Controls, and Other Novel Concepts; 2) Water Management RDD&D; 3) Simulation Based Engineering; 4) Energy Analyses; 5) University Training and Research (UTR), which comprises funding for University Coal Research (UCR), Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI); 6) International Activities; and 7) Energy Storage Grand Challenge.

Carbon Dioxide Removal (New Control Point) ($63M)
Many modeling scenarios to achieve economy-wide decarbonization suggests 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. CDR activities include DAC, bioenergy with carbon capture and storage (BECCS), mineralization, terrestrial carbon removal and sequestration (e.g., improved forest management, afforestation, reforestation), and coastal blue carbon (e.g., CO_2 storage in wetlands). FECM has focused on the chemical and mineral-based CDR approaches, which was previously funded under the Carbon Capture Program. It builds upon past CCUS efforts which have been funded through FECM's CCUS programs, such as past work on DAC mineralization, co-firing of biomass, and capture technology development.

Note: The CDR subprogram is a new budget line in the FY 2022 Budget Request.

Mineral Sustainability (New Control Point) ($45M)
The Mineral Sustainability subprogram will support domestic supply chain networks required for the economically, environmentally, and geopolitical sustainable 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.

Carbon Ore Processing: The Carbon Ore Processing activity (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. 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.

Note: The Mineral Sustainability subprogram is a new budget line in the FY 2022 Budget Request. CM funding is increasing by $10 million (+43.5%) to $33 million, and carbon ore processing is decreasing by $18 million (-60%) to $12 million. In addition, mineralization activities associated with CO_2 as a feedstock will take place in Carbon Storage and CDR programs.

Natural Gas Technologies ($130M)
The Natural Gas Technologies Program addresses critical issues associated with the production and transmission of domestic natural gas. Specifically, the Program's mission is to conduct RDD&D that reduces the environmental impact from the development, transportation, distribution, and storage of natural gas resources.

The Environmentally Prudent Development 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 subprogram will build on research conducted and data collected from the 17 Field Laboratory projects to inform future research. Research includes wellbore integrity, oil spill prevention, and produced water treatment and reuse technologies.

The Emissions Mitigation from Midstream Infrastructure subprogram will develop technologies to reduce emissions from natural gas transmission, distribution, and storage facilities. This includes advanced materials, sensors, data management systems, and more efficient and flexible compressors. The subprogram 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 develop advanced sensor technologies to detect and locate emissions from pipelines, storage facilities, and abandoned wells and will develop modular technologies, materials, and solutions to aid in the remediation of orphaned wells.

The Emissions Quantification from Natural Gas Infrastructure subprogram will focus on developing technologies to detect, locate, and measure emissions. This includes the development and validation of measurement sensor technologies for the collection, dissemination, and analysis of emissions data which will inform efforts such as the EPA's Greenhouse Gas Inventory and orphan well remediation programs.

The new Natural Gas Hydrogen Research subprogram 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 improving carbon neutral natural gas steam methane reforming (SMR), 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, and resource evaluations.

The Transformational Coal Pilots and STEP programs are at the end of their scheduled programming and will not require additional funding in FY 2022.

National Energy Technology Laboratory ($190.4M for NETL; and an additional $38.1M for HQ Program Direction and Special Recruitment – see table below for funding breakdown)

	($K) FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
NETL Program Direction	27,780	27,780	29,400
NETL Infrastructure	55,000	55,000	78,000
NETL Research and Operation	83,000	83,000	83,000
Subtotal, NETL	**165,780**	**165,780**	**190,400**
Special Recruitment	700	700	700
HQ Program Direction (includes Import/Export)	33,720	33,720	37,400
Subtotal, Remaining Programs	**34,420**	**34,420**	**38,100**

The Office of Fossil Energy and Carbon Management is committed to supporting the 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.

- **NETL Infrastructure:** The request of $78 million supports the fixed costs of maintaining NETL's lab footprint in three geographic locations: Morgantown, WV; Pittsburgh, PA; and Albany, OR. These sites include approximately 240 acres of land, including 108 buildings with over 1,100,000 square feet of space. This level of funding includes $25 million for the design and construction of a DAC facility at an NETL campus. This DAC Center will be utilized to lead agency-wide RDD&D projects to advance the development and commercialization of technologies to remove carbon from the air on a significant scale.
- **NETL Research and Operations:** The request of $83 million supports 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 program also funds partnership, technology transfer, and other collaborative research activities and supports the variable operating costs of NETL's research sites.
- **NETL and HQ Program Direction and Special Recruitment Programs:** The request of $67.5 million ($37.4 million for headquarters, $29.4 million for NETL, and $0.7 million for Special Recruitment) provides for the FECM RDD&D organization's federal workforce and contractor support in the Washington, D.C. area 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 RDD&D 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.

Cybersecurity: DOE is engaged in two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities and improving cybersecurity in the electric power subsector and the oil and natural gas subsector. FECM's cybersecurity efforts are described in the Cybersecurity Crosscut – which supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center (JC3) for incident response and the implementation of Department-wide Identity, Credentials, and Access Management (ICAM).

Energy Storage Grand Challenge (ESGC): DOE is participating in the ESGC and provides $5 million of support relevant to that program from within the Crosscutting Research program (see above for description).

FY 2022 Crosscuts ($K)

	Cybersecurity	Energy Storage Grand Challenge	Total
NETL Infrastructure	7,398	0	7,398
Program Direction	1,300	0	1,300
Crosscutting Research	0	5,000	5,000
Total, Crosscuts	**8,698**	**5,000**	**13,698**

Fossil Energy and Carbon Management Research, Development, Demonstration, and Deployment
(FECM RDD&D)
Funding by Congressional Control ($K)
(Comparable)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Carbon Capture, Utilization and Storage (CCUS) and Power Systems					
Carbon Capture	97,800	86,300	150,000	63,700	73.8%
Carbon Utilization	21,000	23,000	38,000	15,000	65.2%
Carbon Storage	79,000	79,000	117,000	38,000	48.1%
Advanced Energy and Hydrogen Systems	111,000	108,100	82,000	-26,100	-24.1%
Crosscutting Research	35,000	32,900	36,500	3,600	10.9%
Carbon Dioxide Removal	20,000	40,000	63,000	23,000	57.5%
Mineral Sustainability	53,000	53,000	45,000	-8,000	-15.1%
Transformational Coal Pilots	20,000	10,000	0	-10,000	-100.0%
Supercritical Transformational Electric Power (STEP)	16,000	14,500	0	-14,500	-100.0%
Subtotal, CCUS and Power Systems	**452,800**	**446,800**	**531,500**	**84,700**	**19.0%**
Natural Gas Technologies	**51,000**	**57,000**	**130,000**	**73,000**	**128.1%**
Unconventional Fossil Energy Technologies from Petroleum - Oil Technologies	**46,000**	**46,000**	**0**	**-46,000**	**-100.0%**
Special Recruitment	**700**	**700**	**700**	**0**	**0.0%**
Program Direction	**61,500**	**61,500**	**66,800**	**5,300**	**8.6%**
NETL Infrastructure	**55,000**	**55,000**	**78,000**	**23,000**	**41.8%**
NETL Research and Operations	**83,000**	**83,000**	**83,000**	**0**	**0.0%**
Total, Fossil Energy and Carbon Management Research & Development, Demonstration, and Deployment	**750,000**	**750,000**	**890,000**	**140,000**	**18.7%**
Federal FTEs	**657**	**679**	**719**	**40**	**5.9%**

SBIR/STTR:

- FY 2020 Enacted: SBIR $12,946; STTR: $2,190
- FY 2021 Enacted: SBIR $12,969; STTR: $2,257
- FY 2022 Request: SBIR $16,846; STTR: $2,369

CCUS and Power Systems
($K)

FY 2021 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
452,800[1]	**446,800**	**531,500**	**+84,700**

Overview

The Carbon Capture, Utilization and Storage (CCUS) and Power Systems program invests in energy technologies that improve the affordability, competitiveness, and environmental performance of domestic power generation; the industrial and manufacturing sectors; improve electric grid reliability and resilience; develop technologies to extract critical minerals from coal and coal by-products; convert coal to value-added products. The program develops transformational energy technologies as part of the Administration's all-of–the-above energy portfolio that enables greater private-sector participation in driving market outcomes to enhance America's competitiveness.

To decarbonize the electricity sector by 2035 and the economy by 2050, CCUS will play a critical role. 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. Significant progress and past investment, in collaboration with universities, national labs, and the private sector have proven successful in reducing emissions of sulfur dioxide, nitrogen oxide, particulate matter, and mercury. Novel technologies and business models will enable low-cost CCUS to improve the environmental performance of power plants, hydrogen (H_2) production, and industrial systems across America; support secure, long-term, regional carbon storage; and provide feedstocks for valuable new products. Overall, CCUS has many potential benefits and can be a cost-competitive option for managing carbon relative to other low-carbon sources of electricity and products.

Hydrogen from hydrocarbon sources, whether it's sourced from natural gas (primary source of hydrogen production globally today) or waste biomass or plastic, is expected to play a key role in the U.S. transition to clean, low-carbon energy systems. The International Energy Agency predicts the United States and other advanced countries that develop a successful H_2 economy will rely primarily on fossil fuels along with carbon capture and dedicated storage.

The RDD&D is focused on the following key priorities:

- **Reduce Methane Emissions:** Develop technologies and deploy regional initiatives to monitor and reduce methane emissions across the fossil fuel infrastructure including coal, oil, and gas. Specifically, develop advanced sensor technologies to detect and locate emissions from pipelines, storage facilities, and abandoned wells, novel technologies in advanced materials, sensors, data management tools, in-pipe inspection and repair, and dynamic compressors and add research, development, demonstration, and deployment for advanced modular technologies to beneficially utilize otherwise flared, vented, or stranded natural gas.
- **Accelerate Carbon-Neutral Hydrogen (H_2):** Develop technologies that leverage the natural gas infrastructure for clean H_2 production, transportation, storage, and use coupled to carbon management. Hydrogen offers an emissions-free fuel for power generation, industrial applications, and the transportation sector.
- **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):** Research, develop, demonstrate and deploy CDR technologies and approaches by investing in direct air capture (DAC) and mineral carbonation projects.
- **Invest in Thoughtful Transition Strategies:** Invest in technologies and approaches and deploy regional initiative to help in the transition to a net-zero carbon economy in coal and fossil-based power plant 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.

[1] Does not include $38 million that was enacted in NETL Coal R&D. This table is showing a comparable budget breakdown to the FY 2022 Congressional Budget Request ($5 million in NETL Infrastructure and $33 million in NETL Research and Operations).

- **Demonstrate and Deploy Point Source Carbon Capture:** RDD&D for CCS in the power and industrial sectors to enable wider, strategic commercial deployment to meet net-zero emissions goals by 2050.
- **Advance Critical Minerals (CM), Rare Earth Elements (REE), Coal Waste to Products and Mine Remediation:** Develop technologies that enable the sustainable recovery of CM, including REEs from multiple feed stocks, throughout the upstream, midstream, and downstream supply chain from carbon and other ores, mining by-products, abandoned mines and other valuable sources. Specifically, develop technologies that improve REE separation/recovery technologies to manufacture products from carbon ore and to address current market and process economics. Develop technologies and validation approaches- including machine learning and artificial intelligence, small- and large-scale pilot projects, and public-private partnerships as well as existing basin partnerships developed through Carbon Ore Rare Earth-Critical Mineral Initiative (CORE-CM).
- **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, optimize dedicated CO_2 storage, and apply remediation technologies to detect and fix methane leakage from legacy fossil infrastructure. Partner with academic institutions and DOE National Laboratories to focus on the application of AI and ML to improve plant operations, technology testing, systems analysis, and technology transfer to industry.
- **Address the Energy Water Nexus:** Improve our efficient use of scarce water resources and advance water remediation technologies associated with produced or displaced water associated with oil, gas, and coal industries, in addition to that associated with dedicated CO_2 storage.

Highlights of the FY 2022 Budget Request
The CCUS and Power Systems program will pursue the following major activities in FY 2022:

<u>Carbon Capture</u>
The Carbon Capture activity has completed its efforts in first-generation technology through successful demonstration projects. FY 2022 activities represent a focus on next-generation capture technologies in addition to the demonstration of more proven capture approaches. The FY 2022 Budget Request provides $150 million to the Carbon Capture activity for pre- and post-combustion capture RDD&D on transformational gas separation technologies that can help achieve decarbonization goals.

Additionally, the Carbon Capture program 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.

<u>Carbon Utilization</u>
In FY 2022, the Budget provides $38 million for this activity for early-stage CO_2 utilization technologies that have the potential to develop additional markets for CO_2 based-products and sequester carbon in useful materials. 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. Funding will support the development of at least one, fully integrated field-test system as well as continued support for carbon utilization test facilities at the National Carbon Capture Center (NCCC) in Alabama.

<u>Carbon Storage</u>
The FY 2022 Budget Request provides $117 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 Carbon Storage subprogram in FY 2022 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 is critical for enabling a CCUS industry that is safe, economically viable, and environmentally benign.

Advanced Energy and Hydrogen Systems

The FY 2022 Budget Request for the Advanced Energy Hydrogen Systems (AEHS) program is $82 million. The program comprises of four activities: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells (R-SOFCs), and (4) Advanced Energy Materials. In FY 2022, these activities will provide research a platform for developing the advanced systems of the future while reducing emissions. In FY 2022, the program will not fund R&D specific to traditional fossil power generation, but rather, will narrow the focus to work on hydrogen-fueled turbines, fuel cells, CCUS-relevant technologies, and production of clean hydrogen through gasification. Improvements to these technologies are also applicable to other energy systems. These improvements to new and existing plants will also make them less carbon intensive and allow these assets to provide continued low-cost baseload power and resilient flexible grid services. These sub-programs align with the administration's priority to reduce the environmental impact of the power sector, especially regarding disadvantaged communities.

Funding for Gasification Systems in the FY 2022 Budget Request is $48 million, an increase of $29 million, to enable hydrogen production. Funding decreases by $28 million for the Reversible Solid Oxide Fuel Cells to $2 million, where significant work has already taken place. Funding also decreases by $16 million for the Transformative Power Generation to $0, which was focused on fossil fuel promotion that are no longer in line with the Administration's goals. There is additional work on hydrogen in the Natural Gas Technologies program

Crosscutting Research

The FY 2022 Budget Request for the Crosscutting Research subprogram is $36.5 million, an increase of $3.6 million, and supports innovative early stage RDD&D for improving reliability, availability, efficiency, and environmental performance. In FY 2022, the program will not fund RDD&D specific to traditional fossil combustion. Rather, the program will narrow focus to technologies that aid in minimizing the environmental impact of the U.S.'s high dependence on fossil fuels, which includes both power and industrial sectors. The subprogram bridges basic and applied research by targeting concepts with the greatest potential for transformational breakthroughs. Research is focused on seven activities: 1) Sensors, Controls, and Other Novel Concepts; 2) Water Management RDD&D; 3.) Simulation Based Engineering; 4) Energy Analyses; 5) University Training and Research (UTR), which comprises funding for University Coal Research (UCR), Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI); 6) International Activities; and 7) Energy Storage Grand Challenge.

Carbon Dioxide Removal (New Control Point)

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 approaches that remove CO_2 from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. The FY 2022 Budget Request for CDR is $63 million, an increase of $23 million. FECM has focused on the chemical and mineral-based CDR approaches, which was previously funded under the Carbon Capture Program.

FY 2022 activities for CDR include:

- Direct air capture (DAC)
- Bioenergy with carbon capture and storage (BECCS); and
- Mineralization, terrestrial carbon removal and sequestration (e.g., improved forest management, afforestation, reforestation), and coastal blue carbon (e.g., CO_2 storage in wetlands).

The CDR subprogram is a new budget line in FY 2022 that will be focused on DAC, BECCS, and enhanced mineralization. It builds upon past CCUS efforts which have been funded through FECM's CCUS programs, such as past work on DAC mineralization, co-firing of biomass, and capture technology development.

Mineral Sustainability (New Control Point)

The FY 2022 Budget Request for the Mineral Sustainability subprogram is $45 million, a decrease of $8 million, and supports domestic supply chain networks required for the economically, environmentally, and geopolitical sustainable production of Critical Minerals (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, rare earth elements (REE) and carbon ore to products production.

Carbon Ore Processing: The 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. Funding decreases by $18 million to $12 million in the FY 2022 Budget Request. 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.

Critical Minerals: In the FY 2022 Budget Request, the CM subprogram (formerly Feasibility of Recovering Rare Earth Elements) funding increases by $10 million to $33 million. In addition, mineralization activities associated with CO_2 as a feedstock will take place in Carbon Storage and CDR programs.

FY 2022 activities for Mineral Sustainability include:

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

Eliminating Direct Fossil Fuel Subsidies

The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. FECM will ensure that its programs are not directly subsidizing fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels. 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 union.

CCUS and Power Systems
Funding by Congressional Control ($K)
(Comparable)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
CCUS and Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	88,800	73,300	128,000	54,700	74.6%
Pre-Combustion Capture Systems	6,000	10,000	18,000	8,000	80.0%
Emissions Control	3,000	3,000	4,000	1,000	33.3%
Subtotal Carbon Capture	**97,800**	**86,300**	**150,000**	**63,700**	**73.8%**
Carbon Utilization	**21,000**	**23,000**	**38,000**	**15,000**	**65.2%**
Carbon Storage					
Storage Infrastructure	57,000	57,500	85,000	27,500	47.8%
Advanced Storage RDD&D	16,100	15,700	32,000	16,300	103.8%
Sub-disciplinary Storage RDD&D	5,900	5,800	0	-5800	-100.0%
Subtotal Carbon Storage	**79,000**	**79,000**	**117,000**	**38,000**	**48.1%**
Advanced Energy and Hydrogen Systems					
Gasification Systems	7,500	19,000	48,000	29,000	152.6%
Advanced Turbines	25,000	27,000	25,000	-2,000	-7.4%
Reversible Solid Oxide Fuel Cell	17,000	30,000	2,000	-28,000	-93.3%
Advanced Energy Materials	21,000	16,100	7,000	-9,100	-56.5%
Transformative Power Generation	40,500	16,000	0	-16000	-100.0%
Subtotal Advanced Energy and Hydrogen Systems	**111,000**	**108,100**	**82,000**	**-26,100**	**-24.1%**
Crosscutting Research					
Sensors, Controls and Other Novel Concepts	9,000	8,000	3,000	-5,000	-62.5%
Water Management RDD&D	9,000	7,500	8,100	600	8.0%
Simulation Based Engineering	6,800	6,200	4,000	-2,200	-35.5%
Energy Analyses	500	500	2,400	1,900	380.0%
University Training and Research					
University Coal Research	*3,000*	*3,000*	*5,000*	*2,000*	*66.7%*
HBCU's, Education, and Training	*2,050*	*2,050*	*8,000*	*5,950*	*290.2%*
Subtotal University Training and Research	5,050	5,050	13,000	7,950	157.4%
International Activities	150	650	1,000	350	53.8%
Energy Storage Grand Challenge	4,500	5,000	5,000	0	0.0%
Subtotal Crosscutting Research	**35,000**	**32,900**	**36,500**	**3,600**	**10.9%**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Carbon Dioxide Removal	**20,000**	**40,000**	**63,000**	**23,000**	**57.5%**
Mineral Sustainability					
Critical Minerals	23,000	23,000	33,000	10,000	43.5%
Carbon Ore Processing	30,000	30,000	12,000	-18,000	-60.0%
Subtotal Mineral Sustainability	**53,000**	**53,000**	**45,000**	**-8,000**	**-15.1%**
Transformational Coal Pilots	**20,000**	**10,000**	**0**	**-10,000**	**-100.0%**
Supercritical Transformational Electric Power (STEP)	**16,000**	**14,500**	**0**	**-14,500**	**-100.0%**
Total, CCUS and Power Systems	**452,800[2]**	**446,800**	**531,500**	**84,700**	**19.0%**

SBIR/STTR:

- FY 2020 Enacted: SBIR $10,376; STTR: $1,756
- FY 2021 Enacted: SBIR $10,472; STTR: $1,822
- FY 2022 Request: SBIR $13,543; STTR: $1,905

[2] Does not include $38 million that was enacted in NETL Coal R&D. This table is showing a comparable budget breakdown to the FY 2022 Congressional Budget Request ($5 million in NETL Infrastructure and $33 million in NETL Research and Operations).

CCUS and Power Systems
Funding by Congressional Control ($K)
(Non-Comparable)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
CCUS AND POWER SYSTEMS					
Carbon Capture					
Post-Combustion Capture Systems	0	0	128,000	54,700	N/A
Pre-Combustion Capture Systems	0	0	18,000	8,000	N/A
Emissions Control	0	0	4,000	1,000	N/A
Subtotal, Carbon Capture	**0**	**0**	**150,000**	**63,700**	**N/A**
Carbon Utilization	**0**	**0**	**38,000**	**15,000**	**N/A**
Carbon Storage					
Storage Infrastructure	0	0	85,000	27,500	N/A
Advanced Storage RDD&D	0	0	32,000	16,300	N/A
Subtotal, Carbon Storage	**0**	**0**	**117,000**	**38,000**	**N/A**
Advanced Energy and Hydrogen Systems					
Gasification Systems	0	0	48,000	29,000	N/A
Advanced Turbines	0	0	25,000	-2,000	N/A
Reversible Solid Oxide Fuel Cell	0	0	2,000	-28,000	N/A
Advanced Energy Materials	0	0	7,000	-9,100	N/A
Subtotal, Advanced Energy and Hydrogen Systems	**0**	**0**	**82,000**	**-26,100**	**N/A**
Crosscutting Research					
Sensors, Controls and Other Novel Concepts	0	0	3,000	-5,000	N/A
Water Management RDD&D	0	0	8,100	600	N/A
Simulation Based Engineering	0	0	4,000	-2,200	N/A
Energy Analyses	0	0	2,400	1,900	N/A
University Training and Research					
University Coal Research	*0*	*0*	*5,000*	*2,000*	*N/A*
HBCU's, Education, and Training	*0*	*0*	*8,000*	*5,950*	*N/A*
Subtotal, University Training and Research	0	0	13,000	7,950	N/A
International Activities	0	0	1,000	350	N/A
Energy Storage Grand Challenge	0	0	5,000	0	N/A
Subtotal, Crosscutting Research	**0**	**0**	**36,500**	**3,600**	**N/A**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Carbon Dioxide Removal	**0**	**0**	**63,000**	**23,000**	**N/A**
Mineral Sustainability					
Critical Minerals	0	0	33,000	10,000	N/A
Carbon Ore Processing	0	0	12,000	-18,000	N/A
Subtotal, Mineral Sustainability	**0**	**0**	**45,000**	**-8,000**	**N/A**
Transformational Coal Pilots	**0**	**0**	**0**	**-10,000**	**N/A**
Supercritical Transformational Electric Power (STEP)	**0**	**0**	**0**	**-14,500**	**N/A**
TOTAL, CCUS AND POWER SYSTEMS	**0**	**0**	**531,500**	**84,700**	**N/A**
CCUS AND POWER SYSTEMS					
Carbon Capture					
Post-Combustion Capture Systems	108,800	108,300	0	-108,300	-100.0%
Pre-Combustion Capture Systems	6,000	15,000	0	-15,000	-100.0%
Emissions Control	3,000	3,000	0	-3,000	-100.0%
Total, Carbon Capture	**117,800**	**126,300**	0	**-126,300**	**-100.0%**
Carbon Utilization					
Carbon Use and Reuse	0	23,000	0	-23,000	-100.0%
Total, Carbon Utilization	**0**	**23,000**	0	**-23,000**	**-100.0%**
Carbon Storage					
Storage Infrastructure	57,000	57,500	0	-57,500	-100.0%
Advanced Storage RDD&D	16,100	15,700	0	-15,700	-100.0%
Carbon Use and Reuse	21,000	0	0		
Sub-disciplinary Storage RDD&D (formerly Focus Area for Carbon Sequestration Science)	5,900	5,800	0	-5,800	-100.0%
Total. Carbon Storage	**100,000**	**79,000**	0	**-79,000**	**-100.0%**
Advanced Energy Systems					
Gasification Systems	7,500	19,000	0	-19,000	-100.0%
Advanced Turbines	25,000	27,000	0	-27,000	-100.0%
Reversible Solid Oxide Fuel Cells (formerly Solid Oxide Fuel Cells)	17,000	30,000	0	-30,000	-100.0%
Advanced Coal Processing (formerly Coal Beneficiation)	30,000	30,000	0	-30,000	-100.0%
Transformative Power Generation	40,500	16,000	0	-16,000	-100.0%
Total, Advanced Energy Systems	**120,000**	**122,000**	0	**-122,000**	**-100.0%**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Crosscutting Research					
Plant Optimization Technologies					
Sensors, Controls and Other Novel Concepts	*9,000*	*8,000*	0	*-8,000*	*-100.0%*
Cross-cutting Materials RDD&D	*5,000*	*16,100*	0	*-16,100*	*-100.0%*
Advanced Ultrasupercritical	*16,000*	*0*	0	*0*	*N/A*
Water Management RDD&D	*9,000*	*7,500*	0	*-7,500*	*-100.0%*
Subtotal, Plant Optimization Technologies	39,000	31,600	0	-31,600	-100.0%
Coal Utilization Science					
Simulation Based Engineering	*6,800*	*6,200*	0	*-6,200*	*-100.0%*
Computational System Dynamics	*0*	*0*	0	*0*	*N/A*
Focus Area for Computational Energy Science	*0*	*0*	0	*0*	*N/A*
Subtotal, Coal Utilization Science	6,800	6,200	0	-6,200	-100.0%
Energy Analyses					
Environmental Activities	*0*	*0*	0		
Technical and Economic Analysis	*500*	*500*	0	*-500*	*-100.0%*
Subtotal, Energy Analyses	500	500	0	-500	-100.0%
University Training and Research					
University Coal Research	*3,000*	*3,000*	0	*-3,000*	*-100.0%*
HBCU's, Education, and Training	*2,050*	*2,050*	0	*-2,050*	*-100.0%*
Subtotal, University Training and Research	5,050	5,050	0	-5,050	-100.0%
International Activities					
Coal Technology Export	*0*	*0*	0	*0*	*N/A*
International Program Support	*150*	*650*	0	*-650*	*-100.0%*
Subtotal *International Activities*	150	650	0	-650	-100.0%
Energy Storage Grand Challenge (formerly Advanced Energy Storage Initiative)	4,500	5,000	0	-5,000	-100.0%
Feasibility of Recovering Rare Earth Elements	0	23,000	0	-23,000	-100.0%
Total Cross Cutting Research	**56,000**	**72,000**	0	**-72,000**	**-100.0%**
NETL Coal Research and Development					
Feasibility of Recovering Rare Earth Elements	23,000	0	0	0	N/A
NETL Coal R&D (Other)	38,000	0	0	0	N/A
NETL Coal Research and Development	**61,000**	**0**	0	0	N/A
Transformational Coal Pilots	**20,000**	**10,000**	0	**-10,000**	**-100.0%**

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Supercritical Transformational Electric Power (STEP)	**16,000**	**14,500**	0	**-14,500**	**-100.0%**
TOTAL CCUS AND POWER SYSTEMS	**490,800**	**446,800**	**0**	**-446,800**	**-100.0%**

SBIR/STTR:
- FY 2020 Enacted: SBIR $10,376; STTR: $1,756
- FY 2021 Enacted: SBIR $10,472; STTR: $1,822
- FY 2022 Request: SBIR $13,543; STTR: $1,905

CCUS and Power Systems
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Carbon Capture: Continue to support RDD&D in carbon capture for the power and industrial sectors to reduce the cost of CO_2 capture by 30% by 2030. Essential pre- and post-combustion capture RDD&D on transformational gas separation technologies that can significantly reduce the cost of CO_2 capture for coal and natural gas-fired power plants, hydrogen, industrial sources, and negative emissions technologies such as DAC will continue. This will include front-end engineering and design (FEED) studies for natural gas and industrial facilities. Funding will also support the NCCC in Alabama.	**+$63,700**
Carbon Utilization: The increase in funding allows continued development of at least one CO_2 utilization integrated system.	**+$15,000**
Carbon Storage: Funding prioritizes CarbonSAFE storage opportunities that will have broad applicability to support the hydrogen, power, industry, and negative emission technology applications. Funding also continues the four Regional Initiative projects to evaluate infrastructure and provide technical assistance to support deployment within their regions. Funding also increases support for storage surety technologies.	**+$38,000**
Advanced Energy and Hydrogen Systems: At the decreased level of funding, work will focus on developing modular systems for hydrogen production, advanced gas turbines for 100% hydrogen fired turbines and high efficiency natural gas turbines with CCS; materials development for extreme conditions; and reversible solid oxide fuel cell systems.	**-$26,100**
Crosscutting Research: The proposed funding increase will support RDD&D activities including advancing technologies, water management RDD&D, and sensors and controls that can be used to monitor and identify transients associated with a cyber-attack, providing increased reliability and grid stability.	**+$3,600**
Carbon Dioxide Removal: The increase in funding expands efforts on mineralization and enhanced weathering. The increase in funding allows for field testing of BECCS both for gasification and combustion.	**+$23,000**
Mineral Sustainability: Support large-scale pilot development through FEED studies to produce high purity, commercial grade REEs and other CMs**.** Additional support to maturation of transformational processing from unconventional resources. No longer provides support the Oak Ridge National Laboratory's (ORNL) Carbon Fiber Technology Facility in Tennessee.	**-$8,000**
Transformational Coal Pilots: No funding is requested for FY 2022.	**-$10,000**

	FY 2022 Request vs FY 2021 Enacted
Supercritical Transformational Electric Power: No funding is requested for FY 2022.	**-$14,500**
Total, CCUS and Power Systems	**+$84,700**

CCUS and Power Systems
Advanced Energy and Hydrogen Systems

Introduction

Thermal power generation with carbon capture and storage plays a critical role in supplying the Nation's and world's electricity demand while providing resilient flexible and baseload power for the industrial and manufacturing sectors. In addition, hydrogen production and use for thermal power generation, energy storage, and chemical production can support a path toward carbon free power, industrial, and transportation sectors. Government-supported research, development, demonstration, and deployment (RDD&D) in advanced energy and hydrogen systems can improve the efficiency and performance of these systems, increasing their competitiveness and making additional revenue streams such as hydrogen available to plant operators. The Advanced Energy and Hydrogen Systems (AEHS) program RDD&D is targeted at improving overall system efficiency, reducing capital and operating costs, hydrogen production and use, and enabling affordable carbon capture. Its mission is to increase the availability, efficiency, and reliability of carbon neutral power derived from fossil fuels and other feedstock such as waste biomass and plastics through RDD&D.

The program comprises of four RDD&D activities: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells (R-SOFCs) and (4) Advanced Energy Materials. This research 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 power systems and hydrogen production from fossil fuels with carbon capture, utilization, and storage (CCUS), 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 sub-programs align with the administration's priority to reduce the environmental impact of the power sectors, especially regarding disadvantaged communities.

AEHS coordinates the activities of several programs in the Office of Fossil Energy and Carbon Management (FECM) regarding hydrogen production, transport, storage, and utilization and works closely with the Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE). Programs within FECM that support the hydrogen initiative with FECM RDD&D are focusing on production of carbon-free hydrogen and hydrogen-based fuels and their utilization through:

- Gasification Systems: Gasification of biomass and waste feedstocks with CCUS;
- Advanced Turbines: Development of combustion turbines firing hydrogen blends and 100% hydrogen fuel or zero carbon fuels such as ammonia;
- Reversible SOFCs/solid oxide electrolyzer cells (SOECs): Development of R-SOFCs that can produce power or hydrogen, depending on the market conditions;
- Pre-combustion Capture: Development of advanced carbon capture systems coupled with gasification systems to eliminate CO_2 emissions;
- Energy Storage: Development of technologies to store hydrogen and ammonia at a large scale to support bulk power generation; and
- The Office of Oil and Gas:
    - Development of hydrogen transport and storage technologies at a scale sufficient to act as energy storage for the electric grid.
    - Advanced natural gas reforming technologies with CCUS.

The current cost for clean hydrogen using coal gasification with CCUS is approximately $2/kg hydrogen. Fiscal year (FY) 2022 efforts will focus on the goal of developing at least two designs of advanced modular systems capable of producing carbon neutral hydrogen with the additional ability of accepting waste coal, waste biomass, and waste plastics as fuels. Furthermore, FY 2022 efforts will also focus on operations at a greater than 90% capacity factor for reliable fuel production with advanced controls and materials for reduced maintenance and operating expenses.

FECM closely coordinates its hydrogen RDD&D with EERE's H_2@Scale Initiative and Bioenergy Technologies Office (BETO) to work collaboratively where appropriate and to ensure no duplication of effort. Areas of collaboration in FY 2022 include:

- High temperature electrolysis development and reversible fuel cells;
- Studies of biomass supply available as feedstock for decarbonization technologies and the sustainability of biomass supply over time;
- Utilization of municipal solid waste, including non-recyclable plastics;
- Advancing polygeneration, including co-gasification with waste biomass;
- Regional studies of hydrogen infrastructure requirements; and
- Systems analysis focused on techno economics, life-cycle analysis, and market modules to support hydrogen deployment.

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

A description of each AEHS sub-program follows below:

<u>Gasification Systems</u>

Gasification technologies can turn any carbonaceous feedstock/mixture into syngas and other chemical building blocks. These can be further synthesized into a variety of valuable products, including carbon neutral hydrogen, fuels (i.e., ammonia), chemicals, and carbon products. Additionally, feedstock blends that consist of coal waste, waste plastics, and waste biomass may afford a carbon neutral, or even negative, emissions profile when used in combination with Carbon Capture, Utilization, and Storage (CCUS). This technology enables flexible feedstock usage and promotes environmental justice by remediating environmental waste.

Despite their advantages, there is a need to improve the cost, efficiency, reliability, and flexibility of existing conversion technologies. Innovative gasification technologies are needed for competitive processes in current and future markets. This is especially true for gasification and syngas technologies on small, modular scales to avoid huge capital investment liabilities and to enable flexible deployment under market conditions.

The approach for gasification technology development will focus on modularization and intensification, as well as solutions for process issues arising when wider feedstock combinations are deployed to support hydrogen production at $1 per kilogram by 2030. The program will also focus on improving the efficiency and cost of small-scale gasification-based plants/systems to make them more attractive in the marketplace.

Advanced Combustion focuses on the development of advanced combustion technologies by continuing ongoing RDD&D on topics such as pressurized oxy-combustion, chemical looping, and co-firing with hydrogen or ammonia. These technologies allow power plants to produce flue gas that is rich in CO_2, as the power generation involves combustion in a high-O_2/near zero-nitrogen concentration environment. An added co-benefit is the dramatic reduction in the emission of conventional pollutants, reducing the impact on the communities living around power plants or fossil fuel energy intensive industries.

These advanced technologies are applicable to new and existing power plants. Combustion systems can be improved by lowering the cost of oxygen supplied to the system and by increasing the overall system efficiency.

In FY 2022, the Budget Request provides $48 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:

- **Fuel-flexible, load-following clean power generation**: Developing robust, fuel-flexible, load-following modular gasification systems, specifically for community-scale gasification of waste coal and opportunity feedstocks. These feedstocks include waste streams such as plastics, municipal/industrial waste and bio wastes that pose environmental and economic burdens to disadvantaged communities. Research is needed to assure reasonable capital costs tailored to localized market needs.
- **Clean hydrogen production**: Developing process technology that integrates oxygen separation from air and uses advanced techniques for gasification of waste feedstocks. These are integrated with pre-combustion carbon capture to produce decarbonized fuels like hydrogen.
- **Modular microwave driven reactor:** Developing small-scale, modular microwave reactor technologies that expand the capability to use low value and waste feedstocks (including waste plastics and coal and biomass) to increase operational flexibility and create carbon neutral jobs in the power sector.

Advanced Turbines

This sub-program recognizes that advanced technologies will be required to:

- Improve flexible operations of combined and simple cycle gas turbines for power generation;
- Support the requirements of an electric grid with increasing levels of variable renewable generation;
- Use hydrogen and hydrogen-natural gas blends as a fuel; and
- Design for optimized capture and geological storage of CO_2.

The FY 2022 Budget Request provides $25 million in funding to increase gas turbine performance to 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). Advanced gas turbine combustion systems will be developed to accommodate hydrogen and hydrogen-natural gas fuel blends while minimizing NOx emissions and maintaining machine efficiency. The long term 70% efficiency goal will result in a new combined cycle platform that is optimized to support goals for electric power with zero or net-negative emissions of CO_2.

Investment will be made in the application of advanced manufacturing and machine learning/artificial intelligence to attain efficiency goals. The program 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.

Sub-elements of this program include:

- **Highly Efficient Gas Turbines:** Developing highly efficient gas turbines will maintain U.S. leadership in export markets and help maintain a low cost of electricity (COE) in the U.S. Highly efficient gas turbines, with a low COE, will help facilitate the development of a hydrogen-based energy ecosystem and decarbonize the electric grid.
  Improving machine efficiency is driven in large part by increasing the turbine inlet temperature. The request will support new designs for gas turbine components, advanced cooling techniques, aerodynamics, sealing, combustion systems and materials. Advanced internal airflow architectures will be developed to minimize the use of cooling flows while allowing a higher temperature working fluid. Minimizing cooling flow results in increased efficiency. These and other improvements will be required to reach the 67% CC and 50% simple cycle efficiency goals.
- **Hydrogen Combustion Systems:** The request will support a significant investment in the development of hydrogen combustion systems for retrofit applications and new gas turbines. The fuels under consideration include 100% hydrogen, hydrogen-natural gas mixtures, and hydrogen carriers like ammonia. The combustion of hydrogen offers technical challenges because of its high flame speed; low energy and mass density; high flame temperature; and on an equal energy basis, higher moisture

production; amongst other issues. Applied studies will be underway in FY 2022 to achieve high temperature hydrogen combustion that is stable with low production of NOx.

- **Pressure Gain Combustion:** The request also supports pressure gain combustion (PGC) RDD&D. This technology offers two to three percentage points improvement in CC performance and slightly better performance in simple cycle applications. Like most gas turbine technology, there is significant interest by other government agencies in PGC technology, thereby allowing the Department to leverage its investment. Part of the benefit to PGC technology is that it offers an alternate pathway to increase efficiency that is additive to conventional efforts to increase turbine efficiency. Because of its highly reactive nature, hydrogen is a particularly attractive fuel to use in the development and final application of engines with PGC.
- **University Turbine Systems Research (UTSR):** The request also supports the UTSR activity within the Advanced Turbines Program. UTSR achieves Department and gas turbine industry goals by investing with U.S. universities. This cost shared activity, with industry endorsement, supports fundamental and applied RDD&D projects that improve the efficiencies of gas turbines and related turbine technologies. Additionally, this program helps train the workforce of combustion turbine scientists, engineers, and technicians.

Reversible Solid Oxide Fuel Cells

Given the cross-cutting nature of fuel cell RDD&D across DOE broadly, FECM is shifting our funding to focus on areas that will achieve greater impact toward achieving a net-zero carbon economy by mid-century. Reversible SOFCs can use natural gas to produce electricity, water and CO_2 when operating in a fuel cell mode. SOFCs can be configured to operate in reverse as an electrolyzer using power, water, and CO_2 as inputs to produce hydrogen, with by-products of oxygen and carbon monoxide. This electrolyzer mode turns the SOFC into an SOEC. SOECs essentially function as an SOFC in reverse and optimize the use of these system to reduce overall costs. The carbon monoxide produced from the process can then be used as a feedstock or combusted and converted back CO_2 and sequestered for storage or use in other applications.

Reversible 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 consume 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:

- Small-scale (nominally 5-25 kWe) distributed power generation systems development;
- Carbon neutral hydrogen production from R-SOFCs;
- Developing and validating the materials proposed for improving the cost, performance, and reliability of R-SOFC systems using natural gas as a feedstock coupled to dedicated CO_2 storage.

The FY 2022 Budget Request provides $2 million to conduct additional basic RDD&D to mature R-SOFC technologies, including operating as SOECs. The program will also continue to support the Hybrid Carbon Conversion activities within FECM and focus on accelerating the development of highly efficient, flexible, and cost-effective fossil-based power systems. This program 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

Given the cross-cutting nature of materials RDD&D across DOE broadly, FECM is shifting our funding to focus on areas that will achieve greater impact toward achieving a net-zero carbon economy by mid-century. Fossil energy applications require materials that can withstand harsh environments, such as high temperatures and/or pressures, and corrosive and/or erosive conditions. The Advanced Energy Materials subprogram focuses primarily on fossil power generation applications with an objective of improving the flexibility and reliability of those applications while enabling high efficiency, low-carbon performance. The program 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.

For some applications, materials that meet performance requirements are unavailable and new materials must be developed and qualified. In other cases, materials that meet stringent operation requirements are available, but costs are too high to justify their use. In those cases, research is needed to improve the efficiency of processing techniques and equipment to bring the manufacturing costs of these materials down. For example, gas and steam turbine power plants could achieve higher efficiencies if they operate at higher inlet temperatures, but operating temperatures are constrained by the thermal stability of existing turbine alloys and coatings at high temperatures and pressures.

The existing fleet of fossil plants will continue to operate for years to come, and hence needs to be as flexible and efficient as possible. These same plants will need repairs and upgrades to optimize performance. New plant builds offer the opportunity to introduce state-of-the-art materials and components developed in this and other FECM programs that can enable highly flexible, low-carbon platforms, such as hydrogen-fired powerplants, 70% efficiency natural gas combined cycles power plants with CCUS.

To enable highly flexible power generation that can support a grid with a high level of renewable energy, fossil plant components must be made of materials that can withstand the thermal stresses associated with cold and warm startups, fast load ramping, and frequent shutdowns. The advancements resulting from this program are used to promote technologies that enhance plant optimization and reduce operating and maintenance costs of both existing and new fossil energy infrastructure.

The subprogram has four main themes:

- **Advanced Materials Development**: This sub-program 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. For example, new materials may be necessary to allow heat recovery steam generators used in combined cycle plants to operate at higher temperatures, increasing efficiency and reducing carbon emissions. Development also focuses on advanced manufacturing methods for high-performance materials and computational materials modeling as enabling technologies. A major barrier to the use of advanced materials is the high cost of the constitutive elements in the material. Manufacturing costs increase as the complexity and performance capabilities of such materials increase. For example, the cost of structural alloys for fossil energy power plants increases exponentially as the temperature limit of the alloys increases.
- **Supply Chain Development**: The Advanced Ultra-Supercritical consortium developed and characterized 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 that readied the domestic supply chain to support construction of advanced power generation technology power plants. Moving forward, this sub-program will continue to focus on enhancing the nation's supply chain of advanced materials and components to ensure the reliable construction and repair of thermal power applications. In addition, this sub-program evaluates 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. These efforts will be conducted in collaboration with HFTO.
- **Work Force Development:** This sub-program supports the education and training of advanced technical workers. The workers are trained in skills necessary to manufacture and repair components suitable for fossil-based power plants applications and other industries. These workers could find employment in the

manufacture and repair of components used in fossil power plants and in the aviation, automotive, and petrochemical industries. This sub-program 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 program 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. Under HPC4Mat, selected projects will have access to the labs' HPC facilities, as well as the labs' expertise in modeling, simulation, and data analysis. The program is part of a larger HPC4Energy Innovation Initiative, a DOE-wide effort comprising FECM, EERE, SC, and the National Laboratories. These government entities collaborate with companies to make material advancements that could save industry millions of dollars in fuel and maintenance across sectors.

The FY 2022 Budget Request will provide funding for supply chain RDD&D to reduce the costs of Ni-based super alloys and enhance cyclic capabilities of materials; for fabrication and testing of advanced alloy components for advanced power cycles; and advanced manufacturing methods to reduce fabrication costs and improve cyclic durability. The Request supports a National Energy Technology Laboratory (NETL)-led National Lab Consortium to develop prediction methods for component lifetimes and accelerate the design of new materials.

Transformative Power Generation: No funding is requested in the FY 2022 Budget.

CCUS and Power Systems
Advanced Energy and Hydrogen Systems

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Enacted vs FY 2022 Request
Advanced Energy and Hydrogen Systems: $108,100,000	**$82,000,000**	**-$26,100,000**
Gasification Systems $19,000,000	**$48,000,000**	**+$29,000,000**
• 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-(s)CO_2 power cycles.	• Develop robust, fuel-flexible, load-following modular gasification systems, specifically for community-scale gasification of waste coal 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.	• Additional funding will accelerate development gasification systems that utilize waste coal, 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	**$25,000,000**	**-$2,000,000**
• 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 gas 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. • A net-zero carbon economy will likely be heavily weighted in energy sourced from

		renewables, compared to our energy dependence today, which is heavily weighted in fossil fuels. Advanced turbine design for carbon-free fuels such as ammonia and hydrogen will be of focus. Less focus will be given to the use of CO_2 as the working fluid in the turbines program since these approaches are aligned with fossil as the primary feedstock.
Reversible Solid Oxide Fuel Cells $30,000,000	**$2,000,000**	**-$28,000,000**
• Integrated Energy Systems work with the Idaho National Laboratory • Funding for the 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	**$7,000,000**	**-$9,100,000**
• Completed ComTEST R&D. • FOA on nickel (Ni) Alloy Cost & Cycling. • Appalachian Regional Commission Welding partnership**.**	• RDD&D for heat recovery steam generators used in combined cycle plants to operate at higher temperatures, increasing efficiency and reducing carbon emissions. • 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.	• The decrease in funding is due to other programmatic priorities.
Transformative Power Generation $16,000,000	**$0**	**-$16,000,000**
• Selected four FEED studies to support the 21st Century Power Plant that includes Critical Components FOA that is funded by relevant programs.	• No funding requested.	• No longer an Administration priority.

CCUS and Power Systems
Crosscutting Research

Description

Historically, the United States (U.S.) has been a world leader in developing efficient clean power generation technologies. Technology advances under development in the U.S. have significant potential to shift efficiency higher while providing benefits in reliability, flexibility, carbon management, and environmental performance.

Technical challenges to improving efficiency and achieving future enhancements for advanced fossil power generation include the cost of technology (capital and development), materials limitations, and viable carbon capture approaches. Major research, development, demonstration, and deployment (RDD&D) investments by the Department of Energy (DOE) and the private sector are helping to accelerate development of this new suite of technologies.

The Crosscutting Research subprogram supports innovative early stage RDD&D for improving reliability, availability, efficiency, and environmental performance. In FY 2022, the program will not fund R&D specific to traditional fossil combustion. Rather, the program will narrow focus to technologies that aid in minimizing the environmental impact of society's dependence on fossil fuels, which includes both power and industrial sectors, where the dependence is high today. The subprogram bridges basic and applied research by targeting concepts with the greatest potential for transformational breakthroughs. Research is focused on seven activities: 1) Sensors, Controls, and Other Novel Concepts; 2) Water Management RDD&D; 3.) Simulation Based Engineering; 4) Energy Analyses; 5) University Training and Research (UTR), which comprises funding for University Coal Research (UCR), Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI); 6) Energy Storage Grand Challenge (ESGC); and 7) International Activities.

With funding in this subprogram, The Office of Fossil Energy and Carbon Management (FECM) is also contributing to the following high-profile crosscutting initiatives:

- **Grid Modernization Initiative (GMI) –** FECM's participation in GMI ensures perspective for fossil generation and fuel security. To achieve net zero carbon emissions by 2050, renewable penetration in the grid will be increasing significantly in the near-term and likely ahead of the paralleled storage required to achieve reliable power equitably. Fossil fuels coupled to carbon capture and dedicated storage to serve as a baseload through the transition and throughout the life of the committed energy infrastructure will be critical to meeting energy demands. Increased funds in this program will enable the investment in projects that couple carbon capture and storage (CCS) from the power sector to renewables in a flexible manner through the transition.

- **Critical Minerals (CM)** – Critical minerals sourced in the U.S. will be an essential component to a clean energy economy where the demand for magnets, catalysts, batteries, etc. will be continually increasing. As we transition to a net-zero carbon economy, the extraction of CM and rare-earth elements (REE) from coal will lead to the preservation of mining jobs in the coal sector enabling a more just transition. Increased funds in this program will expand current efforts to include extraction of alkaline minerals from coal waste to serve as a feedstock to react with and permanently store CO_2 to form a synthetic aggregate to be used for mine land reclamation as a broader remediation strategy, or even to be used as a feedstock for roads and concrete.

- **Energy Storage Grand Challenge (ESGC)** – Energy storage is critical to advance a flexible and resilient electric grid. Flexibility will include providing a portfolio of energy options, which will be regionally dependent. 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 to carbon capture and reliable storage will likely be required for baseload applications in the near-term, in addition to strategic storage that includes hydrogen or ammonia. FECM will leverage its expertise in geologic storage of carbon dioxide (CO_2) to explore and invest in approaches to store hydrogen and ammonia in significant quantities that would be required for grid demand.

- **Harsh Environment Materials Initiative** (HEMI)– No additional funds are requested for this crosscutting program, and the investments in this area will continue to focus on materials development and new materials processing solutions needed to meet stringent application demands for gasification processes in addition to emissions reductions.

- **Energy Sector Cybersecurity** – No additional funds are requested for this crosscutting program, and the investments in this area will continue to focus on advanced sensors that can be used to monitor and identify transients associated with a cyber-attack, providing increased reliability and grid stability. FECM is also exploring technologies to extract useful data from unconventional sources to further enhance capabilities in detecting cyber threats.

<u>Sensors and Controls and other Novel Concepts</u>
This activity provides $3 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. This is needed as a part of greater efforts to achieve a net-zero carbon economy by 2050.

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.

This program 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.

- **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.

Water Management RDD&D

Water is a fixed resource with numerous competing demands. In the future, U.S. water resources may not reliably meet energy needs. The mission of the Water Management RDD&D portfolio is to advance sustainable and efficient water use in power generation; develop cost-competitive technology solutions; and enhance understanding of the life cycle relationship between energy and water resources.

A global climate initiative is underway, driving the power generation industry toward lower carbon intensity technologies. This decarbonization may come in many forms; for example, Carbon Capture, Utilization and Storage (CCUS), fuel switching from coal to biomass or from natural gas to hydrogen or optimizing asset utilization through water treatment and heat rate improvements. Both CCUS use and fuel switching will increase water use for fossil power generation. Additional innovation is needed to reduce the freshwater uptake of power generators and allow for non-traditional water sources (such as brackish groundwater) to be used for low-carbon purposes like hydrogen production and CCUS.

As the global energy transition unfolds, coal-fired power generation is declining, leaving legacy wastewater associated with combustion residuals landfills to be addressed. FECM proposes a new topic of focus for FY 2022: addressing landfill leachate and other legacy wastewater needs. Research in this area would advance the protection of generation asset owners and fenceline communities at risk for environmental harm.

Major focus areas of the program include:

- **Sustainable Freshwater Use**: Development of improved cooling technologies for wet recirculating cooling towers at existing powerplants and dry cooling methods for retrofits and new powerplants.

- **Increase Flexibility to Support a Robust Electricity Grid:** Development and field testing of sensors, enabling on-line monitoring and optimization of water subsystem processes such as wastewater treatment. Funding will be used to conduct field tests of condenser coatings that minimize corrosion, maximize efficiency, and reduce water use intensity.

- **Reduce Environmental Burdens with Improved Water Treatment Technologies:** Funding will be used to conduct RDD&D on wastewater treatment technologies for effluents from powerplants, waters internal to powerplants (e.g., from cooling towers), landfill leachate and other legacy wastewaters. This effort researches the treatment of brines associated with CCUS and other non-traditional sources, such as the treatment of water for hydrogen production.

- **Energy-Water Analysis for a Low-Carbon Future:** Assess impacts of water demand and water availability for power generation, CCUS, and hydrogen production. This includes scenario-planning for stresses on water resources from climate change-induced droughts, which can inform optimum deployment of water management strategies and technologies.

Proposed activities in FY 2022 include $8.1 million for research, development, validation testing, and analysis. A new initiative focused on treating wastewaters associated with legacy fossil applications such as landfill leachate is proposed. RDD&D and field testing will continue technologies that minimize consumption and effluent volumes, increase plant efficiency and flexibility, and reduce plant maintenance. These technologies include surface treatments for condensers, new cooling structure design prototypes, wastewater membranes, sorbents, and sensors.

The FY 2022 Budget Request also provides for development of techno-economic assessments, market analyses, and life cycle analyses to guide technology development pathways. These analyses address state, regional, and national issues around water use as it relates to fossil energy.

Simulation-Based Engineering

The Simulation-Based Engineering (SBE) program includes computational software development, high performance computing, advanced optimization, techno-economic analysis, and artificial intelligence 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. Thus, the SBE program helps accelerate the development and deployment of next-generation zero-emission fossil fuel technologies with significantly improved performance and low environmental impact.

This activity also comprises modeling, simulation, and techno-economic analysis 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 carbon-neutral power generation in addition to low-carbon industrial sectors.

In FY 2022, the Budget Request provides $4 million to continue minimal funding for DOE National Laboratory RDD&D, including existing modeling and analysis projects funded under the GMI; and the NETL-led Institute for the Design of Advanced Energy Systems (IDAES) in collaboration with Sandia National Laboratory and Lawrence Berkeley National Laboratory, 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. Private industry will also use the latest computational tools to mitigate degradation mechanisms imposed by an aging coal fleet and load following to enhance flexibility and extend plant life.

Energy Analyses

The Analysis division evaluates potential economic, jobs, and environmental benefits and impacts from the deployment of carbon management and fossil technologies. This activity supports strategic planning by identifying major challenges and opportunities to improve efficiency, cost, and environmental performance to speed deployments of carbon management applications.

University Training and Research Program

As part of the Administration's Commitment to RDD&D, the FY 2022 Budget Request proposes historic increases in funding for foundational R&D to train the next generation of scientists at HBCUs and MSIs. The UTR activity focuses on developing the next generation of scientists and engineers to strengthen the workforce. The FY 2022 Budget will provide $13 million for a new competitive funding announcement for U.S. academic institutions of higher learning to support fundamental research that cuts across FECM's research focus areas. Such funding aims to sustain a national university program of research in energy and environmental science and engineering that focuses on innovative and fundamental investigations pertinent to advancing Administration goals.

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

- **University Coal Research (UCR) $5M:** This sub-activity provides funding to colleges and universities to support early-stage research consistent with the goals of the program including Advancing Carbon Dioxide Removal, Accelerating Clean Hydrogen, Demonstrating and Deploying Point Source Carbon Capture, and Advancing CMs, REEs, Coal Waste to Products, and Mine Remediation. This sub-activity provides a twofold benefit: conducting directed energy research in an innovative environment and expanding the research capabilities and education of the next generation of scientists and engineers.

- **Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI) $8M**: This sub-activity also supports early-stage mission-focused research. Grants awarded under this program are intended to maintain and upgrade the educational, training and research capabilities of HBCUs/MSIs in the fields of science and technology with project results being used to further DOE's commitment to fossil energy and carbon management and further the Administrations' equity priorities.

Energy Storage Grand Challenge Program

The Energy Storage Grand Challenge (ESGC) activity takes a technology agnostic approach to energy storage with an emphasis on long-duration energy storage that is scalable from small applications to full-scale commercial power plants. To achieve this objective, the program 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 greenhouse gas emissions. Additionally, energy storage enables many heavily decarbonized use cases; for example: the integration of hydrogen energy storage system with a hydrogen turbine power production. Analytical results and stakeholder input suggest this activity will emphasize energy storage technologies that are thermal, chemical - including hydrogen, mechanical, or long-duration electrochemical (e.g., flow battery) in nature.

FECM's activity is coordinated with the balance of the Department of Energy's crosscut activities with 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 ESGC roadmap and regularly communicated among the Department's participating offices.

In FY 2022, the Budget provides $5 million to refine Use Cases indicated in the ESGC Roadmap and their associated metrics, fund RDD&D to enhance domestic energy storage supply chain competitiveness, and support feasibility studies of co-located energy storage technologies with fossil assets.

International Activities

International activities support the deployment of U.S. technologies and resources to international markets that are seeking CCUS technologies and advanced high efficiency power plants. Funding will support international efforts and technical studies with various international partners through bi-lateral and multi-lateral agreements. The Request also supports activities in the Clean Energy Ministerial (CEM), International Energy Agency Greenhouse Gas R&D Programme (IEAGHG), International Center for Sustainable Carbon, Hydrogen Technology Collaboration Program (IEAHTCP), Carbon Sequestration Leadership Forum (CSLF) and Global Carbon Capture and Storage Institute (GCCSI).

Crosscutting Materials RDD&D

This activity has moved to the Advanced Energy and Hydrogen Systems Program.

Advanced Ultra Supercritical Materials RDD&D

This activity has moved to the Advanced Energy and Hydrogen Systems Program.

CCUS and Power Systems
Crosscutting Research

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Crosscutting Research $32,900,000	**$36,500,000**	**+$3,600,000**
Sensors and Controls and other Novel Concepts $8,000,000	**$3,000,000**	**-$5,000,000**
• Development and deployment of wireless sensor systems. • R&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.
Water Management RDD&D $7,500,000	**$8,100,000**	**+$600,000**
• Funding Opportunity Announcement (FOA) for Water Management for Thermal Power Generation. • Testing at the Energy and Environmental Research Center (EERC) Brine Extractions and Storage Test (BEST) Site. • Funding for the National Energy Technology Laboratory (NETL) and other National Labs for R&D on impacts of water demand and water availability for power generation, Carbon Capture, Utilization, and Storage (CCUS), and hydrogen production.	• RDD&D on wastewater treatment technologies for effluents from coal mining, power sector, in addition to produced water for dedicated storage efforts. • Surface treatments for condensers, new cooling structure design prototypes, wastewater membranes, sorbents, and sensors. • FECM is investing broadly in remediation approaches for water produced in oil and gas recovery – in addition to dedicated CO_2 sequestration activities	• Additional funding for new initiatives focused on water remediation technologies for legacy impacts from fossil fuels, such as active and abandoned coal mines. In addition, water remediation will be critical as dedicated CO_2 storage efforts are advanced.
Simulation Based Engineering $6,200,000	**$4,000,000**	**-$2,200,000**
• Supports the development of interactive visualization technology and data communication optimization methods to improve the design and operation of advanced power systems with carbon capture and sequestration. • Provides first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes.	• Funding for Institute for the Design of Advanced Energy Systems (IDAES) in addition to other simulation efforts as needed. IDEAS is a multi-lab, multi-university initiative to develop the next generation of process simulation tools.	• The reduction in funding is due to other program priorities.

Energy Analyses $500,000	**$2,400,000**	**+$1,900,000**
• Support for analysis efforts with potential economic, jobs, 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 storage and infrastructure, CCUS, and general systems-based energy and carbon management modeling. • Funding increase will also enable analysis of opportunities in the industrial sector for carbon management. • Additional analysis to support multi-agency task forces as directed by Consolidated Appropriations Act of 2021.
University Training and Research Program $5,050,000	**$13,000,000**	**+$7,950,000**
• Released competitive funding announcement 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 to the national university program of research in energy and environmental science and engineering 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 strong equity priorities. • 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.
Energy Storage Grand Challenge $5,000,000	**$5,000,000**	**$0**
• R&D is focusing 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.	• RDD&D on functional material development for H_2 storage and transport, reaction engineering of catalysts and carriers, assessment of sub-surface hydrogen storage possibilities, and integration of these technologies with hydrogen production and utilization processes.	• The funding will be maintained for RDD&D to continue to advance hydrogen storage technologies, including the initial assessment of underground hydrogen storage.
International Activities $650,000	**$1,000,000**	**+$350,000**
• Support for international efforts with various international partners in Europe, North America, Asia, and the Middle East through bilateral and multi-lateral agreements.	• Support International Activities and Agreements, and other collaborative international efforts.	• Additional funding will support International Agreements supporting the administration's de-carbonization priorities.

CCUS and Power Systems
Carbon Capture, Utilization, and Storage

Description

To decarbonize the electricity sector by 2035 and get to a decarbonized economy by 2050, carbon capture, utilization, and storage (CCUS) will play a critical role. 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. Significant progress and past investment, in collaboration with universities, national labs, and the private sector have proven successful in reducing emissions of sulfur dioxide, nitrogen oxide, particulate matter, and mercury. Novel technologies and business models will enable low-cost CCUS to improve the environmental performance of power plants, hydrogen production, and industrial systems across America; support secure, long-term, regional carbon storage; and provide feedstocks for valuable new products. CCUS has many potential benefits and can be a cost-competitive option for managing carbon relative to other low-carbon sources of electricity and products.

Carbon Capture involves the separation of carbon dioxide (CO_2) into a pure stream and (in many cases) compression to a liquid for transport via pipeline and then injected into a geologic formation in its supercritical form. Industry has a rich history of CO_2 separation, although few large-scale CCUS power plants are currently in operation worldwide. Successful examples of carbon capture at scale have been achieved with government support and policy incentives. Challenges include the increased capital and operating costs of carbon capture relative to comparable plants with unabated carbon emissions and the possible reduction in net generating capacity. Investments in transformative technology can help to overcome these challenges.

Carbon Utilization involves recycling carbon oxide (CO) emissions, principally CO_2, into value-added products. Challenges include improving efficiency of conversion and reducing energy use of utilization processes. Investments in electrochemical, thermochemical, mineralization and biological approaches can utilize CO_2 and potentially result in reduced greenhouse gas (GHG) emissions, while producing valuable products. Lifecycle analyses with careful carbon accounting are critical for utilization pathways to ensure that utilization pathways result in a net CO_2 reduction.

Carbon Storage involves injecting the supercritical CO_2 into deep rock formations capped by one or more layers of impermeable rock that act as a seal to keep the CO_2 contained. Storage resources for the U.S. are estimated to be well over a trillion metric tons of storage capacity; enough to store U.S. CO_2 emissions for many decades. Challenges include optimizing site selection, characterization, and monitoring activities that improve operational performance while minimizing risks and cost. Investments in new approaches to rapidly integrate and process geologic and storage system data can help developers select low-risk sites, develop optimized monitoring strategies, and operate with real-time information for better decision making.

FECM is proposing a new subprogram (new budget line) named Carbon Dioxide Removal (CDR) to emphasize the difference between the CCUS (reduction of emissions from the power and industrial sectors) and CDR. CDR refers to approaches that remove CO_2 from the atmosphere and store it in geologic formations, long-lived products, durable terrestrial sinks, or in the ocean sink. Many climate modeling scenarios make clear that both CCUS and CDR will be critical to meeting climate goals, including getting to a net-zero carbon economy by 2050, and must be pursued in parallel. CDR in FECM will include direct air capture (DAC); bioenergy with carbon capture and storage (BECCS); and enhanced mineralization.

CCUS and Power Systems
Carbon Capture

Description

Advancements in carbon capture technologies can put the United States (U.S.) within reach of cost-competitive, low carbon dioxide (CO_2) emissions from power generation and industry. Carbon capture from power generation is a technology solution for mitigating CO_2 emissions, and for concentrating CO_2 for high-value applications such as conversion to products. Transformational carbon capture technologies will advance U.S. leadership in low-emission generation and hydrogen technology innovation and 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, cement and steel facilities, refineries, petrochemical facilities, and other sources. Research, development, demonstration, and deployment (RDD&D) is focused on adapting technologies or making them robust enough to capture greater than 95% of the CO_2 emissions from these wide variety of sources. RDD&D is needed on both the materials and systems configurations to address unique challenges such as differences in pollution control systems, oxygen content, and CO_2 concentrations.

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 Carbon Capture program is focused on RDD&D on post-combustion and pre-combustion CO_2 capture. Significant improvements are required to reduce parasitic energy load, and lower capital costs that can support the market potential for large quantities of CO_2 for conversion to high-value products and secure geologic storage. RDD&D conducted in this subprogram could establish an adoption pathway for transformational low-cost CO_2 capture from power plants and other industrial sources. Typically, higher concentration sources of CO_2 will have lower costs compared to lower concentration sources.

- The Carbon Capture activity has completed its efforts in 1st generation technology through successful demonstration projects. FY 2022 activities represent a focus on next-generation capture technologies to enable novel power generation concepts and allow for the integration of advanced carbon capture technologies with these systems as well as other CO_2-containing gas streams. Specifically, the FY 2022 Budget Request provides $150 million to the Carbon Capture activity for pre- and post-combustion capture RDD&D on transformational gas separation technologies that can help achieve decarbonization goals.

These transformational technologies will be designed to adapt to the operational demands of current and future advanced power systems including the increasing need for fossil fuel 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 and integration of carbon capture within existing industrial operations.

Additionally, the Carbon Capture program 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 carbon capture 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 Program 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 technoeconomic studies and lifecycle analyses.

Post-Combustion Capture Systems

Post-combustion capture refers to the removal of the CO_2 after the fuel is combusted. The FY 2022 Carbon Capture program Budget Request includes $128 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, refineries, and petrochemicals. 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 2022 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 test on actual flue gas.

Pre-Combustion Capture Systems

Pre-combustion capture refers to removal of the CO_2 from the syngas (or other high-pressure streams) prior to its combustion for power production, separation of CO_2 to produce hydrogen, or other products.[1] DOE's pre-combustion carbon capture program 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 for hydrogen production and other industrial processes. Lowering the cost of CO_2 separation from pre-combustion systems is a critical step toward enabling industry to develop and commercialize technologies that open markets for the use of this captured CO_2 for conversion to higher value products or enabling long term storage. Funds in the FY 2022 Budget Request will continue to support discovery of capture component systems that can enable the production of carbon-neutral hydrogen.

Emissions Control

This 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 of concern). Additional broad research objectives include technologies to reduce environmental legacy issues such as 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 will be considered.

Additionally, advanced concepts and technologies will be developed for the beneficial use of combustion residuals. RDD&D will be directed at: (1) the fraction of combustion products that are not currently being recycled or beneficially reused at

[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.

high levels such as non-gypsum, wet- and dry-flue gas desulfurization (FGD) materials and bottom ash and/or (2) materials used in current combustion residual facilities that may be impacted by new regulations; improvements in the performance and cost of beneficiation/upgrading of technology associated with high-volume reuse materials (i.e., fly ash and synthetic gypsum) and, (3) advanced cost-effective approaches for removing, upgrading, and beneficially recycling combustion residuals from active and inactive storage impoundments will be developed.

CCUS and Power Systems
Carbon Capture

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Carbon Capture[2] $86,300,000	**$150,000,000**	**+$63,700,000**
Post-Combustion Capture Systems $73,300,000	**$128,000,000**	**+$54,700,000**
• Supports up to four Small Scale and/or Bench Scale Carbon Capture Testing on Actual Flue Gases from coal and natural gas. • Implement Congressional direction on industrial capture RDD&D and front-end engineering design (FEED) studies. • National Carbon Capture Center (NCCC): Fund and operate the NCCC post combustion carbon capture test facility. • Plant design and component testing.	• Continued support for several transformational small scale and/or bench scale carbon capture tests on actual flue gases from coal and natural gas, focused on capture rates >95%. • Support transformational RDD&D and pilot-scale carbon capture projects for industrial sources of CO_2. • NCCC: Fund and operate the NCCC post combustion carbon capture test facility for transformational technology development. • Support up to 10 carbon capture FEED studies for industrial and natural gas sources of CO_2.	• The increase in funding supports additional carbon capture FEED studies for natural gas and industrial sources of CO_2.
Pre-Combustion Capture Systems: $10,000,000	**$18,000,000**	**$8,000,000**
• Lab/bench-scale Transformational Carbon Capture. • 21st century power plant design and component testing.	• Conduct transformational RDD&D and gasification design and component testing for carbon-neutral hydrogen production. • Conduct transformational carbon capture development that supports hydrogen production and other industrial applications.	• Increased funding will be used to support carbon capture associated with pre-combustion or gasification streams that include mixtures of CO2 and hydrogen. Investing in this area will lead to advanced approaches for clean hydrogen production through a variety of feedstocks, including natural gas, waste biomass, and waste plastic for example. Advancing pathways to achieving clean hydrogen will be critical to achieving net-zero as hydrogen will be a flexible fuel, spanning from its direct combustion to being used as a feedstock for synthetic fuel production.

[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 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Emissions Control: $3,000,000	**$4,000,000**	**+$1,000,000**
• Conduct 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 early stage RDD&D, systems analyses and technical assessments to identify and address non-CO_2 emissions from industrial sources (i.e., trace metals, Nitrogen Oxide (NOx), particulate matter, etc.) and their legacy sites.	• The increase in funding expands efforts to address non-CO_2 emissions from industrial sources. Additional efforts will focus on potential environmental issues from ash impoundments and landfills (legacy and active), as well as development of novel technologies to create byproducts from combustion residuals (e.g., low-carbon cement, synthetic aggregates for roads and concrete).

CCUS and Power Systems
Carbon Storage

Description

The Carbon Storage program is focused on the development of technologies for the safe and secure geologic storage of captured carbon dioxide (CO_2). Federal government sponsored 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. This area of research is in the national interest as it has long-term economic and environmental benefits for the U.S. and industry. Realization of these benefits may be aided by financial incentives to store CO_2 such as the California Low Carbon Fuel Standard and the increase to the Section 45Q tax credit as amended in the Bipartisan Budget Act of 2018 and the Consolidated Appropriations Act, 2021. Further advancements in CO_2 storage technology and performance will help ensure that industry has verifiable information to economically and safely assess and monitor long-term storage of CO_2 at commercial volumes and timeframes and ensure the viability of geologic carbon storage as an effective CO_2 emission reduction solution that can be widely implemented.

Carbon Storage

Carbon capture, utilization, and storage (CCUS) is widely regarded as a necessary component in the global effort to reduce CO_2 emissions to the atmosphere in a safe and cost-effective way. 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 provides supporting evidence that CO_2 can be securely and safely contained in the deep subsurface, it is vitally important that the technical means exist to identify suitable sites and monitor stored CO_2 to verify secure containment. The U.S. Department of Energy (DOE) Office of Fossil Energy and Carbon Management (FECM) has supported an active Carbon Storage RDD&D Program to develop the technologies and capabilities for widespread commercial deployment of geologic storage. FE's investments have made DOE a world leader in CCUS technology development as well as the demonstration of CCUS as a viable and safe approach to reducing greenhouse emissions.

CCUS projects supported by DOE and other organizations around the world, injected more than 25 million metric tons of CO_2 in 2019, have shown no adverse impacts to human health or the environment. There has not been an instance where a DOE supported project has observed migration of CO_2 outside of the intended storage reservoir or confining cap rock. 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 FE launched the multi-phase Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative. Additionally, the successors of the original seven RCSPs, which began in 2003, now consolidated to four projects and referred to as the Regional Initiative projects, will continue to serve their broad stakeholder base with technical assistance, project development, and data sharing, as well as assist FE with defining the infrastructure needs and most promising first-mover CCUS opportunities in their respective regions that strongly align with the Administration's CO_2 emission reduction goals. These initiatives and other RDD&D activities are advancing storage security and performance and driving the program forward to accelerate commercial CCUS deployment.

The FY 2022 Budget Request provides $117 million for Carbon Storage RDD&D activities that address the performance challenges of operating and monitoring commercial scale CO_2 storage sites. The RDD&D supported by the Carbon Storage subprogram in FY 2022 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 is critical for enabling a CCUS industry that is safe, economically viable, and environmentally benign.

Storage Infrastructure

CCUS in both the power and industrial sectors is expected to make a substantial contribution toward meeting the Administration's CO_2 emission reduction goals. A critical part of this contribution is identifying and certifying on- and offshore CO_2 storage complexes with certified capacities large enough to serve as CO_2 storage hubs and developing the necessary CO_2 transport infrastructure that is optimized for efficient source/sink matching. Therefore, the Storage Infrastructure sub-activity will focus on broadening the availability of certified resources for geologic storage of CO_2 by deploying field projects that advance characterization and certification of storage complexes in regions where there is known storage capacity and regions where the storage resource potential is more prospective. Through this sub-activity the storage program will also coordinate with FE's Capture Program to help promote the integration of capture/storage projects.

The Carbon Storage Budget Request includes $85 million for Storage Infrastructure RDD&D that will leverage active field projects supported by prior year funding and conduct RDD&D as part of CarbonSAFE efforts to characterize, analyze and evaluate storage opportunities for onshore and offshore formations that will support the deployment of CCUS in the hydrogen, power, and other industrial sectors. The FY 2022 Budget Request includes support for the four Regional Initiative projects (the successors of the original seven RCSP) who are playing an important role in evaluating infrastructure needs and accelerating commercial-scale CCUS start-ups by providing technical and project development assistance to their respective regional stakeholder base. Historically, FE 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. The projects have also aided development of cost-effective monitoring technologies in all storage types. FY 2022 activities will leverage the experience and findings of on-going and new field efforts to improve understandings of infrastructure and transport opportunities, onshore/offshore deployment, impacts of financial incentive to deployment, and storage hub resource assessments and efficiencies. Research will also be conducted through National laboratories to complete on-going field studies that were initiated with prior year appropriations.

Advanced Storage RDD&D

The Advanced Storage RDD&D sub-activity is focused on developing and validating CO_2 storage technologies that improve capabilities in plume detection, storage efficiency, secure storage verification, subsurface stress assessments, and wellbore integrity monitoring and mitigation. Current CO_2 storage technologies have largely been developed and tested at the laboratory, pilot, and large field test scale. But the integration of these technologies as an optimized monitoring system has yet to be fully vetted. Moreover, multiple complex data streams generated from monitoring activities at various time intervals and spatial scales currently cannot be quickly translated to knowledge about the state of the system. This presents a challenge in making more rapid decisions that would minimize cost and risk and better ensure safe and secure operations. Therefore, the rapid conversion of data to knowledge has the potential to transform subsurface operations by enabling rapid decision making and performance assessment based on interpretation of real-time information.

The Carbon Storage Budget Request includes $32 million for the Advanced Storage RDD&D sub activity. FY 2022 activities will initiate deployment and testing of new machine learning/artificial intelligence (ML/AI) tools and storage technologies being developed under the Science-informed Machine learning to Accelerate Real-Time decisions for Carbon Storage (SMART-CS) initiative. These activities will support deployment and testing of promising ML/AI-based technologies for: 1) visualization at relevant scales and machine learning method(s) for real-time visualization; 2) development of real-time history matching capabilities that utilize data from autonomous monitoring platforms; and 3) assessment of enabling smart sensor systems and data processing platforms. Additional activities include RDD&D to advance sensing and data telemetry capabilities, and high priority studies on fault/fracture networks characterization, stress state, fluid/pressure migration, legacy wellbore assessment and mitigation, and operational wellbore integrity monitoring that advance intelligent and adaptive reservoir management capabilities and risk reduction.

FY 2022 funded activities also include tool, sensor, and data development that integrates with SMART activities. These tools will help optimize and improve storage operations performance through higher resolution; improved automation and intelligent systems; and better integration of data sources for improved analysis capabilities. FY 2022 will also fund activities to complete the National Risk Assessment Partnership (NRAP) Phase II tools and development of quantitative, risk-based workflows to address critical stakeholder questions for enabling full-scale geologic carbon storage implementation. FY 2022 funds will support the continued curation of data from projects such as Regional Carbon Sequestration Partnerships into Energy Data Exchange (EDX), to include updates to the Atlas and National Carbon Sequestration Database and Geographic Information System (NATCARB) as needed, and new living database systems that can be easily mined by researchers for future use.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Carbon Storage: $79,000,000	**$117,000,000**	**+$38,000,000**
Storage Infrastructure: $57,500,000	**$85,000,000**	**+$27,500,000**
• 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 (EOR)/storage matching, and early-stage RDD&D for high priority activities.	• Perform studies to evaluate national transport network, and onshore and offshore analyses for geologic/associated storage of CO_2, economic and market analysis, and optimization of value-added opportunities and resource assessments and associated efficiencies. • Initiate additional CarbonSAFE feasibility RDD&D to characterize, evaluate, and analyze storage opportunities for onshore and offshore formations.	• Funding increase prioritizes CarbonSAFE storage opportunities that will have broad applicability to support the hydrogen, power, industry, and negative emission technology applications. • Funding increase also continues the four Regional Initiative projects to evaluate infrastructure and provide technical assistance to support deployment within their regions.
Advanced Storage RDD&D: $15,700,000	**$32,000,000**	**+$16,300,000**
• Supports research, development, demonstration and deployment (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 integrity monitoring that advance adaptive reservoir management capabilities. • Continue support for the National Risk Assessment Partnership (NRAP). • Continue machine learning RDD&D to advance forecasting capabilities and improve real-time operational performance.	• Continue support for the Science-informed Machine learning to Accelerate Real-Time (SMART) Initiative to advance promising machine learning (ML)/artificial intelligence (AI)-based technologies to the deployment and testing phase. • Supports RDD&D on tools, sensors and models that integrates with SMART activities, to include but not limited to CO_2 plume detection and migration, verification of secure storage, geomechanical impacts assessment, legacy well detection and assessment, improvements to automated and intelligent systems, and integrated data sources for improved analysis capabilities. • Continue support for NRAP to complete Phase II open-source tools.	• The increase supports a broader portfolio of storage options outside of sedimentary basins, spanning to mineralization opportunities. In addition, AI/ML-based technologies, and technologies such as advanced sensors and monitoring, that enable AI/ML approaches, showing the greatest promise for optimizing performance of storage operations and so will be pursued.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	• Continued support for Energy Data Exchange (EDX) data curation and development.	
Sub-disciplinary Storage RDD&D: $5,800,000	**$0**	**-$5,800,000**
• 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 2022.	• All efforts from this control point are redirected towards Advanced Storage RDD&D.

Description

The Carbon Utilization program is focused on the development of technologies to recycle carbon dioxide (CO_2) into value-added products back into the economy. Federal government research, development, demonstration, and deployment (RDD&D) in this area is critical to validating the emissions reduction of CO_2-based products, producing economically viable technologies. This area of research is of national interest as it has long-term economic and environmental benefits for the U.S. and industry. These benefits may be realized by financial incentives to utilize CO_2,such as the California Low Carbon Fuel Standard and Low Carbon Fuel Standard (LCFS), and regional procurement policies for lower-carbon or sustainably produced materials. Further advancements in carbon utilization technology will help ensure that industry has verifiable information to economically and accurately assess the CO_2 lifecycle of recycled carbon products. In addition, the creation of platform technologies for effective emissions solutions that can be widely implemented will capitalize on a variety of opportunities such as using excess low-carbon electrons, industrial waste heat, and byproduct streams.

Globally, diverse processes are being investigated to utilize CO_2 for high-value products. For example, fly ash, produced from power and industrial processes, can replace to some extent cement to provide a lower carbon cement supply chain. CO_2 can also be reacted with high-alkalinity waste associated with the mining industry to produce synthetic aggregate, which can then be used as a replacement for locally quarried sand and gravel used in roads and concrete for building.

Carbonates used for construction materials are a potential long-term storage option for CO_2. CO_2 can also be substituted for water in curing concrete with a similar mineralization effect, making the concrete stronger and reducing water use. Cement manufacturing is a significant source of CO_2. These emissions can be captured and purified, then re-injected as a mineralizing bonding agent to be mixed with CO_2-based aggregates.

The variety of challenges in using CO_2 for fuels, chemicals, and building materials provide 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. The result is an energy penalty for the utilization system. Other hurdles include higher cost for novel processes, general aversion to change established product markets such as the building sector, and limited field trials and demonstrations to prove viability and diminish risk.

Carbon Utilization

The Carbon Utilization program focuses on novel approaches to recycle carbon oxide (CO) emissions, principally CO_2, into value-added products. Potential feedstocks include flue gas from power generation, industrial point sources, captured/concentrated CO_2, 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 utilization technology platforms is the cost-effective, energy-efficient, and selective upgrading of CO_2. The Carbon Utilization program 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 the carbon lifecycle of these developing technologies.

The FY 2022 Budget Request provides $38 million for this activity for early-stage CO_2 utilization technologies that 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. Funding will support the development of at least one, fully integrated field-test system as well as continued support for carbon utilization test facilities at the National Carbon Capture Center (NCCC) located in Alabama.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request Level	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Carbon Utilization: $23,000,000	**$38,000,000**	**+$15,000,000**
• Laboratory and bench-scale technologies to convert carbon oxides (CO), 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.	• Laboratory and bench-scale technologies to convert CO, principally CO_2, and carbon neutral hydrogen into valuable products such as chemicals, fuels, and building products.	• The increase in funding allows continued development of at least one CO_2 utilization integrated system.

CCUS and Power Systems
Carbon Dioxide Removal

Description

Many climate modeling scenarios make clear that carbon dioxide (CO_2) removal (CDR) will be critical to meeting climate goals, which includes getting to a net-zero carbon economy by 2050. CDR refers to approaches that remove CO_2 from the atmosphere and store it in geologic formations, long-lived products, durable terrestrial sinks, or in the ocean sink. CDR activities include direct air capture (DAC), bioenergy with carbon capture and storage (BECCS), enhanced mineralization, improved terrestrial carbon removal and sequestration (e.g., improved forest management, afforestation, reforestation), enhanced ocean alkalinity, and coastal blue carbon (e.g., CO_2 storage in wetlands). Since the terrestrial biosphere and oceans already remove roughly half of anthropogenic emissions each year, CDR requires that these carbon sinks are enhanced beyond today's baseline when it comes to ocean and land-based CDR approaches.

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 mitigation portfolio to decrease atmospheric concentrations of CO_2 only after anthropogenic emissions have been eliminated.
- NETs/CDR would likely need to play a large role in mitigating climate change by removing on the scale of gigatons by midcentury.

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 CO_2 from power plants and industrial sources. More recently, the Department has been applying this technology development to various NETs, including BECCS and DAC coupled to dedicated storage.

The FECM CDR subprogram is a new budget line in the FY 2022 Budget Request and funding is focused on DAC, BECCS, and mineralization concepts. However, it builds upon past CCUS efforts which have been funded through FECM's CCUS activities, such as past work on DAC, 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 carbon dioxide in the air, the volume of gas flow per ton of CO_2 captured is much larger for DAC systems compared to other 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.

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.

Biomass waste coupled with CCUS offers an opportunity for near-term deployment of CDR technologies. Biomass waste can be used to produce various products like fossil-based hydrocarbons. The biomass captures CO_2 from the atmosphere through photosynthesis during its growing phase and releases this CO_2 when it is subsequently oxidized. However, if this CO_2 is captured and reliably stored, the CO_2 is permanently 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 Carbon Capture Subprogram can be applied to bioenergy facilities. Technology improvements in capital and operating costs, energy penalty, and integration are directly applicable in the case of power generation and gasification processes.

One area where bioenergy offers a "low-hanging fruit" opportunity is in the production of bioethanol via fermentation. Although a variety of feedstocks are used at these facilities, including, cellulosic biomass, cheese whey, waste sugars and brewery waste, most of these plants currently use corn. Net lifecycle emissions reductions from the capture of biogenic CO_2 from ethanol fermentation can be significant. The application of carbon capture to corn ethanol plants in the U.S. has the potential to reduce the carbon intensity of resulting biofuels production by upwards of 40 percent, if the captured CO_2 is stored in saline geologic formations. Additionally, the technology has already been demonstrated through a DOE/National Energy Technology Laboratory (NETL) large-scale industrial CCUS project in Decatur, Illinois. The next step for these types of facilities is to not only capture the CO_2 from the fermentation process, but to also capture the CO_2 from the point sources within these facilities such as power generation and steam and heat generators. In FY 2022, FECM will work with the Office of Energy Efficiency and Renewable Energy's (EERE) Bioenergy Technologies Office (BETO) to maximize CO_2 emissions reductions from the existing domestic biofuels industry.

The subprogram is also investigating co-firing of coal with biomass waste coupled with CCUS. This could have the potential to achieve negative emissions in an economical manner by leveraging the economies of scale of coal, with emissions reductions potential of biomass waste and coupling it with CCUS. This approach is also an opportunity for leveraging previous FECM investments and providing a transition pathway for coal communities.

An objective of this previously funded RDD&D was to determine the impact of co-firing various types of biomass with coal on both the burner operation and the downstream criteria pollutants in sulfur oxide (Sox) and nitrogen oxide (NOx). More recently, DOE has been exploring the impacts of co-firing of a variety of biomass feedstocks on post-combustion carbon capture technologies. Aerosol mitigation from solvent-based carbon capture systems is a focus of the carbon capture subprogram. Flue gas that is formed by co-firing coal and biomass may have constituents in it that may impact carbon capture systems. Studies and research will be conducted to understand these impacts and develop options to address them.

Regarding enhanced mineralization, 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 reactive 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 also part of the Carbon Storage subprogram's activities. FECM has conducted an extensive RDD&D program on geologic carbon storage over the past two decades. This subprogram has been critical to validating and confirming the safe and secure storage of CO_2 in the subsurface. Through its Regional Carbon Sequestration Partnerships (RCSPs), FECM has conducted preliminary analysis and testing of CO_2 injection in basalts. Basalts are found globally and are a geologic feature that formed millions of years ago from lava flows. They are of interest for CO_2 storage because of their reactivity, which can result in more rapid mineralization of CO_2.

In the United States, basalt formations are in the Pacific Northwest, the Southeast, and offshore mid-Atlantic. The Pacific Northwest National Laboratory (PNNL), working with partners at the Big Sky RCSP, conducted a 1,000-ton injection project near Wallula, Washington. This was followed by extensive monitoring to understand how the CO_2 moved and reacted within the reservoir and how the reservoir itself reacted to CO_2 injection, for example its pressure response. Findings from this test site indicate that it has the potential to convert 90% of injected CO_2 into a solid in as little as a decade.

DOE has also funded other activities on basalts with universities. For example, Columbia University conducted tracer RDD&D at the CarbFix injection site in Iceland. Other universities (e.g., Yale, University of Washington, and Virginia Tech) conducted experimental and modeling studies of CO_2 injection into mafic and ultramafic rocks.

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. While DOE/FECM and NETL have previously conducted studies on the ex-situ mineralization of CO_2, a more recent analysis by the United States Geological Survey (USGS),[1] provides a summary of the U.S. 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.

Based on the recent reports by the USGS, NASEM, and others, DOE is planning to investigate opportunities where carbon mineralization can be utilized, leveraging from its earlier RDD&D work. These activities included analyses on the economic potential, tests to understand impacts of particle size and kinetics to optimize CO_2 uptake, and pilot-scale tests or studies to validate the approach.

For all the CDR approaches, lifecycle analyses (LCA) are critical to ensuring the viability of the various technologies to ensure 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

CCUS and Power Systems
Carbon Dioxide Removal

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Carbon Dioxide Removal: $40,000,000	**$63,000,000**	**+$23,000,000**
• 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) to evaluate challenges and potential concepts for ex situ mineralization and enhanced weathering concepts. • Evaluation of coal-biomass co-feeding concepts coupled with carbon capture, utilization, and storage (CCUS) at existing facilities.	• Continue development of transformational DAC materials and components, and feasibility studies of current DAC systems. • Continue National Laboratory RDD&D on mineralization and enhanced weathering concepts. • Continue evaluation of coal-waste biomass co-feeding concepts with CCUS at existing facilities.	• The increase in funding expands efforts on mineralization and enhanced weathering. • The increase in funding allows for field testing of bioenergy with carbon capture and storage (BECCS) both for gasification and combustion in coordination with the EERE's Bioenergy Technologies Office (BETO).

CCUS and Power Systems
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 FY 2015 Enacted appropriations.

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 2022, 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 2022 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 2022.

The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. FECM will ensure that its programs are not directly subsidizing fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels. 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 union.

CCUS and Power Systems
Supercritical Transformational Electric Power (STEP)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Supercritical Transformational Electric Power (STEP) **$14,500,000**	**$0**	**-$14,500,000**

• Funding for Budget Period (BP) 2 of project:
  • Complete site construction and civil works
  • Fabricate/Install major equipment
  • Simple Cycle commissioning and testing
	• No funding is requested in FY 2022.	• Funding in the FY 2021 Enacted Budget will be sufficient to complete BP2.

CCUS and Power Systems
Transformational Coal Pilots

Overview

The Consolidated Appropriations Act of 2017, H.R. 244, provided $50 million to remain available until expended, for the Transformational Coal Technologies pilot program described in section 4 of the explanatory statement (in the matter preceding Division A of the 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 enabling 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 making the awards for pilots, 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 2021 funds will be carried over into FY 2022.

Description

No funding is requested in the FY 2022 Budget Request. Prior year funding will be used to award up to 2 final Phase III projects.

The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. FECM will ensure that its programs are not directly subsidizing fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels. The Budget focuses on activities that support clean energy development and deployment, environmental benefits, and the creation of good paying jobs that provide a free and fair chance to join a union.

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Transformational Coal Pilots $10,000,000	**$0**	**-$10,000,000**
• Funding will be utilized for Phase III downselect.	• No funding is requested.	• No funding is requested. Unobligated funds will be used for Phase III selections.

Overview

The Mineral Sustainability subprogram will support domestic supply chain networks required for the economically, environmentally, and geopolitically sustainable production of critical minerals (CM). The integration of extraction of carbon ore and CM is naturally part of the upstream process. The Critical Minerals and Carbon Ore Processing subprogram 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, rare earth elements (REE) and carbon ore to products production.

These unconventional resources are defined below:

- 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), and 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, critical mineral 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, America's import dependency for many of the minerals and metals needed for clean energy technology—major steppingstones toward an improved climate quality—has continued to increase dramatically over the past 30 years.

Annual Appropriations Acts from 1997 through 2021 have included the following language in the Fossil Energy and Carbon Management Research, Development, Demonstration, and Deployment (FECM RDD&D) section clearly identifying the Office of Fossil Energy and Carbon Management as an RDD&D organization in the DOE for mineral extraction processing, use, and disposal:

"….*including the acquisition of interest, including defeasible and equitable interests in any real property or any facility or for plant or facility acquisition or expansion, and for conducting* ***inquiries, technological investigations and research concerning the extraction, processing, use, and disposal of mineral substances without objectionable social and environmental costs (30 U.S.C. 3, 1602, and 1603)***" (emphasis added)

The Mineral Sustainability subprogram activities in FECM, along with complementary investments in the 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 first-order 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 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 our nation's economic growth; transition to clean energy technologies; secure our energy independence by reducing our reliance on foreign CM and REE sources; and increase our national security. The Critical Minerals subprogram focuses on the sustainable recovery of all CM, including REE 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 Critical Minerals subprogram activities will continue to develop advanced technologies throughout the supply chain, improve the economics of future projects through the evaluation of co-production of other valuable products (both critical and noncritical), and enable large-scale processing, separation, and metallization pilot-projects.

Other activities within the Critical Mineral subprogram leverages the success of the former, fully integrated "Feasibility of Recovery of Rare Earth Element" RDD&D that developed separation and recovery technologies and the capability to assess and characterize feedstocks, but also demonstrated the technical feasibility of recovering CMs from a diversity of carbon ore feedstocks in small quantities. Building on this success, this activity will continue to enable future commercial technologies while minimizing land disturbance and maximizing environmental stewardship. This will be accomplished through technology development and validation—including machine learning and artificial intelligence, 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, RDD&D has 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 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 thus far 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 United States Geological Survey in 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 2022 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, machine learning 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 activity (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. This activity is focused on developing transformational technologies to enable domestic manufacturing of strategic materials and superior building products from carbon ore at competitive market prices. These transformational technologies have minimal emissions, superior product performance, and better lifecycle for new and existing products in the market.

RDD&D in the Carbon Ore Processing activity will further efforts for the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated 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 2022 Budget Request of $12 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 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Mineral Sustainability $53,000,000	**$48,000,000**	**-$5,000,000**
Critical Minerals $23,000,000	**$33,000,000**	**+$10,000,000**
• 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	**$12,000,000**	**-$18,000,000**
• 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 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	• 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.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Support the development of next generation carbon-based building materials and infrastructure products with superior mechanical properties.	memristor computer chips, using novel technologies.	

Natural Gas Technologies
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
51,000	57,000	130,000	+73,000

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 technology, such as conversion of flared methane to high-value products and cleaning water produced from hydraulic fracturing operations for agriculture use, provide alternative solutions for aspects of oil and natural gas production.

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 with plans in place to install many more miles of pipeline capacity from production regions that have grown rapidly over the last decade. However, pipeline 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 Natural Gas Technologies Program addresses these critical environmental and safety issues associated with the production and transmission of domestic natural gas. Specifically, the Program’s mission is to conduct research, development, demonstration and deployment (RDD&D) that reduces the environmental impact from the development, transportation, distribution, and storage of natural gas resources. The Program comprises of four subprograms: Environmentally Prudent Development, Emissions Mitigation from Midstream Infrastructure, Emissions Quantification from Natural Gas Infrastructure, and Natural Gas Hydrogen Research.

The Environmentally Prudent Development subprogram will focus on developing solutions that address the environmental and social impacts of oil and natural gas development. 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. Hydraulic fracturing requires the use of large amounts of water and chemicals, which needs to be cleaned and safely disposed of without causing induced seismic events. Offshore oil development carries the risk of oil spill 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 from air quality, water contamination, oil spills or induced seismicity.

The Emissions Mitigation from Midstream Infrastructure subprogram 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 subprogram 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.

The Emissions Quantification from Natural Gas Infrastructure subprogram will develop advanced technologies to detect, locate, and measure emissions that will inform research, analytics, and remediation efforts. Finding and measuring emissions from natural gas production fields, transportation and storage systems, and legacy infrastructure, including abandoned and orphaned wells, is critical to reducing emissions and addressing the negative impacts, like ground water contamination, that plague communities.

The Natural Gas Technologies Program is well positioned to support 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 Hydrogen Research subprogram will focus on advancing technologies for the "carbon-neutral" production, transportation, and storage of hydrogen sourced from natural gas.

Highlights of the FY 2022 Budget Request

The Natural Gas Technologies Program will pursue the following major activities in FY 2022:

- The Environmentally Prudent Development subprogram will conduct RDD&D technologies to address wellbore integrity, induced seismicity, water use, produced water treatment, and offshore safety and spill prevention.
- The Emissions Mitigation from Midstream Infrastructure subprogram will:
    - 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 in the remediation of orphaned wells.
- The Emission Quantification from Natural Gas Infrastructure subprogram will:
    - 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 studies, and the Environmental Protection Agency's (EPA) Greenhouse Gas (GHG) Inventory.
- A newly proposed Natural Gas Hydrogen Research subprogram 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 Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. FECM will ensure that its programs are not directly subsidizing fossil fuels, not funding RDD&D focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels (like gas hydrates). The Budget focuses on other activities that support clean energy development and deployment, environmental benefits (including reducing methane leaks), and the creation of good paying jobs that provide a free and fair chance to join a union.

Natural Gas Technologies
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Natural Gas Technologies					
Environmentally Prudent Development	13,000	12,000	28,000	+16,000	+133.3%
Emissions Mitigation from Midstream Infrastructure	12,000	13,500	54,000	+40,500	+300.0%
Emissions Quantification from Natural Gas Infrastructure	6,000	6,500	18,000	+11,500	+176.9%
Gas Hydrates	20,000	25,000	0	-25,000	-100.0 %
Natural Gas Hydrogen Research	0	0	30,000	+30,000	N/A
Total, Natural Gas Technologies	**51,000**	**57,000**	**130,000**	**+73,000**	**+128.1%**

SBIR/STTR:

- FY 2020 Enacted: SBIR $1,351: STTR: $229
- FY 2021 Enacted: SBIR $1,382: STTR: $241
- FY 2022 Request: SBIR $3,303: STTR: $464

Natural Gas Technologies
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Natural Gas Technologies	
Environmentally Prudent Development: 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.	**+$16,000**
Emissions Mitigation from Midstream Infrastructure: 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.	**+$40,500**
Emissions Quantification from Natural Gas Infrastructure: Funding increase 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.	**+$11,500**
Gas Hydrates: Funding decrease reflects the elimination of direct fossil fuel subsidies from the FY 2022 Budget.	**-$25,000**
Natural Gas Hydrogen Research: Funding increase reflects new research on developing and advancing technologies for the production, transportation, and storage of domestically produced Hydrogen.	**+$30,000**
Total, Natural Gas Technologies	**+$73,000**

Natural Gas Technologies

Description

Environmentally Prudent Development

The Environmentally Prudent Development 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 contain oil and gas also hold 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 identifying and mitigating risks from ocean currents and seafloor hazards such landslides; reducing risks associated with infrastructure used to deliver chemicals to the well and to bring produced fluids to the platform; and assessing, predicting, and mitigating the risks associated with an aging offshore infrastructure. DOE is working with the Department of the Interior (DOI), under a Memorandum of Collaboration, to pursue collaborative offshore research to increase safety and reduce environmental risk.

Emissions Mitigation from Midstream Infrastructure

The Emissions Mitigation from Midstream Infrastructure subprogram is committed to developing advanced, cost-effective technologies to reduce emissions from natural gas transmission, distribution, and storage facilities. Priority areas for the subprogram include research in advanced materials for pipeline integrity, initiation of research on passive sensor platforms, 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 subprogram 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 subprogram will also 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 subprogram will accelerate advances in remote sensor technologies that can detect and locate emissions from pipelines, natural gas storage, abandoned and orphaned wells, and other 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, such as orphaned wells.

Emissions Quantification from Natural Gas Infrastructure

The Emissions Quantification from the Natural Gas Infrastructure subprogram 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 Greenhouse Gas Inventory; and data collection, analysis and support related to quantifying emissions from orphan wells. This work will inform future research efforts and priorities; will improve analytics, data collection and modeling; and that will inform mitigation and remediation efforts for natural gas pipelines, storage facilities, and abandoned or orphaned wells.

Natural Gas Hydrogen Research

The United States 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. The Natural Gas Hydrogen Research subprogram will focus on hydrogen production, transportation, and storage as well as developing supporting analytical tools and models.

Steam methane reforming (SMR) is an advanced and mature production process that builds upon the existing natural gas pipeline delivery infrastructure. Hydrogen production research will focus on improving upon natural gas SMR and will support 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. 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, technoeconomic and lifecycle analyses, and resource evaluations. This analysis will provide potential technology pathways and aid in predicting future market penetration of different development strategies.

Natural Gas Technologies

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Natural Gas Technologies $57,000,000	**$130,000,000**	**+$73,000,000**
Environmentally Prudent Development $12,000,000	**$28,000,000**	**+$16,000,000**
• Research on reducing the environmental footprint of unconventional oil and gas development.	• Funding will support research 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.	• Funding will support research that addresses the environmental impacts of oil and natural gas development. These topics include wellbore integrity, oil spill prevention, and produced water treatment and reuse technologies.
Emissions Mitigation from Midstream Infrastructure $13,500,000	**$54,000,000**	**+$40,500,000**
• 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.	• 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 advanced remote detection technologies for natural gas infrastructure. • Funding for the development of modular remediation materials and solutions.	• Increase in funding will expand 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 also support new advanced remote detection technologies for natural gas infrastructure and the development of modular remediation materials and solutions.
Emissions Quantification from Natural Gas Infrastructure $6,500,000	**$18,000,000**	**+$11,500,000**
• Advanced methane detection and measurement technology validation.	• Funding will support the development of direct and remote measurement sensor technologies for the collection, dissemination, and analysis of emissions data.	• Increase in funding will support the development of direct and remote measurement sensor technologies for the collection, dissemination, and analysis of

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
• Field scale methane emissions detection and quantification technology development and validation.	• Research, data collection and analytics that support EPA's Greenhouse Gas Inventory. • Research, technology development, and data analytics on finding and quantifying emissions from orphan wells.	emissions data, including support to EPA's Greenhouse Gas Inventory. • Increase in funding will support new research, technology development, and data analytics on finding and quantifying emissions from fossil fuel infrastructure, including orphan wells.
Gas Hydrates $25,000,000	**$0**	**-$25,000,000**
• Conduct early-stage research such as numerical simulations, fundamental property characterization, and pore-scale visualization of hydrate bearing sediments. • Prepare for long-term reservoir flow test on the North Slope of Alaska. • Prepare for phase two expedition in the Gulf of Mexico.	• No funding is requested within the Natural Gas Technologies Budget Request.	• No funding is requested within the Natural Gas Technologies Budget Request.
Natural Gas Hydrogen Research $0	**$30,000,000**	**+$30,000,000**
• No funding requested or appropriated.	• Research on production of hydrogen from methane, including steam methane reforming and 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 hydrogen production, transportation, and storage.

Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
46,000	46,000	0	-46,000

Overview

The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. The Office of Fossil Energy and Carbon Management (FECM) will ensure that its programs are not directly subsidizing fossil fuels, not funding research, development, demonstration and deployment (RDD&D) focused on unabated fossil combustion, traditional fossil-fueled power generation, or increased production of fossil fuels. 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 union.

In FY 2022, FECM's effort to address high priority challenges to safe and prudent development of oil and natural gas resources will continue under the Environmentally Prudent Development subprogram of the Natural Gas Technologies subprogram budget line.

Highlights of the FY 2022 Budget Request

- No funding is requested in the FY 2022 Budget Request.

Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies
($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies	**46,000**	**46,000**	**0**	**-46,000**	**-100%**
Total, Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies	**46,000**	**46,000**	**0**	**-46,000**	**-100%**

SBIR/STTR:

- FY 2020 Enacted: SBIR $1,219: STTR: $206
- FY 2021 Enacted: SBIR $1,116: STTR: $194
- FY 2022 Request: SBIR $0: STTR: $0

Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies	
• To ensure that FECM programs are not directly subsidizing fossil fuels, no funding is requested for this program within the FY 2022 Budget.	**-$46,000**
Total, Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies	**-$46,000**

Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies

Description

Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies

In FY 2022, FECM's efforts to address high priority challenges to safe and prudent development of oil and natural gas resources will continue under the Environmentally Prudent Development subprogram of the Natural Gas Technologies subprogram budget line.

Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Unconventional Fossil Energy Oil Technologies from Petroleum – Oil Technologies) $46,000,000	**$0**	**-$46,000,000**
• Basin-specific produced water characterization and development of treatment technologies and management tools. • Field laboratory research. • Develop models using high performance computing and big data for predictive analysis. • Research on enhanced oil recovery (EOR) include the Permian and Bakken formations. • Offshore oil and gas research include high-pressure high–temperature resistant materials and pipe coatings. • Unconventional oil and gas research on safe and efficient drilling on the Alaska North Slope and arctic offshore.	• No funding is requested for FY 2022.	• To ensure that FECM programs are not directly subsidizing fossil fuels, no funding is requested for this program within the FY 2022 Budget.

Special Recruitment Programs
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
700	700	700

Overview

The Office of Fossil Energy and Carbon Management (FECM) utilizes educational programs, such as the Mickey Leland Energy Fellowship (MLEF), Minority Educational Institution Student Partnership Program (MEISPP), and the Department of Energy (DOE) Scholars Program to support an increase in the number of females and under-represented minorities entering scientific, technology, engineering, and mathematics (STEM) career fields within the U.S. workforce. The MLEF Program, developed by FECM, is a ten-week educational program that offers undergraduate, graduate, and post-graduate students majoring in STEM disciplines the opportunity to learn about programs, policies, and research, development, demonstration, and deployment initiatives within FECM and the challenges in providing clean, affordable energy for future generations. The MEISPP and DOE Scholars Programs also provide students the opportunity to gain work experience and learn about the FECM and DOE missions to support preparation for careers in the STEM workforce. The program aligns with the Administration's equity prioirites.

Highlights of the FY 2022 Budget Request

In FY 2022, FECM will recruit and select a diverse group of undergraduate, graduate, and post-graduate students in STEM majors to participate in the MLEF program. All participants in the MLEF will complete a hands-on research project under the mentorship of an FECM scientist, researcher, or program official. Students may also be selected into the MEISPP and DOE Scholars Program, as funding permits. MEISPP and DOE Scholars will participate on challenging assignments supporting the FECM mission.

Special Recruitment Programs
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Special Recruitment Programs	700	700	700	0	0%
Total, Special Recruitment Programs	**700**	**700**	**700**	**0**	**0%**

Special Recruitment Programs
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Special Recruitment Programs: The FY 2022 Budget Request level supports administration of the Mickey Leland Energy Fellowship (MLEF) Program at current levels.	**$0**
Total, Special Recruitment Programs	**$0**

Special Recruitment Programs

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Special Recruitment Programs $700,000	**$700,000**	**$0**
• A diverse group of undergraduate, graduate, and post-graduate students in science, technology, engineering, and mathematics (STEM) majors will be recruited and selected to participate in the Mickey Leland Energy Fellowship (MLEF) program, the Minority Educational Institution Student Partnership Program (MEISPP) or the DOE Scholars program. Provides students opportunity to gain hands-on research and work experience and learn more about the DOE and the Office of Fossil Energy and Carbon Management (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 program, the MEISPP, or the DOE Scholars program. Provides students opportunities to gain hands-on research and work experience and learn more about the DOE and FECM missions.	• No change

Program Direction
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)
61,500	61,500	66,800	+5,300

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. Import/Export Authorization is managed by the Division of Natural Gas Regulation within the Office of Oil & Natural Gas. 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 2022 Budget Request
The FY 2022 Budget Request is $66.8 million and reflects a $5.3 million increase from the FY 2021 Enacted level. This 8.6% increase is driven by a 2.7% pay increase, and a requested 18.7% increase in FECM RDD&D 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 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Washington Headquarters					
Salaries and Benefits	21,031	21,937	25,860	+3,923	+17.9%
Travel	403	394	400	+6	+1.5%
Support Services	558	546	550	+4	+0.7%
Other Related Expenses	9,361	8,476	7,710	-766	-9.0%
Total, Washington Headquarters	**31,353**	**31,353**	**34,520**	**+3,167**	**+10.1%**
National Energy Technology Laboratory					
Salaries and Benefits	16,206	17,000	19,300	+2,300	+13.5%
Travel	485	400	400	0	0.0%
Support Services	7,988	7,280	6,600	-680	-9.3%
Other Related Expenses	3,101	3,100	3,100	0	0.0%
Total, National Energy Technology Laboratory	**27,780**	**27,780**	**29,400**	**+1,620**	**+5.8%**
Import/Export Authorization					
Salaries and Benefits	1,554	1,554	1,845	+291	+18.7%
Travel	18	18	20	+2	+11.1%
Support Services	231	231	485	+254	+110.0%
Other Related Expenses	564	564	530	-34	-6.0%
Total, Import/Export Authorization	**2,367**	**2,367**	**2,880**	**+513**	**+21.7%**
Total Program Direction					
Salaries and Benefits	38,791	40,491	47,005	+6,514	+16.1%
Travel	906	812	820	+8	+1.0%
Support Services	8,777	8,057	7,635	-422	-5.2%
Other Related Expenses	13,026	12,140	11,340	-800	-6.6%
Total Program Direction	**61,500**	**61,500**	**66,800**	**+5,300**	**+8.6%**

Program Direction Summary	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Federal FTEs – HQ	**121**	**124**	**141**	**+17**	**+13.7%**
Federal FTEs – NETL[1]	**121**	**125**	**138**	**+13**	**+10.4%**
Federal FTEs – Total	**242**	**249**	**279**	**+30**	**+12.0%**
Support Services					
Technical Support					
Headquarters	558	546	550	+4	+0.7%
NETL	0	0	0	0	0.0%
Import/Export Authorization	231	231	485	+254	+110.0%
Total, Technical Support	**789**	**777**	**1,035**	**+258**	**+33.2%**
Management Support					
Headquarters	0	0	0	0	0.0%
NETL	7,988	7,280	6,600	-680	-9.3%
Import/Export Authorization	0	0	0	0	0.0%
Total Management Support	**7,988**	**7,280**	**6,600**	**-680**	**-9.3%**
Total, Support Services	**8,777**	**8,057**	**7,635**	**-422**	**-5.2%**
Other Related Expenses					
Headquarters	9,361	8,476	7,710	-766	-9.0%
NETL	3,101	3,100	3,100	0	0.0%
Import / Export Authorization	564	564	530	-34	-6.0%
Total, Other Related Expenses	**13,026**	**12,140**	**11,340**	**-800**	**-6.6%**

[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 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $61,500,000	**$66,800,000**	**+$5,300,000**
Salaries and Benefits $40,491,000	**$47,005,000**	**+$6,514,000**
• 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.	• HQ increase reflects the addition of 17 full-time equivalents (FTE) to support FECM's mission as well as a 2.7% pay raise for federal staff, the Federal Employees Retirement System (FERS) increase, and awards pool funding increase in FY 2022. • NETL increase reflects the addition of 13 FTEs to support FECM's mission as well as a 2.7% pay raise for federal staff, FERS increase, and awards pool funding increase in FY 2022.
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	**$7,635,000**	**-$422,000**
• 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. • 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 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Other Related Expenses $12,140,000	**$11,340,000**	**-$800,000**
• 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.

NETL Infrastructure
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
55,000	**55,000**	**78,000**	**+23,000**

Overview
The National Energy Technology Laboratory (NETL) Infrastructure Program supports the fixed costs of NETL's laboratory footprint in three geographic locations: Morgantown, WV; Pittsburgh, PA; and Albany, OR. Table 1 below provides relevant information on the relative sizes of the sites.

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 2022 Budget Request includes $6.0 million for the first year of a 3-year lease upon the expiration of the current lease.

(2) **Laboratory and Sitewide Facilities** includes repairs to existing laboratory facilities, general-purpose buildings, and sitewide infrastructure and the continued reduction 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 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 Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) obligations 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 September 30, 2020

	Morgantown	Pittsburgh	Albany	Total NETL
Buildings	41	30	37	**108**
Sq. Ft. of Building Space (000s)	445	434	253	**1,132**
Acres	136	57.4	43.9	**237.3**
NETL Federal Workforce	222	218	40	**480**[2]
NETL Contractor Workforce (FTEs)	346	397	93	**836**[3]
Assets Replacement Value	$285.9M	$240.5M	$177.7M	**$704.1M**

[1] Table 1 reflects on board employees as of March 31, 2021 and Table 2 reflects authorized and requested FTEs.
[2] Total NETL includes three employees located in Houston, TX and one located in Germantown, MD.
[3] Total NETL includes three contractors located in Houston, TX.

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

	FY 2021 Enacted	FY 2022 Request	FY 2022 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 2022 Budget Request

The FY 2022 Budget Request for NETL Infrastructure is $78 million. The funding includes $25 million for the design and construction of a Direct Air Capture (DAC) Center to be located at NETL. This DAC Center will be utilized to lead agency-wide research, development, demonstration, and deployment projects to advance the development and commercialization of technologies to remove carbon from the air on a significant scale. Research focus will be on process design, including modeling, analytics, and simulation, with an emphasis on modular design and materials manufacturability. The DAC Center will accelerate the development and deployment of DAC technologies by offering a research facility for prototyping and qualifying DAC technologies. The DAC Center would be of value to universities, research institutions and U.S. businesses developing DAC technologies. Typically, these institutions would not have the resources or experience to construct, operate, and comprehensively analyze the results of DAC tests at this scale on their own. Furthermore, the DAC facility would be of particular value to the DOE and other agencies attempting to reduce/control greenhouse gas emissions by providing a key stepping stone between bench scale and commercial scale, effectively placing a bridge over the so-called valley of death for technology development.

FY 2022 Departmental Crosscuts ($K)

	Cybersecurity	
	2021 Enacted	**2022 Request**
NETL Infrastructure	4,772	7,398

The FY 2022 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 Control and Access Management initiative. Within the FY 2022 Budget Request for NETL Infrastructure, $7.398 million will be used to support these crosscutting cyber activities. Cybersecurity is funded under the Safeguards and Security subprogram.

NETL Infrastructure
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
NETL Infrastructure					
Super Computer	6,000	6,000	6,000	0	0.0%
Laboratory- & Site-Wide Facilities	39,500	39,000	62,000	+23,000	+59.0%
Safeguards and Security	7,500	8,000	8,000	0	0.0%
Environmental Restoration	2,000	2,000	2,000	0	0.0%
Total, NETL Infrastructure	**55,000**	**55,000**	**78,000**	**+23,000**	**+41.8%**

NETL Infrastructure
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
NETL Infrastructure: The requested $23.0 million increase results from the inclusion of $25.0 million for a major capital project for a Direct Air Capture Center design and construction at NETL.	**+$23,000**
Total, NETL Infrastructure	**+$23,000**

NETL Infrastructure

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
NETL Infrastructure $55,000,000	**$78,000,000**	**+$23,000,000**
High Performance Computer (Super Computer) $6,000,000	**$6,000,000**	**$0**
• Funding is for the 3-year lease of Joule, NETL's 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 $39,000,000	**$62,000,000**	**+$23,000,000**
• 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 goals.	• Funding includes design and construction of a new Direct Air Capture Center (DAC) and 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 goals. Funding also includes information technology (IT) development, modernization, and enhancement (DME) investment.	• The FY 2022 Budget Request includes $25.0 million for the design and construction of a new DAC Center. The request also includes $8.0 million for IT DME.
Safeguard and Securities $8,000,000	**$8,000,000**	**$0**
• Funding is to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the FECM RDD&D mission.	• Funding is to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the FECM RDD&D mission.	• No change

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Environmental Restoration $2,000,000	**$2,000,000**	**$0**
• Continue active operation and maintenance of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12 under the guidance of the Wyoming Department of Environmental Quality (DEQ). • Continue all NETL on-site Resource Conservation and Recovery Act (RCRA) hazardous waste compliance and management activities. • Continue all NETL Albany ground water investigation and compliance activities.	• Continue active operation and maintenance of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12 under the guidance of the Wyoming DEQ. • Continue all NETL on-site RCRA hazardous waste compliance and management activities. • Continue all NETL Albany ground water investigation and compliance activities.	• No change

Plant and Capital Equipment
Capital Summary ($K)

	Total	Prior Years	FY 2020 Enacted	FY 2020 Actuals	FY 2021 Enacted	FY 2022 Request	FY 2022 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	0
Minor Construction Project (>$5M)	44,372	0	7,372	7,372	12,000	25,000	+13,000
Total, Capital Operating Expenses	**44,372**	**0**	**7,372**	**7,372**	**12,000**	**25,000**	**+13,000**
Capital Equipment > $500K (including MIE)							
Total Non-MIE Capital Equipment	n/a	0	0	0	0	0	0
Total, Capital Equipment (including MIE)	**n/a**	**0**	**0**	**0**	**0**	**0**	**0**
Minor Construction Projects (>$5M)							
Computational Science & Engineering Center	19,372	0	7,372	7,372	12,000	0	-12,000
Direct Air Capture Center	25,000	0	0	0	0	25,000	+25,000
Total, Minor Construction Projects	**44,372**	**0**	**7,372**	**7,372**	**12,000**	**25,000**	**+13,000**
Total, Capital Summary	**44,372**	**0**	**7,372**	**7,372**	**12,000**	**25,000**	**+13,000**

NETL Research and Operations
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
83,000	83,000	83,000

Overview

The National Energy Technology Laboratory (NETL) is an integral part of the U.S. Department of Energy (DOE) national laboratory system. There are 17 National Laboratories in the DOE laboratory system; NETL is 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 of three subprograms:

(1) **Research, Development, Demonstration, and Deployment** 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) Research, Development, Demonstration, and Deployment (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 labs, 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, utilities, 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 2022 Budget Request

The NETL Research and Operations Request is consistent with the FY 2021 Enacted level in total. 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 excepted 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.

NETL Research and Operations
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
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 2022 Request vs FY 2021 Enacted
NETL Research and Operations: The NETL Research and Operations Budget Request is flat with the FY 2021 Enacted level. 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.	**$0**
Total, NETL Research and Operations	**$0**

NETL Research and Operations
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 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 also 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 also 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.
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, utilities, 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, utilities, etc.	• The net reduction reflects decreased contractor support in the areas of fleet and transportation management, warehouse and property management, and business integration support. These reductions are partially offset by

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
		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.

Fossil Energy and Carbon Management Research, Development, Demonstration, and Deployment
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 2020 Actual Cost	FY 2020 Planned Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
National Energy Technology Laboratory	19,282	15,695	10,915	19,780
Total, Direct-Funded Maintenance and Repair	**19,282**	**15,695**	**10,915**	**19,780**

Report on FY 2020 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 2020 to the amount planned for FY 2020, including Congressionally directed changes.

Total Costs for Maintenance and Repair ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost
National Energy Technology Laboratory	19,282	15,695
Total, Direct-Funded Maintenance and Repair	**19,282**	**15,695**

In review of the planned vs actual costs for FY 2020, the National Energy Technology Laboratory invested approximately $4 million for Phase 1 of a renovation to a research building as directed in the FY 2020 Appropriations Act. This cost had not been in the planned FY 2020 costs.

Excess Facilities

Excess Facilities are facilities no longer required to support the Department's needs, present or future missions or functions, or the discharge of its responsibilities. This table reports the funding to deactivate and dispose of excess infrastructure, including stabilization and risk reduction activities at high-risk excess facilities, resulting in surveillance and maintenance cost avoidance and reduced risk to workers, the public, the environment, and programs. This includes maintenance of excess facilities (including high-risk excess facilities) necessary to minimize the risk posed by those facilities prior to disposition.

Fossil Energy and Carbon Management Research, Development, Demonstration, and Deployment
Excess Facilities

Costs for Direct-Funded Excess Facilities ($K)

	FY 2020 Actual Cost	FY 2020 Planned Cost	FY 2021 Planned Cost	FY 2022 Planned Cost
National Energy Technology Laboratory (All)	54	125	45	40
NA	0	0	0	0
Total, Direct-Funded Excess Facilities	**54**	**125**	**45**	**40**

Fossil Energy and Carbon Management Research, Development, Demonstration, and Deployment
Capital Summary ($K)

	Total	Prior Years	FY 2020 Enacted	FY 2020 Actuals	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment)							
Capital Equipment >$500K (inc. MIE)	n/a	0	0	0	0	0	0
Minor Construction Project (>$5M)	44,372	0	7,372	7,372	12,000	25,000	+13,000
Total, Capital Operating Expenses	**44,372**	**0**	**7,372**	**7,372**	**12,000**	**25,000**	**+13,000**
Capital Equipment > $500K (including MIE)							
Total Non-MIE Capital Equipment	n/a	0	0	0	0	0	0
Total, Capital Equipment (including MIE)	**n/a**	**0**	**0**	**0**	**0**	**0**	**0**
Minor Construction Projects (>$5M)							
Computational Science & Engineering Center	19,372	0	7,372	7,372	12,000	0	-12,000
Direct Air Capture Center	25,000	0	0	0	0	25,000	+25,000
Total, Minor Construction Projects	**44,372**	**0**	**7,372**	**7,372**	**12,000**	**25,000**	**+13,000**
Total, Capital Summary	**44,372**	**0**	**7,372**	**7,372**	**12,000**	**25,000**	**+13,000**

Fossil Energy and Carbon Management Research, Development. Demonstration, and Deployment
Research and Development
($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Basic Research	34,022	0	0	0
Applied Research	646,411	691,633	822,020	+130,387
Development	0	0	0	0
Subtotal, R&D	**680,433**	**691,633**	**821,020**	**+130,387**
R&D Related Equipment	29,000	29,000	46,000	+17,000
R&D Related Construction	0	0	0	0
Total, R&D	**709,433**	**720,633**	**868,020**	**+147,387**

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

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request/ Projected Transfer	FY 2022 Request vs FY 2021 Enacted ($)
CCUS and Power Systems				
SBIR	10,376	10,471	13,543	+3,072
STTR	1,756	1,822	1,905	+83
Natural Gas Technologies				
SBIR	1,351	1,382	3,303	+1,921
STTR	229	241	464	+223
Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies				
SBIR	1,219	1,116	0	-1,116
STTR	206	194	0	-194
Total, SBIR/STTR	**15,137**	**15,226**	**19,215**	**+3,989**

National Energy Technology Laboratory Direct Air Capture Center
New Project Data Sheet is for Design and Construction

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

Summary

The Direct Air Capture (DAC) Center is a new project for the National Energy Technology Laboratory (NETL) Infrastructure Program. This DAC Center will be utilized to lead agency-wide research, development, demonstration, and deployment (RDD&D) projects to advance the development and commercialization of technologies to remove carbon from the air on a significant scale. Research focus will be on process design, including modeling, analytics, and simulation, with an emphasis on modular design and materials manufacturability. The DAC Center will accelerate the development and deployment of DAC technologies by offering a research facility for prototyping and qualifying DAC technologies. The DAC Center would be of value to universities, research institutions and U.S. businesses developing DAC technologies. Typically, these institutions would not have the resources or experience to construct, operate, and comprehensively analyze the results of DAC tests at this scale on their own. Furthermore, the DAC facility would be of particular value to the Department of Energy (DOE) and other agencies attempting to reduce/control greenhouse gas (GHG) emissions by providing a key stepping stone between bench scale and commercial scale, effectively placing a bridge over the so-called valley of death for technology development.

Significant Changes

This Project Data Sheet (CPDS) for the DAC Center represents a new start for Fiscal Year 2022.

As the total project cost is projected to be below $50 million, DOE Order 413.3B is not applicable and thus NETL will not be using the DOE Order 413.3B Critical Decision (CD) process.

Critical Milestone History

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2022	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B	CD-3C	CD-3D
FY 2022	N/A	N/A	N/A	N/A	N/A

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

Project Cost History

	TEC, Design ($000)	TEC, Construction ($000)	TEC, Total ($000)	OPC Except D&D ($000)	OPC, D&D ($000)	OPC, Total ($000)	TPC ($000)
FY 2022	2,000	23,000	25,000	0	0	0	25,000

2. Project Scope and Justification

Scope

The DAC Center is a new project for the NETL Infrastructure Program. This DAC Center will be utilized to lead agency-wide RDD&D projects to advance the development and commercialization of technologies to remove carbon from the air on a significant scale. Research focus will be on process design, including modeling, analytics, and simulation, with an emphasis on modular design and materials manufacturability. The DAC Center will accelerate the development and deployment of DAC technologies by offering a research facility for prototyping and qualifying DAC technologies. The DAC Center would be of value to universities, research institutions and U.S. businesses developing DAC technologies.

NETL will design, construct, house and operate a center for evaluating emerging technologies for DAC. The DAC Center would target technologies that are above lab scale but below full pilot scale. The center will consist of two test beds for evaluating DAC concepts: (1) Air feed streams with a variety of environmental conditions (including variable humidity, temperature, and contaminants) at an approximate scale of up to 3,000 ft3/min (~0.1 tons/day CO_2 available for capture); and (2) A drop-in sorbent reactor for evaluating novel sorbent materials using a flexible and generic reactor design. To support the experiments the DAC Center will also have dedicated engineering, technician, and scientific support for the design, installation, operation of experiments, and interpretation of results for projects. The DAC Center will also have dedicated process modeling and analysis support to evaluate the technoeconomic potential of new technologies.

Justification

As greenhouse gas emissions continue to rise, there is a need to mitigate against growing CO_2 concentration in the atmosphere and even reduce the CO_2 concentration. Direct removal of CO_2 from the atmosphere, commonly referred to as direct air capture, is an emerging area of research which shows promise to reduce the atmospheric CO_2 concentration. This emerging technology is still in the early stages but will soon be ready for larger scale testing. There is not currently an easily available and accessible facility to test these emerging technologies at larger scales.

The DAC Center will accelerate the development and deployment DAC technologies by offering a research facility for prototyping and qualifying DAC technologies. The DAC Center would be of significant value to universities, research institutions and US businesses developing DAC technologies. Typically, these institutions would not have the resources or experience to construct, operate, and comprehensively analyze the results of DAC tests at this scale on their own. Furthermore, the DAC facility would be of particular value to the DOE and other agencies attempting to reduce/control greenhouse gas emissions by providing a key stepping stone between bench scale and commercial scale, effectively placing a bridge over the so-called valley of death for technology development.

As a world leader in the development of CO_2 capture technologies, NETL is uniquely suited to housing this facility. On site engineering and technician support will be readily available to ensure that test equipment brought on site is compatible with the DAC test system, and to maintain drawings, chemical inventory control, and other record keeping. Similarly, scientific support will be provided to assist with analysis and interpretation of results, pre- and post-test characterization of materials, and recommendations for technology design improvement. Further, as a government-operated research laboratory also performing financial assistance project management functions, NETL will implement the DAC program for FECM, including managing extramural research projects. This provides for ready-made partners which can utilize the DAC Center to accelerate the development of FECM supported technologies.

3. Project Cost and Schedule

Financial Schedule

	($K) Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2022	$2,000	$2,000	$2,000
FY 2023	N/A	$0	$
FY 2024	N/A	$0	$
FY 2025	N/A	$0	$
FY 2026	N/A	$0	$
FY 2027	N/A	$0	$
Total, Design	**$2,000**	**$2,000**	**$2,000**
Construction			
FY 2022	$23,000	$23,000	$5,000
FY 2023	N/A	$0	$18,000
FY 2024	N/A	$0	$
FY 2025	N/A	$0	$
FY 2026	N/A	$0	$
FY 2027	N/A	$0	$
Total, Construction	**$23,000**	**$23,000**	**$23,000**
TEC			
FY 2022	$25,000	$25,000	$7,000
FY 2023	N/A	$0	$18,000
FY 2024	N/A	$0	$
FY 2025	N/A	$0	$
FY 2026	N/A	$0	$
FY 2027	N/A	$0	$
Total, TEC	**$25,000**	**$25,000**	**$25,000**
Other Project Cost (OPC)			
FY 2022	$0	$0	$0
FY 2023	$0	$0	$0
FY 2024	$0	$0	$0
FY 2025	$0	$0	$0
FY 2026	$0	$0	$0
FY 2027	$0	$0	$0
Total, OPC	**$0**	**$0**	**$0**
Total Project Cost (TPC)			
FY 2022	$25,000	$25,000	$7,000
FY 2023	$0	$0	$18,000
FY 2024	$0	$0	$0
FY 2025	$0	$0	$0
FY 2026	$0	$0	$0
FY 2027	$0	$0	$0
Total, TPC	**$25,000**	**$25,000**	**$25,000**

Schedule of Appropriations Requests

The intent is to execute DAC within the authorized revenue ceiling proposed in the FY 2022 Budget Request shown below.

($K)

Request		FY 2022	Total
FY 2022	TEC	25,000	25,000
	OPC	---	---
	TPC	**25,000**	**25,000**

4. Details of Project Cost Estimate

Budget Authority (Thousands of Dollars)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	2,000	N/A	N/A
Contingency	-	N/A	N/A
Total, Design	2,000	N/A	N/A
Construction			
Site Work	1,000	N/A	N/A
Equipment	1,000	N/A	N/A
Construction	18,000	N/A	N/A
Other, as needed	-	N/A	N/A
Contingency	3,000	N/A	N/A
Total, Construction	23,000	N/A	N/A
Other TEC, if any			
Cold Startup	-	N/A	N/A
Contingency	-	N/A	N/A
Total Other TEC	-	N/A	N/A
Total Estimated Cost	**25,000**	**N/A**	**N/A**
Contingency, TEC	3,000	N/A	N/A
Other Project Costs (OPC)			
OPC Except D&D			
R&D	-	N/A	N/A
Conceptual Planning	-	N/A	N/A
Conceptual Design	-	N/A	N/A
Other OPC	-	N/A	N/A
Contingency	-	N/A	N/A
Total, OPC	-	**N/A**	**N/A**
Contingency, OPC	-	N/A	N/A
Total Project Cost	**25,000**	**N/A**	**N/A**
Total Contingency (TEC + OPC)	**3,000**	**N/A**	**N/A**

5. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	10/1/2023
Expected Useful Life (number of years)	50
Expected Future Start of D&D of this capital asset (fiscal quarter)	N/A

(Related Funding requirements)

	($K)			
	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	$4,500	N/A	380,607	N/A
Maintenance & Repair	500	N/A	42,290	N/A
Total *	$5,000	N/A	422,897	N/A

*Annual and Life Cycle cost projections are preliminary and will be updated as the project matures. Life cycle costs reflect 50-year operating life and assume 2% annual inflation in costs.

6. D&D Information

This project does not require D&D funding.

7. Acquisition Approach

NETL will follow Federal Acquisition Regulations (FAR) Part 36 for construction, including Part 19, Small Business Set-aside options. These options include direct award to an Alaskan Native Corporation or a Native American Tribal Unit.

Fossil Energy and Carbon Management Research, Development, Demonstration, and Deployment
Safeguards and Security ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)
Protective Forces	2,983	3,072	3,164	+92
Physical Security Systems	159	1,195	171	-1,024
Information Security	273	319	156	-163
Cyber Security*	4,416	4,772	7,398	+2,626
Personnel Security	225	285	346	+61
Material Control and Accountability	0	0	0	0
Research, Development, Demonstration, and Deployment (RDD&D)	0	0	0	0
Program Management	456	491	316	-175
Security Investigations	0	0	0	0
Transportation Security	0	0	0	0
Construction	0	0	0	0
Total, Safeguards and Security	**8,512**	**10,134**	**11,551**	**+1,417**

*Does not include Fossil Energy and Carbon Management (FECM) RDD&D-funded HQ cybersecurity (FY 2020, $0.920M; FY 2021, $1.170M; FY 2022, $1.300M)

National Energy Technology Laboratory (NETL) - Within the Budget Request, the NETL Infrastructure line 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 Control and Access Management initiative. The $1,000,000 reduction for the Physical Security Systems line-item is for a one-time expenditure, investing in a Video Surveillance Project at NETL's Albany, Morgantown, and Pittsburgh facilities to enhance on-site threat detection and mitigation capabilities. The NETL Cybersecurity totals are: FY 2020 = $4.416M; FY 2021 = $4.772M; FY 2022 = $7.398M.

Indian Energy Policy and Programs

Indian Energy Policy and Programs

Office of Indian Energy
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
$22,000	$22,000	$122,000

Overview

The Office of Indian Energy Policy and Program's (IE) financial and technical assistance are beneficial to: promoting energy development, efficiency, and use; reducing or stabilize energy costs; strengthening energy and economic infrastructure; and bringing electrical power and service to Indian land and homes -- with the ancillary benefit of providing employment on Tribal Lands and Alaska Native communities. This assistance is intended to overcome barriers to energy development, increase energy reliability and resiliency, and electrify lands and homes.

The Financial Assistance program will support funding opportunities toward energy development and electrification in Native American and Alaska Native communities. The FY 2022 Budget provides a major increase in funding for IE to fund the first year of two new multi-year initiatives: 1) transition all of the nation's tribal colleges and universities to 100% renewable energy; and 2) provide universal energy access for the thousands of tribal homes that currently lack electricity. Both efforts will include a substantial tribal job training component. DOE will work together with USDA and DOI to ensure that incentives are properly aligned, the right mix of loans, grants, and technical assistance is deployed, and the objectives are achieved as cost-effectively as possible, while fully respecting tribal sovereignty and self-determination. The FY 2022 Budget also provides funding increases to expand its current efforts for the transition of Indian Country to clean energy.

From 2010-2019, DOE's Office of Indian Energy has invested nearly $85 million in more than 180 tribal energy projects implemented across the contiguous 48 states and in Alaska. These projects, valued in excess of $180 million, are leveraged by $100 million in recipient cost share. Of those more than 180 tribal energy awards, greater than 85 are energy hardware installation projects, resulting in tangible positive benefits to those Native American and Alaska Native communities. Specifically, those investments represent the installation of nearly 44 megawatts (MW) of new energy generation, affecting more than 750 tribal buildings and savings greater than $22 million each year.

In 2020, the Office of Indian Energy selected nine tribal energy infrastructure deployment projects which exceeds $10 million. DOE's investment of more than $5 million are projected to result in over 3.7 MW of new generation, power at least 180 tribal buildings, and result in a lifetime savings of in excess of $24 million.

Technical Assistance program facilitates expeditious energy deployment. By building internal technical capability and utilizing the DOE laboratories and partner organizations, local support is being provided. Specifically, increased on-site staff and local partner organizations, the Office of Indian Energy can deliver Alaskan solutions with Alaskans familiar with the nuances and challenges of the state. Technical analysis is offered to address a specific technical or financial barrier or to assist with energy planning. Since 2010, over 350 technical assistance requests have been completed, providing technical, financial and energy planning expertise to bear on overcoming barriers to Indian energy development.

Office of Indian Energy
Appropriation Level and Program Level Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Assistance Programs[1]					
Financial Assistance	15,810	15,810	110,841	95,031	601%
Technical Assistance	1,190	1,190	5,636	4,446	374%
Total, Assistance Programs	17,000	17,000	116,477	99,477	585.2%
Program Direction					
Salaries and Benefits	1,986	1,986	2,443	457	23%
Travel	75	75	134	59	79%
Support Services	2,579	2,579	2,568	-11	0%
Other Related Expenses	360	360	377	17	5%
Total, Program Direction	5,000	5,000	5,523	523	10.5%
Total, Office of Indian Energy	22,000	22,000	122,000	100,000	454.5%
Federal FTEs	7	12	15	3	25%

[1] Formerly named Tribal Energy Program which was an EERE Program

Office of Indian Energy
Assistance Programs

Overview

The Office of Indian Energy Policy and Programs serves all Federally recognized Indian tribes, which include Alaska Native Regional Corporations and Village Corporations, as well as tribal and intertribal organizations, and tribal energy development organizations. Numerous factors burden Indian tribes interested in developing their vast energy resources which at current values, present-day revenue projects for energy resources on Indian lands amount to nearly $1.5 trillion[2] with only 2.1 million acres of the 15 million acres of potential energy and mineral resources[3]. Energy and infrastructure development in Indian Country is constrained due to limited funding and financing, inadequate infrastructure, limited technical capacity, and a complicated legal and regulatory structure governing Indian lands. As a result, Native Americans are three times as likely to live in overcrowded housing and with inadequate infrastructure, about one in four (25%) of American Indians and Alaska Natives lives in poverty[4,] and unemployment rates are twice as high as those among non-Indians nationally[5]. Additionally, more than 175 Alaska Native villages rely almost exclusively on diesel fuel for electricity and oil for heat. In some communities, electricity costs exceed $1.00/kilowatt-hour, more than eight times the national average of $0.12/ kilowatt-hour[6].

In consultation with tribal and other stakeholders, IE achieves its mission by promoting Indian energy development, electrifying Indian Country, and helping to reduce or stabilize the cost of electricity. IE achieves the mission through financial assistance, technical assistance, and education and outreach.

Financial assistance, primarily through competitive grants to Indian tribes, supports the deployment of energy infrastructure, efficiency and electrification projects, reducing energy costs, increasing reliability and resiliency, and building human capacity within and among tribes.

In the area of technical assistance, IE is transitioning to become more effective and efficient using local Subject Matter Experts (SME's) to assist Native American and Alaska Native communities in developing energy projects and providing support for energy planning. In Alaska, this is being implemented through an interagency agreement with the Denali Commission for local SME's.

Policy initiatives include coordination and collaboration with various sectors of government that are critical to investment, job creation, project development, and operation of energy systems throughout Indian Country, including the Indian Country Energy and Infrastructure Working Group (ICEIWG). ICEIWG advises the Secretary of Energy on behalf of Indian tribes on their policy priorities. Policy analysts survey energy needs and energy resources on Indian lands, including available infrastructure support, and develop strategies for electrification and energy deployment and development. Policy initiatives also include coordination and collaboration through a

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2 Indian Energy and Energy Efficiency. Hearing before the Committee on Indian Affairs. Senate. 111th Cong. 1 (2009). (Testimony of Marcus Levings). https://www.indian.senate.gov/sites/default/files/upload/files/October222009.pdf. Accessed April 2017.

3 Indian Energy Development. Hearing before the Committee on Indian Affairs. Senate. 110th Cong. 2 (2008). (Testimony of Robert Middleton). https://www.indian.senate.gov/sites/default/files/upload/files/May12008.pdf. Accessed April 2017.

4 U.S. Census Bureau. Macartney, S., Bishaw, A., Fontenot, K. Poverty Rates for Selected Detailed Race and Hispanic Groups by State and Place: 2007 – 2011. https://www.census.gov/library/publications/2013/acs/acsbr11-17.html. Accessed April 2017.

5 U.S. Department of Housing and Urban Development. Public and Indian Housing, Native American Housing Block Grants 2017 Summary Statement and Initiatives. https://portal.hud.gov/hudportal/documents/huddoc?id=11-Nat.Am_HSNG_BlK_Grants.pdf. Accessed April 2017.

6 Schwabe, P. (2016). *Solar Energy Prospecting in Remote Alaska: An Economic Analysis of Solar Photovoltaics in the Last Frontier State* (No. NREL/TP-6A20-65834; DOE/IE-0040). NREL (National Renewable Energy Laboratory (NREL), Golden, CO (United States). https://energy.gov/sites/prod/files/2016/02/f29/Solar-Prospecting-AK-final.pdf. Accessed April 2017.

Memorandum of Understanding with the Department of the Interior on issues including electrification and energy development in Indian Country.

Highlights and Major Changes in the FY 2022 Budget Request

IE's FY 2022 budget priorities are: Universal Energy Access for Indian Country, 100% Renewable Tribal Colleges and Universities; transitioning Indian Country to clean energy; and Capacity Building.

Universal Energy Access for Indian Country
Thousands of US citizens living on tribal reservations currently live in homes without electricity. Without electricity, these families lack access to what many consider basic necessities like wired lights, computers, and refrigeration. The Department of Energy, working through the Office of Indian Energy, seeks to remedy this inequitable situation and bring clean energy to every tribal home that wants it. IE will work in partnership with the US Department of Agriculture (USDA), the Department of the Interior (DOI), States, Tribes, and local utilities to ensure that incentives are properly aligned, the right mix of loans, grants, and technical assistance is deployed, and that universal electrification is achieved as cost-effectively as possible, while fully respecting tribal sovereignty and self-determination.

100% Renewable Tribal Colleges and Universities
Tens of thousands of tribal students study at the nation's 37 tribal colleges and universities each year – seeking an education that will lead to meaningful work that will help their homelands and provide good paying jobs for their families. This initiative will combine the ingenuity of tribal students with the vast energy potential of tribal lands to bring renewable energy projects to every tribal college and university in the nation, with the ultimate goal of those schools being powered by 100% renewable energy. Students will be engaged in hands-on learning, with opportunities to help plan, design, and install renewable projects at their schools – helping to equip them to go on to good paying jobs in the renewable energy sector.

Transitioning Indian Country to Clean Energy
Building on past successes, IE will expand efforts to transition Native American and Alaska Native communities to clean energy while building local economies, stabilizing and reducing energy costs and building local capacity. Native communities pay some of the highest energy costs in the Country. By transitioning to clean energy Native Nations can tap into their vast indigenous resources, build local economies and internal capacity and increase resiliency for future generations.

Capacity Building
Indian country has only just barely tapped into its vast energy resources. IE will work through technical assistance, education, and outreach to build capacity in Indian country to take advantage of these energy resources, provide good paying jobs, and power Indian country with renewable energy. IE will partner with tribal climate and energy education programs to train and build capacity of community members, college students, and professionals in Indian Country – and – expand IE's local network of technical assistance providers to improve effectiveness and efficiency and to target the needs of tribes using local experts.

Office of Indian Energy
Assistance Programs
Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Assistance Programs $17,000,000	$116,477,474	$99,477,474
Financial Assistance $15,810,000	$110,841,410	$95,031,410
Competitive grant program supporting energy development and electrification in Indian Country, and associated support contracts.	Competitive grant program supporting energy development and electrification in Indian Country, and associated support contracts. Financial Assistance: Maximize available funding for financial assistance awards and expand opportunities for historically underserved populations, including those who have not received funding from IE.	Continue to provide grants for energy development, energy cost savings, and electrification in Indian Country. Increase energy access into tribal homes and partner with tribal colleges and universities to transition to clean energy.
Technical Assistance $1,190,000	$5,636,064	$4,446,064
Technical Assistance disseminates information to Indian Country through in-person and on-line training, internships, regional/national workshops, webinars, and printed guides and materials. On-request assistance efforts provides high-level support for electrification and energy development in Indian Country. Efforts will also focus on building partnerships and leveraging resources to maximize education, training, and technical assistance.	Technical Assistance: Reconfigure technical assistance by expanding the network of local service providers to improve effectiveness and efficiency and to target needs of tribes based on data collected and analyzed by IE. Education and Outreach: Expand STEM education and internship programs to include K-12, vocational/technical opportunities, and non-traditional students, and increase stakeholder outreach efforts to better educate the public on tribal energy potential, development challenges, and viable deployment solutions.	Continue to expand technical assistance focused on energy development, energy cost savings, and electrification in Indian Country. Partner with tribal climate and energy education programs to train and build capacity of community members, college students, and professionals in Indian Country.

Office of Indian Energy
Program Direction

Overview

Program direction provides federal staff responsible for the management and execution of IE's programs and activities, as well as the associated support contractors, rent, supplies, travel, and other related expenses. The staff is responsible for providing overall guidance and direction for DOE program offices on tribal energy activities and initiatives necessary to achieve IE's program objectives and provides day-to-day management of financial assistance, technical assistance, and outreach and education. Program direction also provides managerial support for the reporting, compliance, and other statutory responsibilities.

The FY 2022 Budget anticipates 15 federal staff: 8 FTEs in Washington, D.C., 2 FTEs in Anchorage, Alaska, and 5 FTEs in Golden, Colorado. The Washington, D.C. staff includes executive leadership, operations, and policy analysis. The Anchorage, Alaska staff provides education and technical assistance for the nearly 230 Alaska Native villages, over 200 Alaska Native Village Corporations, and 13 Alaska Regional Corporations. The Golden, Colorado staff provides management and oversight for approximately 79 existing financial assistance awards throughout the nation, while delivering technical assistance within the contiguous US for nearly 340 Indian tribes and dozens of tribal and intertribal organizations.

Highlights and Major Changes in the FY 2022 Budget Request

- Education and Outreach: Expand STEM education and internship programs to include K-12, vocational/technical opportunities, and non-traditional students, as well as increasing stakeholder outreach efforts to better educate the public on tribal energy development challenges. Develop partnership with tribal climate and energy education programs to train and build capacity of community members, college students, and professionals in Indian Country

- Support project management and procurement across IE's portfolio of projects, including closing out completed financial assistance awards; and

- Maximize the efficient and effective use of additional resources to accomplish IE's new initiatives and core mission while reducing overall expenses and improving the delivery of IE's services in Indian Country.

Program Direction Funding
($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted	FY 2022 Request vs FY 2021 Enacted (%)
Program Direction Summary					
Indian Energy Federal Salaries and Expenses					
Salaries and Benefits	1,986	1,986	2,443	457	23%
Travel	75	75	134	59	79%
Support Services	2,579	2,579	2,568	-11	0%
Other Related Expenses	360	360	377	17	5%
Total, Washington Headquarters	5,000	5,000	5,523	523	10.5%
Federal FTEs	7	12	15	3	25%

Office of Indian Energy
Program Direction
Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $5, 000,000	$5,522,526	$522,526
Salaries and Benefits $1,986,000	$2,442,750	$456,750
Federal Salaries and benefits to implement program activities, monitor 70 active projects, generally 15-20 TA requests in process, up to 10 contractor support activities, and provide program management functions.	15 Federal Salaries and benefits to implement new initiatives program activities, monitor 70 active projects, an increase in TA requests related to education/outreach environmental justice, energy access, and energy poverty.	A slight Increase in the federal staff to support the new initiatives and funding level.
Travel $75,000	$134,476	$59,476
Travel required for Federal staff delivery of program management and Office of Indian Energy deployment activities, including outreach and education, technical assistance, and project management to support the 574 federally recognized Indian tribes throughout the nation, many of which are located in remote and rural areas.	Travel required for Federal staff delivery of program management and Office of Indian Energy deployment activities, including outreach and education, technical assistance, and project management to support the 574 federally recognized Indian tribes throughout the nation, many of which are in remote and rural areas.	Travel to support new initiatives, additional TA support, energy access, and education/outreach.
Support Services $2,579,000	$2,567,900	-$11,100
Management, administrative, mission and technical support.	Management, administrative, and operations support.	Contractual staff to support operations.
Other Related Expenses $360,000	$377,400	$17,400
Computer hardware and software provided through the OCIO, Working Capital Fund, office space, registration fees, supplies, and small purchases through the micro-purchase credit card.	Computer hardware and software provided through the OCIO, Working Capital Fund, office space, registration fees, supplies, and small purchases through the micro-purchase credit card.	Other related expenses to support operations.

Advanced Technology Vehicles Manufacturing Loan Program

Advanced Technology Vehicles Manufacturing Loan Program

Advanced Technology Vehicles Manufacturing Loan Program
Proposed Appropriation Language

For Department of Energy administrative expenses necessary in carrying out the Advanced Technology Vehicles Manufacturing Loan Program, $5,000,000, to remain available until September 30, 2023.

Explanation of Changes

The FY 2022 Budget continues the Advanced Technology Vehicles Manufacturing Loan Program.

Public Law Authorizations

- P.L. 110-140, Energy Independence and Security Act of 2007, as amended
- P.L. 110–329, Consolidated Security, Disaster Assistance, and Continuing Appropriations Act of 2009

Overview

The Budget proposes $5 million for the continuation of the Advanced Technology Vehicle Manufacturing Loan Program in its loan originating and portfolio monitoring responsibilities. No additional loan authority is requested for FY 2022, with $17.7 billion remaining in loan authority to catalyze domestic manufacturing of fuel efficient, light-duty passenger vehicles and eligible components.

Currently, the ATVM program is limited to support manufacturing of light-duty vehicles and components. The Administration believes the definition of advanced technology vehicles should be expanded to fully leverage the ATVM program to reduce transportation emissions and create good paying jobs that provide the free and fair choice to join a union.

The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. The Loan Program Office will ensure that ATVM is encouraging projects that support the transition to zero-emission vehicles and not directly subsidizing fossil fuels by excluding projects that manufacture gas-only light duty vehicles. Under an expanded definition of advanced technology vehicle, highly efficient fossil fueled medium- and heavy- duty vehicle manufacturing projects would be permitted to pursue a loan, though zero-emission vehicles would be encouraged.

History

Section 136 of the Energy Independence and Security Act of 2007 established the Advanced Technology Vehicles Manufacturing (ATVM) Loan Program, consisting of direct loans of up to $25 billion in total loan authority to support the development and manufacturing of advanced technology vehicles and qualifying components in the U.S. The ATVM Loan Program has issued 5 total loans, of which $7.28 billion has been obligated[1] and completely disbursed to borrowers including Tesla, Nissan, and Ford. Together, these borrowers have repaid a collective $5.9 billion in principal, plus interest. Tesla and Nissan have repaid their loans in full; Ford continues to make active and on-time principal and interest payments.

The Loan Programs Office can provide first-of-a-kind projects and other high-impact ventures with access to debt capital that private lenders cannot or will not provide, given the lack of history with new technology that is considered cutting edge. LPO is a committed partner in the early stages of development and throughout the lifetime of the project while monitoring the loans provided. The advanced technologies being proposed and developed will contribute to the reduction of carbon emissions and create new job opportunities with a free and fair choice to join a union. To date, projects that have been financed in part by ATVM loans have produced vehicles that are estimated to have saved over 2.8 billion gallons of gasoline, equivalent to a cumulative 25.4 million metric tons of carbon dioxide emissions. Projects supported by the program currently produce 2.4 million low-emission vehicles annually, with 20.3 million vehicles produced since the program's inception, and has created and supported 36,000 permanent jobs across 20 states. The active project is a $5.9 billion loan with the Ford Motor Company. LPO has one ATVM project in due diligence to retrofit a manufacturing plant to produce electric light-duty trucks.

Portfolio Project Data	*ATVM – 12/31/2020**
Total Number of Active Projects	1
Number of Projects in Construction	0
Number of Projects in Operation	1
Production Capacity (Million vehicles/year)	2.4
Vehicles Produced (Millions, Cum.)	20.3
CO_2 Avoided (Mtons, Cum.)	25.4

** Most recent available data based on company reporting cycles*

[1] Net of recoveries

The ATVM program is currently authorized to provide long-term, low-interest rate debt capital to companies looking to manufacture fuel-efficient components and advanced technology light-duty passenger vehicles. The Administration believes the definition of advanced technology vehicles should be expanded to fully leverage the ATVM program to reduce transportation emissions and create good paying jobs that provide the free and fair choice to join a union.

DOE remains an active participant in all stages of the project through completion. LPO has developed a strong and unique set of capabilities and expertise to manage the ATVM loan program, making it ideally positioned to serve as the federal government's hub for achieving America's energy objectives in advanced vehicle manufacturing and invigorate economic growth.

The FY 2022 Budget will allow LPO to continue outreach and origination activities, including developing marketing materials, engaging in stakeholder outreach, and ensuring that LPO's unique value proposition is widely known across the entire advanced technology vehicles manufacturing supply chain. Additionally, LPO outreach efforts have targeted financial institutions and private lenders to encourage participation in financing eligible projects. In CY 2020, LPO began specifically tracking its outreach efforts. For the period January 1, 2020 through September 30, 2020, LPO held 64 outreach meetings, including follow-up discussions, to disseminate information on ATVM's availability, benefits, and application process to potential applicants.

ATVM Outreach Data	*First Half of FY 2021* Oct 1, 2020 – March 31, 2021	Targets for FY 2021
Total[2]	109	75

Stemming from these outreach efforts, LPO offers business development services to potential applicants ready to receive financing. Business development refers to LPO's in-house financial, technical, environmental, and legal team of experts advising companies on how to submit successful applications under the Advanced Technology Vehicles Manufacturing direct loan program. The FY 2022 Budget will allow LPO to continue providing this valued service. LPO has a goal of moving at least 5 potential ATVM applicants to business development from outreach in FY 2021.

Organization

LPO currently utilizes seven divisions to originate new loans and proactively monitor the portfolio: Office of the Director, Origination Division, Portfolio Management Division, Risk Management Division, Technical and Project Management Division, Legal Division, and Management Operations Division.

The Office of the Director houses the Director and their immediate team, LPO's Outreach Team, and the Environmental Compliance Division. The Outreach Team is charged with identifying and establishing relationships with potential applicants and other external stakeholders deemed necessary to help meet LPO's strategic objectives. The Environmental Compliance Division ensures that applicants' projects meet federal environmental regulatory standards by helping applicants navigate through required reviews and consultations prior to loan closing.

[2] Data reflects total number of engagements, including follow-up discussions.

The Origination Division is responsible for coordinating the assessments of applications and leads the credit underwriting of transactions and the negotiating, closing and first disbursements of loans or loan guarantees. The division participates in business development and outreach activities.

The Portfolio Management Division (PMD) leads LPO's monitoring functions by approving disbursements, repayments, operating budgets, and long-term forecasts. In the event of non-payment and/or default, PMD leads activities to maximize recoveries either through bankruptcy, note sale, or compromise of the claim. The division participates in business development and outreach activities.

The Risk Management Division conducts continuous risk assessments of the assets in the portfolio to comply with regulatory requirements such as OMB Circular No. A-129 of the Federal Credit Reform Action of 1990. The division participates in business development and outreach activities.

The Technical and Project Management Division (TPMD) evaluates the technical performance of assets and project management throughout the entire lifecycle of the loan to ensure meeting the technical requirements of the loan agreement. TPMD conducts site visits, provides expertise on project construction status and budget, and identifies potential technical risks inhibiting the borrower's ability to meet requirements and repay the loan. The division participates in business development and outreach activities.

The Legal Division supports all on-going monitoring activities, negotiations and documentations of waivers, consents, routine loan amendments, approvals and denials of transfer withdrawals, and legal aspects of any project developments. The division participates in business development and outreach activities.

The Management and Operation Division is responsible for LPO employee resources, administrating and monitoring LPO administrative and working capital funds, providing enterprise architecture and information technology support, and providing contract administration to obtain services.

Highlights and Major Changes in the FY 2022 Budget Request

In FY 2022, LPO requests $5 million to originate ATVM direct loans and monitor the program's portfolio as more loans reach financial close. The program has been key in propelling the resurgence of the American auto manufacturing industry, and the request will allow LPO to continue operating this crucial program. This funding level allows LPO help achieve the Administration's climate and manufacturing objectives in FY 2022. This includes providing access to capital for domestic manufacturers revitalizing U.S. manufacturing, creating good-quality jobs producing electric vehicles, securing domestic supply chains from raw materials to parts, and retooling factories to compete globally. To support the increase in expected loan activity, 6 additional Federal full-time equivalent (FTE) positions are requested, raising the staffing at the end of FY 2022 to 20 FTEs from the current level of 14 FTEs.

Advanced Technology Vehicles Manufacturing Loan Program
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Advanced Technology Vehicles Manufacturing Loan Program					
Administrative Expenses	5,000	5,000	5,000	0	0%
Total, Advanced Technology Vehicles Manufacturing Loan Program	**5,000**	**5,000**	**5,000**	**0**	**0%**

Advanced Technology Vehicles Manufacturing Loan Program
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Administrative Expenses:	**0**
LPO will utilize approximately $2.0 million in available balances carried over from prior appropriations in addition to the request of $5 million to support 20 FTEs, an increase of 6 from FY 2021, and contractors to support increased loan origination, portfolio monitoring, and related administrative expenses.	
Total, Advanced Technology Vehicles Manufacturing Loan Program	**0**

Administrative Expenses
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Request (%)
Administrative Expenses					
Salaries & Benefits	1,598	2,530	3,860	+ 1,330	53%
Travel	8	20	75	+ 55	275%
Support Services	2,734	1,912	522	- 1,390	-73%
Other Related Expenses	660	538	543	+ 5	1%
Total, Administrative Expenses	**5,000**	**5,000**	**5,000**	0	0%
Federal FTEs	8	14	20	+ 6	43%
Support Services					
Management and Professional Support Services					
Mission Support	1,520	1,191	1,837	+ 646	54%
IT Support	1,173	721	763	+ 42	6%
Total, Management and Professional Support Services	2,693	1,912	2,600	+ 688	36%
Studies, analyses, and evaluations	41	0	0	0	N/A
Subtotal, Support Services	2,734	1,912	2,600	+ 688	36%
Use of Available Balances			-2,078		
Total, Support Services	2,734	1,912	522	- 1,390	-73%
Other Related Expenses					
Communication and Misc. Charges Related to IT	23	32	34	+ 2	6%
Other Services	4	4	4	0	0%
Other Purchases from Government Accounts	6	0	0	0	N/A
Working Capital Fund	398	404	404	0	0%
Operation and Maintenance of Facilities	76	0	0	0	N/A
Supplies, Subscriptions and Publications	141	85	87	+ 2	2%
Equipment	12	13	14	+ 1	8%
Total, Other Related Expenses	660	538	543	+ 5	1%
Total, Support Services	660	538	543	+ 5	1%

Administrative Expenses
Funding ($K)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Salaries and Benefits $1,598	**$2,530**	**+$1,330**
• Provides for salaries and benefits of 14 full-time equivalent employees to administer functions across the Loans Programs Office.	• Provides for salaries and benefits of 20 full-time equivalent employees to administer functions across the Loans Programs Office. Estimate includes 2.7% raise effective January 1, 2022.	• Funds 6 additional FTEs to support enhanced loan activity.
Travel $8	**$75**	**+$55**
• Supports the travel of staff to attend meetings, conferences, and site visits if needed.	• Supports the travel of staff to attend meetings, conferences, and site visits if needed.	• Increase is due to the anticipated lifting of travel restrictions due to the COVID-19 pandemic.
Support Services $1,912	**$522**	**-$1,390**
• Supports a range of contract services including administrative support, training, subject matter experts, legal services, information technology, credit analysis, and market assessments. The total EITS share and direct services estimate for LPO is $939,000, $118,950 is included here. The total request for LPO IT directed activities is $4,980,000, $602,080 is included here.	• Supports a range of contract services including administrative support, training, all aspects of loan guarantee origination activities, including, subject matter experts, legal services, information technology, credit analysis, and market assessments. The total EITS share and direct services estimate for LPO is $986,000, $124,940 is included here. The total request for LPO IT directed activities is $5,280,000, $638,350 is included here. Total obligations in FY 2022 are estimated at $2,600,000, with an estimated $2,078,000 of available balances being used.	• After considering the use of available balances in FY 2022, support service funding increases by $688,000 in FY 2022 compared to FY 2021. The increase is needed to meet rising IT costs and additional support service contractors to support enhanced loan activity.
Other Related Expenses $538	**$543**	**+$5**
• Supports DOE Working Capital Fund, DOE IT Services expenses, equipment, other services including conferences attendance fees, and publications. The total LPO WCF estimate is $3,109,000, $404,000 is included here. The total EITS share and direct services estimate for LPO is $939,000, $3,120 is included here. The total request for LPO IT directed activities is $4,980,000, $45,320 is included here.	• Supports DOE Working Capital Fund, DOE IT Services expenses, equipment, other services including conferences attendance fees, and publications. The total LPO WCF estimate is $3,109,000, $155,000 is included here. The total EITS share and direct services estimate for LPO is $986,000, $3,240 is included here. The total request for LPO IT directed activities is $5,280,000, $48,050 is included here.	• No change in funding levels.

Title 17 Innovative Technology Loan Guarantee Program

Title 17 Innovative Technology Loan Guarantee Program

Title 17 Innovative Technology Loan Guarantee Program
Proposed Appropriation Language

For the cost of guaranteed loans, $150,000,000, to remain available until expended, for innovative technology projects as authorized under Title XVII of the Energy Policy Act of 2005: Provided, That such costs, including the cost of modifying such loans, shall be as defined in section 502 of the Congressional Budget Act of 1974: Provided further, That these funds are available in addition to the authority provided in any other Act for the costs to guarantee loans under the heading "Department of Energy-Energy Programs-Title 17 Innovative Technology Loan Guarantee Program": Provided further, That these funds are available to subsidize total loan principal, any part of which is to be guaranteed, not to exceed $1,500,000,000: Provided further, That such sums as are derived from amounts received from borrowers pursuant to section 1702(b) of the Energy Policy Act of 2005 under this heading in prior Acts, shall be collected in accordance with section 502(7) of the Congressional Budget Act of 1974: *Provided further*, That for necessary administrative expenses of the Title 17 Innovative Technology Loan Guarantee Program, as authorized, [$32,000,000] $32,000,000 is appropriated, to remain available until September 30*, 2023*: Provided further, That up to [$32,000,000] $32,000,000 of fees collected in fiscal year *2022* pursuant to section 1702(h) of the Energy Policy Act of 2005 shall be credited as offsetting collections under this heading and used for necessary administrative expenses in this appropriation and remain available until September 30, *2023*: *Provided further,* That to the extent that fees collected in fiscal year *2022* exceed [$32,000,000] $32,000,000, those excess amounts shall be credited as offsetting collections under this heading and available in future fiscal years only to the extent provided in advance in appropriation Acts: *Provided further*, That the sum herein appropriated from the general fund shall be reduced (1) as such fees are received during fiscal year 2022 (estimated at [$3,000,000] $3,000,000 and (2) to the extent that any remaining general fund appropriations can be derived from fees collected in previous fiscal years that are not otherwise appropriated, so as to result in a final fiscal year *2022* appropriation from the general fund estimated at $0: *Provided further*, That the Department of Energy shall not subordinate any loan obligation to other financing in violation of section 1702 of the Energy Policy Act of 2005 or subordinate any Guaranteed Obligation to any loan or other debt obligations in violation of section 609.10 of title 10, Code of Federal Regulations.

Explanation of Changes

$150 million is requested for the credit subsidy costs, associated with an additional $1.5 billion of guaranteed loan authority, for innovative electric vehicle infrastructure, carbon management, and other clean energy projects that create good paying jobs with a free and fair choice to join a union. The FY 2022 Budget request for administrative expenses is $32 million, offset by an estimated $3 million in collected fees, for administrative expenses associated with carrying out the Title 17 Innovative Technology Loan Guarantee Program.

Public Law Authorizations

- P.L. 109-58, Energy Policy Act of 2005, as amended
- P.L. 110-5, Revised Continuing Appropriations Resolution, 2007
- P.L. 111-5, American Recovery and Reinvestment Act of 2009
- P.L. 111-8, Omnibus Appropriations Act, 2009
- P.L. 112-10, Department of Defense and Full-Year Continuing Appropriations Act, 2011

Title 17 Innovative Technology Loan Guarantee Program
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
29,000	29,000	179,000

Overview

The Budget proposes continuing the Title 17 Innovative Technology Loan Guarantee Program because the program is ideally positioned to tackle the climate crisis and achieve a net-zero carbon emission economy by no later than 2050 by accelerating the deployment of innovative projects to help launch new clean energy markets, reduce greenhouse gas emission, and drive American economic growth by providing flexible, custom financing and access to debt capital that helps to meet the specific needs of individual borrowers. Further, this Budget also requests new loan authority and credit subsidy to provide debt capital for innovative electric vehicle infrastructure, carbon management, and other clean energy projects that create good paying jobs with a free and fair choice to join a union. As requested, this Budget will allow LPO to continue actively monitoring its Title 17 Innovative Technology Loan Guarantee Program portfolio and engaging resources to help support the achievement of project milestones, overcome issues that may arise, and provide guidance and risk mitigation for the long-term success of projects.

The FY 2022 Budget begins the process of ensuring that Federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. The Loan Program Office will ensure that the Title 17 program is only encouraging projects that help achieve a carbon-pollution free electric sector by 2035 and net-zero emissions, economy-wide, by 2050. The program will avoid directly subsidizing fossil fuels by excluding traditional fossil projects from consideration for a loan guarantee.

History

Section 1703 of the Energy Policy Act of 2005 authorizes DOE to provide loan guarantees for innovative energy projects in categories including advanced nuclear facilities, coal gasification, carbon sequestration, energy efficiency, renewable energy systems, and various other types of projects. Projects supported by DOE loan guarantees must avoid, reduce, or sequester pollutants or anthropogenic emissions of greenhouse gases; employ new or significantly improved technologies compared to commercial technologies in service in the United States at the time the guarantee is issued; and offer a reasonable prospect of repayment of the principal and interest on the guaranteed obligation. Section 406 of the American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5 (Recovery Act) amended Title XVII of the Energy Policy Act of 2005 by establishing Section 1705 as a temporary program for the rapid deployment of renewable energy and electric power transmission projects, as well as leading edge biofuels projects. The authority to enter into new loan guarantees under Section 1705 expired on September 30, 2011, but the program continues to administer and monitor the portfolio of loan guarantees obligated prior to the expiration date.

Over the past decade, LPO has issued 37 Title 17 loan guarantees totaling $28.4 billion, with $23.3 billion disbursed. To date, borrowers have repaid $5.8 billion in principal and $2.4 billion in interest. Meanwhile, the program has recorded $0.6 billion in losses due to default, or 2.78% of funds disbursed. Of the 37 Title 17 loan guarantees, 32 were issued between 2009 and 2011 under Section 1705. By providing access to debt capital and flexible financing that private lenders cannot or will not provide, the Title 17 Innovative Technology Loan Guarantee Program has allowed the U.S. to keep pace with other nations' renewable energy sector growth.

Among its key achievements, the Title 17 program financed the first new commercial nuclear reactors to be licensed and constructed in the U.S. in 30 years, supporting permanent jobs and reliable, zero-emission power in Georgia. Meanwhile, its 235-mile One Nevada Line transmission project innovated on the design and implementation of long-distance power transmission, reducing both financial and environmental costs while bolstering regional access to renewable power.

More broadly, LPO's diverse solar and wind projects have made significant contributions to state-level emissions intensity reductions and Renewable Portfolio Standard (RPS) targets, both through their direct zero-emission generation and their critical role in commercializing key technologies. LPO continues to expand its portfolio, most recently through a conditional commitment of up to $2 billion for construction of the world's first methanol production facility to employ carbon capture technology.

The Title 17 Innovative Technology Loan Guarantee Program goes beyond incentivizing innovation and commercial scale deployment. Together, Title 17 projects support tens of thousands of good-paying jobs across 20 states, collectively avoided 36.5 million tons of carbon emissions to-date, and will bolster clean power generation for decades to come. These are figures that steadily increase annually and with each new loan guarantee that is finalized.

Portfolio Project Data	*Title 17 – 2/28/2021*
Total Number of Active Projects	17[1]
Number of Projects in Construction	1
Number of Projects in Operation	16
Generation Capacity (MW)	3,963
Electricity Generated (GWh, Cum.)	77,793
CO_2 Avoided (Mtons, Cum.)	36.5

This FY 2022 Budget will also allow LPO to continue outreach and origination activities, including developing marketing materials, engaging in stakeholder outreach, and ensuring that LPO's unique value proposition is widely known in the innovative energy technology market. Additionally, LPO outreach efforts have targeted financial institutions and private lenders to encourage participation in financing eligible projects. In CY 2020, LPO began specifically tracking its outreach efforts. For the period January 1, 2020 through September 30, 2020, LPO held 293 outreach meetings, including follow-up discussions, to disseminate information on Title 17's availability, benefits, and application process to potential applicants. Of the total Title 17 outreach meetings, 33 were for Advanced Nuclear projects, 156 were for Renewable Energy and Energy Efficiency projects, and 104 were for Advanced Fossil projects.

Title 17 Outreach Data	*First Half of FY 2021* Oct 1, 2020 – March 31, 2021	Targets for FY 2021
Advanced Nuclear Energy	29	75
Renewable Energy and Energy Efficiency	210	150
Advanced Fossil Energy	61	100
Total[2]	299	325

Stemming from these outreach efforts, LPO offers business development services to potential applicants ready to receive financing. Business development refers to LPO's in-house financial, technical, environmental, and legal team of experts advising companies on how to submit successful applications under active Title 17 loan guarantee solicitations. This Budget will allow LPO to continue providing this valued service. LPO has a goal of moving at least 14 potential Title 17 applicants into business development from outreach in FY 2021.

Organization

The Loan Programs Office (LPO) currently utilizes seven divisions to originate new loans and proactively monitor the portfolio: Office of the Director, Origination Division, Portfolio Management Division, Risk Management Division, Technical and Project Management Division, Legal Division, and Management Operations Division.

The Office of the Director houses the Director and their immediate team, LPO's Outreach Team, and the Environmental Compliance Division. The Outreach Team is charged with identifying and establishing relationships with potential applicants

[1] The number of loan guarantees and projects are different because multiple loan guarantees may be issued for a project.
[2] Data reflects total number of engagements, including follow-up discussions.

and other external stakeholders deemed necessary to help meet LPO's strategic objectives. The Environmental Compliance Division ensures that applicants' projects meet federal environmental regulatory standards by helping applicants navigate through required reviews and consultations prior to loan closing.

The Origination Division is responsible for coordinating the assessments of applications, and leads the credit underwriting of transactions and the negotiating, closing and first disbursements of loans or loan guarantees. The division participates in business development and outreach activities.

The Portfolio Management Division (PMD) leads LPO's monitoring functions by approving disbursements, repayments, operating budgets, and long-term forecasts. In the event of non-payment and/or default, PMD leads activities to maximize recoveries either through bankruptcy, note sale, or compromise of the claim. The division participates in business development and outreach activities.

The Risk Management Division conducts continuous risk assessments of the assets in the portfolio to comply with regulatory requirements such as OMB Circular No. A-129 of the Federal Credit Reform Action of 1990. The division participates in business development and outreach activities.

The Technical and Project Management Division (TPMD) evaluates the technical performance of assets and project management throughout the entire lifecycle of the loan to ensure that the technical requirements of the loan agreement are met. TPMD conducts site visits, provides expertise on project construction status and budget, and identifies potential technical risks that inhibit the borrower's ability to meet requirements and repay the loan. The division participates in business development and outreach activities.

The Legal Division supports all on-going monitoring activities, negotiations and documentations of waivers, consents, routine loan amendments, approvals and denials of transfer withdrawals, and legal aspects of any project developments. The division participates in business development and outreach activities.

The Management and Operation Division is responsible for LPO employee resources, administrating and monitoring LPO administrative and working capital funds, providing enterprise architecture and information technology support, and providing contract administration to obtain services.

Highlights and Major Changes in the FY 2022 Budget Request

In FY 2022, $150 million is requested for the credit subsidy costs, associated with an additional $1.5 billion of guaranteed loan authority, for innovative electric vehicle infrastructure, carbon management, and other clean energy projects that create good paying jobs with a free and fair choice to join a union. The Energy Act of 2020 amended several provisions of Title XVII of the Energy Policy Act of 2005 (as amended) (42 U.S.C 16512 et seq.) including how LPO will charge and collect costs and fees to cover administrative expenses. The Act requires the Secretary to "charge and collect on or after the date of financial close of an obligation, a fee for a guarantee in an amount that the Secretary determines is sufficient to cover applicable administrative expenses (including any costs associated with third-party consultants engaged by the Secretary)." Effective January 1, 2021, per the updated statute, applicants who reach financial close of a Title 17 loan guarantee will be charged an origination fee. Previously, all applicants were required to submit nonrefundable fees upon submission of Part I and Part II applications, as well as pay costs at different phases of the due diligence process. Now, applicants who reach financial close will pay an origination fee that is sufficient to cover applicable administrative expenses associated with the review and due diligence of their loan guarantee application. The FY 2022 Budget request includes $16 million to cover the costs of the third-party consultants engaged during due diligence. To fund the additional third-party consultant costs and increased loan origination and portfolio monitoring activity, LPO will use $23 million in unobligated balances carried forward from prior-year appropriation in addition to the $32 million requested for Administrative Expenses. An increase of 16 Federal FTEs is included in the request.

Title 17 Innovative Technology Loan Guarantee Program
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Title 17 Innovative Technology Loan Guarantee Program					
Administrative Expenses	32,000	32,000	32,000	0	0%
Title XVII Credit Subsidy	0	0	150,000	+150,000	N/A
Offsetting Collections	-3,000	-3,000	-3,000	0	0%
Total, Title 17 Innovative Technology Loan Guarantee Program	**29,000**	**29,000**	**179,000**	**+150,000**	**517%**

Title 17 Innovative Technology Loan Guarantee Program
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Administrative Expenses:	**0**
Increase is needed to support a total of 93 FTE an increase of 16 from FY 2021 and to pay for the costs for Third-Party Advisors as required by the Energy Act of 2020, estimated at $16 million in FY 2022. An estimated $23 million in available balances from prior years will offset the anticipated increases in salary and benefits, Third-Party Advisors costs, and support services increases need to support anticipated loan guarantee activity in FY 2022.	
Title XVII Credit Subsidy:	**+150,000**
$150 million is requested of the credit subsidy costs, associated with and additional $1.5 billion of guaranteed loan authority, for innovative electric vehicle infrastructure, carbon management, and other clean energy projects that create good paying jobs with a free and fair choice to join a union.	
Offsetting Collections:	**0**
LPO anticipates receiving $3 million in maintenance fees from the current portfolio in FY 2022. As required by the Energy Act of 2020, fees are now collected at the financial close of a loan guarantee. Previously, LPO charged and collected certain fees prior to financial close.	**0**
Total, Title 17 Innovative Technology Loan Guarantee Program	**+150,000**

Administrative Expenses
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Request (%)
Administrative Expenses					
Salaries & Benefits	14,809	15,539	17,800	+ 2,261	15%
Travel	89	90	400	+ 310	344%
Support Services	13,704	12,776	10,191	- 2,585	-20%
Other Related Expenses	3,398	3,595	3,609	+ 14	0%
Total, Administrative Expenses	32,000	**32,000**	**32,000**	0	0%
LPO FTEs	72	75	91	+ 16	21%
Office of the General Counsel FTE	1	1	1	0	0%
Office of Management FTE	1	1	1	0	0%
Support Services					
Management and Professional Support Services					
Third-Party Advisor		6,000	16,000	+ 10,000	167%
Mission Support	8,549	10,237	12,099	+ 1,862	18%
IT Support	4,606	4,649	4,921	+ 272	6%
Total, Management and Professional Support Services	13,155	20,886	33,020	+ 12,134	58%
Studies, analyses, and evaluations	549	86	171	+ 85	99%
Subtotal, Support Services	13,704	20,972	33,191	+ 12,219	58%
Use of Available Balances		- 8,196	-23,000		
Total, Support Services	13,704	12,776	10,191	- 2,585	-20%
Other Related Expenses					
Communication and Misc. Charges Related to IT	297	124	134	+ 10	8%
Other Services	135	140	123	- 17	-12%

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Request (%)
Working Capital Fund	2,297	2,550	2,550	0	0%
Operation and Maintenance of Facilities	35	0	0	0	N/A
Supplies, Subscriptions and Publications	561	694	708	+ 14	2%
Equipment	73	87	94	+ 7	8%
Total, Other Related Expenses	3,398	3,595	3,609	+ 14	0%
Total, Other Related Expenses	3,398	3,595	3,609	+ 14	0%

Administrative Expenses
Funding ($K)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Salaries and Benefits $14,809	**$15,539**	**+$2,261**
· Provides for salaries and benefits of 77 full-time equivalent employees to administer functions across the Loans Programs Office.	· Provides for salaries and benefits of 93 full-time equivalent employees to administer functions across the Loans Programs Office. Estimate includes 2.7% raise effective January 1, 2022.	· Funds 16 additional FTEs to support enhanced loan activity.
Travel $90	**$400**	**+$310**
· Supports the travel of staff to attend meetings, conferences, and site visits if needed.	· Supports the travel of staff to attend meetings, conferences, and site visits if needed.	· Increase is due to the anticipated lifting of travel restrictions due to the COVID-19 pandemic.
Support Services $12,776	**$10,191**	**-$2,585**

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
· Supports a range of contract services including administrative support, training, subject matter experts, legal services, information technology, credit analysis, and market assessments. Third-Party Advisor costs are estimated at $6,000,000. The total EITS share and direct services estimate for LPO is $939,000, $750,300 is included here. The total request for LPO IT directed activities is $4,980,000, $3,879,420 is included here. The total for support services in FY 2021 is estimated to be $ 20,972,000 million, with an estimated $8,196,000 of available balances being used.	· Supports a range of contract services including administrative support, training, all aspects of loan guarantee origination activities, including, subject matter experts, legal services, information technology, credit analysis, and market assessments. The total EITS share and direct services estimate for LPO is $986,000, $788,050 is included here. The total request for LPO IT directed activities is $5,280,000, $4,113,120 is included here. Third-Party Advisor costs are estimated at $16,000,000. The total for support services in FY 2022 is estimated at $33,191,000, with an estimated $23,000,000 of available balances being used.	· After considering the use of available balances in FY 2022, support service funding increases by $12,219 in FY 2022 compared to FY 2021. The increase is needed to pay for the costs for Third-Party Advisors as required by the Energy Act of 2020, for rising IT costs and additional support service contractors to support the increase in loan activity.
Other Related Expenses $3,595	**$3,609**	**+$14**
· Supports DOE Working Capital Fund, DOE IT Services expenses, equipment, other services including conferences attendance fees, and publications. The total LPO WCF estimate is $3,109,000, $2,549,380 is included here. The total EITS share and direct services estimate for LPO is $939,000, $19,680 is included here. The total request for LPO IT directed activities is $4,980,000, $204,180 is included here.	· Supports DOE Working Capital Fund, DOE IT Services expenses, equipment, other services including conferences attendance fees, and publications. The total LPO WCF estimate is $3,109,000, $2,549,380 is included here. The total EITS share and direct services estimate for LPO is $986,000, $20,470 is included here. The total request for LPO IT directed activities is $5,280,000, $216,480 is included here.	· No change in funding levels

Tribal Energy Loan Guarantee Program

Tribal Energy Loan Guarantee Program

Tribal Energy Loan Guarantee Program
Proposed Appropriation Language

For Department of Energy administrative expenses necessary in carrying out the Tribal Energy Loan Guarantee Program, $2,000,000, to remain available until September 30, *2023.*

Explanation of Changes

The FY 2022 Budget continues the Tribal Energy Loan Guarantee program.

Public Law Authorizations

- P.L.102-486, Energy Policy Act of 1992, as amended

Tribal Energy Loan Guarantee Program

($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
2,000	2,000	2,000

Overview

Section 2602 of the Energy Policy Act of 1992, as amended by the Energy Policy Act of 2005, authorizes a loan guarantee program at the Department of Energy to support energy development by Indian tribes. The FY 2022 Budget provides Administrative Expense funding for the Tribal Energy Loan Guarantee Program (TELGP) to continue loan guarantee originating activities, as well as to monitor its expected portfolio. No additional loan authority is requested for the FY 2022 budget.

History

Authorized by the Energy Policy Act of 2005, funding was first appropriated for TELGP in FY 2017. In FY 2018, the U.S. Department of Energy (DOE) issued the first TELGP solicitation to support tribal energy development. Through intra-agency, interagency, and national laboratory collaborations, LPO's team of experts are diligently meeting with potential applicants to increase availability of commercial debt financing to enhance tribal economic opportunities through the energy development.

The budget will also allow LPO to continue outreach and origination activities, including developing marketing materials, engaging in stakeholder outreach, and ensuring that LPO's unique value proposition is widely known across Indian tribes and Alaska Native Corporations. Additionally, LPO outreach efforts have targeted financial institutions and private lenders to encourage participation in financing eligible projects. In calendar year (CY) 2020, LPO began specifically tracking its outreach efforts. For the period January 1, 2020, through September 30, 2020, LPO held 41 outreach meetings, including follow-up discussions, to disseminate information on the availability, benefits, and application process of TELGP to potential applicants.

	First Half of FY 2021	
TELGP Outreach Data	Oct 1, 2020 – March 31, 2021	Target for FY 2021
Total[1]	37	60

Stemming from these outreach efforts, LPO offers business development services to potential applicants ready to receive financing. Business development refers to LPO's in-house financial, technical, environmental, and legal team of experts advising companies on how to submit successful applications under the TELGP. The budget will allow LPO to continue providing this valued service. LPO has a goal of moving at least 1 potential TELGP applicant to business development from outreach in FY 2021.

Organization

The Loan Programs Office (LPO) currently utilizes seven divisions to originate new loans and proactively monitor the portfolio: Office of the Director, Origination Division, Portfolio Management Division, Risk Management Division, Technical and Project Management Division, Legal Division, and Management Operations Division.

The Office of the Director houses the Director and their immediate team, LPO's Outreach Team, and the Environmental Compliance Division. The Outreach Team is charged with identifying and establishing relationships with potential applicants and other external stakeholders deemed necessary to help meet LPO's strategic objectives. The Environmental Compliance Division ensures that applicants' projects meet federal environmental regulatory standards by helping applicants navigate through required reviews and consultations prior to loan closing.

[1] Data reflects total number of engagements, including follow-up discussions.

The Origination Division is responsible for coordinating the assessments of applications and leads the credit underwriting of truncations and the negotiating, closing and first disbursements of loans or loan guarantees. The division participates in business development and outreach activities.

The Portfolio Management Division (PMD) leads LPO's monitoring functions by approving disbursements, repayments, operating budgets, and long-term forecasts. In the event of non-payment and/or default, PMD leads activities to maximize recoveries either through bankruptcy, note sale, or compromise of the claim. The division participates in business development and outreach activities.

The Risk Management Division conducts continuous risk assessments of the assets in the portfolio to comply with regulatory requirements such as OMB Circular No. A-129 of the Federal Credit Reform Action of 1990. The division participates in business development and outreach activities.

The Technical and Project Management Division (TPMD) evaluates the technical performance of assets and project management throughout the entire lifecycle of the loan to ensure that the technical requirements of the loan agreement are met. TPMD conducts site visits, provides expertise on project construction status and budget, and identifies potential technical risks that inhibit the borrower's ability to meet requirements and repay the loan. The division participates in business development and outreach activities.

The Legal Division supports all on-going monitoring activities, negotiations and documentations of waivers, consents, routine loan amendments, approvals and denials of transfer withdrawals, and legal aspects of any project developments. The division participates in business development and outreach activities.

The Management and Operation Division is responsible for LPO employee resources, administrating and monitoring LPO administrative and working capital funds, providing enterprise architecture and information technology support, and providing contract administration to obtain services.

Highlights and Major Changes in the FY 2022 Budget Request

In FY 2022, LPO requests $2 million to continue origination- and monitoring-related activities for the TELGP to invigorate economic opportunities in tribal communities through the development of energy projects. This funding level allows LPO to help achieve the Administration's climate, clean energy, and Justice40 goals in FY 2022. Specifically, the TELGP provides government support to encourage commercial lenders to provide debt capital to Tribal companies and organizations installing robust energy projects and creating jobs modernizing power generation in the nation's most vulnerable communities.

Tribal Energy Loan Guarantee Program
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Tribal Energy Loan Guarantee Program					
Administrative Expenses	2,000	2,000	2,000	0	0%
Total, Tribal Energy Loan Guarantee Program	**2,000**	**2,000**	**2,000**	**0**	**0%**

Tribal Energy Loan Guarantee Program
Explanation of Major Changes ($k)

	FY 2022 Request vs FY 2021 Enacted
Administrative Expenses: Approximately $.5 million in unobligated balances carried forward from prior year appropriations will be utilized in addition to the request of $2 million to support increased loan origination and related administrative expenses.	**0**
Total, Tribal Energy Loan Guarantee Program	**0**

Tribal Energy Loan Guarantee Program
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Request (%)
Administrative Expenses					
Salaries & Benefits	184	990	990	0	0%
Travel	4	10	25	+ 15	150%
Support Services	1,645	768	752	-16	-2%
Other Related Expenses	167	232	233	+ 1	0%
Total, Administrative Expenses	2,000	**2,000**	**2,000**	0	0%
Federal FTEs	1	5	5	0	0%
Support Services					
Management and Professional Support Services					
Mission Support	1,413	486	964	+ 478	98%
IT Support	232	282	299	+ 17	6%
Total, Management and Professional Support Services	1,645	768	1,263	+ 495	64%
Available balances			-511		
Total, Support Services	1,645	768	752	-16	-2%
Other Related Expenses					
Communication and Misc. Charges Related to IT	4	7	8	+ 1	14%
Other Services	9	1	1	0	0%
Working Capital Fund	97	155	155	0	0%
Operation and Maintenance of Facilities	50	50	50	0	0%
Printing Supplies and Materials	5	14	14	0	0%
Equipment	2	5	5	0	0%
Total, Other Related Expenses	167	232	233	+ 1	0%

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Request (%)
Salaries & Benefits	184	990	990	0	0%
Travel	4	10	25	+ 15	150%
Support Services	1,645	768	752	-16	-2%
Other Related Expenses	167	232	233	+ 1	0%
Total, Administrative Expenses	2,000	**2,000**	**2,000**	0	0%
Federal FTEs	1	5	5	0	0%
	184	198	198	0	0%
Support Services					
Management and Professional Support Services					
Mission Support	1,413	486	964	+ 478	98%
IT Support	232	282	299	+ 17	6%
Total, Management and Professional Support Services	1,645	768	1,263	+ 495	64%
Available balances			-511		
Total, Support Services	1,645	768	752	-16	-2%
Other Related Expenses					
Communication and Misc. Charges Related to IT	4	7	8	+ 1	14%
Other Services	9	1	1	0	0%
Working Capital Fund	97	155	155	0	0%
Operation and Maintenance of Facilities	50	50	50	0	0%
O&M of Equipment or IT Equipment				0	N/A
Equipment	2	5	5	0	0%
Total, Other Related Expenses	167	232	233	+ 1	0%

Administrative Expenses
($K)

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Salaries and Benefits $990	**$990**	**$0**
• Provides for salaries and benefits of 5 full-time equivalent employees to administer functions across the Loans Programs Office.	• Provides for salaries and benefits of 5 full-time equivalent employees to administer functions across the Loans Programs Office. Estimate includes 2.7% raise effective January 1, 2022.	• No change in funding level.
Travel $10	**$25**	**+$15**
• Supports the travel of staff to attend meetings, conferences, and site visits if needed.	• Supports the travel of staff to attend meetings, conferences, and site visits if needed.	• Increase is due to the anticipated lifting of travel restrictions due to the COVID-19 pandemic.
Support Services $768	**$752**	**-$16**
• Supports a range of contract services including administrative support, training, subject matter experts, legal services, information technology, credit analysis, and market assessments. The total EITS share and direct services estimate for LPO is $939,000, $45,750 is included here. The total request for LPO IT directed activities is $4,980,000, $237,000 is included here.	• Supports a range of contract services including administrative support, training, all aspects of loan guarantee origination activities, including, subject matter experts, legal services, information technology, credit analysis, and market assessments. The total EITS share and direct services estimate for LPO is $986,000, $48,050 is included here. The total request for LPO IT directed activities is $5,280,000, $251,000 is included here. Total obligations in FY 2022 are estimated at $1,263,000, with an estimated $511,000 of available balances being used.	• After considering the use of available balances in FY 2022, support service funding increases by $495,000 in FY 2022 compared to FY 2021. The additional funds are needed to meet rising IT costs and additional support service contractors needed to support the increase in loan origination activities.
Other Related Expenses $232	**$233**	**+$1**
• Supports DOE Working Capital Fund, DOE IT Services expenses, equipment, other services including conferences attendance fees, and publications. $50,000 is included for outreach support from the NREL. The total LPO WCF estimate is $3,109,000, $155,000 is included here. The total EITS share and direct services estimate for LPO is $939,000, $1,200 is included here. The total request for LPO IT directed activities is $4,980,000, $12,450 is included here.	• Supports DOE Working Capital Fund, DOE IT Services expenses, equipment, other services including conferences attendance fees, and publications. The total LPO WCF estimate is $3,109,000, $155,000 is included here. The total EITS share and direct services estimate for LPO is $986,000, $1,250 is included here. $50,000 is included for outreach support from the NREL. The total request for LPO IT directed activities is $5,280,000, $13,200 is included here.	• No change in funding level.

Energy Information Administration

Energy Information Administration

U.S. Energy Information Administration
Proposed Appropriation Language

For necessary expenses in carrying out the activities of the U.S. Energy Information Administration, $126,800,000 to remain available until expended.

Explanation of Change

Public Law (P.L.) Authorizations
P.L. 83-703, Atomic Energy Act (1954)
P.L. 93-275, 15 U.S.C. 761, Federal Energy Administration Act (1974)
P.L. 93-319, Energy Supply and Environmental Coordination Act (1974)
P.L. 94-163, Energy Policy and Conservation Act (1975)
P.L. 94-385, 15 U.S.C. 790, Energy Conservation and Production Act (1976)
P.L. 95-91, 42 U.S.C. 7135, Department of Energy Organization Act (1977)
P.L. 95-619, 42 U.S.C. 7141 National Energy Conservation Policy Act (1978)
P.L. 95-620, 42 U.S.C. 8301, Power Plant and Industrial Fuel Use Act (1978)
P.L. 95-621, Natural Gas Policy Act (1978)
P.L. 96-294, Energy Security Act (1980)
P.L. 97-229, 42 U.S.C. 6245, Energy Emergency Preparedness Act (1982)
P.L. 97-415 Nuclear Regulatory Commission Authorization Act (1983)
P.L. 99-58, National Coal Imports Reporting Act (1985)
P.L. 99-58, 42 U.S.C. 6201, Energy Policy and Conservation Act Amendments of 1985
P.L. 99-509, 42 U.S.C. 7135, Omnibus Budget Reconciliation Act of 1986
P.L. 100-42, 42 U.S.C. 8312, Power Plant and Industrial Fuel Use Act Amendments of 1987
P.L. 102-486, 42 U.S.C. 13385, Energy Policy Act (1992)
P.L. 107-347, Title V of E-Government Act of 2002, Confidential Information Protection and Statistical Efficiency Act of 2002
P.L. 109-58, 42 U.S.C. 15801, Energy Policy Act of 2005
P.L. 110-140, Energy Independence and Security Act (2007)
P.L. 112-81, National Defense Authorization Act for Fiscal Year 2012
P.L. 112-158, Iran Threat Reduction and Syria Human Rights Act of 2012
P.L. 113-125, Reliable Home Heating Act of 2014
P.L. 114-11, Energy Efficiency Improvement Act of 2015

U.S. Energy Information Administration
Congressional Control: National Energy Information System (NEIS)
Funding ($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
$126,800	$126,800	$126,800	$0

Overview
The U.S. Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy (DOE). EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment. EIA is the nation's premier source of energy information and, by law, its data, analyses, and forecasts are independent of approval by any other officer or employee of the U.S. government.

EIA conducts a wide range of data collection, analysis, forecasting, and dissemination activities to ensure that its customers, including Congress, federal and state governments, the private sector, the public, and the media, have ready access to timely, reliable, and relevant energy information. EIA's data and analysis inform important energy-related decisions, such as the availability of energy sources; government, business, and personal investment decisions; and policy development.

Highlights of the FY 2022 Budget Request
The FY 2022 Budget Request of $126,800,000 will enable EIA to continue statistical and analysis activities that deliver valuable information to key stakeholders:

- The Wee*kly Natural Gas Storage Report* (WNGSR), which is designated as one of the nation's Principal Federal Economic Indicators; and *Weekly Petroleum Status Report* (WPSR), which provides statistics on oil and petroleum product stocks, imports, and production.

- The *Short-Term Energy Outlook* (STEO), which provides monthly forecasts of U.S. and global energy supply, consumption, trade, stocks, and prices projected out 12 to 24 months.

- The *Annual Energy Outlook* (AEO), which projects U.S. energy supply, consumption, trade, and energy-related carbon dioxide emissions over a 30-year period.

- The Energy Consumption and Efficiency Program, including activities to execute EIA's large-scale, multi-year commercial buildings, residential, and manufacturing energy end-use surveys.

The FY 2022 funding will also enable EIA to continue cybersecurity initiatives that will bolster information security across the enterprise.

Energy Data Program

EIA's comprehensive energy data program conducts surveys of energy suppliers and consumers and then processes the data to produce a full range of publicly available reports. EIA provides this high-quality, relevant, and timely data in a range of formats and structures to serve the various analytical needs of its customers. Where feasible, EIA uses administrative and third-party data to cost-effectively close energy information gaps and minimize respondent burden. The energy data program also provides the basis for EIA's energy analysis and forecasting activities, including key inputs for its short- and long-term energy models. EIA regularly reviews its energy data program to ensure the agency remains current with evolving market trends.

Energy Supply Surveys

The energy supply survey program represents EIA's data foundation and largest operational area. Information from these surveys is published in more than 300 reports each year across weekly, monthly, quarterly, and annual product lines. EIA also collects and disseminates hourly electricity demand data from the nation's balancing authorities, which provides timely insights into grid operations. The energy supply survey program collects comprehensive data that illustrate the complex flows of energy production, distribution, and end uses across the nation, including oil and natural gas, coal, refined products, nuclear power, renewables, biofuels, and electric power. The program is staffed with a broad range of technical expertise to ensure the quality of EIA's data and the integrity of its underlying statistical processes. Producers, consumers, investors, traders, and analysts use EIA energy statistics in their day-to-day activities. For example, the WPSR and WNGSR typically spur price formation activity to balance energy markets.

Energy Consumption and Efficiency Surveys

EIA collects and publishes national, end-use consumption data for commercial buildings, residential buildings, and manufacturing through three large-scale, multi-year surveys. The *Commercial Buildings Energy Consumption Survey* (CBECS) provides the only comprehensive, statistically reliable source of information on energy consumption, expenditures, and end uses in U.S. commercial buildings. The *Residential Energy Consumption Survey* (RECS) collects information from a national sample of housing units, including data on energy characteristics of homes, usage patterns, and household demographics. The *Manufacturing Energy Consumption Survey* (MECS), which is linked to production and employment data from Census Bureau economic surveys, provides information on energy throughput and economic and operational characteristics of U.S. manufacturers. These surveys are critical to understanding changes in U.S. energy use and are the basis for forecasting future U.S. energy scenarios. Because of the scale and complexity of these surveys, EIA continues to explore innovative methods for collecting valid data at lower costs.

Energy Analysis Program

EIA conducts a robust energy analysis program to help explain the complex and changing energy marketplace. The program maintains and operates the *National Energy Modeling System* (NEMS), the nation's leading tool for developing long-term projections of U.S. energy production, consumption, prices, and technology usage; the *World Energy Projection System Plus* (WEPS+), used for developing long-term projections of international energy markets; and the Regional Short-Term Energy Model (RSTEM), used to develop short-term domestic energy market forecasts. EIA's energy models support the production of its flagship publications: the STEO, AEO, and the *International Energy Outlook* (IEO), as well as other special and periodic topical analyses.

EIA also produces many recurring reports that provide context for dynamic energy markets, such as *Today in Energy*, a concise, highly accessible overview of a topical energy issue each day on EIA's website. The *Drilling Productivity Report, This Week in Petroleum*, and *Natural Gas Weekly Update* are additional examples of relevant analysis products that serve EIA's broad stakeholder community. In addition, EIA provides periodic reports and ad hoc analyses of important emerging energy issues, including, for example, battery storage for the U.S. electric grid. The program is staffed with experts in all areas of the energy sector, including oil, gas, coal, nuclear, renewables, electricity, transportation, emissions, and energy consumption and efficiency.

EIA also provides context and analysis for international energy issues, especially regarding trade flows and their impact on U.S. energy markets. For example, EIA analyzed the implications of removing restrictions on U.S. crude oil and natural gas exports—which included modeling of prices, production, and trade effects. In addition, EIA publishes updated reports that focus on the energy sectors in specific countries and regions, as well as country-level international energy statistics and rankings for major fuels and activities. EIA also responds to official government requests for international energy analysis, coordinating its responses with other DOE programs while maintaining its mission-mandated independence and impartiality.

Resource and Technology Management
This function provides overall business management, analysis, and mission support to EIA and responds to requests from other DOE offices and programs. Activities include workforce development and administration, financial and budget management, acquisition of support services, project management, program evaluation, and communications activities. The program also manages EIA's information technology (IT) enterprise to ensure a stable, operable IT infrastructure that meets data confidentiality and cybersecurity requirements.

EIA's robust communications program interacts with a diverse external customer base and manages the public website (www.eia.gov), press and media relations, marketing and outreach services, and the employee intranet. EIA's website features state-of-the-art tools such as customizable data browsers; interactive state, national, and North American energy infrastructure maps; open data initiatives such as Application Programming Interfaces (APIs); and highly visited online resources such as *Energy Kids* and *Energy Explained* that have increased information accessibility to EIA's customers.

Cybersecurity
EIA will allocate funding for cybersecurity, while continuing to modernize its IT processing platform. EIA's cybersecurity program identifies vulnerabilities and develops strategies to minimize potential vulnerabilities.

Information Technology Modernization
EIA is modernizing the technological platforms that support its comprehensive energy information program. For example, EIA has undertaken a multi-year project to migrate its energy supply surveys to a more modern and efficient IT processing platform. EIA is also assessing its highly complex energy modeling capabilities to ensure its ongoing ability to provide timely, relevant forecasts and projections of domestic and global energy markets.

Using Administrative Data for Statistical Purposes
EIA will continue to engage with other federal agencies in sharing and using administrative data sets for statistical purposes where appropriate. Using administrative and third-party data sets is a key strategy for EIA to close energy information gaps while minimizing the costs and respondent burden of survey data collection. EIA currently uses more than 60 administrative data sets and has negotiated successfully to obtain movements of commodities (crude oil, ethanol, coal) by rail using data from the Surface Transportation Board; and weekly petroleum export data from the U.S. Department of Homeland Security's Customs and Border Protection. EIA maintains strict measures to safeguard the privacy and confidentiality of the businesses, individuals, and institutions providing the data.

Key Program Accomplishments
Recent budgets have enabled EIA to deliver information that has increased public understanding of a dynamic energy landscape. For example, key recent accomplishments include:

- Delivered timely, relevant data and analysis to increase understanding of rapidly changing energy markets during the COVID-19 pandemic.
- Released new 30-year projections of U.S. energy markets in the *Annual Energy Outlook 2021.*
- Launched the *U.S. Energy Atlas*, a comprehensive reference for data and interactive maps of U.S. energy resources and infrastructure.
- Developed a new *Monthly Biofuels Production Report* that enables users to better track U.S. biofuels production capacities and feedstock consumption.
- Added weekly estimates of U.S. crude oil storage capacity utilization in the *Weekly Petroleum Status Report.*
- Provided timely energy information on severe Gulf Coast storms and western U.S. wildfires.
- Delivered expanded analysis of battery storage and the U.S. electric grid.
- Provided detailed analysis of Africa, Asia, and India in the *International Energy Outlook 2020.*
- Expanded information on usage factors for utility-scale storage generators in the *Electric Power Monthly.*
- Released new energy consumption data for commercial buildings and the manufacturing sector.

Congressional Control: National Energy Information System (NEIS)
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Salaries and Benefits:	**+2,287**
Projected increase for salaries and benefits increase of 2.7% and 7 additional FTEs.	
Support Services:	
Decrease in Energy Modeling and Analysis.	**-2,287**
Total, Program Direction	**$0**

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Salaries and Benefits	$54,250	$55,255	$58,082	$2,827	5%
Travel	$306	$306	$306	$0	0%
Support Services	$51,746	$50,741	$47,914	-$2,827	-6%
Other Related Expenses	$20,498	$20,498	$20,498	$0	0%
Total, Program Direction	**$126,800**	**$126,800**	**$126,800**	**$0**	**0%**
Federal FTEs	**359**	**359**	**366**	**7**	**2%**
Support Services					
Technical Support					
Administrative Support Services	$9	$9	$9	$0	0%
Human Resources Support Services	$4	$4	$4	$0	0%
E-Government Support Services	$1	$1	$1	$0	0%
Scientific/Technical and IT Training	$40	$40	$40	$0	0%
Data Center (Application Hosting/Housing)	$180	$180	$180	$0	0%
IT Management Services	$5,508	$5,508	$5,508	$0	0%
Other Advisory and Assistance Services	$44,574	$43,569	$40,742	-$2,827	-6%
Total, Technical Support	**$50,316**	**$49,311**	**$46,484**	**-$2,827**	**-6%**
Management Support					
Program Management	$1,430	$1,430	$1,430	$0	0%
Total, Management Support	$1,430	$1,430	$1,430	$0	0%
Total, Support Services	**$51,746**	**$50,741**	**$47,914**	**-$2,827**	**-6%**
Other Related Expenses					
Communications, utilities, and misc. charges	$4,257	$4,257	$4,257	$0	0%
Training	$466	$466	$466	$0	0%
Other goods and services from Federal sources	$345	$345	$345	$0	0%
Working Capital Fund	$9,694	$9,694	$9,694	$0	0%
O&M of IT systems or equipment	$1,144	$1,144	$1,144	$0	0%
Printing, supplies and materials	$1,300	$1,300	$1,300	$0	0%
Equipment	$2,967	$2,967	$2,967	$0	0%
Grants, subsidies, and contributions	$325	$325	$325	$0	0%
Total, Other Related Expenses	**$20,498**	**$20,498**	**$20,498**	**$0**	**0%**

Program Direction
Funding

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Salaries and Benefits $55,255,000	**Salaries and Benefits $58,082,000**	**+$2,827,000**
Provide salaries and benefits for 359 FTEs.	Provide salaries and benefits for 366 FTEs	Increase for salaries and benefits increase of 2.7% and seven additional FTEs in EIA's Energy Modeling and Analysis program to expand expertise in key areas.
Travel $306,000	**Travel $306,000**	**$0**
Provide essential travel for EIA stakeholder engagement—for representing EIA in public forums and engaging with industry experts.	Provide essential travel for EIA stakeholder engagement—for representing EIA in public forums and engaging with industry experts.	Maintain travel costs at FY 2021 level.
Support Services $50,741,000	**Support Services $47,914,000**	**-$2,827,000**
Energy Supply Surveys $15,965,000 Continue to operate the core energy supply data collection program.	*Energy Supply Surveys $15,965,000* Continue to operate the core energy supply data collection program.	*Energy Supply Surveys $0* Continue to operate the core energy supply data collection program.
Energy Consumption and Efficiency Surveys $13,321,000 Conduct commercial, residential, and manufacturing surveys: • Conduct field survey collection phase of CBECS • Completion of Energy Consumption Surveys	*Energy Consumption and Efficiency Surveys $13,321,000* Conduct commercial, residential, and manufacturing surveys.	*Energy Consumption and Efficiency Surveys $0* Continue to operate the core Energy Consumption and Efficiency Survey program.
Energy Modeling and Analysis $9,121,000 Deliver core analysis, forecasts, and projections (e.g., AEO, IEO, and STEO).	*Energy Modeling and Analysis $6,294,000* Deliver core analysis, forecasts, and projections (e.g., AEO, IEO, and STEO).	*Energy Modeling and Analysis -$2,827,000* As noted above, EIA is adding seven federal FTEs in the Energy Modeling and Analysis program; corresponding funding will be reduced from the support services budget.
Resource and Technology Management $12,334,000 Continue providing business management, IT and network services, and administrative support to EIA staff. Maintain communication activities and invest in flexible web platforms to enhance data delivery. Maintain scope of energy mapping system and continue to integrate mapping with relevant EIA data.	*Resource and Technology Management $12,334,000* Continue providing business management, IT and network services, and administrative support to EIA staff. Maintain communication activities and invest in flexible web platforms to enhance data delivery. Maintain scope of energy mapping system and continue to integrate mapping with relevant EIA data.	*Resource and Technology Management $0* Continue cybersecurity initiatives and IT system and infrastructure modernization efforts.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Other Related Expenses $20,498,000	**Other Related Expenses $20,498,000**	**$0**
Pay rent and shared services through the DOE Working Capital Fund and provide IT equipment and licenses, subscriptions and data purchases, and employee training among other activities.	Pay rent and shared services through the DOE Working Capital Fund and provide IT equipment and licenses, subscriptions and data purchases, and employee training among other activities.	Continue Other Related Expenses activities.

Advanced Reasearch Projects Agency-Energy

Advanced Reasearch Projects Agency-Energy

Advanced Research Projects Agency - Energy
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
425,000	427,000	500,000

The U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) was established by the America COMPETES Act of 2007 (Public Law 110–69), as amended. The mission of ARPA-E is to enhance the economic and energy security of the United States through the development of energy technologies that reduce imports of energy from foreign sources; reduce energy-related emissions, including greenhouse gases; improve the energy efficiency of all economic sectors; provide transformative solutions to improve the management, clean-up, and disposal of radioactive waste and spent nuclear fuel; and improve the resilience, reliability, and security of infrastructure to produce, deliver, and store energy. ARPA-E will ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies. ARPA-E will identify and promote revolutionary advances in energy-related applied sciences, translating scientific discoveries and cutting-edge inventions into technological innovations. It will also accelerate transformational technological advances in areas where industry by itself is not likely to invest due to technical and financial uncertainty. The role of ARPA-E is not to duplicate DOE's basic research and applied programs but to focus on novel early-stage energy research and development (R&D) with technology applications that can be meaningfully advanced with a small investment over a defined period of time.

Public Law Authorizations
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 109-58, "Energy Policy Act of 2005"
P.L. 110-69, "America COMPETES Act of 2007"
P.L. 111-358, "America COMPETES Reauthorization Act of 2010"
P.L. 116-260, Section 10001, "Consolidated Appropriations Act, 2021" ARPA-E Amendments

Overview
ARPA-E has established a nimble, effective management structure and developed a portfolio of technical programs that is delivering innovative, investable opportunities to the commercial sector. ARPA-E will continue to deliver value to the U.S. economy with continued emphasis on maintaining a healthy portfolio of projects. These projects cover a broad range of energy topics, with a growing focus on additional scale-up of the most promising projects that have demonstrated success in technical development, project management, and definition of commercial pathways.

Since its inception in 2009, ARPA-E has provided approximately $2.6 billion in funding to over 1,000 projects through focused programs and Open funding solicitations. 177 ARPA-E projects have attracted more than $4.9 billion in private-sector follow-on funding, 237 project teams have partnered with other agencies for further development, and 88 companies have been formed from ARPA-E projects. In addition, ARPA-E project teams have generated 4,614 peer-reviewed journal articles and received 716 patents from the U.S. Patent and Trademark Office.

In 2017, the National Academy of Sciences (NAS), in response to a congressional request, assessed ARPA-E's first six years of operation[1]. NAS reported that "There are clear indicators that ARPA-E is making progress toward achieving its statutory mission and goals, and it cannot reasonably be expected to have completely fulfilled those goals given so few years of operation and the size of its budget." The report went on to state, "Importantly, especially at this early stage, the committee found no signs that ARPA-E is failing, or on a path to failing, to deliver on its mission and goals."

In FY 2020, ARPA-E was appropriated a 16.5% year-over-year increase for its program budget and set a record of $404.2 million in funding obligated. This funding was spread over 271 projects across a wide range of technical areas. Additionally, in FY 2020 ARPA-E launched eleven Focused Programs with up to $342.5 million in total available funding. The Focused Programs fill technical whitespace that ARPA-E's talented scientific team identified, with the assistance of academia and industry. ARPA-E launched 19 Solicitations on Topics Informing New Program Areas with up to $41.25 million in total

[1] https://www.nap.edu/catalog/24778/an-assessment-of-arpa-e

funding. These are investigatory programs that pursue innovative technologies and unconventional ideas that can lead to focused ARPA-E programs in the future and also drive high-risk R&D for potentially disruptive technologies. In addition to Focused Programs and Solicitations on Topics Informing New Program Areas, ARPA-E introduced a new approach to help previously funded technology get deployed by establishing a program called SCALEUP (Seeding Critical Advances for Leading Energy technologies with Untapped Potential). SCALEUP is designed to fund successful technologies that were previously funded by ARPA-E for which the proof-of-concept R&D challenges have been addressed, and which can progress toward real-world impact through scaling.

Highlights and Major Changes in the FY 2022 Budget Request

In FY 2022, ARPA-E plans to release up to fifteen new funding opportunity announcements (FOAs). The FOAs will address new areas not represented in the present portfolio and develop new opportunities opened by the outcomes of previous programs.

Advanced Research Projects Agency - Energy
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
ARPA-E Projects	390,000	392,000	463,000	+71,000	+18%
Program Direction	35,000	35,000	37,000	+2,000	+6%
Total, Advanced Research Projects Agency - Energy	**425,000**	**427,000**	**500,000**	**+73,000**	**+17%**
Federal FTEs	**64**	**64**	**64**	**+0**	**+0%**

ARPA-E Projects

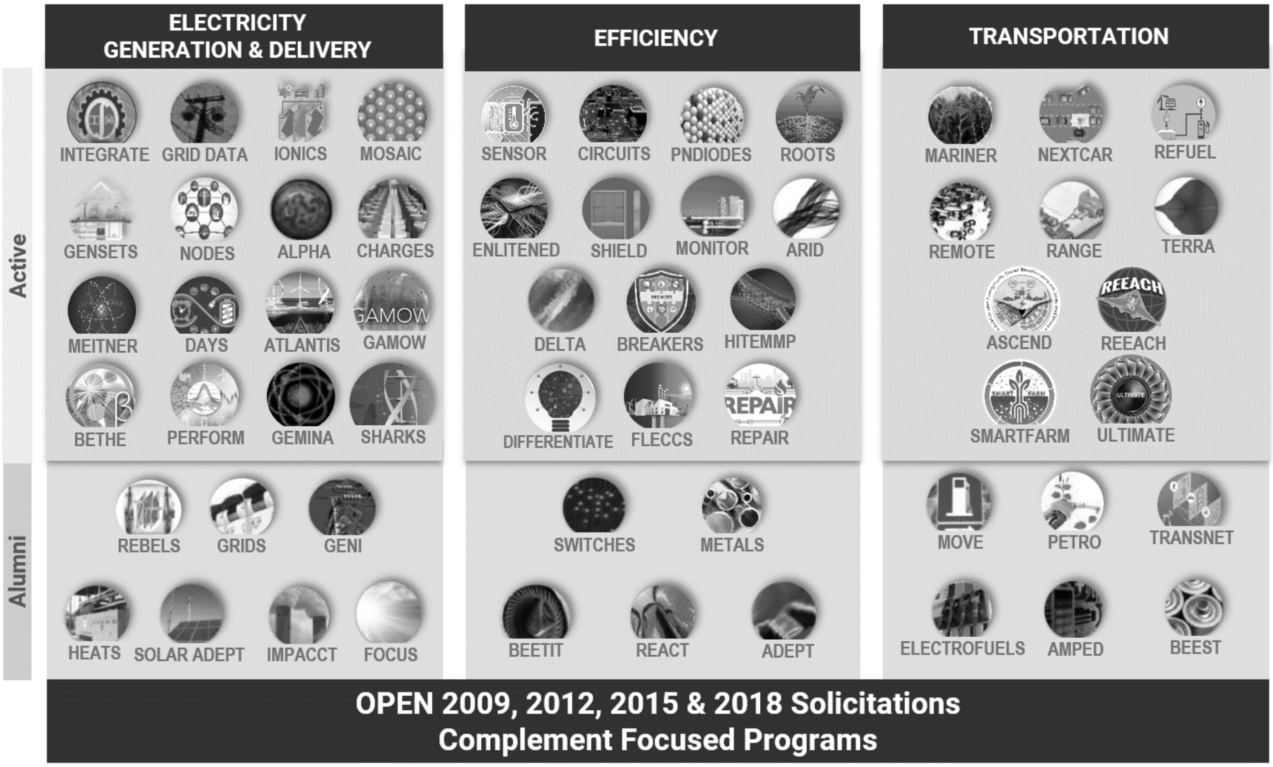
Overview

ARPA-E identifies and supports revolutionary energy inventions and transformational energy technology advances, which requires constant evolution of its programmatic focus. This is accomplished by establishing dynamic technical programs (each lasting about three years) designed to accelerate innovation in high-potential areas. The breadth of the program portfolio that has developed over ARPA-E's lifetime addresses different parts of the energy technology space from year to year.

ARPA-E has demonstrated the efficacy of its model for accelerating high-potential, novel technical approaches to existing and emerging U.S. energy challenges. Program Directors, recruited for their technical expertise, leadership, and experience in energy issues, are given significant autonomy in identifying potential high-impact areas for R&D investment. ARPA-E's Program Directors work to develop their proposals in the context of both private sector and federally funded work in the technical space, and ultimately propose a program designed to accelerate research and commercial development in the topic area. As a complement to its focused technology programs, ARPA-E also supports OPEN solicitations. OPEN solicitations seek the most innovative new ideas in energy technology across the full spectrum of energy applications, allowing the Agency to support the development of important technologies that otherwise would fall outside the scope of its focused programs. OPEN solicitations were run in 2009, 2012, 2015, 2018, and 2021.

Selection of project awards within each program occurs by a rigorous process of proposal review. Selection criteria include the transformative character of the technology, the potential impact of the technology on ARPA-E's energy missions as defined in its authorizing statute, and the potential for the project to yield commercial applications that benefit U.S. economic and energy security. Within these criteria the most highly rated proposals are selected for award negotiations. The majority of the funded projects involve more than one institution, and the lead institutions are distributed among universities, businesses, federally funded R&D centers (FFRDCs), and non-profit organizations.

The resulting portfolio of alumni and active R&D projects (shown below) broadly covers the U.S. energy technology landscape, from transportation fuels and energy storage, through residential, commercial and manufacturing efficiency to the storage, distribution and generation of electrical power. The programs are designed to deliver value given a targeted investment over a defined period of time. The projects are structured in a portfolio funding approach to 'de-risk' areas of technological opportunity by supporting multiple high-potential approaches to the program goals to the point where their relative value for further applications can be determined. This allows the most effective approaches to emerge based on their technical performance and potential. Under ARPA-E's rigorous project management process, project teams work to quarterly milestones for both technical and commercialization goals.



FOA Acronym	Definition
	Electricity Generation and Delivery – Active
ALPHA	Accelerating Low-Cost Plasma Heating and Assembly
ATLANTIS	Aerodynamic Turbines Lighter and Afloat with Nautical Technologies and Integrated Servo-control
BETHE	Breakthroughs Enabling THermonuclear-fusion Energy
CHARGES	Cycling Hardware to Analyze and Ready Grid-Scale Electricity Storage
DAYS	Duration Addition to electricitY Storage
GAMOW	Galvanizing Advances in Market-Aligned Fusion for an Overabundance of Watts
GEMINA	Generating Electricity Managed by Intelligent Nuclear Assets
GENSETS	Generators for Small Electrical and Thermal Systems
GRID DATA	Generating Realistic Information for the Development of Distribution and Transmission Algorithms
INTEGRATE	Innovative Natural-gas Technologies for Efficiency Gain in Reliable and Affordable Thermochemical Electricity-generation
IONICS	Integration and Optimization of Novel Ion-Conducting Solids
MEITNER	Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration
MOSAIC	Micro-scale Optimized Solar-cell Arrays with Integrated Concentration
NODES	Network Optimized Distributed Energy Systems
PERFORM	Performance-based Energy Resource Feedback, Optimization, and Risk Management
SHARKS	Submarine Hydrokinetic And Riverine Kilo-megawatt Systems
	Electricity Generation and Delivery – Alumni
FOCUS	Full-Spectrum Optimized Conversion and Utilization of Sunlight
GENI	Green Electricity Network Integration
GRIDS	Grid-Scale Rampable Intermittent Dispatchable Storage
HEATS	High Energy Advanced Thermal Storage
IMPACCT	Innovative Materials and Processes for Advanced Carbon Capture Technologies
REBELS	Reliable Electricity Based on ELectrochemical Systems
Solar ADEPT	Solar Agile Delivery of Electrical Power Technology

FOA Acronym	Definition
	Efficiency – Active
ARID	Advanced Research In Dry cooling
BREAKERS	Building Reliable Electronics to Achieve Kilovolt Effective Ratings Safely
CIRCUITS	Creating Innovative and Reliable Circuits Using Inventive Topologies and Semiconductors
DELTA	Delivering Efficient Local Thermal Amenities
DIFFERENTIATE	Design Intelligence Fostering Formidable Energy Reduction and Enabling Novel Totally Impactful Advanced Technology Enhancements
ENLITENED	ENergy-efficient Light-wave Integrated Technology Enabling Networks that Enhance Dataprocessing
FLECCS	FLExible Carbon Capture and Storage (FLECCS)
HITEMMP	High Intensity Thermal Exchange through Materials, and Manufacturing Processes
MONITOR	Methane Observation Networks with Innovative Technology to Obtain Reductions
PNDIODES	Power Nitride Doping Innovation Offers Devices Enabling SWITCHES
REPAIR	Rapid Encapsulation of Pipelines Avoiding Intensive Replacement
ROOTS	Rhizosphere Observations Optimizing Terrestrial Sequestration
SENSOR	Saving Energy Nationwide in Structures with Occupancy Recognition
SHIELD	Single-Pane Highly Insulating Efficient Lucid Designs
	Efficiency – Alumni
ADEPT	Agile Delivery of Electrical Power Technology
BEETIT	Building Energy Efficiency Through Innovative Thermodevices
METALS	Modern Electro/Thermochemical Advances in Light Metals Systems
REACT	Rare Earth Alternatives in Critical Technologies
SWITCHES	Strategies for Wide Bandgap, Inexpensive Transistors for Controlling High-Efficiency Systems
	Transportation – Active
ASCEND	Aviation-class Synergistically Cooled Electric-motors with iNtegrated Drives
MARINER	Macroalgae Research Inspiring Novel Energy Resources
NEXTCAR	Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles
RANGE	Robust Affordable Next Generation Energy Storage Systems
REEACH	Range Extenders for Electric aviation with Low Carbon and High Efficiency
REFUEL	Renewable Energy to Fuels Through Utilization of Energy-Dense Liquids
REMOTE	Reducing Emissions using Methanotrophic Organisms for Transportation Energy
SMARTFARM	Systems for Monitoring and Analytics for Renewable Transportation Fuels from Agricultural Resources and Management
TERRA	Transportation Energy Resources from Renewable Agriculture
ULTIMATE	Ultrahigh Temperature Impervious Materials Advancing Turbine Efficiency
	Transportation – Alumni
AMPED	Advanced Management and Protection of Energy Storage Devices
BEEST	Batteries for Electrical Energy Storage in Transportation
ElectroFuels	Microorganisms for Liquid Transportation Fuel
MOVE	Methane Opportunities for Vehicular Energy
PETRO	Plants Engineered to Replace Oil
TRANSNET	Traveler Response Architecture using Novel Signaling for Network Efficiency in Transportation

One significant component of ARPA-E's mission is accelerating the economic impact of U.S. investments in energy R&D, and advancing the commercialization readiness of successful projects (depth of investment) is essential to achieving this goal. Developing the pathway to commercial applications is an intrinsic component of all projects, and project teams are required to conduct activities such as develop a detailed techno-economic analysis, market research, intellectual property protection, and engagement with potential customers and investors. As project teams demonstrate success, ARPA-E's Technology-to-Market Advisors and Program Directors work closely with the teams to help identify pathways toward commercial deployment. Many of ARPA-E's alumni projects have been able to obtain follow-on funding from private investors, state agencies and/or federal programs, and ARPA-E's maturing portfolio is offering increasing opportunities for commercialization of ARPA-E funded technologies.

Despite the level of technology 'de-risking' projects from the focused and OPEN solicitations achieved, ARPA-E determined that in some areas, further de-risking was necessary to validate technologies at a scale pertinent to investment. To this end, in FY 2020, ARPA-E instituted a new solicitation called SCALEUP. SCALEUP is designed to fund successful technologies that were previously funded by ARPA-E for which the proof-of-concept R&D challenges have been addressed, and which can progress toward real-world impact through scaling. An enduring challenge to ARPA-E's mission is that even technologies that achieve substantial technical advancement under ARPA-E support are at risk of being stranded in their development path once ARPA-E funding ends. Experience across ARPA-E's diverse energy portfolios, and with a wide range of investors, indicates that pre-commercial "scaling" projects are critical to establishing that performance and cost parameters can be met in practice for these very early stage technologies. Success in these scaling projects would enable industry, investors, and partners to justify substantial commitments of financial resources, personnel, production facilities, and materials to develop promising ARPA-E technologies into early commercial products.

In FY 2022, ARPA-E plans to release up to fifteen new FOAs, including additional investment in SCALEUP. The FOAs will address new areas not represented in the present portfolio and develop new opportunities opened by the outcomes of previous programs. The assessment process for the new programs is now underway as described below.

Potential technology areas for up to fifteen focused programs in FY 2022:
ARPA-E is developing programs for transformational research across a wide range of energy technologies, and applications including:

- Materials for carbon-neutral or carbon-negative buildings: Novel technologies could enable buildings to be transformed into carbon sinks to reduce their embodied emissions, and potentially make future buildings carbon neutral or even carbon negative. If successful, these technologies would have a significant impact on energy usage and provide a valuable pathway for carbon sequestration. This focus area entails novel materials derived from feedstocks including forestry and other purpose-grown raw materials, agricultural residues, as well as direct use of greenhouse gases (e.g., carbon dioxide, methane). Attaining this vision requires radical new developments in building materials and manufacturing methods. Comprehensive and robust life-cycle analyses and carbon accounting, along with permanency of storage and end-of-life design, will also be necessary.

- Technologies to dramatically reduce high-level nuclear waste: The realization of safe, economical nuclear energy is a critical component for multiple ARPA-E mission areas. Addressing urgent needs for the disposal of existing nuclear waste via novel technologies and processes that eliminate inherent risks, regarding both safety and security, is a key element of this focus. New technologies are required such as modular separations and processing systems which could economically, safely, and securely reduce by an order of magnitude the amount of high-level waste in spent nuclear fuel. Technologies developed in this area may prove beneficial for waste from commercial nuclear reactors, from emerging advanced reactor concepts, or from other sources.

- Advanced battery electrodes and conductors for high capacity and rapid charge: New, disruptive pathways to develop the next generation of batteries are crucial to formulate now to achieve U.S. leadership in this highly competitive area. This focus area seeks to develop battery systems that can withstand extremely fast charging, have a much higher capacity at lower weight, or utilize abundant, easily-sourced materials – all well beyond the capability of current generation Li-ion, or even emerging solid-state Li-metal batteries. Such attributes could enable broad adoption of electrified transportation applications, including electric vehicles and electrified aviation.

- Grid resilience, reliability, and flexibility: The needs for the future grid are rapidly evolving with increased levels of renewable power, the proliferation of distributed energy resources (DERs), and the strains and disruptions of extreme weather. These needs are extremely challenging, as the infrastructure for the future grid will still be highly dependent on legacy systems that are decades, or in some cases over a century, old. This presents a tremendous challenge to integrate new technologies within an old system in the face of rapidly changing requirements. In this focus area, ARPA-

E is developing technologies that flexibly utilize grid resources – new and old – through approaches in topology and power flow optimization, integration of DERs into transmission-level operations, and microgrids. These approaches may enhance legacy grid operation systems in the near-term, and seek to provide a path to the fully flexible, resilient, and reliable grid system of the future.

- Advanced Fusion Approaches and Energy Applications: Fusion energy is one of a very few potential baseload, low-carbon energy sources that could scale to global proportions. It is an important technology option to develop given this large-scale potential, and if successful, could provide a long-term sustainable energy solution for humanity. Most fusion research today focuses on the Deuterium-Tritium (D-T) thermonuclear reaction, which is the most scientifically mature and accessible path to fusion power, however this is still decades away. There are many other fuel options that, while less scientifically mature than D-T, could offer significant system advantages with far lower levels of neutron production and resultant radiological waste, along with novel power conversion approaches.

- SCALEUP: Expanding the SCALEUP program both in scope and funding level in order to continue the push toward commercialization for previous extremely early-stage ARPA-E programs and to continue the focus on ensuring manufacturing in the U.S.

ARPA-E will also continue its stand-alone SBIR/STTR program to provide additional support to small businesses beyond the significant number of awards to small businesses via ARPA-E's standard non-SBIR/STTR solicitations. ARPA-E plans to release SBIR/STTR funding through its annual Supporting Entrepreneurial Energy Discoveries (SEED) program as well as focused FOAs targeted for SBIR/STTR awards.

ARPA-E Projects
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
ARPA-E Projects:				
Transportation Systems	195,000	196,000	231,500	+35,500
Stationary Power Systems	195,000	196,000	231,500	+35,500
Total, ARPA-E Projects	**390,000**	**392,000**	**463,000**	**+71,000**

SBIR/STTR

- FY 2020 Enacted: $14,235 total (SBIR $12,480 / STTR $1,755)
- FY 2021 Enacted: $14,308 total (SBIR $12,544 / STTR $1,764)
- FY 2022 Request: $16,900 total (SBIR $14,816 / STTR $2,084)

ARPA-E Projects
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
Transportation Systems: The FY 2022 Congressional Request proposes an additional $71 million above the FY 2021 Enacted. ARPA-E will continue to invest roughly half of its mission funding in transportation systems.	**+35,500**
Stationary Power Systems: The FY 2022 Congressional Request proposes an additional $71 million above the FY 2021 Enacted. ARPA-E will continue to invest roughly half of its mission funding in stationary power systems	**+35,500**
Total, ARPA-E Projects	**+71,000**

Program Direction – Appropriations Request
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Washington Headquarters				
Salaries and Benefits	11,500	11,810	12,129	+319
Travel	1,750	400	1,600	+1,200
Support Services	16,000	16,432	16,876	+444
Other Related Expenses	5,750	6,358	6,395	+37
Total, Program Direction	**35,000**	**35,000**	**37,000**	**+2,000**
Federal FTEs	**64**	**64**	**64**	**0**
Support Services				
Technical Support	5,600	5,751	5,907	+156
Management Support	10,400	10,681	10,969	+288
Total, Support Services	**16,000**	**16,432**	**16,876**	**+444**
Other Related Expenses				
Working Capital Fund	3,773	4,123	4,123	0
Energy Information Technology Services (EITS)	1,588	1,588	1,667	+79
Other Services	389	647	605	-42
Total, Other Related Expenses	**5,750**	**6,358**	**6,395**	**+37**

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $35,000,000	**$37,000,000**	**+ $2,000,000**
Salaries and Benefits		
At the FY 2021 Enacted level, ARPA-E anticipates supporting up to 64 Federal FTEs.	At the FY 2022 Request level, ARPA-E anticipates needing up to 64 Federal FTEs. It is assumed that S&B will escalate 2.7% from the FY 2021 Enacted level. Additional Program Directors and Tech to Market staff will be added in FY22 to support ARPA-E's growing portfolio but overall FTE utilization is expected to remain level as some ARPA-E staff will split time with ARPA-C to facilitate the establishment of ARPA-C.	+ $319,000: Increase in cost due to FTE cost escalation.
Travel		
At the FY 2021 Enacted level, ARPA-E Program Directors and Technology-to-Market advisers will visit performers as part of ARPA-E's hands-on engagement, which is the primary component of ARPA-E travel. The number of site visits will be commensurate with the number of ongoing projects.	At the FY 2022 Request level, ARPA-E Program Directors and Technology-to-Market advisers will visit performers regularly as part of ARPA-E's hands-on engagement, which is the primary component of ARPA-E travel. The number of site visits will be commensurate with the number of ongoing projects. FY 2022 Travel is expected to return to pre-COVID levels.	+ $1,200,000: Travel will increase as new projects initiate and ARPA-E Program Directors and Technology-to-Market advisers visit performers as part of ARPA-E's hands-on engagement. FY 2022 is expected to return to pre-COVID levels and increase four times over the FY 2021 level.
Support Services		
At the FY 2021 Enacted level, ARPA-E anticipates continuing the use of support service contractors to support ARPA-E federal staff in the management and oversight of projects and other required functions. The level of support is commensurate to the number of ongoing and anticipated projects.	At the FY 2022 Request level, ARPA-E anticipates continuing the use of support service contractors to support ARPA-E federal staff in the management and oversight of projects and other required functions. The level of support is commensurate with the number of ongoing and anticipated projects.	+ $444,000: Increase from FY 2021 levels as ARPA-E continues management and oversight of its growing portfolio.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Other Related Expenses		
The FY 2021 Enacted level for other related expenses primarily consists of Working Capital Fund and Energy Information Technology support costs, which are commensurate with the level of FTEs and support services requested.	The FY 2022 Request level for other related expenses primarily consists of Working Capital Fund and Information Technology support costs, which are commensurate with the level of FTEs and support services requested.	+ $37,000: IT costs are expected to increase up to 5% in FY 2022 due to enterprise-wide data center migrations, Office 365 upgrades, IT modernization, VTC upgrades, and Security Operations Center maturity. It is assumed that WCF costs will remain flat in FY 2022.

Advanced Research Projects Agency - Energy
Research and Development ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Basic	0	0	0	0
Applied	195,000	196,000	231,500	+35,500
Development	195,000	196,000	231,500	+35,500
Subtotal, R&D	390,000	392,000	463,000	+71,000
Equipment	0	0	0	0
Construction	0	0	0	0
Total, R&D	**390,000**	**392,000**	**463,000**	**+71,000**

Advanced Research Projects Agency - Energy
Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
ARPA-E Projects			
SBIR	12,480	12,544	14,816
STTR	1,755	1,764	1,764
Total, SBIR/STTR	**14,235**	**14,308**	**16,900**

- FY 2020 Enacted: $14,235 total (SBIR $12,480 / STTR $1,755)
- FY 2021 Enacted: $14,308 total (SBIR $12,544 / STTR $1,764)
- FY 2022 Request: $16,900 total (SBIR 14,816 / STTR $2,084)

Advanced
Reasearch Projects
Agency-Climate

Advanced Reasearch Projects Agency-Climate

Advanced Research Projects Agency - Climate
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
0	0	200,000

The U.S. Department of Energy's Advanced Research Projects Agency-Climate (ARPA-C) will invest in climate-related innovations necessary to enable adaptation, increase resilience and achieve net zero non-energy emissions by 2050. ARPA-C's climate mission complements ARPA-E's advanced energy mission but reflects the need to address research activities that encompass more than energy emissions. Appropriations requested here are a down payment on the Administration's broader climate technology agenda that will drive innovation to tackle the climate crisis while creating good paying jobs, assure the United States remains the world's leader in climate technologies, and increase societal resilience to climate change impacts.

Funding proposed will seed the development of ARPA-C, leveraging ARPA-E's innovation model which has proven effective in developing advanced energy technologies and moving them towards deployment. By using ARPA-E as a model for ARPA-C, the Department of Energy (DOE) will be able to instill the "ARPA" culture that has made it unique within DOE. Full expression of ARPA-C will require legislation beyond the current ARPA-E authorization. These include provisions relating to technology investments needed to enable mitigation of non-energy greenhouse gas (GHG) emissions and others to enhance climate resiliency and adaptation. None of these climate-critical mission areas are fully authorized to the ARPA-E currently, and application spaces that may be only partially pertinent to ARPA-E could be addressed much more broadly and effectively under an ARPA-C.

ARPA-C's mission will be to harness innovation to solve the global climate crisis while enhancing the economic and energy security of the United States through development of new technologies that will lead to economic opportunities for American workers and businesses. ARPA-C will identify and promote revolutionary advances in climate-related applied sciences, translating scientific discoveries and cutting-edge innovations into products, services, and systems that the market, government agencies, non-profits, or other community organizations can adopt. It will also accelerate transformational technological advances in areas where industry by itself is not likely to invest due to technical and financial uncertainty. The role of ARPA-C is not to duplicate the basic research and applied programs within DOE and the other Federal research and development (R&D) enterprises, but to focus on R&D with technology applications that can be meaningfully advanced with a targeted investment over a defined period of time. The Climate Innovation Working Group as part of the National Climate Task Force, co-chaired by the White House Office of Domestic Climate Policy, Office of Science of Technology and Policy, and Office of Management and Budget, will spur initial coordination among climate-related technology agencies. ARPA-C will enable the U.S. to seize a once-in-a-generation opportunity to create and deploy technologies that will transform the U.S. and Global economies, and to capture their value for the benefit of the American people.

The Administration has requested funding for ARPA-C in the FY 2022 Budget as well as the American Jobs Plan. The combined $1 billion in the FY 2022 Budget funds ARPA-E, seeds a new ARPA-C, and includes $300 million for other Federal agencies to further fund ARPA-C's mission. The American Jobs Plan includes an additional $15 billion specifically for ARPA-C, an infusion to address the crisis in the near-term with a temporary, but significant effort in supporting novel technology solutions to increase adaptation and resilience as well as creating economic opportunities.

ARPA-C will be placed within the DOE in order to leverage ARPA-E's existing management, processes, culture, and operations capabilities to ensure a rapid and effective start. ARPA-C would use ARPA-E's flexible hiring authorities and reputation to bring in top talent for program direction and management. Interagency partners with ARPA-C funding (or any agency with technology needs that ARPA-C can support) should play a key part in recruiting potential program directors to join the Agency. As a part of the interagency coordination, ARPA-E and ARPA-C could train a broad array of staff from throughout the Federal government in the ARPA approach.

The imperative to address climate-related emissions necessitates that creation of ARPA-C commence expeditiously, including an initial investment to solve the most immediate and pressing problems. To bridge these climate adaptation, resilience and mitigation needs, the Budget also requests $300 million in FY 2022 for the Departments of Agriculture, Commerce, Homeland Security, Housing and Urban Development, Interior, and Transportation, and the Environmental Protection Agency. These interagency ARPA-C partners would coordinate most closely with ARPA-C, making the ARPA-C unique in a mission that spans several agencies rather than ARPA-E or DARPA that primarily serve their Department's. Additional coordination and communication may take place with General Services Administration, National Aeronautics and Space Administration, and National Science Foundation. Any non-DOE agency may request ARPA-C management of designated funds to support programs that meet their mission needs; ARPA-E has managed and selected R&D investments using other agency appropriations in the past to develop promising technologies for Defense applications.

Public Law Authorizations
P.L. 95-91, "Department of Energy Organization Act" (1977)

Overview
The FY 2022 budget facilitates the establishment of ARPA-C to identify and promote research with the potential to make revolutionary advances in breakthrough sciences, translate scientific discoveries and cutting-edge inventions into technological innovations, and accelerate transformational technological advances in areas that industry by itself will not support because of technical and financial risk and uncertainty. ARPA-C will support these technologies until they are competitive in the market or at a stage that they can be adopted by government agencies or other organizations that may be the end-users.

Benefits
To accomplish its mission, ARPA-C will draw upon the Nation's strengths of having the best R&D infrastructure in the world, an unparalleled innovation ecosystem in business and entrepreneurship, and the American enthusiasm for pioneering and taking risks. ARPA-C will fund transformational research, development, and deployment projects that are conducted by teams from universities, small businesses, large businesses, non-profits, National Laboratories, and other Federally Funded R&D centers to tackle the climate crisis.

Beyond providing funds to projects, ARPA-C will have substantial involvement with the ongoing technical work, conducting in-depth quarterly reviews with the project teams using a milestone driven structure. Combining this with active portfolio management will ensure that multiple technical pathways are accurately tested, while the most effective ones will receive crucial financial, technical, and commercialization assistance for a limited period. This will ensure rapid development toward a point where interested private or public investors are willing to commit funds.

ARPA-C will be modeled on ARPA-E and organized and administered in ways that enable the program to be lean, effective, and agile, striving to be a model of excellence for a government funding agency.

ARPA-C's program development process includes distinctive and desirable features.
ARPA-C will adopt ARPA-E's novel process for the development and creation of programs that features extensive technical community engagement, topical workshops, a three-stage peer review process that allows for rebuttals to reviewer comments, and rapid contract negotiation, as shown in the figure below. Despite its depth of engagement and multi-stage evaluation, this model affords a timeline from conception to execution that is greatly accelerated. This in turn will allow ARPA-C to respond rapidly to newly emerging technological discoveries, market trends, and policy events.

The first two phases of the program development process serve to answer: 'What is the right problem to solve, why, and what should the solution look like to ensure impact?'. This process refines what is a significant amount of background work into a Funding Opportunity Announcement (FOA) in an area where ARPA-C's limited funding will have substantial impact in the long term. The third phase utilizes a novel peer review process to inform the building of a portfolio of projects that have the most potential to produce transformational and disruptive technologies. The fourth phase features the negotiation of contracts where technical milestones, budgets, and other terms and conditions are finalized.

The process will begin with the idea or vision for a potential program. ARPA-C staff engages the technical community and performs extensive background research and a technical "deep dive" that seeks to state the problem, define the current state of the art, identify revolutionary advances in breakthrough sciences, and propose preliminary focus areas. ARPA-C staff concurrently engage DOE and Other Government Agency (OGA) colleagues in this process, as well as identify any pertinent gaps in the current research portfolios for ARPA-C to fill. This also serves to leverage DOE and OGA knowledge to accelerate the development of a potential program and to eliminate redundancy.

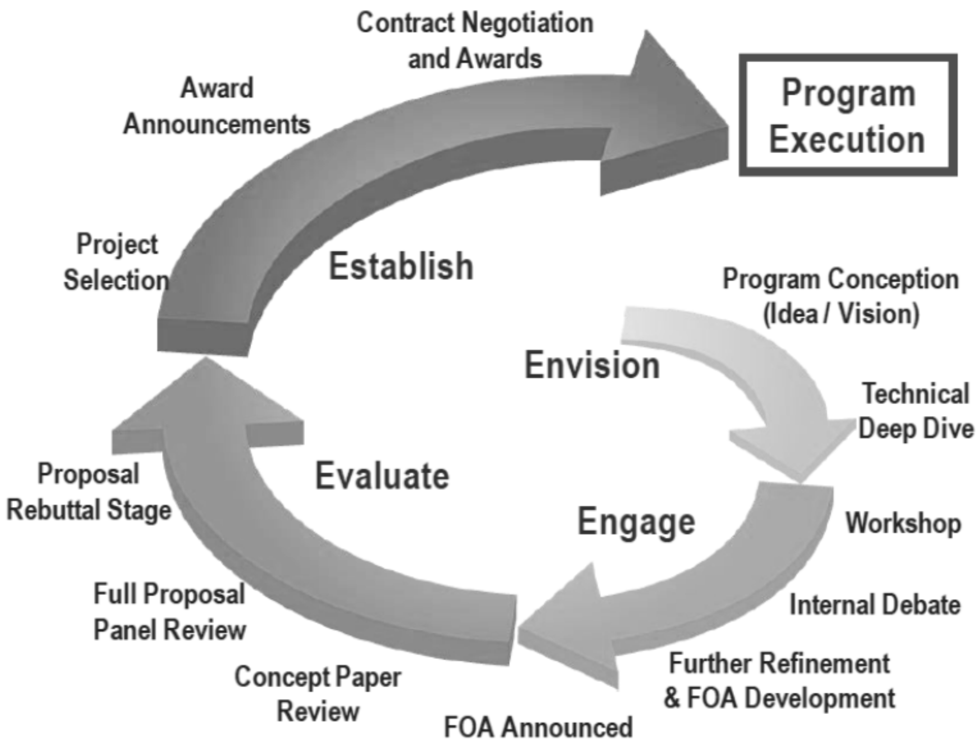
In the second phase of program development, Program Directors will hold a workshop in order to engage the external scientific community. This may include relevant DOE offices, OGA offices, commercial industry, potential future investors, end users of the technology, and technical experts from academia, National Laboratories, small businesses, and corporations. ARPA-C will hold workshops to focus this collective expertise to help determine the state of the art in a given field, to discuss solutions to the critical challenges identified, and to inform performance targets the technical community thinks are aggressive that can be adopted by the market or other government agencies. After a workshop ARPA-C will determine whether to issue a FOA, and if so, the technical community will be involved extensively again in the peer review process once applications are received.

The third phase, a peer review process, is a key component of the program's success. Engaging the leading experts in the technical community at every turn is very important to ARPA-C. Program Directors and staff will solicit input both formally and informally during the conceptualization phase and the workshops, and it is perhaps most significant during the peer review process. The involvement of world-class scientists and engineers and leaders from the technical community brings to the process unparalleled expertise and knowledge. For example, ARPA-C will recruit dozens of the leading experts in the world in a particular field to review concept papers and full applications over several weeks, and then bring them together for a Merit Panel Review. ARPA-C's evaluation process will include another facet that is common for works such as journal articles, but not common among Federal R&D programs – the opportunity for the applicant to read (anonymized) reviewer comments and to provide a rebuttal.

The final phase, the negotiation of cooperative agreements, is another key business innovation and is a hallmark of the ARPA-E process to be leveraged for ARPA-C. A defining feature of this innovation is to have embedded dedicated procurement and contracting teams. To eliminate potential bureaucratic stovepipes that hinder innovation and efficiency, this arrangement will allow ARPA-C to achieve a fast pace of transferring awards from announcement to signing cooperative agreements.

During this final phase, both the technical and market metrics developed for the FOA are translated into a bespoke milestone-driven agreement for each selected performer. ARPA-C's technical and market metrics are planned to be particularly aggressive, another characteristic of the program, and seek not to advance prevailing technology along existing learning curves, but rather to establish entirely new learning curves. These technical and market metrics become deliverables and milestones for the selected projects and are codified in the final funding agreement. ARPA-C employees will learn the ARPA-E process, adopt the best practices that ARPA-E has learned over its 12 years of existence, and tailor ARPA-E's processes to fit ARPA-C's mission.

ARPA-C's Planned Program Development Process



<u>ARPA-C Program Directors will be world-class scientists and engineers, and will be term-limited</u>. The rapid hiring of high-caliber personnel is one more notable feature of ARPA-E and ARPA-C. Like ARPA-E, ARPA-C will need special hiring authority to hire Program Directors and other program leadership for terms limited to an initial three years. In turn, some of the best and brightest minds in the related fields have been attracted to come to ARPA-E to serve their Nation for a few years and then return to the technical community. ARPA-E's Program Directors are the top scientists and engineers in the world and have significant experience in bridging science, technology, and business, and leading multidisciplinary teams. Similar to ARPA-E Program Directors, ARPA-C Program Directors will lead topic programs and work directly with the award recipient project teams. They will be expected to know all the scientific details of the projects they manage. This will enable technical brainstorming and sharing of knowledge that significantly shortens the technology development pipeline. ARPA-C Program Directors practice active hands-on risk management for each project, typically including conducting two site visits per year, quarterly program reviews, and the enforcement of go/no go technical milestones. Rotating program leadership in this way provides fresh perspectives and enthusiasm to the Agency, and this 'bottom up' program generation and management process is critical to enable the Agency the flexibility to build the most pertinent, impactful programs.

<u>Scaling Technologies to Application</u>

ARPA-C will build upon ARPA-E's innovation in program delivery models, which are devised to meet the specific needs, challenges, and opportunities technologies confront as they move from laboratory concepts toward wide adoption. This includes initiatives to take ARPA-E's primary R&D focus to support the scaling of high-risk and potentially disruptive new technologies across the full spectrum of carbon mitigation applications. The desire is to fund technologies for which the proof-of-concept R&D challenges have been addressed, but where there remains a need to further validate the technologies at a scale relevant to the market to enable investment and adoption. The goal for ARPA-C programs is to have an impact related to the ARPA-C mission areas as quickly as possible. There could be multiple routes to this end; attracting private sector investment is one and ARPA-C will also take lessons from ARPA-E's recent SCALEUP program to support successful R&D projects into the market wherever possible.

Commercialization/Transfer to User Community/OGA and Impact
ARPA-C will adopt ARPA-E's structure for preparing technologies for an eventual transfer from lab to real-world feasibility as a key element of its mission. ARPA-C programs will be conceived and structured around a market thesis that considers the entire value chain (customer requirements, cost, manufacturing, etc.). This will feed into the overall program strategy and structure; where possible this will include the recruitment of financial and commercial partners to the innovation process. At the portfolio level, ARPA-C programs will have a thesis and plan for how the portfolio will deliver value to the U.S. economy. At the project level, ARPA-C awardees will be asked to prepare a Technology-to-Market Plan that serves as a guide to assess and advance the commercial viability of their technology. ARPA-C will model its structure on the ARPA-E Tech to Market structure and will assist teams in constructing and carrying out these plans. ARPA-C's goal will be to help project teams develop the knowledge and skills they need to prepare for and expedite deployment of their technologies, whether in the private or public sector.

Accountability and Results. ARPA-E is unique among federal R&D institutions in that it systematically tracks the results of its projects to assess their outcomes and successes. The totality of this data provides ARPA-E leadership and stakeholders with data-driven insights into the Agency's performance, including support to capital formation for business ventures, start-ups, new products, patents, and creation of seminal research analyses. The same will apply to ARPA-C.

Highlights and Major Changes in the FY 2022 Budget Request
The $200 million requested will support the buildout of ARPA-C and fund up to six initial programs. While ARPA-C is currently planned to reside within DOE, ARPA-C will have a broad mission and will be a cross-disciplinary effort with an additional $300 million requested for other government agencies to support ARPA-C programs. ARPA-C will work with the other Agencies to develop transformative solutions for the climate crisis including adaptation, and resilience, and lay the foundation for future improvements in R&D across the Federal Government.

Advanced Research Projects Agency - Climate
Funding by Congressional Control ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
ARPA-C Projects	0	0	180,000	+180,000	N/A
Program Direction	0	0	20,000	+20,000	N/A
Total, Advanced Research Projects Agency - Climate	**0**	**0**	**200,000**	**+200,000**	**N/A**
Federal FTEs	**0**	**0**	**37**	**+37**	**N/A**

ARPA-C Projects

Potential technology areas for programs in FY 2022:
Initial programming at ARPA-C will focus on creating investments in topical areas of high potential for alleviating the climate crisis that cannot be addressed individually by other Agencies. Programs will be developed in accordance with ARPA-C's program development process; Illustrative examples may include:

- Climate sensors and monitoring for dramatically improved GHG detection, climate analysis, and severe event prediction. Data tools that can assess quantities and permanence of GHGs stored in land, underground, or in oceans, as well as provide relevant regional and local information for adaptation and long-term planning.

- Carbon neutral/negative agricultural production and general land, freshwater, and ocean use (including various carbon sequestration technologies and/or albedo engineering).

- Prevention of GHG emissions from land sources (methane from warming permafrost, landfills, and other activities); new approaches to permafrost protection.

- Carbon neutral waste and recycling, including e-waste processes that concurrently provide critical materials for climate mitigation technologies.

- Resilient infrastructure to protect against climate related severe events, including roads/transit; coastal impacts; building technologies (including reducing heat island impacts), self-healing materials, and air quality systems; water supply and distribution; agriculture and related supply chains.

As the Nation's premier research agency on climate solutions, ARPA-C will serve as a locus of cross-agency research programming and a key implementer of the Administration's Whole-of-Government approach to climate change and innovation. As such, ARPA-C may channel funding from other agencies into research activities.

ARPA-C will also create a stand-alone SBIR/STTR program to provide additional support R&D projects for small businesses.

ARPA-C Projects
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
ARPA-C Projects	0	0	180,000	+180,000
Total, ARPA-C Projects	**0**	**0**	**180,000**	**+180,000**

SBIR/STTR
- FY 2020 Enacted: $0 total (SBIR $0 / STTR $0)
- FY 2021 Enacted: $0 total (SBIR $0 / STTR $0)
- FY 2022 Request: $6,570 total (SBIR $5,760 / STTR $810)

ARPA-C Projects
Explanation of Major Changes ($K)

	FY 2022 Request vs FY 2021 Enacted
ARPA-C Projects The FY 2022 budget proposes $180M for ARPA-C projects.	**+180,000**
Total, ARPA-C Projects	**+180,000**

Program Direction
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Washington Headquarters				
Salaries and Benefits	0	0	6,600	+6,600
Travel	0	0	500	+500
Support Services	0	0	8,620	+8,620
Other Related Expenses	0	0	4,280	+4,280
Total, Program Direction	**0**	**0**	**20,000**	**+20,000**
Federal FTEs	**0**	**0**	**37**	**+37**
Support Services				
Technical Support	0	0	3,017	+3,017
Management Support	0	0	5,603	+5,603
Total, Support Services	**0**	**0**	**8,620**	**+8,620**
Other Related Expenses				
Working Capital Fund	0	0	3,000	+3,000
Energy Information Technology Services (EITS)	0	0	900	+900
Other Services	0	0	380	+380
Total, Other Related Expenses	**0**	**0**	**4,280**	**+4,280**

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $0	**$20,000,000000**	**+ $20,000,000000**
Salaries and Benefits		
N/A – Program did not exist in FY 2021	At the FY 2022 Request level, ARPA-C anticipates needing up to 37 Federal FTEs.	+ $6,600,000: Increase for new program
Travel		
N/A – Program did not exist in FY 2021	At the FY 2022 Request level, ARPA-C Program Directors and Technology-to-Market advisers will travel to support program shaping and kickoff as well as visit new performers regularly as part of ARPA-C's hands-on engagement.	+ $500,000: Increase for new program
Support Services		
N/A – Program did not exist in FY 2021	At the FY 2022 Request level, ARPA-C anticipates the use of support service contractors to support ARPA-C federal staff in the management and oversight of projects and other required functions. The level of support is commensurate with the number of anticipated projects and program initiation activities.	+ $8,620,000: Increase for new program
Other Related Expenses		
N/A – Program did not exist in FY 2021	The FY 2022 Request level for other related expenses primarily consists of Working Capital Fund and Energy Information Technology support costs, which are commensurate with the level of FTEs and support services requested.	+ $4,280,000: Increase for new program.

Advanced Research Projects Agency - Climate
Research and Development ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Basic	0	0	0	0
Applied	0	0	90,000	+90,000
Development	0	0	90,000	+90,000
Subtotal, R&D	0	0	180,000	+180,000
Equipment	0	0	0	0
Construction	0	0	0	0
Total, R&D	**0**	**0**	**180,000**	**+180,000**

Advanced Research Projects Agency - Climate
Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
ARPA-C Projects			
SBIR	0	0	5,760
STTR	0	0	810
Total, SBIR/STTR	**0**	**0**	**6,570**

Clean Energy Demonstrations

Clean Energy Demonstrations

Office of Clean Energy Demonstrations

Proposed Appropriation Language

For Department of Energy expenses, including the purchase, construction, and acquisition of plant and capital equipment and other expenses necessary for clean energy demonstrations in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, $400,000,000, to remain available until expended: Provided, That of such amount, $13,500,000 shall be available until September 30, 2023, for program direction.

Public Law Authorizations
Public Law 95–91, "Department of Energy Organization Act", 1977
Public Law 106-554, "Consolidated Appropriations Act, 2001"
Public Law 107-50, "Small Business Technology Transfer Program Reauthorization Act of 2001"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-140,"Energy Independence and Security Act of 2007"
Public Law 112-81, "National Defense Authorization Act for Fiscal Year 2012"
Public Law 116-260, "Energy Act of 2020"

Explanation of Change

In FY 2022, funding is being requested to establish the Office of Clean Energy Demonstrations, a technology-neutral office with expertise in large-scale energy project management and finance that will leverage the existing technical expertise throughout the Department of Energy. The OCED is envisioned to issue at least one technology-neutral commercial-scale demonstration solicitation per year focused on a crosscutting energy challenge.

Office of Clean Energy Demonstrations

($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
0	0	400,000

Overview

In FY 2022, the Department of Energy (DOE) proposes to establish the Office of Clean Energy Demonstrations (OCED). The OCED will serve as the Department's hub for accelerating the maturation of near- and mid-term clean energy technologies and systems with the goal of quicker commercial adoption and increased availability. The OCED will accomplish this through a systematic approach that is informed by, and integrated with, existing clean energy innovation initiatives across DOE's diverse program and functional offices, sites and associated National Laboratories.

The OCED will conduct an annual process of competitive solicitation, selection, negotiation, and award of cost-shared agreements for specific technology demonstrations from the private sector. The demonstrations will be established as multi-year projects, identifying and incorporating appropriate project management information, including milestones, schedules and cost profiles. The OCED will also conduct administrative steps such as issuing requests for information to obtain technical and programmatic input from industry to help inform the subsequent solicitation, define program parameters, establish merit evaluation boards to review submissions, and conduct the competitive solicitation process.

The OCED will not displace current technology-specific demonstration efforts across the DOE program offices. Instead, the program will solicit demonstration projects that address energy challenges that cut across technology silos. For the purposes of the program, the competitive solicitation will focus on clean energy technologies that are at or beyond the prototype level and ready for scale-up to procurement or construction activities. The initial competitive solicitation will focus on commercial-scale energy storage demonstrations, open to all types of technologies and system that provide storage attributes. By sponsoring commercial-scale demonstrations of emerging clean energy technologies, the OCED will seek to accelerate the development, delivery, and market adoption of those technologies based on their technical merit and performance attributes, as opposed to their technology silo. The program supports the Secretary's vision for cross-cutting clean energy projects that are aligned with the President's climate policies and infrastructure initiatives and will create good paying jobs for welders, electricians, and other trades that provide a free and fair choice to join a union and collectively bargain. OCED will engage DOE programs, functional offices, sites, and associated National Laboratories for development and oversight of funded clean energy projects for transparency, shared learning, and to ensure that DOE's efforts align and fulfill the Nation's clean energy priorities.

The OCED is intended to be a technology neutral office with expertise in large-scale energy project management and finance. The OCED will leverage the existing technical expertise throughout the applied programs and the crosscutting coordination of DOE's Research and Technology Investment Committee. In addition, the office will provide project management support to the applied offices and National Labs on scale-up funded within their existing programs to ensure a consistent approach to capital intensive late-stage technology development. The OCED will work to ensure demonstration projects maximize the creation of high-quality jobs with a free and fair choice to join a union.

For these large multi-year demonstration projects, OCED will employ a staged approach that will divide the project scope into reasonably-sized subprojects, each with defined milestones, schedule, and cost basis that connects directly to the goals, cost estimate, and schedule for the overall project. OECD will retain funding control at the project level, providing appropriate flexibility in determining subproject funding levels and funding transfer among the subprojects as circumstances and progress dictates. To ensure transparency, OCED will track and manage detailed information on each subproject status for DOE, to be provided to Congress through budget requests and briefings.

Highlights of the FY 2022 Budget Request

The Department requests $400,000,000 for OCED in FY 2022. This level of funding will allow OCED to begin operations and issue an initial competitive solicitation on commercial-scale energy storage demonstrations. The OCED is envisioned to issue at least one technology neutral commercial-scale demonstration solicitation per year focused on a crosscutting energy challenge.

Office of Clean Energy Demonstrations
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
Clean Energy Demonstrations					
Program Support	0	0	386,500	+386,500	+100%
Program Direction	0	0	13,500	+13,500	+100%
Total, Office of Clean Energy Demonstrations	**0**	**0**	**400,000**	**+400,000**	**+100%**

SBIR/STTR:

FY 2020 Enacted: SBIR $0; STTR: $0

FY 2021 Enacted: SBIR $0; STTR: $0

FY 2022 Request: SBIR $12,368; STTR $1,739

Office of Clean Energy Demonstrations
Funding ($K)

	FY 2022 Request vs FY 2021 Enacted
Program Support No funding in FY 2021.	**$+386,500**
Program Direction No funding in FY 2021.	**+$13,500**
Total, Office of Clean Energy Demonstrations	**+$400,000**

Office of Clean Energy Demonstrations
Program Support

In addition to the work of federal employees funded through Program Direction, the new OCED requests $386,500,000 in Program Support to fund a multi-year series of competitive solicitations for the private sector to conduct demonstrations of commercial-scale energy storage technologies. The OCED is envisioned to issue at least one technology neutral commercial-scale demonstration solicitation per year focused on a crosscutting energy challenge. In FY 2022, the solicitation will focus on commercial scale energy storage. In addition, the program will scope crosscutting topics for future solicitations.

Clean Energy Demonstrations
Program Support

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Support $0	**$386,500,000**	**+$386,500,000**
• No Funding in FY 2021.	• Funding will be used to support a competitive solicitation process, including awards, for commercial-scale demonstration projects of clean energy technologies. In FY 2022, the solicitation will focus on commercial scale energy storage. In addition, the program will scope crosscutting topics for future solicitations.	• Funding will initiate the first solicitation cycle focused on commercial scale energy storage solutions.

Clean Energy Demonstrations
Program Direction

For FY 2022, the new OCED requests $13,500,000 of Program Direction to fully fund the establishment and staffing of this new office. This amount will fund the Federal salaries and benefits (including staff training and performance awards) for the anticipated 35 full-time equivalent positions, as well as the anticipated staff travel, associated support services contracts, and administrative expenses to execute the OCED mission.

Clean Energy Demonstrations
Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $0	**$13,350,000**	**+$13,350,000**
Salaries and Benefits $0	**$6,300,000**	**+$6,300,000**
• **No funding in FY 2021.**	• Funding supports salaries and benefits for 35 FTEs to provide project management support, competitive solicitation development support, and financial control. • OCED FTEs will develop and issue competitive solicitations for demonstration(s) of commercial-scale energy technology. • OCED FTEs will provide project management support to the applied offices on scale-up of promising technology from the demonstration projects.	• New funding will meet the anticipated staffing needs of the new office to execute anticipated roles and responsibilities, as well as to provide supplemental funding for performance award pools.
Travel $0	**$200,000**	**+$200,000**
• **No funding in FY 2021.**	• Funding will support staff travel for onsite solicitation process requirements and project management support.	• New funding reflects anticipated need for staff to travel in conducting information exchanges and administration during competitive cycle and post-award/implementation period of initial clean energy demonstration project solicitation.
Support Services $0	**$5,000,000**	**+5,000,000**
• **No funding in FY 2021.**	• Anticipated need for support services to provide support with technical and administrative support during project solicitation cycle, and during office management of project implementation. Also anticipate need for support in conducting associated information gathering and analysis, developing communications and marketing tools and content, and conducting	• New funding reflects anticipated office need for technical/administrative support services in launching and managing multiple years of project solicitation cycles and active project management.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
	other required data collection, verification, validation and reporting requirements.	
Other Related Services $0	**$2,000,000**	**+$2,000,000**
• **No funding in FY 2021.**	• Anticipated related expenses for Energy IT Services (EITS), Working Capital Fund (WCF), training, and other services.	• New funding reflects anticipated office costs for supporting up to 35 new FTE positions.

Program Direction
Funding ($K)

	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Program Direction			
Salaries and Benefits	0	6,300	+6,300
Travel	0	200	+200
Support Services	0	5,000	+5,000
Other Related Expenses	0	2,000	+2,000
Total, Program Direction	**0**	**13,500**	**+13,500**
FTEs	**0**	**35**	**+35**
Support Services			
Technical Support			
Mission Related	0	880	+880
Advisory and Assistance	0	720	+720
Total, Technical Support	**0**	**1,600**	**+1,600**
Management Support			
Administrative	0	2,850	+2,850
Information Technology	0	550	+550
Total, Management Support0	**0**	**3,400**	**+3,400**
Total, Support Services	**0**	**5,000**	**+5,000**
Other Related Expenses			
Working Capital Fund	0	450	+450
Training	0	200	+200
Miscellaneous	0	600	+600
Rents and Utilities	0	750	+750
Total, Other Related Expenses	**0**	**2,000**	**+2,000**

GENERAL PROVISIONS-DEPARTMENT OF ENERGY
[(INCLUDING TRANSFER OF FUNDS)]

SEC. 301. (a) No appropriation, funds, or authority made available by this title for the Department of Energy shall be used to initiate or resume any program, project, or activity or to prepare or initiate Requests For Proposals or similar ar-rangements (including Requests for Quotations, Requests for Information, and Funding Opportunity Announcements) for a program, project, or activity if the program, project, or activity has not been funded by Congress.

(b) (1) Unless the Secretary of Energy notifies the Committees on Appropriations of both Houses of Congress at least 3 full business days in advance, none of the funds made available in this title may be used to-

(A) make a grant allocation or discretionary grant award totaling $1,000,000 or more;

(B) make a discretionary contract award or Other Transaction Agreement totaling $1,000,000 or more, including a contract covered by the Federal Acquisition Regulation;

(C) issue a letter of intent to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B); or

(D) announce publicly the intention to make an allocation, award, or Agree-ment in excess of the limits in subparagraph (A) or (B).

(2) The Secretary of Energy shall submit to the Committees on Appropriations of both Houses of Congress within 15 days of the conclusion of each quarter a report detailing each grant allocation or discretionary grant award totaling less than $1,000,000 provided during the previous quarter.

(3) The notification required by paragraph (1) and the report required by paragraph (2) shall include the recipient of the award, the amount of the award, the fiscal year for which the funds for the award were appropriated, the account and program, project, or activity from which the funds are being drawn, the title of the award, and a brief description of the activity for which the award is made.

(c) The Department of Energy may not, with respect to any program, project, or activity that uses budget authority made available in this title under the heading "Department of Energy-Energy Programs", enter into a multiyear contract, award a multiyear grant, or enter into a multiyear cooperative agreement unless-

(1) the contract, grant, or cooperative agreement is funded for the full period of performance as anticipated at the time of award; or

(2) the contract, grant, or cooperative agreement includes a clause conditioning the Federal Government's obligation on the availability of future year budget authority and the Secretary notifies the Committees on Appropriations of both Houses of Congress at least 3 days in advance.

(d) Except as provided in subsections (e), (f), and (g), the amounts made available by this title shall be expended as authorized by law for the programs, projects, and activities specified in the "Final Bill" column in the "Department of Energy" table included under the heading "Title III-Department of Energy" in the ex-planatory statement described in section 4 (in the matter preceding division A of this consolidated Act).

(e) The amounts made available by this title may be reprogrammed for any program, project, or activity, and the Department shall notify[, and obtain the prior approval of,] the Committees on Appropriations of both Houses of Congress at least 30 days prior to the use of any proposed reprogramming that would cause any program, project, or activity funding level to increase or decrease by more than $5,000,000 or 10 percent, whichever is less, during the time period covered by this Act.

(f) None of the funds provided in this title shall be available for obligation or expenditure through a reprogramming of funds that-

(1) creates, initiates, or eliminates a program, project, or activity;

(2) increases funds or personnel for any program, project, or activity for which funds are denied or restricted by this Act; or

(3) reduces funds that are directed to be used for a specific program, project, or activity by this Act.

(g)(1) The Secretary of Energy may waive any requirement or restriction in this section that applies to the use of funds made available for the Department of Energy if compliance with such requirement or restriction would pose a substan-tial risk to human health, the environment, welfare, or national security.

(2) The Secretary of Energy shall notify the Committees on Appropriations of both Houses of Congress of any waiver under paragraph (1) as soon as practic-able, but not later than 3 days after the date of the activity to which a require-ment or restriction would otherwise have applied. Such notice shall include an explanation of the substantial risk under paragraph (1) that permitted such waiver.

(h) The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

SEC. 302. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 3094) during fiscal year [2021] 2022 until the enactment of the Intelligence Authorization Act for fiscal year [2021] 2022.

SEC. 303. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of Enterprise Assessments to ensure the project is in compliance with nuclear safety require-ments.

SEC. 304. None of the funds made available in this title may be used to approve critical decision-2 or critical decision-3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

SEC. 305. Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), upon a determination by the President in this fiscal year that a regional supply shortage of refined petroleum product of significant scope and duration exists, that a severe increase in the price of refined petroleum product will likely result from such shortage, and that a draw down and sale of refined petroleum product would assist directly and significantly in reducing the adverse impact of such shortage, the Secretary of Energy may draw down and sell refined petroleum product from the Strategic Petroleum Reserve. Proceeds from a sale under this section shall be deposited into the SPR Petroleum Account established in section 167 of the Energy Policy and Conservation Act (42 U.S.C. 6247), and such amounts shall be available for obligation, without fiscal year limitation, consistent with that section.

[SEC. 306. (a) Of the offsetting collections, including unobligated balances of such collections, in the "Department of Energy-Power Marketing Administra-tion-Colorado River Basins Power Marketing Fund, Western Area Power Admin-istration", $21,400,000 shall be transferred to the "Department of the Interior-Bur-eau of Reclamation-Upper Colorado River Basin Fund" for the Bureau of Reclam-ation to carry out environmental stewardship and endangered species recovery efforts.

(b) No funds shall be transferred directly from "Department of Energy-Power Marketing Administration-Colorado River Basins Power Marketing Fund, Western Area Power Administration" to the general fund of the Treasury in the current fiscal year.]

TITLE V-GENERAL PROVISIONS
(INCLUDING TRANSFER OF FUNDS)

SEC. 501. None of the funds appropriated by this Act may be used in any way, directly or indirectly, to influence congressional action on any legislation or appro-priation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913.

[SEC. 502. (a) None of the funds made available in title III of this Act may be transferred to any department, agency, or instrumentality of the United States Government, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a depart-ment, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(b) None of the funds made available for any department, agency, or instrumentality of the United States Government may be transferred to accounts funded in title III of this Act, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(c) The head of any relevant department or agency funded in this Act utilizing any transfer authority shall submit to the Committees on Appropriations of both Houses of Congress a semiannual report detailing the transfer authorities, except for any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality, used in the previous 6 months and in the year-to-date. This report shall include the amounts transferred and the purposes for which they were transferred, and shall not replace or modify existing notification require-ments for each authority.]

SEC. [503]*502*. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations).

SEC. [504]*503*. (a) None of the funds made available in this Act may be used to maintain or establish a computer network unless such network blocks the viewing, downloading, and exchanging of pornography.

(b) Nothing in subsection (a) shall limit the use of funds necessary for any Federal, State, Tribal, or local law enforcement agency or any other entity carrying out criminal investigations, prosecution, or adjudication activities.

[SEC. 505. (a) Requirements relating to non-Federal cost-share grants and co-operative agreements for the Delta Regional Authority under section 382D of the Agricultural Act of 1961 and Consolidated Farm and Rural Development Act (7 U.S.C. 2009aa-3) are waived for grants awarded in fiscal year 2020 and in sub-sequent years in response to economic distress directly related to the impacts of the Coronavirus Disease (COVID-19).

(b) Requirements relating to non-Federal cost-share grants and cooperative agreements for the Northern Border Regional Commission under section 15501(d) of title 40, United States Code, are waived for grants awarded in fiscal year 2020 and in subsequent years in response to economic distress directly related to the impacts of the Coronavirus Disease (COVID-19).

(c) Requirements relating to non-Federal cost-share grants and cooperative agreements for the Denali Commission are waived for grants awarded in fiscal year 2020 and in subsequent years in response to economic distress directly re-lated to the impacts of the Coronavirus Disease (COVID-19).]

SEC. [506]*504*. Of the unavailable collections currently in the United States Enrichment Corporation Fund, [$291,000,000] $415,670,000 shall be transferred to and merged with the Uranium Enrichment Decontamination and Decommis-sioning Fund and shall be available only to the extent provided in advance in ap-propriations Acts.