

June 2007

Coal Research and Development to Support National Energy Policy

Coal provides nearly a quarter of U.S. energy supplies and is used to generate more than half of the nation's electricity. Although future demand for coal may be impacted by regulation of carbon dioxide emissions, coal use is expected to remain constant or even increase over the next several decades. An increased investment in research and development is needed to ensure that the nation's coal resource is used efficiently, safely, and in an environmentally responsible manner.

The coal mining and processing industry in the United States is a relatively small but vitally important component of the nation's economy. About 80,000 miners produce more than one billion tons of coal in the U.S. each year. Investment in coal-related research and development (R&D) is a critical requirement for continued advances in efficiency, safety, and productivity.

Overwhelmingly, the environmental impacts of coal use, especially carbon dioxide emissions associated with global climate change, pose the greatest potential constraint on future coal utilization. Forecasts suggest that demand for coal over the next 10-15 years is likely to range from 25 percent above to 15 percent below 2004 levels. Further into the future, forecasts range from 70 percent above to 50 percent below 2004 levels. Even with the uncertainty regarding future emissions regulations, coal will continue to provide a major portion of the energy required in the United States for at least the next several decades.

In 2005, over 90 percent of federal R&D funding supported "downstream activities," that is, those associated with the clean and efficient utilization of coal (primarily electric power generation in power plants). Less than 10 percent of funds supported the various "upstream" coal mining and processing activities (see Figure 1, p. 2). At the request of Congress, the National Research Council convened a committee to assess coal-related R&D, focusing primarily on those needs that support upstream activities. The committee was also asked to highlight any potential obstacles to increased coal production.

There is a critical need for R&D investment to support coal mining and processing, to assess the location, size, and quality of the nation's coal reserves; improve worker safety; reduce environmental impacts; and increase mining productivity. The report recommends increased coordination of coal-related R&D among federal agencies, with participation of states, industry, and academic institutions. The total new funding to support these activities amounts to approximately \$144 million per year (see Table 1, p. 4).



Surface mining in the Powder River Basin, Wyoming

Assessing the Location, Quantity, and Quality of U.S. Coal Reserves

Accurate and comprehensive estimates of national coal reserves are essential for a coherent national energy strategy, particularly for community, workforce, and infrastructure planning. Although the United States is endowed with a vast amount of coal, coal reserves (i.e., the coal that can be economically mined using current mining practices) are a small proportion of total coal resources.

Present estimates of coal reserves—which take into account location, quality, recoverability, and transportation issues—are based upon methods that have not been updated since their inception in 1974, and much of the input data were compiled in the early 1970s. Recent programs to assess coal recoverability in limited areas using updated methods indicate that only a small fraction of previously estimated reserves are actually recoverable. Such findings emphasize the need for a reinvigorated coal reserve assessment program using modern methods and technologies.

A coordinated federal-state-industry initiative to determine the magnitude and characteristics of the nation’s recoverable coal reserves, using modern mapping, coal characterization, and database technologies, should be instituted with the goal of providing policy makers with a comprehensive accounting of national coal reserves within 10 years. The report estimates that such an initiative, which should be led by the U.S. Geological Survey and involve participation by the Energy Information Administration at DOE, states,

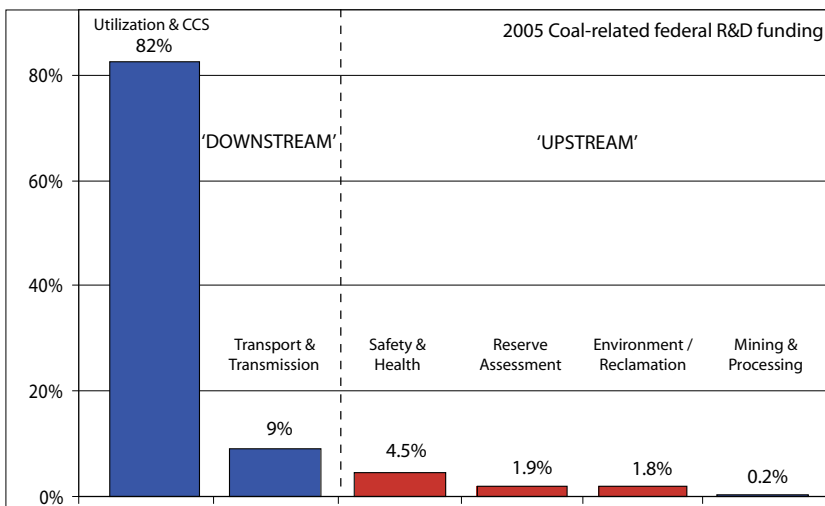


Figure 1. In 2005, over 90 percent of federal R&D funding supported “downstream activities” associated with the clean and efficient utilization of coal (primarily electric power generation). Less than 10 percent of funds supported the various “upstream” processing activities.

and industry, will require additional funding of approximately \$10 million per year.

Using Our Nation’s Coal Resources Wisely and Safely

The coal mines of the future will encounter a range of new or more difficult mining and processing challenges as more easily accessed coal seams are depleted and the industry turns to less accessible reserves. Increasingly difficult mining conditions will require improved methods to protect the health and safety of mine workers, careful environmental management of mined lands and waste products, and improved recovery to optimize the use of coal resources.

Improved Worker Health and Safety

A range of factors increase health and safety risks to the coal mining workforce, including the introduction of new equipment and systems, mining in virgin areas, training requirements of new workers, and the mining of multiple seams, seams that are thinner, thicker, or deeper than those mined at present, and new seams that underlie or overlie previously mined seams. There are major knowledge gaps and technology needs in the areas of survival, escape, communications systems, and emergency preparedness and rescue. Health and safety R&D should be expanded to anticipate increased hazards in future coal mines, emphasizing methane control,

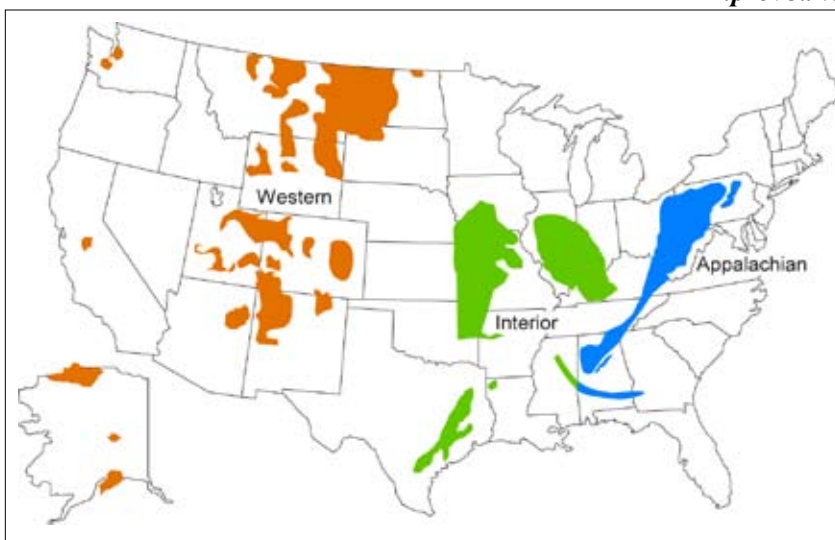


Figure 2. Major coal-producing regions in the United States. SOURCE: EIA

mine ventilation, roof control, repetitive and traumatic injuries, respiratory disease, escape and rescue procedures, communications systems, and research to reduce explosions and fires. R&D should also be directed toward lowering the exposure of mine workers to hazardous conditions, particularly through expanded use of remote sensing and the automation of mining operations.

The report estimates that an enhanced health and safety program would require approximately \$35 million in additional annual funding, and recommends that NIOSH continue as the lead agency with enhanced coordination with MSHA and industry.

Improved Environmental Protection

As mining activities extract coal from deeper and operationally more difficult seams, a range of existing environmental issues and concerns will be exacerbated and new concerns are likely to arise, particularly related to greater disturbance of hydrologic systems, ground subsidence, and waste management at mines and processing plants. Research activities should focus on developing techniques to mitigate the alteration and collapse of rock layers overlying mined areas, to model the hydrological impacts of coal mining, to improve mine mapping and void detection, to increase stability of waste heaps on steep slopes, and to improve the construction and monitoring of coal waste impoundments. Research also offers considerable potential to mitigate the effects of past mining practices, particularly acid mine drainage on abandoned mine lands.

The report estimates that additional annual funding of approximately \$60 million will be required to conduct the research necessary to achieve these goals, and recommends that OSM should lead the coordinated effort, with participation by EPA, states, and industry.

Mine Productivity and Resource Optimization

Although technology developments and industry changes have increased the productivity of U.S. coal mines considerably over the past three decades, mining companies and equipment manufacturers have made only incremental improvements in recent years. Over the past decade, there has been little R&D directed towards truly advanced mining technologies. Only 0.2 percent of total federal coal-related R&D funding is directed towards development of the advanced mining technologies and practices that will be

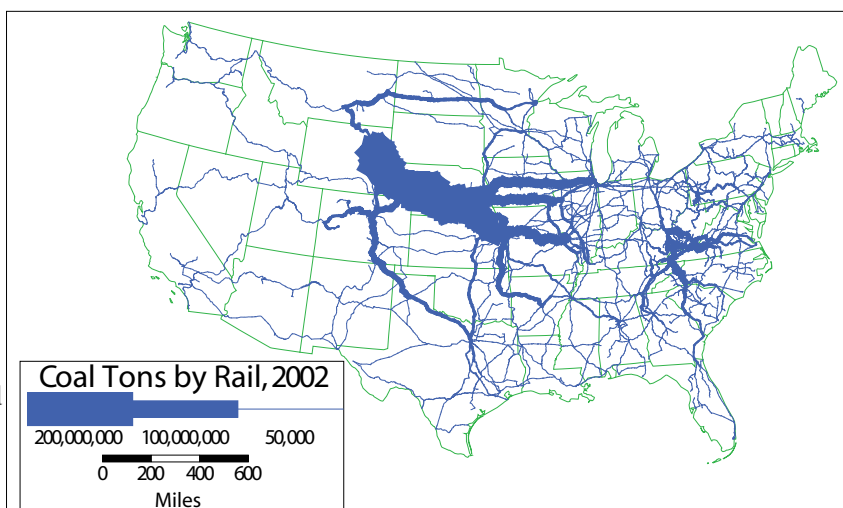


Figure 3. Schematic showing coal tonnage transported by rail in 2002. SOURCE: courtesy Bruce Peterson, Center for Transportation Analysis, Oak Ridge National Laboratory

necessary to optimize utilization of the nation's coal resource. Small percentage increases in coal recovery have the potential to significantly expand economically recoverable coal reserves, and advanced technologies will be needed as coal reserve quality decreases over time.

The report recommends renewed support for advanced coal mining and processing R&D with a focus on developing and deploying improved materials, sensors, and controls; monitoring; and automated mining systems. Support for advanced coal mining and processing R&D will require a total of approximately \$30 million per year in federal funds, with additional cost-sharing from non-federal sources. The Office of Fossil Energy at DOE should lead the effort, with participation by NSF, OSM, NIOSH, academic institutions, and industry.

Transport of Coal

Growth in the use of coal depends on having sufficient capacity to deliver increasing amounts of coal or electricity derived from coal reliably and at reasonable prices to an end user. The capacity, reliability, and price of rail transportation—the dominant mode of coal transport—depend largely on supply and demand factors, as well as on prevailing business practices, the investment climate, and the nature of regulatory oversight of the railroad industry. Reliable and sufficient waterborne transportation—the second most prevalent method of coal transport—depends on the construction and maintenance of waterway infrastructures, especially lock-and-dam infrastructure and port capacity.

The coal transportation and electrical transmission systems are large and complex networks where

localized disruptions can have severe and wide-spread impacts. An improved understanding of the factors that control these networks will help to minimize the risks of cascading system disruptions.

Carbon Sequestration

If coal is to continue as a major component of the nation's future energy supply in a carbon-constrained world, large-scale demonstrations of carbon capture and sequestration (CCS) to reduce CO₂ emissions from coal-based power plants will be required. Detailed assessments are needed to identify potential geological formations that are capable of sequestering large quantities of CO₂. The USGS should play a leading role in a program to identify, characterize, and catalogue the CO₂ sequestration capacity of potential geologic sequestration resources, with participation by the DOE Carbon Sequestration Program and state agencies.

Conclusion

Coal will continue to provide a major portion of energy requirements in the United States for at least the next several decades, and it is imperative that policy makers are provided with accurate information describing the amount, location, and quality of the coal resources and reserves that will be available to fulfill these energy needs. It is also important that we extract our coal resource efficiently, safely, and in an environmentally responsible manner. A renewed focus on federal support for coal-related research, coordinated across agencies and with the active participation of the states and industrial sector, is a critical element for each of these requirements. Table 1 summarizes the report's R&D funding recommendations.

Table 1. R&D FUNDING SUMMARY	FY2005 Funding (\$M)	Proposed New Funding (\$M/yr)	Total Proposed Funding (\$M/yr)
Resource & Reserve Assessments and Characterization (coal & CO ₂) USGS + DOE-EIA, DOE-FE, states, industry	10	20	30
Mine Worker Health and Safety NIOSH + MSHA, industry	25	35	60
Environmental Protection and Reclamation OSM + EPA, states, industry	10	60	70
Mining Productivity and Resource Optimization DOE-FE + NSF, OSM, NIOSH, academic institutions, industry	1	29	30
TOTALS	46	144	190

Committee on Coal Research, Technology, and Resource Assessments to Inform Energy Policy: Corale L. Brierley (*Chair*), Brierley Consultancy LLC, Highlands Ranch, Colorado; **Francis P. Burke**, CONSOL Energy Inc. (retired), South Park, Pennsylvania; **James C. Cobb**, University of Kentucky, Lexington; **Robert B. Finkelman**, University of Texas at Dallas; **William Fulkerson**, Institute for a Secure and Sustainable Environment, University of Tennessee, Knoxville; **Harold J. Gluskoter**, U.S. Geological Survey (emeritus), McLean, Virginia; **Michael E. Karmis**, Virginia Polytechnic Institute and State University, Blacksburg; **Klaus S. Lackner**, Columbia University, New York; **Reginald E. Mitchell**, Stanford University, California; **Raja V. Ramani**, The Pennsylvania State University, University Park; **Jean-Michel M. Rendu**, Mining Consultant, Englewood, Colorado; **Edward S. Rubin**, Carnegie Mellon University, Pittsburgh, Pennsylvania; **Samuel A. Wolfe**, New Jersey Board of Public Utilities, Newark; **David A. Feary** (*Study Director*), National Research Council.

This report brief was prepared by the National Research Council based on the committee's report. For more information, contact the Board on Earth Sciences and Resources (202) 334-2744 or visit <http://nationalacademies.org/besr>. Copies of *Coal: Research and Development to Support National Energy Policy* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.

