the ENERGY lab

PROGRAM FACTS

Strategic Center for Coal

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Overview

As the Department of Energy's (DOE) sole government-owned and -operated national laboratory, the National Energy Technology Laboratory (NETL) develops technology options that enable America to continue benefiting from its abundant, affordable coal resources, helping ensure a secure energy future. NETL's Strategic Center for Coal (SCC) shapes, funds, and manages the development of carbon capture and storage (CCS) technologies at existing and new power plants and industrial facilities that require a range of capture alternatives and CO_2 storage options for a variety of geologic formations. In parallel, to drive down the cost of implementing CCS as a climate change mitigation strategy, the SCC supports R&D aimed at investigating a range of advances in combustion, gasification, turbines, fuels, and fuel cell technologies that can increase power plant efficiency, improve plant economics, and reduce the amount of CO_2 byproduct per unit of electricity generated.

FE Research — The Return on Investment

16 million tons of avoided NO_x emissions 2000–2020[1] *37 million tons of avoided SO_2 emissions 2000–2020[1]*	*1.2 million jobs created 2000–2020[1]* *Thousands of scientists and engineers trained*	*$111 billion in benefits 2000–2020[1]* *$13 return for every $1 invested[1]*	*650 U.S. fossil energy patents 1976–2013[4]*	*58 GW of mercury-control technology installed [2]* *148 GW projected by 2015[3]*	*$1.9 trillion in health benefits[5]* *FE research contributes to EPA-estimated health benefits from reduced pollution 1990–2020*

Return on Investment from Fossil Energy R&D

[1] Bezdek, R. Wendling, R., The Return on Investment of the Clean Coal Technology Program in the USA. Energy Policy, Vol. 54, March 2013, pp. 104-112

[2] Institute of Clean Air Companies, http://www.icac.com/?page=Mercury_Controls, Updated Commercial Hg Control Technology Bookings (October 2011), Accessed 8-21-13

[3] EPA Base Case, IPM analysis of EGU GHG NSPS, downloaded from http://www.epa.gov/airmarkets/progsregs/epa-ipm/proposedEGU_GHG_NSPS.html, 8/21/13

[4] USPTO online search 08/29/13 on ABST/("fossil fuel*" OR coal OR oil OR petroleum OR "natural gas" OR methane OR hydrate) AND (electric* OR energy OR power OR generat* OR turbine) AND (AN/"department of energy" OR GOVT/"department of energy")

[5] The Benefits and Costs of the Clean Air Act from 1990 to 2020, U.S. EPA Office of Air and Radiation, March 2011

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The SCC performs energy research for DOE's Clean Coal Research Program (CCRP). Administered by the Office of Fossil Energy's Office of Clean Coal, the CCRP focuses on development of efficient, cost-effective energy systems that capture and store CO_2. These systems will enable our fossil fuel resources to remain a major contributor to the nation's "all of the above" energy strategy, allowing the United States to realize a significant return on its current fossil energy technology research and development investments, as it has in the past.

Benefits of Public Investment in Research

As part of the Energy Department's Office of Fossil Energy, NETL uses the public's investment to carry out high-risk, high-value research, development, and demonstration (RD&D) that can:

- Accelerate the development of new energy technologies beyond the pace dictated by normal market or regulatory forces.
- Expand the slate of beneficial energy options beyond those developed by the private sector on its own.
- Invest in longer-term, high-reward R&D to develop "transformational" breakthrough technologies that achieve environmental, efficiency, and cost goals well beyond those currently pursued by the private sector.

The SCC manages the technology development process, beginning with lab- or bench-scale testing. This early, foundational research is relatively inexpensive and is funded with up to an 80-percent government cost share. The University Coal Research and the Historically Black Colleges and Universities and Other Minority Institutions programs require no cost share. Researchers typically explore a variety of ideas early on, but as the most promising concepts are advanced, the number of options actively being pursued decreases, while the scale of the efforts and private-sector cost sharing increase. Government-funded research managed by the SCC culminates in large-scale testing performed by public/private partnerships to enable technology to more quickly achieve its cost, reliability, performance, and environmental objectives; position it for deployment; and enable the ensuing public benefits to be realized.

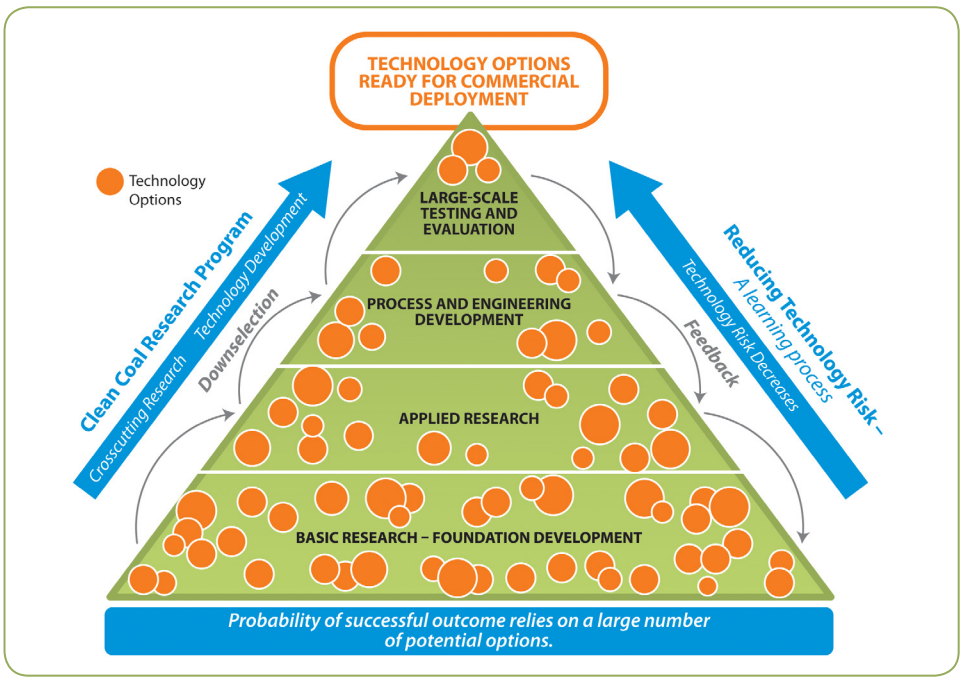
SCC Offices

Office of Coal and Power R&D

The SCC's Office of Coal and Power R&D manages the CCRP's technology development efforts from inception through maturation, positioning the most promising technologies for demonstration-scale testing and evaluation. The elements of the CCRP managed by this office are organized into the following program areas:

Advanced Energy Systems—This research is aimed at developing a new generation of clean coal-fueled energy conversion systems capable of producing competitively priced electric power while reducing CO_2 and other emissions, improving efficiency, increasing plant availability, and reducing cooling water requirements. Key aspects of this research include improving overall system thermal efficiency, reducing capital and operating costs, and enabling affordable CO_2 capture. Technology research areas include:

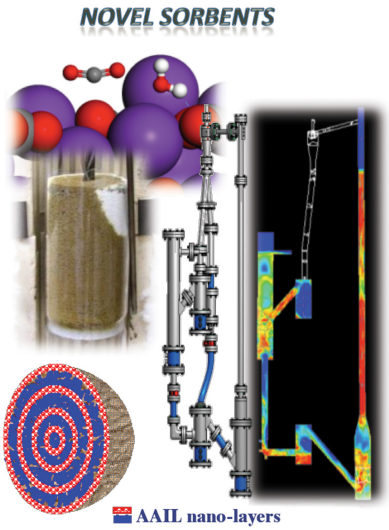
- ***Gasification Systems*** that convert coal into clean synthesis gas (syngas) that can, in turn, be converted into electricity, chemicals, hydrogen, and liquid fuels to suit market needs.
- ***Advanced Combustion Systems*** using new high-temperature materials and oxy-combustion technologies.



- ***Advanced Turbines*** that efficiently and cleanly convert fossil fuels, including hydrogen and other high-temperature working fluids like supercritical CO_2 and steam, to useful electric power.

- ***Solid Oxide Fuel Cells*** for low-cost, highly efficient power systems capable of producing electric power from coal with carbon capture when integrated with coal gasification.

Carbon Capture—Technologies developed through this research could reduce both the cost and energy penalties associated with currently available technology options. The Carbon Capture area addresses the challenges that stymie cost-effective implementation of carbon capture technologies throughout the power-generation sector. Researchers are investigating liquid solvent, solid sorbent, and membrane-based capture technologies, as well as advanced compression (novel internal cooling, cryogenic pumping) for both combustion- and gasification-based energy conversion systems in new and existing power plants.



Carbon Storage—Onshore and offshore technologies that enable safe, cost-effective, permanent geologic storage of CO_2 throughout the United States are developed and advanced through this research. The technologies being developed are intended for widespread commercial deployment and will benefit industrial and power sector facilities that will need to reduce future CO_2 emissions. The Carbon Storage area increases understanding of the effectiveness of these advanced technologies and management approaches in different geologic reservoirs appropriate for CO_2 storage. It also improves our ability to quantify the behavior of CO_2 in the subsurface.

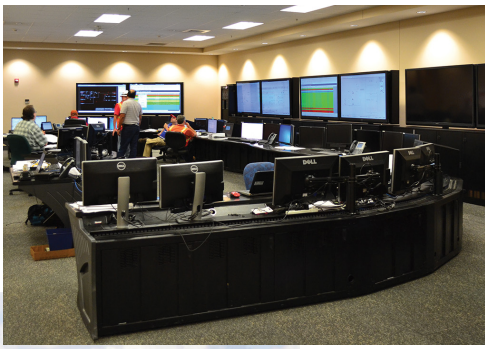
Crosscutting Research— Projects under Crosscutting Research develop tools and technologies that offer step-change improvements in the design and operation of advanced power systems and emerging carbon capture and storage technologies. Crosscutting areas that support these advancements include high performance materials, novel sensor and control technologies, and state-of-the-art computation and simulation-based engineering capabilities. The primary focus is on applied research using a multidisciplinary approach aimed at addressing barriers to clean, efficient fossil energy-based power generation.

Crosscutting Research also leads research-based educational programs aimed at training the next generation of scientists and engineers. This area oversees the longstanding University Coal Research (UCR) Program and the Historically Black Colleges and Universities and Other Minority Institutions Programs (HBCU/OMI). It further supports innovative energy concepts for efficient, environmentally friendly, and cost-effective fossil fuel-based power generation. The research is focused on growing and evaluating concepts and determining their viability. Finally, this area oversees projects and programs related to water use/reuse and emissions control technology. Research collaborators include other DOE national laboratories, other government agencies, and large and small businesses.

Office of Major Demonstrations

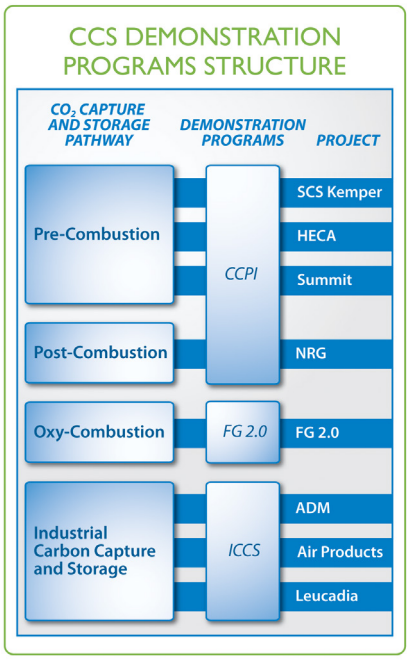
The SCC's Office of Major Demonstrations manages the CCRP's portfolio of large-scale technology demonstration projects. Advanced technologies developed by the research programs within the CCRP must be tested at full scale in an integrated facility before they are ready for commercial deployment. To achieve success in the marketplace, technical, environmental, and financial challenges associated with the deployment of new advanced coal technologies must be overcome. Commercial-scale demonstrations help industry understand and overcome component scale-up, integration and startup performance issues. By reducing the risk profile associated with new and often first-of-a-kind technologies, the opportunity for private financing and investment for subsequent plants is greatly improved.

Kemper IGCC Demonstration Project – Under Construction April 2013



These demonstrations are categorized into four CO_2 capture pathways, each followed by CO_2 storage:

- ***Pre-combustion***—A hydrocarbon fuel is gasified, and the resulting carbon monoxide is converted to CO_2 that is captured from the synthesis gas before it is combusted.
- ***Post-combustion***—CO_2 is captured from the stack gas after a fuel has been combusted in air.
- ***Oxy-combustion***—A hydrocarbon fuel is combusted in an advanced combustion system in pure or nearly pure oxygen, rather than air, producing a mixture of CO_2 and water that can easily be separated to produce pure CO_2.



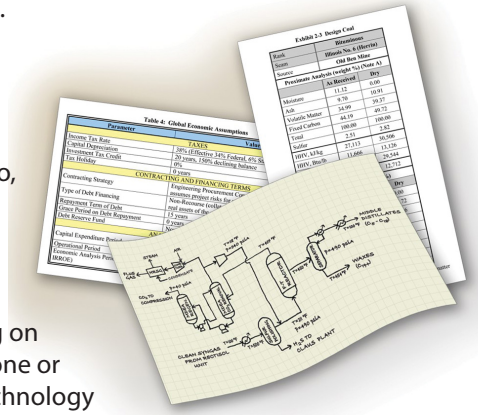
- ***Industrial Carbon Capture and Storage***—CO_2 is captured from industrial sources that produce a variety of commodities, including power.

Demonstration of key CCS technologies is currently achieved via eight diverse power-generation and industrial platforms. These demonstration platforms represent various technology configurations, utilize a diverse set of feedstocks, produce a variety of commodities, and utilize the captured CO_2 in multiple ways, including producing chemicals or facilitating oil recovery from depleted fields. The CO_2 may also be permanently stored in saline reservoirs.

Office of Program Performance and Benefits

Within the SCC, the Office of Program Performance and Benefits performs analyses that help guide and evaluate RD&D programs and inform related policy and regulatory decisions. The Performance Division of this Office conducts component-level and plant-level process and cost engineering analyses to assess the current and potential environmental and economic performance of advanced technologies. It compares their projected performance to that of existing and competing technologies and assesses their ability to achieve relevant R&D goals. The Benefits Division of this Office conducts higher level engineering and macroeconomic analyses using regional or national data to assess the national benefits of RD&D programs resulting from the impacts that advanced technology options have on the economy, the environment, and energy security.

The CCRP's technology areas sponsor the performance of systems analyses to aid in program evaluation and execution, increasing overall effectiveness. These analyses span technology evaluations, engineering and economic analyses, performance assessments, and market studies.



To evaluate the advanced technologies in NETL's R&D portfolio, researchers synthesize and model conceptual energy conversion processes, focusing on the integration of one or more advanced technology components into the overall system. The results of these studies are used to identify cost and performance requirements for new technologies, screen candidates for R&D funding, compose R&D roadmaps, and support the definition, monitoring, and attainment of R&D goals. To establish a technology benchmark, NETL also completes and regularly updates studies that quantify the baseline cost and performance of current state-of-the-art energy conversion technologies. These NETL studies—based in large part on quotes and estimates from technology vendors and major engineering, procurement, and construction firms—have been widely referenced within the relevant energy analysis community.

The economic, environmental, and energy security benefits of NETL's R&D programs are estimated under various scenarios by forecasting the deployment of advanced technologies in competitive markets. Macroeconomic analyses are primarily performed using the Energy Information Administration's (EIA) National Energy Modeling System (NEMS). When NEMS lacks the capability to adequately portray certain advanced technologies, NETL modifies NEMS to add the required functionality. This effort has led to a productive collaboration with the EIA, including the adoption into NEMS of new models developed by NETL for the transport and storage of captured CO_2, that features the option of utilizing CO_2 for enhanced oil recovery. Other tools used by NETL to perform macroeconomic analyses include the Energy Velocity Suite for data on U.S. power plants and the FE/NETL Econometric Input/Output Model for estimating GDP and employment impacts. A comprehensive inventory of NETL's published analyses may be found on the NETL website.[1]

[1] http://www.netl.doe.gov/energy-analyses/refshelf/Default.aspx and http://www.netl.doe.gov/technologies/coalpower/refshelf.html