



U.S. DEPARTMENT OF
ENERGY

Fossil
Energy



U.S. Department of Energy
Office of Fossil Energy

2018–2022 STRATEGIC VISION



Message from the Assistant Secretary for Fossil Energy



I am pleased to present the *Office of Fossil Energy's (FE) 2018–2022 Strategic Vision*, guided by the President's *America First Energy Plan* with the goal of achieving American energy dominance. This goal promotes U.S. domestic homegrown energy development to achieve energy security and jobs in energy and technology around the world. It also means producing fossil energy resources—oil, gas, and coal—safely and hand-in-hand with responsible environmental stewardship. This vision lays out our goals and objectives to support the Department's mission and achieve the Administration's priorities in the coming years. Recognizing that the world continues to change rapidly, this is an organic strategic vision with a strong, but flexible, framework designed to be revisited periodically as we

remain committed to addressing the evolving challenges of the fossil energy sector.

FE plays a critical role in the effort to achieve American energy dominance, generating impactful early-stage research and development (R&D) that is poised for further advancement and scale-up of technologies and commercialization by industry. Furthermore, we have targeted our research focus to increase the efficiency of power systems, recognizing that a 1-percent improvement in the efficiency of fossil fuel-fired electricity generating stations would save consumers in excess of \$600 million annually.

The vast majority of recent progress made on fossil energy technology development started with investments made by FE—and that progress demonstrates our impact. To name a few, our achievements and investments include advances in the recovery of critical rare earth elements from coal and coal by-products—which could create new industries and good jobs in America's coal country. Other examples include highly efficient coal technologies that achieve near-zero emissions, and are commercially deployable in a competitive energy market, as well as horizontal drilling and stimulation methods that paved the way for oil and gas operators to create the shale revolution. The shale revolution set us on the pathway toward energy independence for the first time in decades. The United States is now the top producer of both oil and natural gas. At the same time, we have authorized more than 34 billion cubic feet per day of liquefied natural gas (LNG) exports from over a dozen export facilities in the United States.

The Strategic Petroleum Reserve (SPR) continues to serve as a valuable national emergency resource during natural disasters and other oil supply disruptions, as seen during Hurricane Harvey in 2017. The SPR is beginning a large scale effort to repair and replace key infrastructure to maintain the short-term and long-term effectiveness of its operation. The SPR is also analyzing the best taxpayer use of excess capacity that will be available at the end of oil sales currently mandated by law.

The past decade has seen significant changes in the energy sector in the United States and throughout the world. However, fossil fuels provide more than 80 percent of the energy mix in the United States and around the world. The U.S. Energy Information Administration projects that fossil energy will remain at nearly 80 percent of the energy mix in 2040, both in the United States and worldwide.¹ So, fossil energy is the lifeblood of both the United States and the global economy and it will continue to power the world's economy for decades to come.

The changing energy landscape, evolving requirements of the electricity grid, and projected energy growth throughout the world pose challenges that we must address today to be ready for the future. We have the opportunity to build on FE's successes and unique capabilities—and to partner with other national laboratories, industry, and academia—to make great strides in efficiency improvements to our power systems. To that end, we will focus our R&D on five significant areas to address challenges currently confronting the industry: modernizing the aging coal fleet; revolutionizing energy systems to give power producers options in the future; engineering an evolving energy infrastructure; water management; and mastering the subsurface to engineer geologic systems. We will also work to expand fossil fuel and energy production in a secure, sustainable, and environmentally sustainable manner and to create additional value streams throughout the fossil energy life cycle.

FE's diverse workforce brings together personnel with a wide range of backgrounds and experiences to help solve America's fossil energy challenges. Innovative science and engineering, coupled with comprehensive analytical expertise, will enable efficient and effective implementation of this plan. We achieve only through our people, and to that end, we will also develop and maintain world-class organizational excellence.

FE's R&D efforts will set a solid foundation for our Nation's future prosperity, and with continued industry-led technological advances, we will collectively ensure that the Nation can continue to thrive with the availability of safe, secure, reliable, and affordable fossil energy.

I look forward to working with all stakeholders to make our vision a reality.

Sincerely,



Steven Winberg

Assistant Secretary for Fossil Energy

¹ *International Energy Outlook 2018* (Washington, DC: U.S. Energy Information Administration, July 2018), <https://www.eia.gov/outlooks/ieo>

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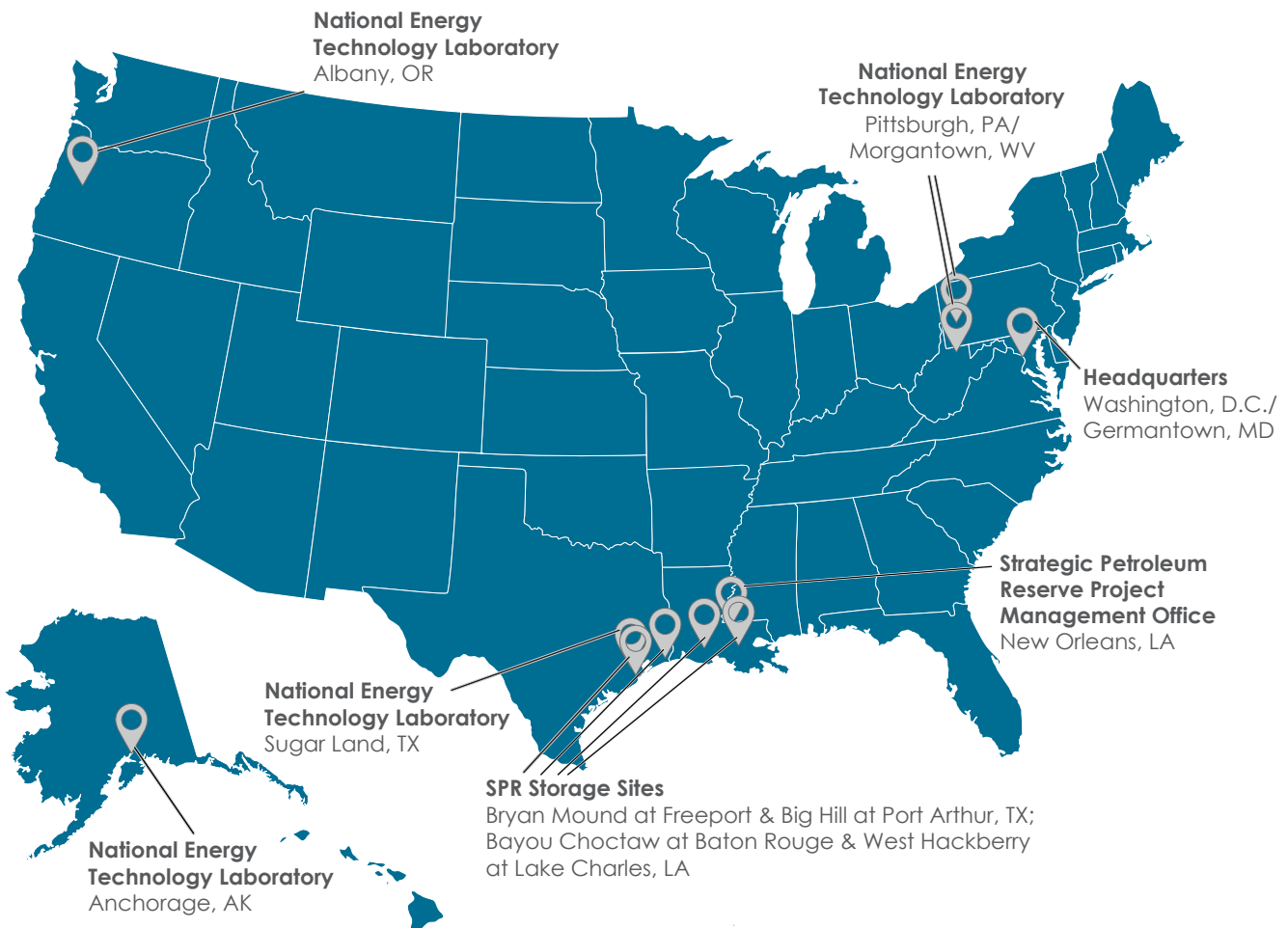
ORGANIZATIONAL SUMMARY

The Office of Fossil Energy (FE) organization of the U.S. Department of Energy (DOE) is made up of nearly 2,500 Federal and contractor employees—scientists, engineers, technicians, and other professionals—located at its headquarters in Washington, DC and Germantown, Maryland; the National Energy Technology Laboratory (NETL); the Strategic Petroleum Reserve (SPR) Project Management Office; four SPR field sites in the Gulf Coast region; and a marine terminal. The FE operational footprint is shown in Exhibit 1.

FE is committed to maintaining a safe and secure work environment for all personnel and to ensuring that its operations preserve the health, safety, and security of the surrounding communities. FE’s Office of Operations

supports mission execution through innovative, efficient, and cost-effective programs, processes, and systems. This office guides strategic planning; advances key organization-wide priorities; improves organizational management; coordinates enterprise-wide communications; facilitates information technology and cyber support; and provides financial advice and oversight on budget formulation, justification, submission, and presentation. The Office of Operations also oversees and assists with environmental, security, safety, health, and emergency management activities across the FE enterprise. In addition, it provides guidance and support to FE Senior Leadership through the development and implementation of FE-wide management, administrative, and human resource policies and programs.

Exhibit 1 | Fossil Energy Laboratories and Facilities



FE is responsible for overseeing and managing Federal research and development (R&D) efforts to improve the performance of existing coal-fueled generation, develop advanced fossil energy systems, and advance the prudent development of domestic oil and natural gas resources. In addition, FE reviews applications for exports of natural gas and manages the Nation's SPR and other strategic reserves, which are key emergency response tools available to protect the Nation from energy supply disruptions.

FE comprises four key mission organizations: Office of Clean Coal and Carbon Management; Office of Oil and Natural Gas; Office of Petroleum Reserves; and the National Energy Technology Laboratory.

Office of Clean Coal and Carbon Management supports R&D on advanced technologies to ensure the availability of clean, affordable products from coal. The R&D focuses on discovery and development of technologies that improve the efficiency, emissions, and performance of the current and future coal-based power plants; reduce the cost of carbon capture, utilization, and storage (CCUS); ensure efficient use and management of water resources; and create new markets for coal and coal products through innovative conversion processes and utilization and conversion of carbon dioxide (CO₂) to create added value. Additionally, the office has had several successes including in: pilot-scale testing for extraction of rare earth elements from coal, engineered advanced membranes that lower the cost of carbon capture, advances in material and sensor development, and the launch of the Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) initiative to develop first-of-a-kind coal plants of the future.

Office of Oil and Natural Gas supports R&D on technologies that maximize the resources and minimize the environmental impacts of hydrocarbon production and transport. In addition, the R&D advances the evaluation of new sources of natural gas, such as methane hydrates. This effort includes the quantification and mitigation of impacts/risks of resource development, with a focus on unconventional and offshore resource development. Finally, the Office reviews applications to import or export natural gas from the United States through its regulatory authority under the Natural Gas Act. Additionally, the office has had several successes including in: drilling a methane hydrates well at Prudhoe Bay Unit on the

Alaska North Slope in preparation for a long-term methane hydrates flow test, completing a Report to Congress on the Feasibility of Establishing an Ethane Storage and Distribution Hub in the U.S., and issuing a Policy Statement in the Federal Register on eliminating the end use reporting provision in liquefied natural gas (LNG) export authorizations.

Office of Petroleum Reserves protects the U.S. economy from severe petroleum supply interruptions through the acquisition, storage, distribution, and management of emergency petroleum stocks. It also carries out U.S. obligations under the International Energy Program. The Office manages three stockpiles: the SPR, the Northeast Home Heating Oil Reserve (NEHHOR), and the Northeast Gasoline Supply Reserve (NGSR). The SPR is the largest stockpile of government-owned emergency crude oil in the world, and it provides the President with a powerful response option should a disruption in commercial oil supplies threaten the U.S. economy. The heating oil and gasoline reserves are regional supplies of ultra-low-sulfur diesel and seasonally adjusted, regionally

Strategic Petroleum Reserve (SPR)

The SPR remains a key national energy security asset, even as domestic energy production grows. Recent increased domestic oil production and reduced U.S. oil import dependency have profoundly changed the U.S. energy landscape. Regardless of U.S. oil import levels, a severe global oil supply disruption today would impact domestic petroleum product prices. In the event of a serious international oil supply disruption, commercial stocks and global spare production capacity could provide some relief for lost output, but they cannot ensure additional supply. Offsetting disrupted supplies with SPR oil, in concert with other countries that hold strategic oil stocks and accelerated domestic production, can counteract an increase in international oil prices and the resulting adverse economic impacts.

appropriated gasoline supplies for the northeastern United States.





National Energy Technology Laboratory is an integral part of FE, and the foundation upon which FE R&D is performed. It is DOE's only government-owned and government-operated laboratory. NETL leverages its unique core capabilities to deliver innovative technology solutions to America's energy-related and environment-related challenges through onsite R&D and collaborative partnerships with public and private entities, universities, and other national laboratories. NETL's core technical competencies include:

- **Energy Conversion:** Developing efficient energy-conversion systems to enable sustainable fossil energy utilization
- **Materials Engineering & Manufacturing:** Developing and deploying affordable, high-performance materials
- **Computational Science & Engineering:** Utilizing multi-scale computational approaches to provide in-depth objective analyses
- **Geological & Environmental Systems:** Enabling efficient production and use of fossil fuels through engineering of the subsurface

- **Systems Engineering & Analysis:** Accelerating technology innovation, development, and deployment to enable new energy technologies to gain market acceptance.

Notable FE successes at NETL include the development of technologies enabling synthetic fuels production from domestic fossil resources; the mitigation of trans-boundary acid rain; and steep reductions in mercury and other power plant emissions. NETL's expertise is also leveraged to address fossil energy incidents of national significance, such as the Deepwater Horizon oil spill in 2010. Moreover, NETL research stimulated the development of high-efficiency, combustion turbines now used commercially; generated technology solutions for capturing carbon to boost domestic oil production; and initiated the development of advanced drilling and completion technology (i.e., hydraulic fracturing) that enabled the recent expansion of oil and gas production from shale formations. See Appendix A for an expanded description of NETL core technical capabilities.

The activities of FE's four key mission organizations are highlighted in Exhibit 2.

			
Clean Coal and Carbon Management	Oil and Natural Gas	Petroleum Reserves	National Energy Technology Laboratory (NETL)
<ul style="list-style-type: none"> • Advance R&D on small-scale modular coal plants of the future, which are highly efficient and flexible, with near-zero emissions. • Develop treatment technologies that may economically and selectively remove low-level contaminants found in plant waste streams (e.g., selenium, boron). • Develop next-generation materials, components, and systems to improve the performance, reliability, and efficiency of the existing coal-fired fleet. • Advance novel processes and techniques that increase the competitiveness and environmental performance of advanced fossil power systems. • Reduce the cost of capturing CO₂ and non-CO₂ emissions from fossil and industrial sources, and develop ways to safely store it underground long-term or use the CO₂ to develop usable products and fuels. 	<ul style="list-style-type: none"> • Promote the development of domestic oil and natural gas resources. • Improve resource recovery through better understanding of shale geology and fracture dynamics. • Convert produced water from a waste to a resource. • Develop well control technology to prevent oil spills offshore. • Enhance the operational efficiency of natural gas supply and delivery infrastructure. • Evaluate the occurrence, nature, and behavior of naturally occurring gas hydrates. • Review applications to import or export liquid natural gas from the United States through its regulatory authority under the Natural Gas Act. 	<ul style="list-style-type: none"> • Ensure U.S. energy security by reducing the impacts of petroleum supply disruptions. • Provide protection from potential supply disruptions in the Northeast from winter shortages through the Northeast Home Heating Oil Reserve. • Complete environmental cleanup and remediation of the former Naval Petroleum Reserves. • Conduct congressionally directed sales of Strategic Petroleum Reserves (SPR) crude oil. • Modernize SPR infrastructure through the Life Extension II Program. • Make efficient use of excess storage capacity resulting from legislatively directed oil sales. 	<ul style="list-style-type: none"> • Support DOE's mission to advance the energy security of the United States as a DOE-owned and operated national laboratory. • Enable domestic coal, natural gas, and oil to economically power the Nation's homes, industries, businesses, while reducing the environmental impacts of energy production and generation. • Possess expertise in coal, natural gas, and oil technologies; contract and project management; energy systems analysis; and international energy issues. • Reduce cooling water requirements and improve power plant conceptual designs to reduce the amount of water required for other plant processes.

Mission

Discover and develop advanced fossil energy technologies to ensure American energy dominance, create American jobs, support a resilient infrastructure, maintain environmental stewardship, and enhance America's economy. Ensure America's access to and use of safe, secure, reliable, and affordable fossil energy resources and strategic reserves.

Vision

FE strives to deliver technologies, systems, processes, and methods that utilize fossil energy resources efficiently and responsibly, ensuring that FE is continuously improving the living standards of the American people with clean, efficient, and reliable energy.

American Energy Dominance

FE directly supports achievement of the Department's primary goal of American energy dominance through R&D activities across the breadth of the ever-changing fossil energy landscape. Accordingly, the goals, objectives, and sub-objectives within the *FE 2018–2022 Strategic Vision* are

designed to generate and govern a set of activities within the four pillars of FE that achieve American energy dominance. Furthermore, FE performance measures are identified to track progress toward achievement of FE objectives and inform future advancements across FE's four organizations.

Fossil Energy Strategic Goals

FE's four Strategic Goals are:

1. Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources.
2. Enhance U.S. economic and energy security through prudent policy, advanced technology, and the use of strategic reserves.
3. Promote exports of domestically produced hydrocarbons and fossil energy technologies.
4. Develop and maintain world-class organizational excellence.

FE will focus on the priorities outlined in Exhibit 3 to meet its strategic goals.

Programmatic Priorities		<p>Strategic Petroleum Reserve</p> <p>Maintaining drawdown readiness while completing Life Extension 2, carrying out mandated crude oil sales, and investigating new ways to monetize the asset</p>
		<p>Appalachian Petrochemical Renaissance</p> <p>Catalyzing private sector investment in Appalachian petrochemicals infrastructure to generate economic opportunity for the region and diversify the U.S. manufacturing base.</p>
		<p>Efficient LNG Authorization</p> <p>Practicing an efficient regulatory review of applications to export liquefied natural gas and promote global energy security.</p>
		<p>NETL Capabilities</p> <p>Strengthen NETL's technical capabilities through investments in talent and infrastructure that advance safe, affordable, and environmentally sound technology innovations to increase efficiency, reduce emissions, and drive down energy costs.</p>
Research Priorities		<p>Develop the Coal Plants of the Future</p> <p>Advancing small-scale modular coal plants of the future, which are highly efficient and flexible, with near-zero emissions</p>
		<p>Modernize the Existing Coal Fleet</p> <p>Improving the performance, reliability, and efficiency of the existing coal-fired fleet</p>
		<p>Reduce the Cost of CCUS</p> <p>Reducing the cost and risk of CCUS to enable wider commercial deployment</p>
		<p>Expand the Use of Big Data by Leveraging Artificial Intelligence</p> <p>Optimizing coal plant performance, CO₂ sequestration, and the recovery of oil and gas resources with real-time analysis informed by machine learning</p>
		<p>Address the Energy Water Nexus</p> <p>Improving our efficient use of scarce water resources</p>
		<p>Advance Rare Earth Elements, Critical Materials, and Coal Products Technologies</p> <p>Improving REE separation and recovery technologies and processes to manufacture valuable products from coal, to address current global market and process economics</p>

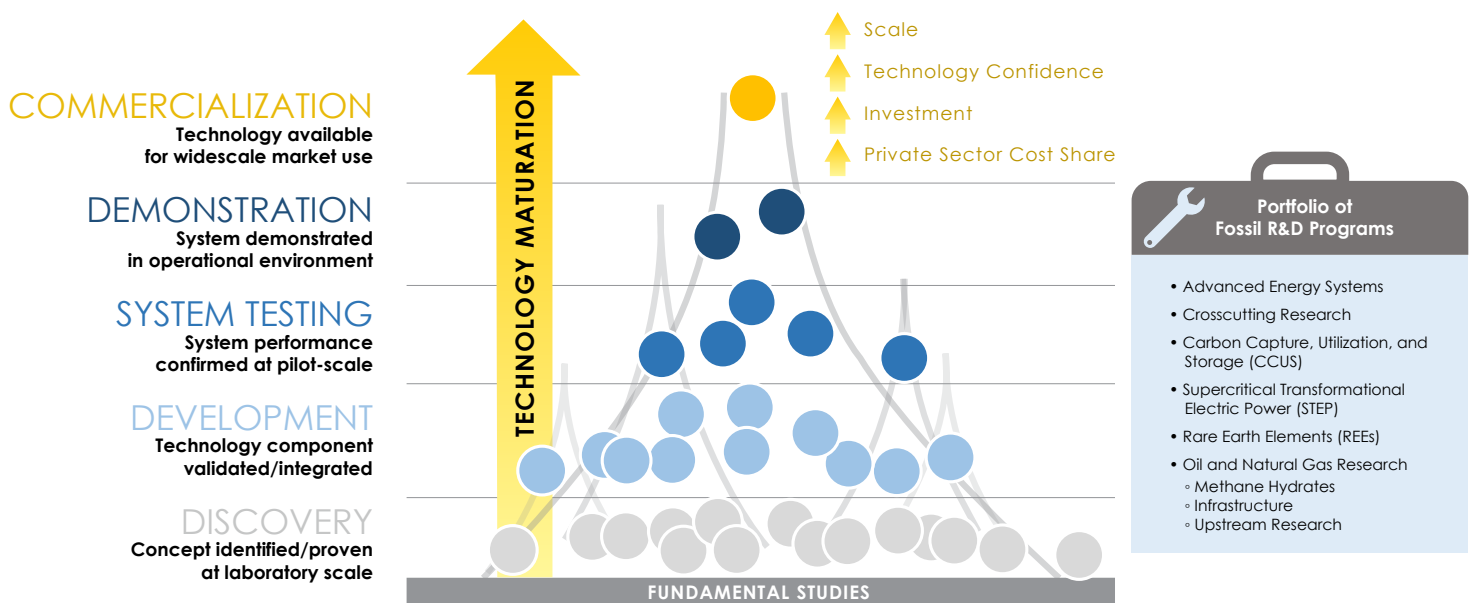
TECHNOLOGY DEVELOPMENT PATHWAYS & FOSSIL ENERGY PRIORITIES

Through Technology Development Pathways (TDPs), shown in Exhibit 4, FE’s R&D Portfolio executes the Office’s stated mission and vision while ensuring that taxpayer dollars are spent to conduct sound, evidence-based scientific research. TDPs are intended to increase the pace of innovation to realize rapid impacts of technologies that span the entire fossil energy value chain and to ensure that those technologies, with maximum commercial application and impact, reach maturity.

Beginning at the earliest stage of discovery, the most promising concepts are validated at laboratory scale. After testing, those technologies that promise improved performance and reduced cost continue in the development process in preparation for market acceptance. As technologies mature, uncertainty decreases, scalability and confidence increase, and public investment over time gives way to increased private sector investment as the technologies continue to market.

The FE R&D programs pursue a portfolio of TDPs that focus primarily on innovative early-stage R&D to improve the reliability, availability, efficiency, cost, and environmental performance of advanced fossil-based production, conversion, and delivery systems. Program success depends on creating strategic and collaborative partnerships with industry, academia, other national laboratories, and other research organizations, while also leveraging the core technical and scientific competencies of FE to generate knowledge and contribute to new products and processes. This approach to R&D, predicated on scientific integrity, best embodies FE’s view on social responsibility, through fiscal prudence, as it furthers the advancement of a robust peer-reviewed portfolio of fossil energy technologies to better ensure American energy dominance.

Exhibit 4 | Office of Fossil Energy’s Technology Development Pathways Concept



FE GOALS, OBJECTIVES, AND SUB-OBJECTIVES

FE will apply its resources to execute its mission and achieve its vision by accomplishing its strategic goals and objectives. Specific targets and performance measures (see Appendix B) will be achieved on the basis of budget availability. Exhibit 5 summarizes the goals, objectives, and sub-objectives described in this strategic vision. Although the *FE 2018–2022 Strategic*

Vision timeline extends to 2022, a 20-year time horizon was used for planning purposes. To that end, some of the goals and performance measures date past 2022, to demonstrate longer-term strategic objectives that helped shaped the near-term goals described in this vision.

Message from Mark Maddox, Senior Policy Advisor to the Secretary of Energy

“The Office of Fossil Energy’s strategic vision is deeply rooted in making the R&D investments necessary to achieve our goals and objectives that will move the needle toward near-zero emissions and support the Nation’s energy demand.”

– Mark Maddox

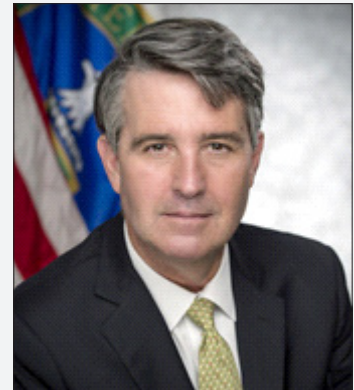


Exhibit 5 | Office of Fossil Energy Mission, Vision, Goals, Objectives, and Sub-Objectives

FE Mission

Discover and develop advanced fossil energy technologies to create American jobs, support resilient infrastructure, maintain environmental stewardship, and enhance America's economy. Ensure America's access to and use of secure, affordable, and reliable fossil energy resources and strategic reserves.

FE Vision

FE strives to deliver technologies, systems, processes, and methods that utilize fossil energy resources efficiently and responsibly, ensuring that FE is continuously improving the living standards of the American people with clean, efficient, and reliable energy.

Goals, Strategies, and Objectives

FE Strategic Goal 1. Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources.

Objectives	Sub-Objectives
1.1 – Develop cost-effective, environmentally responsible transformational technologies that will underpin coal-based facilities of the future	1.1.1 – Accelerate development of highly efficient, flexible, near-zero emissions, and cost-effective coal-fired power plants 1.1.2 – Safely and cost-effectively enable environmental stewardship of fossil energy-based conversion systems
1.2 – Develop technologies to maximize the value from fossil energy resources, including their production and use	1.2.1 – Maximize value from coal, coal by-products, and fossil fuel-related critical materials and minerals 1.2.2 – Utilize CO ₂ or coal to produce valuable products, including chemicals, fuels, or high-value materials 1.2.3 – Use currently wasted or underutilized fossil fuels (e.g., flared gas)
1.3 – Engineer the subsurface to maximize recovery and efficient use of resources (e.g., hydrocarbon and storage space) while ensuring environmental stewardship	1.3.1 – Accelerate the potential of emerging and untapped hydrocarbon resources 1.3.2 – Enable the development of new hydrocarbon resources 1.3.3 – Develop technologies to enable safe and efficient water management 1.3.4 – Ensure safe and secure subsurface storage of fossil energy-related commodities or by-products
1.4 – Create smart infrastructure technologies for fossil energy	1.4.1 – Develop advanced, integrated tools for transmission, delivery, and underground storage systems 1.4.2 – Develop technologies to reduce losses of natural gas in transmission and distribution infrastructure 1.4.3 – Create new multi-purpose pipeline technology that will enable the reliable transport of hydrocarbons, hydrogen, CO ₂ , and other high-value materials

FE Strategic Goal 2. Enhance U.S. economic and energy security through prudent policy, advanced technology, and the use of strategic reserves.

Objectives	Sub-Objectives
2.1 – Protect the U.S. economy from severe petroleum supply interruptions	2.1.1 – Maintain operational readiness to release petroleum products from the Strategic Petroleum Reserve (SPR), the Northeast Gasoline Supply Reserve, and the Northeast Home Heating Oil Reserve 2.1.2 – Conduct legislatively directed sales from the SPR efficiently and effectively 2.1.3 – Share technical expertise, best practices, and lessons learned from SPR operations with international partners in support of global petroleum stockpiling 2.1.4 – Carry out the SPR Life Extension Phase II Project 2.1.5 – Make efficient use of excess storage capacity resulting from legislatively directed oil sales
2.2 – Advance technologies to improve the efficiency, reliability, emissions, and performance of existing fossil-based power generation	2.2.1 – Improve the efficiency of existing coal-fired power plants 2.2.2 – Improve the reliability, emissions, and performance of existing coal-fired power plants

FE Strategic Goal 3. Promote exports of domestically produced hydrocarbons and fossil energy technologies.

Objectives

- 3.1 – Identify and address policy, regulatory, and technical barriers that hinder U.S. energy exports
- 3.2 – Ensure a stable and transparent regulatory environment in the United States for natural gas exports

FE Strategic Goal 4. Develop and maintain world-class organizational excellence.

Objectives	Sub-Objectives
4.1 – Drive enterprise-wide culture of high performance, innovation, empowerment, and scientific integrity	4.1.1 – Develop and implement performance-reporting processes and tools that enable effective organizational decision making 4.1.2 – Align human capital strategies and practices to the <i>FE 2018–2022 Strategic Vision</i> , ensuring employees are well positioned to succeed in delivering the mission 4.1.3 – Promote employee engagement and partnerships within the FE workforce that drive success 4.1.4 – Cultivate and maintain a highly qualified, diverse, and well-trained workforce capable of achieving the FE mission and objectives
4.2 – Promote knowledge sharing and transparent communication	4.2.1 – Develop and implement an Information Management Strategy defining the roadmap of goals, strategies, and objectives to implement technology-enabled business management and knowledge management systems 4.2.2 – Develop, execute, and monitor a strategic communications plan for internal and external stakeholder engagement
4.3 – Foster responsible stewardship of resources, facilities, a safe work environment, and the communities FE serves	4.3.1 – Strengthen values-based safety culture and maintain the highest standards of workplace safety, health, and security for all employees, facilities, and information 4.3.2 – Maintain environmental stewardship 4.3.3 – Align financial and infrastructure resources to the <i>FE 2018–2022 Strategic Vision</i>

FE STRATEGIC GOAL 1

Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources

FE will focus on advanced technology R&D that will enable the continued and improved use of all fossil energy resources by improving the safety, efficiency, and cost-effectiveness of production, transportation, and conversion of coal, oil, and natural gas while enhancing environmental stewardship. To do this, FE will create strategic partnerships to develop cost-effective, environmentally responsible transformational technologies that will underpin the coal-based facilities of the future; develop technologies to maximize the value from fossil energy resources, including their production and use; engineer the subsurface to maximize recovery and efficient use of resources (e.g., hydrocarbon and carbon storage space) while ensuring environmental stewardship; and create smart infrastructure technologies for fossil energy.

1.1 Develop cost-effective, environmentally responsible transformational technologies that will underpin coal-based facilities of the future

For most of the 20th century, the United States led the world in developing efficient coal-powered technologies. Today, the Nation has fallen behind a number of countries in both average fleet efficiency and competitiveness in the global supply market for coal power equipment. The coal-based power plant of the future will need to be highly efficient, be flexible, be reliable, be cost-effective, and have near-zero emissions. This includes reducing dispatch costs, increasing quicker cycling, and utilizing multiple fuel types (e.g., coal, natural gas, and biomass). To thrive in a global marketplace, new coal power technologies will need to have low emissions at competitive cost. Under the Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) initiative, FE will research and develop advanced technologies, enabling greater

private-sector participation in driving market outcomes to enhance America's competitiveness.

To develop these Coal FIRST technologies, FE will accelerate the development of highly-efficient, flexible, and cost-effective coal-fired power plants, while safely and cost-effectively enabling environmental stewardship of fossil energy-based conversion systems.

Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative)

DOE envisions that the future coal fleet may be based on electricity generating units possessing many of the following traits: small (50 to 350 megawatts (MW)), highly efficient, flexible, reliable, and environmentally responsible to compete with other sources of power generation. The program's Coal FIRST initiative will develop technologies for such future plants and provide secure, stable, and reliable power. This R&D will underpin coal-fired power plants that are capable of flexible operations to meet the needs of the grid; use innovative and cutting-edge components that improve efficiency and reduce emission of greenhouse gasses; provide resilient power to Americans; are small compared to today's conventional utility-scale coal; and will transform how coal technologies are designed and manufactured. Technologies developed through this program will not only benefit the U.S. coal fleet, but also provide export opportunities to Asia, Africa, and small market economies on island nations.

1.1.1 Accelerate development of highly efficient, flexible, near-zero emissions, and cost-effective coal-fired power plants

Technology has changed the way people produce and use energy. For future electricity production with advanced coal energy systems, a facility must be capable of flexible operations to compete in domestic electricity markets. Furthermore, the facility may also be flexible with respect to the products it produces.

Though some new technological advancements are causing disruption, they are also providing significant opportunities. For example, advanced manufacturing, high-performance computing, and big data analytics can be leveraged to accelerate testing and design, paving the way for the coal plant of the future. Coal may not be used for electricity alone; it may increasingly serve as a feedstock for a variety of products and processes, which can be integrated into the plant to provide additional value streams. One can also envision a future where coal facilities take advantage of regional strategic opportunities—from local market conditions to available industries and resources.

As progress is made toward achieving these goals, existing plants and infrastructure will thus maintain reliability today and provide a pathway for a lower-cost future with resilient, flexible energy systems. Increasing the pace of innovation is essential for realizing a rapid impact from emerging technologies, while conventional development demands that new ideas be progressively tested at larger scales, sometimes requiring years before wide deployment. To accelerate progress, FE is pursuing optimization analyses and advanced design, fabrication, and manufacturing approaches for developing components and smaller (50–350 megawatts (MW)) unit sizes. This will result in increased component standardization, better quality control, and lower capital costs. Innovative design incorporating large-scale system optimization and advanced computational approaches can help develop integrated systems and reduce project cycle time and costs

1.1.2 Safely and cost-effectively enable environmental stewardship of fossil energy-based conversion systems

Creating a viable technology for the global marketplace requires ensuring that emissions from power generation, including CO₂, are at low levels and that water used to remove low-temperature waste heat (which often represents more than 50 percent of energy consumed by a power plant) is minimized while maintaining cost-competitiveness. Systems capable of co-firing coal, biomass, and natural gas may help improve the environmental performance of coal-fired plants.

FE will invest in improving environmental control technology to reduce environmental impacts, forced outages, and shutdowns. FE will also invest in the development of new capture approaches and integration of capture with novel energy conversion (such as chemical looping, oxycombustion, and direct cycle supercritical CO₂ systems) to drive down the price of carbon capture. Science and technology areas of focus will include: (1) advances in computational/combinatorial material discovery; (2) predictive material performance/degradation; and (3) device and system optimization using experimentally validated models.



The Chemical Looping Reactor at NETL, Morgantown, West Virginia – The combustion of fossil fuels in nearly pure oxygen, rather than air, presents an opportunity to simplify CO₂ capture in power plant applications. Chemical looping combustion is considered a potentially “transformational” technology.

FE has also developed a unique modeling capability that enables the incorporation of water availability issues into energy-economy forecasts. This capability has been incorporated into the National Drought Resilience Partnership’s (NDRP) draft strategic plan, which involves

numerous Federal departments and agencies and is being employed to identify high-risk watersheds in which drought may impact the reliability of the electric grid. In collaboration with the NDRP, this information will be used to evaluate the effectiveness of programs that promote water conservation among agricultural producers to pilot a watershed effort identified by the FE modeling capability. FE will also develop technology to optimize and reduce the use of freshwater through improved waste heat recovery or alternate heat transfer fluids. Integrating wastewater and brine cleanup with cooling is a promising research area.

1.2 Develop technologies to maximize the value from fossil energy resources, including their production and use

Fossil fuel resources themselves can be used for purposes other than energy or power generation. Discovering opportunities to use coal, CO₂, hydrocarbon liquids, or natural gas in new and novel ways can provide significant economic value and help maintain or expand the Nation's fossil energy jobs base. For example, future energy-conversion technologies for coal will be designed so that ash (coal combustion residual) is treated as a potential feedstock rather than a waste stream. In addition, rare earth elements (REEs) may be extracted from coal and its by-products. FE will also invest in the most promising opportunities to create additional value at all stages of the fossil energy life cycle, including CO₂ utilization, to provide economic value and achieve more affordable energy. Further, FE will investigate the potential for using flared natural gas to improve recovery efficiency of operations from shale formations.



FE's REE program is focused on developing technologies for the recovery of REEs from coal and coal by-products. The R&D program consists of process/production technologies, environmental management, sampling, characterization, and analysis, and system integration and optimization for the production of REEs.

1.2.1 Maximize value from coal, coal by-products, and fossil fuel-related critical materials and minerals

REEs are used in electronics and domestic-critical components so domestic production of REEs is important for both economic and national security. DOE identified the diversification of the critical materials and REE supply chains within the *DOE 2014–2018 Strategic Plan*, with the objective of addressing supply chain shortages and encouraging action to facilitate extraction, processing, and manufacturing in the United States. In doing so, DOE will further enable the reduction of the environmental impact of coal REE production and deliver technologies that can be manufactured within the United States.

The pathway toward economic recovery of REEs from coal and coal by-products requires:

- Continued identification of domestic sources of coal and coal by-products with the highest known concentration of REEs
- Research to better understand the form and structure of REEs in coal and coal by-products
- Design, development, and testing of alternative separation technologies for the extraction and recovery of REEs and critical materials from U.S. coal and coal by-products for downstream processing and purification.

FE will perform R&D for economic onshore production of REEs and important chemicals to develop new carbon-based materials from coal that result in high-performance, high-value products and to maintain coal as a resource option for production of chemicals and fuels.



1.2.2 Utilize CO₂ or coal to produce valuable products, including chemicals, fuels, or high-value materials

Cost-effective capture and use of CO₂ from fossil fuel power generation could potentially lead to new opportunities for high-value products. For example, CO₂ injection for enhanced oil recovery is the likeliest near-term option for CO₂ utilization. FE will conduct basin-specific research to potentially improve CO₂-enhanced oil and natural gas recovery from conventional and unconventional formations, both onshore and offshore, including shales and residual oil zones. Additionally, FE will investigate chemical and biological processes that could convert CO₂ into usable products or chemical feedstocks at competitive cost.

1.2.3 Use currently wasted or underutilized fossil fuels (e.g., flared gas)

In some areas of the country, the shale revolution has enabled the production of significant volumes of oil, but often there is no infrastructure to deal with the gas produced with that oil. In such cases, significant volumes of otherwise valuable natural gas are flared and therefore lost. FE will investigate the potential for using flared natural gas to improve recovery efficiency of operations from shale formations. FE will also consider the development of small-scale modular conversion systems that could utilize flared gas (e.g., for power generation, space heating) or other fossil energy waste products.

1.3 Engineer the subsurface to maximize recovery and efficient use of resources (e.g., hydrocarbon and storage space) while ensuring environmental stewardship

Current technology recovers only fractions of the hydrocarbons that exist in place, even from conventional reservoirs. For unconventional reservoirs, recovery is often less than 10 percent of the oil and gas in place.

How Clean Coal Boosts Domestic Oil Production and the American Economy



Petra Nova Parish Holdings, LLC (Petra Nova) recently demonstrated the addition of commercial-scale post-combustion carbon capture technology at the coal-fired W.A. Parish Generating Station, located southwest of Houston in Thompsons, Texas. With \$190 million in financial assistance from FE/NETL, the \$1 billion Petra Nova facility was brought online on time and on budget to begin commercial operation on December 29, 2016. It has the capability to capture more than 5,000 tons of CO₂ per day, which is used for enhanced oil recovery at a nearby oil field and is expected to boost production at the oil field. Petra Nova was named POWER magazine's 2017 "Plant of the Year" for leading the industry in the successful deployment of an advanced technology that maximizes efficiency while minimizing environmental impact. It also won *Power Engineering's* 2017 "Coal Project of the Year Award."

Additionally, excess or insufficient water can pose challenges at different stages of the oil and gas life cycle. For example, during oil and gas production, produced water is generally a by-product that must be disposed of because more is produced than can be used onsite.

Finally, the subsurface has a significant unrealized potential for storage of hydrocarbons, heat, energy, or other products associated with fossil energy production.

FE will explore technologies that accelerate the potential of emerging and untapped hydrocarbon resources, enable the development of new hydrocarbon resources, support safe and efficient water management, and ensure safe and secure subsurface of fossil energy-related commodities or by-products.

1.3.1 Accelerate the potential of emerging and untapped hydrocarbon resources

Although domestic hydrocarbon recovery has increased significantly in the past decade, the vast majority of the resource remains in the ground. Even in conventional reservoirs, a sizable quantity of oil and gas (often 30–70 percent) is unrecovered. Additionally, wellbore integrity is essential for minimizing the loss of valuable products and impact to the environment. To enable or accelerate dramatic

improvements in per-well recovery efficiency, drainage volume, and ultimate oil and gas recovery, there is a need for new technologies and approaches that will increase oil and gas production while further decreasing the environmental footprint. New approaches that contain distributed downhole sensing exhibit great promise, including the engineering of extreme small-scale nano-materials or nano-sensors for injection into reservoirs to gather subsurface information far from the wellbore. New modeling and simulation capabilities utilizing high-performance computing to interpret vast data sets in addition to fundamental understandings of the nature shale formations are also needed.

FE will conduct innovative research and develop breakthrough technologies to improve the understanding of unconventional oil and natural gas formations to enable cost-effective increases in the recovery efficiency of those formations. FE will invest in technologies to improve the ability to measure, monitor, and control critical properties of the subsurface, such as pressure, stress, and fluid properties. These measurements will validate coupled process (mechanical, chemical, and flow) models that have recently been generated and are necessary to better understand and forecast the behavior of unconventional hydrocarbon recovery and seal integrity.



A view of the Marcellus Shale Energy and Environment Laboratory – a dedicated FE field laboratory at the Northeast Natural Energy production site in Morgantown, West Virginia. The project provides a resource to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental impacts of unconventional resource development.

When applicable, FE will partner with others in DOE and externally, such as the U.S. Geological Survey and other parts of the Department of the Interior, and the National Science Foundation, to leverage resources and accelerate the development of novel technologies.

Additionally, in the anticipation that offshore development will further expand in the future, FE will collaborate with industry and academia to conduct early-stage R&D that ultimately leads to increased recovery, improved operational efficiency, and reduced risks of exploration and production in offshore oil and natural gas reservoirs. Such research will focus on offshore spill prevention, including geologic characterization, drilling and completions, and surface and subsea system integrity.

1.3.2 Enable the development of new hydrocarbon resources

Gas hydrates (or methane hydrates) are one of the new hydrocarbon resources and represent a potentially vast methane resource for both the Nation and the world. Gas

hydrates occur in great abundance in association with arctic permafrost and in the shallow sediments of the deep-water continental shelves. FE will ensure America's role as a global leader in hydrates by developing technologies to enable commercial-scale production of hydrates within the next 20 years. To this end, FE will:

- Quantify domestic in-place and recoverable methane hydrates resources in the United States
- Engineer and validate advanced technical solutions to enhance domestic, commercial viability of methane hydrates through production feasibility field testing
- Conduct scientific drilling and sampling to understand the nature and evolution of gas-hydrate-bearing systems.

FE will enter into strategic partnerships with other countries and industry partners to help develop and test new production technologies and approaches. FE will conduct R&D to resolve technical barriers to commercial viability through a series of controlled field experiments that evaluate flow over time frames measured in months (as opposed to days).



Methane hydrate is a cage-like lattice of ice inside of which are trapped molecules of methane, the primary constituent of natural gas. If methane hydrate is either warmed or depressurized, it will revert back to water and natural gas. Pictures shown are: (1) drill core showing white methane hydrate nodules mixed with mud; (2) methane hydrate deposit at ocean floor; (3) when methane hydrate is exposed or "melted," the enclosed methane molecules are released as gas and can be ignited; (4) a device developed by researchers is used to measure physical properties of hydrate-containing core while it is maintained at in situ pressure to keep the hydrate from dissociating into methane gas and water.

1.3.3 Develop technologies to enable safe and efficient water management

The large volumes of water currently used for hydraulic fracturing can cause stress on the water supply in some parts of the country; also in some basin reservoirs, stimulation can result in excess wastewater. Water is also used in power plants for generating electricity with steam-driven turbine generators. Research that will enable data integration and analysis is needed to maximize the benefits that may be gained through more effective fluid management.

FE will explore water-treatment technologies that will reduce the amount of water that needs to be injected. Such technologies can lower risks and create a commodity available for agriculture or other uses. FE will conduct R&D for developing breakthrough shale-stimulation technologies that reduce water use, as well as evaluate technologies and innovative fluid management approaches to reduce the burden on local or regional water supplies.

Additionally, FE will work with DOE's Advanced Manufacturing Office to support investment in cost-effective treatment options for produced water from oil and gas development, including technologies that will enable beneficial use and reuse options.

Water Security Grand Challenge

U.S. Department of Energy (DOE) Secretary Rick Perry on October 25, 2018, announced the Water Security Grand Challenge. The Water Security Grand Challenge is a White House-initiated, DOE-led framework to advance transformational technology and innovation to meet the global need for safe, secure, and affordable water. Fossil Energy leads two key goals:

- Transforming produced water to a resource
- Reducing water impacts in the power sector.

1.3.4 Ensure safe and secure subsurface storage of fossil energy-related commodities or by-products

Fossil energy operations can require the injection of many types of fluids in the subsurface for formation stimulation and temporary or permanent storage, including natural gas, natural gas liquids, CO₂, and produced water. Subsurface disposal or storage could bring risks, such as fluid migration. Advanced diagnostic approaches and tools are needed to detect compromised well construction and very low fluid leak rates, both within a well and in the near-wellbore region.

To help reduce and mitigate risks, enable the generation of more effective operational and regulatory practices, and streamline the selection and permitting of new development, FE will conduct research and communicate results to provide science-based, useful information to stakeholders, regulators, and operators, including reservoir stimulation and wastewater disposal operators. To advance diagnostic approaches and tools, FE will:

- Develop novel technologies and tools to improve and monitor the integrity of operational wells, especially ones that minimize the impact on well operations
- Develop technologies to cost-effectively evaluate the integrity of existing wells
- Invest in new measurements and analysis of seismic events
- Monitor and model changes in subsurface stress associated with reservoir stimulation and injection and production activities within the formations.

1.4 Create smart infrastructure technologies for fossil energy

The energy transmission, storage, and distribution (TS&D) infrastructure links subsurface fossil energy resources, the industries that convert them into energy products, and the consumers that utilize these products. A safe and reliable energy infrastructure is necessary for future economic growth and energy security. Thousands of miles of pipelines transport oil, natural gas, CO₂, and many other fossil fuel products, commodities, or by-products each day. Changes in the

energy sector are already placing new requirements on TS&D infrastructure. The use of natural gas is likely to increase as a heating source for homes and businesses and as a strategic resource for electricity generation. Natural gas infrastructures must continue to efficiently and cost-effectively support the production and delivery of natural gas without impacting safety, reliability, and security. FE will explore intelligent tools, advanced technologies, and novel materials that automatically monitor, control, and optimize the entire system and contribute to a more efficient and cost-effective fossil fuel infrastructure.

1.4.1 Develop advanced, integrated tools for transmission, delivery, and underground storage systems

The continued growth of renewable and natural gas power systems creates unique challenges for the existing electrical grid, especially with respect to dynamic interaction. New approaches are needed to characterize, quantify, and offset the variable and intermittent nature of adding renewables to the grid. Engineering this heterogeneous and highly coupled system requires scientific and technology advances. To accelerate the development of a modern transmission, storage, and delivery infrastructure, FE will invest in technologies that:

- Support the smart integration of electric and natural gas transmission with real-time sensors and controls
- Improve infrastructure cybersecurity, reduce consumer costs, increase system reliability, and optimize utility efficiency and asset utilization
- Create tools to assess and quantify infrastructure disruption, such as disruption from corrosion-related incidents
- Enhance pipeline integrity and reliability with new cost-effective materials.

FE will invest in technology capable of delivering natural gas at pressures and volumes required to operate fast-ramping generation facilities more efficiently. The integration of this sensing technology into infrastructure will improve coordination between electric and natural gas transmission to allow real-time response. As appropriate, FE will collaborate with other offices within DOE and the U.S. Department of Transportation.

1.4.2 Develop technologies to reduce losses of natural gas in transmission and distribution infrastructure

FE will invest in advanced sensors for natural gas quality monitoring and management. The sensors will provide gas system operators with information on heat content, composition, and trace constituents throughout the transmission and distribution system. FE will invest in the development of infrastructure systems and controls that prevent leaks; accurately detect and quickly mitigate leaks; use real-time system data to predict, assess, and prevent failures; and maintain cybersecurity. Secure monitoring technology will increase system reliability, improve efficiency and asset utilization, and reduce cost to consumers.

1.4.3 Create new multi-purpose pipeline technology that will enable the reliable transport of hydrocarbons, hydrogen, CO₂, and other high-value materials

FE will invest in advanced material science research that can enhance pipeline integrity and allow for the transition of different fluids through the same pipeline. The technology, coupled with smart meters, will help reduce the amount of lost and unaccounted-for natural gas, and improve efficiencies of pipeline infrastructure.

FE STRATEGIC GOAL 2

Enhance U.S. economic and energy security through prudent policy, advanced technology, and the use of strategic reserves

The U.S. Energy Information Administration projects that both domestic and worldwide consumption of petroleum, natural gas, and coal will remain at nearly 80 percent through the year 2040.² Maintaining strategic reserves and assets will protect domestic fossil energy markets from disruptions and shortages and enhance economic security. Additionally, coal power continues to play a role in maintaining the resilience of the domestic electricity grid. FE remains committed to protecting the U.S. economy from severe petroleum supply disruptions and advancing technologies to improve the reliability, resilience, and viability of existing fossil-based power generation.

2.1 Protect the U.S. economy from severe petroleum supply interruptions

FE will efficiently and effectively manage strategic petroleum reserves to protect the economy from severe petroleum supply interruptions. FE will continually work with other stakeholders within the Administration to ensure that the U.S. strategic petroleum reserves meet the needs of evolving domestic and international petroleum markets.

2.1.1 Maintain operational readiness to release petroleum products from the Strategic Petroleum Reserve, the Northeast Gasoline Supply Reserve, and the Northeast Home Heating Oil Reserve

Operational readiness is a steady-state period during which each reserve site is configured and ready to draw down, upon direction of the President or the Secretary of Energy. Execution of a comprehensive maintenance program,

combined with program oversight and evaluation, ensures operational readiness, integrity, reliability, and functionality of equipment critical to draw down.

FE will continue to maintain operational readiness of the SPR to release oil when needed by complying with established DOE orders, directives, policies, and standards. FE oversight ensures adherence to specific maintenance quality indicators and the performance of a series of predictive, preventive, and corrective maintenance activities are conducted in accordance with established directives.

FE will continue to conduct an annual analysis of the SPR's ability to distribute crude oil using the current connected commercial distribution systems. The annual distribution assessment determines if the distribution capability of the SPR is equal to or exceeds 120 percent of the SPR's drawdown rate. The assessment also identifies the need to develop remedial plans, as appropriate, to maintain sufficient SPR connectivity to commercial distribution assets, such as pipelines, terminals, and refineries. The analysis integrates recent and planned changes to U.S. petroleum transportation infrastructure, including connected pipelines and contracted docks, used by the SPR to distribute crude oil. The SPR may enhance or modify distribution mechanisms, petroleum characteristics, and processes for delivery to respond to changes in infrastructure and markets.

FE will also maintain operational readiness of the NEHHOR and the NGSR through a comprehensive quality assurance program. This program includes annual visits to the storage terminals to verify that the reserves meet all quantity and quality specifications and that the terminals can meet

² *International Energy Outlook 2018* (Washington, DC: U.S. Energy Information Administration, July 2018), <https://www.eia.gov/outlooks/ieo/>



The SPR currently operates and maintains four major oil storage facilities in the Gulf Coast region. Oil is stored in caverns created deep within the massive salt deposits that underlie most of the Texas and Louisiana coastline.

operational distribution requirements defined in each reserve's distribution plans. However, both the NEHHOR and the NGSR are expensive to maintain and have limited operational effect given the size of each of these refined product reserves. It is for these reasons that the Administration has proposed disestablishing both programs in the Fiscal Year 2020 budget request.

2.1.2 Conduct legislatively directed sales from the Strategic Petroleum Reserve efficiently and effectively

FE will conduct congressionally mandated oil sales from the SPR at optimal value and on schedule. Optimal value will be based upon a percentage of the base reference price as determined by the market crude that most closely matches the crude oil quality being sold. FE will also manage petroleum sales while continuing to meet all U.S. obligations under the International Energy Program.

2.1.3 Share technical expertise, best practices, and lessons learned from Strategic Petroleum Reserve operations with international partners in support of global petroleum stockpiling

FE represents DOE in various international forums, including the International Energy Agency and the Annual Coordinating Meeting of Entity Stockholders (ACOMES), an association of petroleum stockpiling countries. FE will continue to provide leadership on stockpiling issues worldwide; participate in biannual technical exchanges within the ACOMES framework; and participate in routine bilateral meetings with individual countries to exchange technical ideas and practices on stockpiling issues.

2.1.4 Carryout the Strategic Petroleum Reserve Life Extension Phase II Project

FE will carry out the SPR Life Extension Phase II (LE2) Project to ensure short-term and long-term operational effectiveness and modernize aging SPR infrastructure through systems upgrades and associated equipment replacement. FE will execute the LE2 Project while continuing to operate in order to protect the Nation from potential supply disruptions and meet requirements under the International Energy Program.

2.1.5 Make efficient use of excess storage capacity resulting from legislatively directed oil sales

Over the past several years, Congress passed numerous laws mandating SPR oil sales, resulting in as much as 300 million barrels in excess capacity. FE is analyzing opportunities to lease space to commercial entities or international partners to make sound use of this government asset.

2.2 Advance technologies to improve the efficiency, reliability, emissions, and performance of existing fossil-based power generation

The competitiveness of coal can be strengthened with technology solutions to allow the existing coal fleet to operate more efficiently, with lower emissions and extended unit life. The overall environmental performance of the coal fleet can be improved by making cost-effective modifications to existing coal power plants. For example, FE will pursue public/private partnerships to develop smart controls that: (1) predict and improve the power plant operational status; (2) maximize efficiency; (3) minimize emissions; and (4) maintain cybersecurity. To prevent premature retirements,

FE will also pursue interagency collaboration on regulatory reform, in part by defining clear pathways to address state and Federal regulatory challenges to technology deployment. DOE will inform relevant stakeholders regarding operational requirements and financial and life-cycle assessment tools to accelerate adoption of advanced technology in the marketplace.

2.2.1 Improve the efficiency of existing coal-fired power plants

FE will develop cost-effective technologies to improve the performance, reliability, and efficiency of coal-based power plants, resulting in better operations and commensurately lower CO₂ emissions. R&D investments will include new materials that can withstand high pressures and temperatures, advanced compression systems, more efficient heat recovery, and other innovative plant optimization technologies.

2.2.2 Improve the reliability, emissions, and performance of existing coal-fired power plants

Historically, coal-fueled plants have provided baseload power to the grid. In an increasingly diverse energy system, coal plants are being used to provide non-baseload power as well, meaning coal plants are operating with more frequent cycling (time on and off the power grid). Without careful management and attention, cycling can decrease component life. R&D is essential to address performance concerns at the unit, plant, and grid levels caused by aging or increased time spent in cycling mode. More cycling leads to less economic units, lower efficiency, and more stress on equipment, leading to a shortened expected plant life, thereby reducing the reliability and resiliency of the electric power generation system. FE will invest in advanced sensors and controls to help increase coal plant efficiency, reduce forced outages, and avoid downtime related to equipment failures and compliance with environmental regulations.

FE STRATEGIC GOAL 3

Promote exports of domestically produced hydrocarbons and fossil energy technologies

The United States possesses abundant and economically recoverable natural gas, coal, and crude oil resources. Identifying policy, regulatory, and technical approaches to increase the United States' allies' and trading partners' access to those resources will enhance U.S. leadership in the world and promote American jobs and economic growth. To do this, FE will identify and address policy, regulatory, and technical barriers that hinder U.S. energy exports and will ensure a stable and transparent regulatory environment in the United States for natural gas.

3.1 Identify and address policy, regulatory, and technical barriers that hinder U.S. energy exports

America's economy and energy security stand to benefit when U.S. companies can optimize exports of coal, oil, and natural gas, as well as advanced fossil fuel technology, to markets around the world. The United States also gains advantage when American companies can develop their technical capabilities and earn returns by investing in projects in fossil energy sectors of the United States' foreign partners. The United States further benefits when its foreign partners enhance global energy security by developing their own domestic oil and natural gas resources. FE will expedite its process time for LNG export permits where possible; partner with other agencies and entities to identify and eliminate barriers to LNG and other fossil fuel exports; and provide assistance to importing countries in developing markets with technical and policy expertise. FE will share technical and environmental expertise and research with foreign partners to help make the case for importing American coal-, oil-, and natural gas-related technology. FE will continue to initiate and support cooperative activities that lead to new fossil energy export and investment opportunities for U.S. companies.



Sabine Pass LNG Export Terminal, Cameron Parish, Louisiana
(Photo courtesy of Cheniere Energy, Inc.)

3.2 Ensure a stable and transparent regulatory environment in the U.S. for natural gas exports

FE has the responsibility to review all applications to import or export natural gas from the United States through its regulatory authority under the Natural Gas Act. FE seeks a clear, consistent, and predictable regulatory practice, to the extent allowable under the law, while also maximizing benefits to the public. To accomplish these goals, FE will continue to regularly review and adjust its procedures to address stakeholder concerns, as appropriate. FE will partner with other Federal regulators of natural gas and LNG to coordinate their reviews of natural gas export applications to minimize redundancies and delays. In June 2018, DOE/FE released its fifth study that examines the macroeconomic impacts of LNG exports. The study found that increased exports of natural gas will improve the U.S. balance of trade and provide sustainable employment for thousands of Americans.

FE STRATEGIC GOAL 4

Develop and maintain world-class organizational excellence

People are FE's most important resource. FE will attract, develop, and retain high-quality staff and function as a high-performing team to deliver its mission safely and securely in state-of-the-art laboratories. To do this, FE will drive an enterprise-wide culture of innovation and empowerment; strengthen a values-based safety culture and maintain the highest standards of workplace safety, health, and security for all employees and the community FE serves; promote knowledge sharing and transparent communication; and foster responsible stewardship of people, resources, and facilities.

4.1 Drive enterprise-wide culture of high performance, innovation, empowerment, and scientific integrity

In today's competitive and ever-changing landscape, FE will channel employees' creative energy and empower innovation at every level.

4.1.1 Develop and implement performance-reporting processes and tools that enable effective organizational decision making

FE will identify critical performance indicators and measures that are tied to the *DOE 2014–2018 Strategic Plan*, the *FE 2018–2022 Strategic Vision*, and the *FE Roadmap* to inform managers and leaders of organizational performance and opportunities for improvement. Cascading and aligning goals within FE will create a shared accountability that is vital to achieving its mission. It will also build a foundation for managers and leaders to make key strategic decisions for the organization.

4.1.2 Align human capital strategies and practices to the *FE 2018–2022 Strategic Vision*, ensuring employees are well positioned to succeed in delivering the mission

FE will develop short- and long-term talent management strategies and practices that foster employee engagement and organizational effectiveness. These strategies will align with the *FE 2018–2022 Strategic Vision* in order to successfully foster the acquisition, development, and retention of talented employees capable of accomplishing the FE mission and program goals.

4.1.3 Promote employee engagement and partnerships within the FE workforce that drive success

The degree to which FE fosters employee engagement, inclusion, and satisfaction influences its success in attracting and retaining employees who want to help the organization meet its mission. FE will utilize the annual Federal Employee Viewpoint Survey's results to better understand specific organizational strengths, uncertainties, and challenges and identify and prioritize actions to improve the workplace experience.

4.1.4 Cultivate and maintain a highly qualified, diverse, and well-trained workforce capable of achieving the FE mission and objectives

The FE workforce is facing three challenges. First, the workforce is aging and increasingly eligible for retirement. In FY 2018, approximately 22 percent of the FE workforce was eligible for voluntary retirement. Over the next 5 years,

another 21 percent of the workforce will reach retirement eligibility. Meanwhile, only 17 percent of the workforce is under age 40 (including less than 1 percent under age 30) and 58 percent is age 50 and over. These demographics make it imperative for the organization to engage in succession planning; increase bench strength of science, technology, engineering, and mathematics (STEM), as well as non-STEM professionals; and provide opportunities for professional development so that employees are ready to assume more senior roles and responsibilities when attrition and retirements occur. Second, the FE workforce is highly technical and comprises 17 occupational groups with 60 percent of the workforce in STEM occupations. Fifty-four percent of FE employees possess at least a Master's Degree or higher level of education. Successful recruitment for technical positions with a high level of education requires effective planning to attract highly qualified candidates. Third, there are opportunities to increase diversity within the workforce, which is currently 65 percent male and 81 percent white.

FE will employ innovative strategies and programs designed to cultivate and maintain a workforce with the capacity to achieve the FE mission and current and future objectives. FE will implement a Talent Management approach that focuses on the full life cycle of employment within the organization. This includes identifying workforce requirements; building a pipeline of future STEM (and non-STEM) talent; identifying current and future workforce requirements; acquiring the talent needed to complete the mission; and developing, engaging, and recognizing FE's talent in order to foster high performance and a high degree of inclusion, helping FE to retain valued skills and competencies.

4.2 Promote knowledge sharing and transparent communication

The timeliness and quality of FE business decisions depend on the availability of accurate, reliable information and timely communication. To that end, FE will ensure the availability of enterprise-wide information, knowledge, resource, and program management systems that include all FE sites, as well as the national laboratory complex.

4.2.1 Develop and implement an Information Management Strategy defining the roadmap of goals, strategies, and objectives to implement technology-enabled business management and knowledge management systems

The Information Management (IM) Strategy covers the FE enterprise and all information, documentation, and data that FE creates, owns, collects, and retains in paper and electronic format. The goals and objectives for this plan will be developed within the context of key business drivers that inform how FE manages information, as well as communication between FE Headquarters and field sites to identify and discuss priorities and activities that will maximize FE's management and use of information. These priorities and activities will stem from FE's strategic planning process; management decisions regarding formalizing FE's information request management processes; development of a knowledge management system; as well as synchronization and optimization of FE's budget management systems. This strategy will connect FE's IM vision, mission, principles, strategic goals and objectives, priorities, and activities so that FE's information management capabilities can quickly and adeptly respond to evolving mission needs and address gaps in current business processes.

4.2.2 Develop, execute, and monitor a strategic communications plan for internal and external stakeholder engagement

FE will develop a national media strategy highlighting the important impact that fossil energy has on the American people, including federally recognized tribes. The national media strategy will be driven by capitalizing on the news of the day and inserting FE leadership into the conversation. Key elements of the national strategy will be a listing of key internal and external stakeholders; development of FE messaging themes; and an associated strategic communications plan addressing internal and external requirements.

To develop a stronger, more consistent, and more coordinated output of communications, FE will develop a strategic communications plan. This plan will ensure that FE is using uniform messaging across numerous communication channels to maximize its reach and keep its stakeholders informed of key advances toward achieving FE's Strategic Goals. It will also create a more regular "drumbeat" of communications to make sure FE is communicating with its stakeholders on a frequent, routine basis (See Appendix C). As part of this plan, FE will implement a coordinated social media plan to increase both its social media audience and engagement rates. Because social media is an effective tool for reaching a broad audience very quickly, FE will work to increase the number of its social media posts across different platforms, including Twitter, Facebook, and LinkedIn. To measure FE communications' success and effectiveness, FE will establish a series of metrics for gauging the visibility and engagement levels of its posts. FE will then analyze its performance against its established metrics on a monthly basis, to determine how FE's posts are performing and what improvements can be made to enhance FE's mission.

To foster internal communications, FE will conduct management and innovation lunchtime forums to promote cross-communication and information sharing across offices in FE. These forums will support FE's ongoing efforts to nurture an improvement and innovation culture.

4.3 Foster responsible stewardship of resources, facilities, a safe work environment, and the communities FE serves

Responsible stewardship of FE's people, resources, and facilities begins with a culture that puts safety first. The well-being of FE staff is paramount. The security of FE's facilities and information is also important, as is a commitment to serve the public and FE's communities in a responsible manner. In addition, building a successful

research portfolio and world-class laboratory capabilities through a comprehensive understanding of the economic, environmental, technological, regulatory, and political landscapes will propel new technologies for the next generation.

4.3.1 Strengthen values-based safety culture and maintain the highest standards of workplace safety, health, and security for all employees, facilities, and information

Workplace safety, security, and employee health and well-being is paramount in FE culture. It is a crucial priority that every employee who comes to work goes home with no injuries. It is also important that our facilities are secure and that sensitive information is secured with cutting-edge cybersecurity programs. FE will continue to strengthen its values-based safety culture and ensure that a safe and healthy work environment is key to team productivity and employee loyalty to the mission.

4.3.2 Maintain environmental stewardship

FE is committed to maintaining environmental stewardship to ensure that its operations are conducted efficiently while mitigating impacts on the environment.

4.3.3 Align financial and infrastructure resources to the FE 2018–2022 Strategic Vision

In order to be responsible stewards of taxpayer funds, FE must use its resources in line with strategic objectives, and do so in a transparent, reportable way that maintains accountability to Congress and the Administration. FE will regularly review the relationship between *FE 2018–2022 Strategic Vision* elements and the congressional direction behind financial resources to show at a glance the relative funding going toward each strategic objective. Additionally, FE will undergo a comprehensive examination of strategy and scope of responsibilities to ensure alignment of financial and infrastructure resources with strategic objectives.

CONCLUSION

Fossil fuels will remain the primary source of domestic and global energy for the foreseeable future. Overcoming challenges to fossil energy that are inherent in the ever-changing energy landscape is critical to the future prosperity of the Nation. The Office of Fossil Energy is uniquely placed to pursue the game-changing technologies that the current energy environment demands.

The Office of Fossil Energy has a long, successful history of developing fossil energy technologies to meet America's energy needs in a safe, affordable, and environmentally responsible manner, and this rich history of technology innovation will continue for decades to come. This *FE 2018–2022 Strategic Vision* is a comprehensive framework and catalyst for developing those technologies.

APPENDIX A

NETL Core Technical Competencies

To execute a national energy research portfolio that discovers and matures innovative technologies, FE must maintain cutting-edge and enduring core scientific competencies. These competencies support FE's Strategic Goals and allow FE to provide the Nation with today's technology solutions and tomorrow's technology innovations. As the only FE laboratory, NETL plays a critical role in maintaining and developing these core competencies. Additionally, FE invests in strategic partnerships with other national laboratories, effectively leveraging capabilities across the national laboratory complex. These collaborative partnerships include focused multi-institutional initiatives that comprehensively address fossil energy challenges that are too complex for any single organization. Two recent examples, the Carbon Capture Simulation Initiative and the National Risk Assessment Partnership,³ demonstrate that this highly integrated, coordinated approach can significantly accelerate the development of new solutions.

New technological advancements challenge the status quo and can transform improvements in the energy system and the economy. For example, advanced manufacturing, high-performance computing, large-scale systems optimization, and data analytics can be leveraged to spark imagination and change the way people think about and use fossil fuels in the future. FE maintains the following competencies to meet these challenges:

Energy Conversion

FE has a long history of developing energy-conversion systems to produce power, fuels, and chemicals from coal, oil, natural gas, and integrated fossil fuel and renewable energy resources. Flexible and reliable power systems in a range of sizes will be necessary to meet future energy demands—such

FE-Wide Analysis Capabilities

The comprehensive analysis expertise within FE is used extensively to support strategic planning, define program direction, and inform key stakeholders on policy issues. Notably, the depth of expertise within FE enables technical, economic, and policy analysis to inform regulatory decision-making. Key analyses, such as the NETL Cost and Performance Baseline Studies, provide a techno-economic and market basis for the pursuit of advanced technologies. In addition, FE analyses support the development of new fossil-based programs, such as the Rare Earth Elements Program, and the assessment of FE R&D program impact on U.S. employment and gross domestic product.

as district heating and cooling, micro-grids, energy storage, and further integration with non-fossil fuels. FE pioneers new technologies that enable low-carbon power production while optimizing environmental performance, water use, efficiency, and waste minimization. Through modeling and experimental testing, researchers accelerate technology development by reducing the time, cost, and technical risk associated with bringing advanced technologies from concept to market. Capabilities related to this competency include clean energy systems, multiphase flow science, thermal sciences, innovative energy concepts, reaction engineering, and diagnostics and controls.

³ The Carbon Capture Simulation Initiative (CCSI) and the National Risk Assessment Partnership (NRAP) are two successful, multi-lab collaborations, led by NETL, that have addressed significant FE challenges through focused, tightly coordinated R&D. The CCSI and NRAP Toolsets received R&D 100 Awards in 2016 and 2017, respectively.

Materials Engineering and Manufacturing

Advanced energy systems require cutting-edge materials that can withstand high-pressure, high-temperature, corrosive, or otherwise demanding service environments. FE specializes in the design, development, and deployment of these materials. Researchers have access to advanced tools, unique and specialized facilities, and broad expertise to design, synthesize, and process a variety of material classes. This capability also leverages partnerships ranging from academia and national laboratories to industry and utilities. Functional materials⁴ improve performance of both carbon capture and power-generation technologies, such as advanced turbines, chemical looping combustion, and solid oxide fuel cells. Structural materials⁵ have enhanced strength to enable higher-efficiency steam and gas turbines, coal gasification, faster drilling, and stronger wells, among others. Related FE capabilities include intelligent materials design and synthesis, functional materials, structural materials, and materials characterization.

Computational Science and Engineering

To keep pace with growing energy demand, scientists increasingly depend on shared simulations and data, analytical tools, and research collaborations—all of which require high-speed information access and high-performance computational infrastructure. State-of-the-art computing facilities enable the use of collaborative workspaces for multiple organizations (e.g., laboratories, academia, and industry) to create cutting-edge modeling tools that facilitate rapid technology development and understanding. Scientists nationwide connect to FE's advanced visualization center and use statistical and analytical software packages to reduce risk, identify knowledge gaps, and evaluate environmental hazards. High-performance computing and data analytics capabilities accelerate advancements in several areas, from materials discovery to actionable control systems based on distributed sensing. Specifically, FE regularly invests in its own high-

performance computer—known as Joule and housed at NETL—to ensure the availability of high-performance computing resources for fossil energy applications. FE also invests in extensive high-performance computational capabilities throughout the national laboratory complex, as well as significant advancements in modeling software. Fossil energy applications include R&D, power plant design and operations, oil and gas production, and smart natural gas pipelines.

Capabilities related to this competency include hardware and networks, software automation, information access and infrastructure, data analysis and visualization, and supercomputing.

Sensors and Controls

Advanced sensors and controls are crosscutting technologies that support nearly all of FE's R&D goals. They are being developed to enhance the reliability of today's power plants, to improve productivity of oil and gas activities, to transport and store fossil fuels and by-products more securely, and to enable the highly integrated, flexible power systems of the future. Development of advanced sensors and controls leverages all of FE's core technical competencies. For example, researchers are using advanced manufacturing techniques to develop new sensing materials capable of withstanding the extreme temperatures and pressures of fossil energy systems. Advanced computing resources and cutting-edge data analysis techniques enable real-time control systems that dynamically optimize operations for energy conversion and geoscience systems alike.

⁴ Materials including polymers and polymer-composites, ceramics and electroceramics, as well as nano-engineered materials.

⁵ Materials fabricated from stainless steels, superalloys, and ceramics, etc.

Geological and Environmental Systems

The application of new technologies that enhance geologic characterization and improve the predictability of fluid and rock behavior will help optimize recovery efficiencies from oil and gas reservoirs. Novel technical solutions involving new sensors, materials, and techniques help ensure the efficient recovery and storage of fossil fuel resources and by-products in an environmentally safe manner. Research catalyzes the development of these new technologies; provides objective data to improve modeling accuracy and decrease technical and market risk of oil and gas development; and characterizes emerging energy resources like methane hydrates. The geoscience competency addresses the challenges of engineered natural systems such as geological CO₂ storage, unconventional tight gas resources, methane hydrates exploration, and deep water offshore oil and gas production. Capabilities related to this competency include geomaterials science, geospatial analysis, geochemistry, field monitoring, geophysics and geomechanics, risk and impact assessment, reservoir fluid characterization, and numerical modeling.

Systems Engineering and Analysis

The discovery, design, and operation of energy systems benefit from systematic decision-making techniques to address often competing goals of maximizing profits, minimizing costs, addressing market and policy drivers, and meeting environmental and technical constraints. These techniques include advanced models coupled with optimization and uncertainty quantification. Methodologies based in the fundamental disciplines of mathematics, economics, finance, operations research, chemical engineering, and computer science are complemented by experimental capabilities in chemistry, physics, and biology, as well as pilot-scale evaluation. Integration of computational and applied research provides insights to new technology; identifies new energy concepts; and analyzes energy system interactions at plant, regional, national, and global scales. Capabilities related to this competency include energy systems analysis, process systems engineering, process innovation, enterprise-wide energy systems, and portfolio and risk assessment.

APPENDIX B

Goals, Objectives, Sub-Objectives, and Performance Measures

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>1: Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources.</p>	<p>1.1 – Develop cost-effective, environmentally responsible transformational technologies that will underpin coal-based facilities of the future</p>	<p>1.1.1 – Accelerate development of highly efficient, flexible, near-zero emissions, and cost-effective coal-fired power plants</p>	<ul style="list-style-type: none"> By the end of FY 2020, perform a minimum of four Pre-FEED studies that identify technical approaches to improve the average modeled efficiency (heat rate) of an advanced or new coal plant by 5% from the 2017 baseline of 38% by the end of FY 2023. By the end of FY 2022, perform a minimum of four Pre-FEED studies that would enable FE to meet the GPRA goal of "By the end of FY 2023, improve the average modeled efficiency (heat rate) of an advanced or new coal plant by 5% from the 2017 baseline of 38% (i.e., to 40%). By the end of FY 2023, advance at least two engineering studies of advanced high efficiency, low emission (HELE) coal fired systems that have flexible operating capacity to meet baseload and load following requirements needed for the evolving grid.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>1: Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources.</p>	<p>1.1 – Develop cost-effective, environmentally responsible transformational technologies that will underpin coal-based facilities of the future</p>	<p>1.1.2 – Safely and cost-effectively enable environmental stewardship of fossil energy-based conversion systems</p>	<ul style="list-style-type: none"> By 2022, complete bench-scale test of at least two novel materials and processes (e.g., metal-organic frameworks and non-binding organic liquid solvents) that show potential to meet the 2030 target of CO₂ capture with a cost of electricity at least 30% lower than a supercritical PC plant with CO₂ capture, or approximately \$30 per tonne of CO₂ captured. By CY 2025, develop economically viable technologies, verified through modeling, that would reduce the volume of freshwater consumed in a typical power plant in the existing fleet by 30% on a per megawatt-hour basis from a 2018 baseline.
	<p>1.2 – Develop technologies to maximize the value from fossil energy resources, including their production and use</p>	<p>1.2.1 – Maximize value from coal, coal by-products, and fossil fuel-related critical materials and minerals</p> <p>1.2.2 – Utilize CO₂ or coal to produce valuable products, including chemicals, fuels, or high-value materials</p> <p>1.2.3 – Use currently wasted or underutilized fossil fuels (e.g., flared gas)</p>	<ul style="list-style-type: none"> By the end of CY 2020, develop separation technologies at the pilot-scale capable of producing 10 lb/day of commercial grade rare earth oxides from coal waste products. By CY 2028, build at least one pilot-scale prototype that would improve the economics of an existing power plant by providing an additional revenue stream related to CO₂. By the end of FY 2030, advance conversion and utilization technologies that will result in at least a 75% reduction in the planned flared volume of natural gas from a 2015 baseline.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>1: Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources.</p>	<p>1.3 – Engineer the subsurface to maximize recovery and efficient use of resources (e.g., hydrocarbon and storage space) while ensuring environmental stewardship</p>	<p>1.3.1 – Accelerate the potential of emerging and untapped hydrocarbon resources</p>	<ul style="list-style-type: none"> By the end of FY 2022, develop basin-specific technologies for unconventional resources, including emerging plays; and pursue and build upon unconventional oil and gas big data analytics and high-performance computing capabilities to improve modeled recovery of shale oil and gas by 20%, from current baseline of 10% to 12% recovery efficiency. By the end of FY 2028, develop basin-specific technologies for unconventional resources, including emerging plays; and pursue and build upon unconventional oil and gas big data analytics and high-performance computing capabilities to improve modeled recovery of shale oil and gas by 40%, from current baseline of 10% to 14% recovery efficiency.
		<p>1.3.2 – Enable the development of new hydrocarbon resources</p>	<ul style="list-style-type: none"> By the end of FY 2022, complete a methane hydrate stratigraphic well test on the Arctic North Slope. By the end of FY 2035, confirm viable methane hydrates production (Technology Readiness Level-7) by demonstrating sustainable and economically feasible gas production and ensure well integrity.
		<p>1.3.3 – Develop technologies to enable safe and efficient water management</p>	<ul style="list-style-type: none"> By FY 2023, develop advanced produced water treatment technologies that, verified through modeling, enable reductions of wastewater disposed via injection by 50% from a 2018 baseline.
		<p>1.3.4 – Ensure safe and secure subsurface storage of fossil energy-related commodities or by-products</p>	<ul style="list-style-type: none"> By the end of FY 2022, support the effort to reduce and improve regulations government-wide by assessing and applying best practices and experiences on geologic storage from DOE R&D projects.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>1: Develop secure and affordable fossil energy technologies to realize the full value of domestic energy resources.</p>	<p>1.4 – Create smart infrastructure technologies for fossil energy</p>	<p>1.4.1 – Develop advanced, integrated tools for transmission, delivery, and underground storage systems</p>	<ul style="list-style-type: none"> • By the end of FY 2025, deploy new quantitative assessment and risk decision tools for pipeline infrastructure and corrosion prediction.
		<p>1.4.2 – Develop technologies to reduce losses of natural gas in transmission and distribution infrastructure</p>	<ul style="list-style-type: none"> • By the end of FY 2022, develop technologies that will reduce modeled fugitive methane emissions from natural gas transmission and distribution infrastructure by 50 percent to a level of 13.4 million metric tons (MMT) CO₂ from the current level of 26.7 MMT CO₂, as identified in the EPA’s Greenhouse Gas Inventory. • By the end of FY 2029, develop technologies to reduce losses of natural gas in transmission and distribution infrastructure to support industry efforts to achieve 99% efficiency across the natural gas supply chain.
		<p>1.4.3 – Create new multi-purpose pipeline technology that will enable the reliable transport of hydrocarbons, hydrogen, CO₂, and other high-value materials</p>	<ul style="list-style-type: none"> • By the end of FY 2022, identify at least one potential alloy for a multi-purpose pipe capable of transporting natural gas, hydrogen, and CO₂.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>2: Enhance U.S. economic and energy security through prudent policy, advanced technology, and the use of strategic reserves.</p>	<p>2.1 – Protect the U.S. economy from severe petroleum supply interruptions</p>	<p>2.1.1 – Maintain operational readiness to release petroleum products from the Strategic Petroleum Reserve (SPR), the Northeast Gasoline Supply Reserve, and the Northeast Home Heating Oil Reserve</p>	<ul style="list-style-type: none"> • Maintain the capability to drawdown the SPR at the design drawdown rate of 4.415 million barrels per day. • Ensure the operational readiness of the SPR through the achievement of equal to or greater than 95% of maintenance performance and reliability goals annually. • Ensure the cost efficiency of SPR operations through the achievement of a fiscal year average operating cost per barrel of crude oil storage capacity of no more than \$0.30 per barrel. • Ensure the efficiency of the SPR modernization project through the achievement of performance index scores of .90 at completion in FY 2022 on the cost and schedule indices that measure variation from established cost and schedule baselines.
	<p>2.1.2 – Conduct legislatively directed sales from the SPR efficiently and effectively</p>	<ul style="list-style-type: none"> • The sale price of all mandated sales will be at least 95% of the government-estimated price. 	

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>2: Enhance U.S. economic and energy security through prudent policy, advanced technology, and the use of strategic reserves.</p>	<p>2.1 – Protect the U.S. economy from severe petroleum supply interruptions</p>	<p>2.1.3 – Share technical expertise, best practices, and lessons learned from SPR operations with international partners in support of global petroleum stockpiling</p>	<ul style="list-style-type: none"> • Continue bilateral multilateral cooperation with International Energy Agency partners and participate in bilateral meetings with individual countries to exchange technical ideas and practices on stockpiling issues. • Participate in biannual technical exchanges within the Annual Coordinating Meeting of Entity Stockholders (ACOMES) framework.
		<p>2.1.4 – Carry out the SPR Life Extension Phase II Project</p>	<ul style="list-style-type: none"> • To reach overall ≥ 90 Score on both the Cost and Schedule Performance Index at project closeout.
		<p>2.1.5 – Make efficient use of excess storage capacity resulting from legislatively directed oil sales</p>	<ul style="list-style-type: none"> • By the end of FY 2019, complete the SPR Post-Sale Configuration Study.
	<p>2.2 – Advance technologies to improve the efficiency, reliability, emissions, and performance of existing fossil-based power generation</p>	<p>2.2.1 – Improve the efficiency of existing coal-fired power plants</p>	<ul style="list-style-type: none"> • By the end of CY 2022, enable at least one technology that will improve the reliability of existing and future coal plants by 10% from a 2017 baseline.
		<p>2.2.2 – Improve the reliability, emissions, and performance of existing coal-fired power plants</p>	<ul style="list-style-type: none"> • By the end of CY 2022, enable at least one technology that will improve the reliability of existing and future coal plants by 10% from a 2017 baseline. • By CY 2030, for retrofitting an existing coal-fired power plant with CO₂ capture, ensure capture technologies are available to reduce the cost of capture by 30 percent (actual cost of capture varies for each unit).

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
3: Promote exports of domestically produced hydrocarbons and fossil energy technologies.	3.1 – Identify and address policy, regulatory, and technical barriers that hinder U.S. energy exports	-	<ul style="list-style-type: none"> By the end of FY 2019, decrease, by a minimum of 30 days from the current processing time of 92 days, the amount of time it takes DOE to render a decision on applications for small-scale exports of natural gas to non-free-trade-agreement countries from facilities that do not require environmental review.
	3.2 – Ensure a stable and transparent regulatory environment in the United States for natural gas exports	-	<ul style="list-style-type: none"> DOE will meet 90% of all milestones on time in issuing decisions for LNG export applications covered under Title 41 of the Fixing America's Surface Transportation Act.
4: Develop and maintain world-class organizational excellence.	4.1 – Drive enterprise-wide culture of high performance, innovation, empowerment, and scientific integrity	4.1.1 – Develop and implement performance-reporting processes and tools that enable effective organizational decision making	<ul style="list-style-type: none"> By the third quarter FY 2019, provide quarterly measures of performance progress updates to FE leadership. By the third quarter FY 2019, complete a high-level FE planning calendar that aligns the FE Strategic Plan and the FE Technology Roadmap with the budgeting process and program execution.
		4.1.2 – Align human capital strategies and practices to the FE Strategic Plan, ensuring employees are well positioned to succeed in delivering the mission	<ul style="list-style-type: none"> By the end of first quarter FY 2020, 90% of employee performance plans will align with the FE Strategic Plan. By the end of first quarter FY 2020, FE will complete a FE Human Capital Strategic Plan that aligns with the FE Strategic Plan.
		4.1.3 – Promote employee engagement and partnerships within the FE workforce that drive success	<ul style="list-style-type: none"> Employ strategies to achieve a 65% participation rate in annual Federal Employee Viewpoint Survey (FEVS). Develop, execute, and monitor an annual FEVS Results Action Plan within 6 months of receiving FEVS results to improve FEVS scores in the global satisfaction and employee engagement indices.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>4: Develop and maintain world-class organizational excellence.</p>	<p>4.1 – Drive enterprise-wide culture of high performance, innovation, empowerment, and scientific integrity</p>	<p>4.1.4 – Cultivate and maintain a highly qualified, diverse, and well-trained workforce capable of achieving the FE mission and objectives</p>	<ul style="list-style-type: none"> • Foster a talent pipeline of current and future STEM (and non-STEM) professionals by providing educational and experiential learning opportunities through government, DOE, and FE programs, such as the Mickey Leland Energy Fellowship, with tracking and annual reporting to assess program performance. • By the end of FY 2019, complete a longitudinal assessment of the historical and ongoing impact of the Mickey Leland Energy Fellowship Program. • Foster succession planning through the incorporation of entry-level and developmental positions into the FE FY 2019–FY 2023 Staffing Plans. • Ensure that each fiscal year, 90% of FE employees have a current Individual Development Plan in place by January 31. • Execute 70% of planned and budgeting training, including selecting and funding the academic degree and leadership development training for at least seven FE employees, each fiscal year. • Starting in FY 2019, report quarterly on FE workforce demographics and the efficiency and effectiveness of the FE hiring process in relation to established benchmarks. • By the end of FY 2018, establish internal time to hire and report performance. • Starting in FY 2019, report on the efficiency and effectiveness of the FE hiring process (including information on FE workforce demographics) on a quarterly basis.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>4: Develop and maintain world-class organizational excellence.</p>	<p>4.2 – Promote knowledge sharing and transparent communication</p>	<p>4.2.1 – Develop and implement an Information Management Strategic Plan defining the roadmap of goals, strategies, and objectives to implement technology-enabled business management and knowledge management systems</p>	<ul style="list-style-type: none"> • By the end of FY 2019 second quarter, develop and implement FE enterprise-wide, fully inclusive of field sites, an Information Management Strategic Plan defining roadmap of goals, strategies, and objectives to implement technology-enable business management and knowledge management solutions. • By the end of FY 2019, develop and implement FE enterprise-wide knowledge management system with the availability of subject matter expert profiles, publications, technical communities of practice, wiki-style FE glossary and datasets, and a high-level/on-in news feeds to knowledge resources. • By the end of second quarter FY 2019, establish an information request management governance board, and develop and implement guidance and technological solutions to streamline the information request process. • By the end of second quarter FY 2019, develop and integrate FE Headquarters Budget Allocation Tracking System (BATS) and the Financial Accounting and Control System (FACS) into a single enterprise-wide resource management and executive-level reporting dashboard for program direction information. • By the end of FY 2019, develop and implement FE enterprise-wide, fully inclusive of field sites, a program management tool for R&D programs to include budget formulation and execution.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>4: Develop and maintain world-class organizational excellence.</p>	<p>4.2 – Promote knowledge sharing and transparent communication</p>	<p>4.2.2 – Develop, execute, and monitor a strategic communications plan for internal and external stakeholder engagement</p>	<ul style="list-style-type: none"> Establish and execute a national communications strategy that expands audience reach to new venues from the current baseline and provides a “drumbeat” of coordinated messages to inform stakeholders of key issues and progress in advancing FE’s mission. Enhance FE’s social media presence and monitor internal and external media analytics to gauge the effectiveness of communication strategies on a monthly basis. Conduct management and innovation lunchtime forums at least monthly to promote an improvement and innovation culture.
	<p>4.3 – Foster responsible stewardship of resources, facilities, a safe work environment, and the communities FE serves</p>	<p>4.3.1 – Strengthen values-based safety culture and maintain the highest standards of workplace safety, health, and security for all employees, facilities, and information</p>	<ul style="list-style-type: none"> Enterprise-wide, maintain a safe workplace by achieving a quarterly recordable case rate of less than 1.6, a Days Away/Restricted Time (DART) case rate of less than 1.0, and a DART rate of less than 1.5. Enterprise-wide, strive for zero major security incidents and emergency events with a target of less than five per year. Ensure enterprise-wide compliance with cyber security plans and report quarterly on cyber security vulnerability. Review recommendations provided by the Safety Performance Metrics Working Group to strive to minimize redundancies, improve safety performance, optimize allocation of safety resources, and determine the effectiveness of various safety program interventions in order to manage risk and unwanted cost. Coordinate and participate in all Continuity of Operations (COOP) activities. Oversee and coordinate all FE environmental sustainability and energy efficiency activities.

FE STRATEGIC GOAL	OBJECTIVE	SUB-OBJECTIVE	PERFORMANCE MEASURES
<p>4: Develop and maintain world-class organizational excellence.</p>	<p>4.3 – Foster responsible stewardship of resources, facilities, a safe work environment, and the communities FE serves</p>	<p>4.3.2 – Maintain environmental stewardship</p> <p>4.3.3 – Align financial and infrastructure resources to the FE Strategic Plan</p>	<ul style="list-style-type: none"> • Achieve a grade of “Green” based on a five-criteria Environmental Management System/Office of Management and Budget metric annual rating. • By the end of second quarter FY 2019, develop an FE Technology Roadmap that fits within and enhances the current FE Strategic Planning system. • Semi-annually fully leverage acquisition and financial assistance tools to prioritize competing requests for facilities and/or other resources and maximize return on investment and value, using contracting metrics, Funding Opportunity Announcement monitoring, and Investment Review Boards.

APPENDIX C

External Interactions

Interdepartmental

FE regularly seeks out opportunities to engage with other DOE offices in areas where synergies exist between their programs. Some of the most notable collaborations include energy-water systems, subsurface science and engineering, critical materials development, grid modernization, high-performance computing, and cyber-security.

Other Government Agencies

Many agencies—Federal, state, local, and tribal—perform work that is critical to safe and effective fossil energy resources development. FE seeks opportunities for detailed, technical, interactive, interagency engagement to address the barriers and challenges associated with the demonstration and deployment of emerging, private-sector fossil energy technologies. FE's strong analytical capabilities and technical knowledge can help provide objective science-based information to other Federal agencies and departments regarding fossil energy-related policy decisions, including the U.S. Environmental Protection Agency, the U.S. Department of Transportation, and the U.S. Department of the Interior, as well as state governments. Such information helps improve actions related to tax policies, regulations, permits, and other programs that impact coal, oil, or natural gas production, use, and export. FE also works with DOE's Office of Indian Energy Policy and Programs to engage with tribal organizations across the country, and FE engages state organizations directly, as well as other entities that involve collaborations among state representatives. Such coordination can also lead to more consistent and timely information exchanges, enhancing communication and awareness between the government and stakeholders on issues such as Federal funding opportunities and project accomplishments and milestones.

Advisory Committees and Partnerships

FE manages three formal Federal Advisory Committees—the National Coal Council, the National Petroleum Council, and the Methane Hydrates Advisory Committee. The advisory committees include representatives from industry, academia, and non-governmental organizations and are tasked with providing recommendations to the Secretary of Energy regarding fossil energy R&D and supporting policies. Additionally, FE forms public/private partnerships with industry, academia, and other private organizations and leverages workshops, seminars, and requests for information to gather data from the private sector that is useful for planning processes.

International

FE engages with international partners to help ensure global energy security, accelerate fossil energy R&D, and share technical information regarding safe and environmentally sound development and use of fossil energy resources. FE also utilizes its expertise to support the broader mission, goals, and objectives of the Administration, DOE, and other Federal government departments and agencies with fossil-energy related international interests and responsibilities.

FE supports and implements activities with international partners that focuses on joint R&D and large-scale projects, as well as the exchange of information on technologies, best practices, regulations, financing, and cost and performance analyses of new technologies. These exchanges include bilateral collaboration with several countries on ongoing carbon capture, utilization, and storage efforts. Due to natural gas becoming a more viable product, FE also shares the latest knowledge and information on LNG technologies and unconventional oil and gas recovery. For those countries without an existing bilateral relationship, FE engages directly through several other avenues, including the Carbon Sequestration Leadership Forum, the International Energy Agency, and the Asia-Pacific Economic Cooperation.



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