This study focuses on six primary components related to the upstream coal production cycle that could influence the ability of the U.S. coal industry to meet projected production targets over the next few decades and achieve a coal production capacity consistent with the nation’s long-term energy goals and environmental aspirations. Although much of the data and analysis included in the study focuses on the next two decades, to the year 2030, many of the issues have a longer time horizon.

The upstream addressed by this study are: coal resources and reserves; mining technology and resource optimization; coal preparation; health and safety issues; environmental protection, practices, and standards; and workforce challenges. The study reviews each topic in detail. It identifies problems, discusses progress and strengths, and recommends areas of improvement. Where appropriate, the discussion references the broad coal sector and community (i.e., coal industry, government, equipment suppliers, academia, environmental groups, and the public).

While preparing the study and formulating the conclusions, the Report Committee received valuable input from industry leaders, government agency employees, academics, other experts in the field, and interested citizens, all of whom contributed towards framing the discussion around the six major issues.

The central findings and themes of this study, extensively supported by background information, discussions, and conclusions in the main chapters of this report, are presented below.
1. INFORMATION CHALLENGES

There is a fundamental need for better and timelier data related to all aspects of the coal sector. Much of the information that would enable sound decision-making regarding the future of coal production, including scientific data and information on current performance, is not available. Government and industry must work with other stakeholders to ensure the information is collected, disseminated, and analyzed in a way that is useful.

All six chapters clearly demonstrate and document the need for publicly accessible and reliable information. In many cases, the data necessary to make sound judgments regarding coal reserves, the effectiveness of current or proposed environmental or health and safety regulatory programs, the demographics of current and future labor pools, and other such issues were either difficult to obtain or simply not available. By way of comparison, information and data from several federal regulatory agencies, the Energy Information Administration, the U.S. Geological Survey, the International Energy Agency, and Office of Surface Mining Reclamation and Enforcement on reserves, production, and environmental performance for the coal sector are far less available than that for the oil and gas sectors. In today’s information-based society, information and access to data and other substantive knowledge are critical for decision-makers in industry, government, and the public sector. It is therefore essential that regulatory, scientific, and resource-management agencies, and private entities collect and make available useful and timely information related to coal production.

2. TECHNOLOGY NEEDS

To address changing conditions, there is a need to develop and adopt better technologies in all facets of the upstream cycle. Although new technologies are imperative for effective and efficient coal production and for improving health and safety conditions and environmental performance and stewardship, over the past few years, the reduction of government and private R&D investment has limited their development and adoption. Government, the coal industry, and academic and research institutions must work together to increase funding in this area.

The reduction of government funding, in particular, including the elimination of the U.S. Bureau of Mines in the 1990s, has significantly impacted the U.S. R&D infrastructure necessary to support the coal sector. The preservation of knowledge in crucial technical areas of coal mining is threatened by the lack of support for graduate-level research programs and Ph.D. programs in a number of areas (e.g., ventilation, mining systems, coal preparation, reclamation/restoration).

Large, global mining equipment manufacturers and vendors are engaged in equipment- and product-oriented R&D that benefits the coal industry as a whole. In addition, other new technologies also enter the U.S. coal mining sector from international R&D efforts, mainly from Australia. Because equipment manufacturers benefit from selling equipment to broader industrial markets, special equipment needs of the relatively small coal sector often go unmet. On top of this, equipment manufacturers
are often committed to evolutionary development of already existing product lines, rather than researching revolutionary technologies and alternatives to existing approaches. Products and technologies developed internationally often do not meet specific challenges of U.S. mining conditions, such as mining thin coal seams, alternatives of mining under the severe topography encountered in the Appalachian region, novel methods of cleaning and processing U.S. quality coals, and meeting national environmental and health and safety concerns and regulatory measures.

Advanced technologies are needed for U.S. coal operations to integrate mining systems with the geologic environment and allow more predictable and truly continuous operations. Increased introduction of automatic mine monitoring systems for air, water, ground stability, and other important parameters will enhance health, safety, productivity, and production. To reduce the ergonomic stresses that accompany working in thin seams, it is necessary to develop automatic and autonomous controls on underground mining machinery.

Coal quality is expected to decline, necessitating new technologies to process this new coal. In the Appalachian and Interior regions, new technologies are required to process feed coals with increasingly difficult washing characteristics. Because western coals have traditionally required little preparation, Western coal operations could potentially face even greater challenges if additional coal preparation is needed.

Although significant progress has been made in the last 30 years in implementing changes in coal mining and reclamation practices to protect the public and the environment, increased attention must focus on technologies in other areas described in this report, such as water resources protection, revegetation practices, air quality concerns, and waste management, including excess spoil placement and stream buffer zones.

Because of economic and technical risks and the large investments required, few mining companies undertake cutting-edge research and development. Concerns over competitive advantage have limited collaboration, and equipment manufacturers are reluctant to invest in technology unless there is a proven market for adoption. Thus, there is a need for greater involvement in and support of mining technology research by the federal government and the private sector to meet these challenges.

3. IMPROVING PERFORMANCE

There is a fundamental need to change the culture of the entire coal sector to one that focuses on “beyond compliance” approaches to dealing with regulations and public trust. To become publicly accountable, the coal industry must voluntarily adopt practices that go beyond minimum standards and assume beyond compliance practices. Additionally, government agencies must also be accountable and focus on continuously improved science-based regulations and technology transfer. Beyond compliance for government agencies should include a greater amount of technical and compliance assistance and active involvement with local, state, and corporate entities in ensuring public education on environmental and health and safety issues.
The coal industry as a whole should widely adopt the approaches that several leading companies already practice to achieve results that go beyond what is required for compliance. While this philosophy has predominantly focused on environmental and health and safety standards and performance, many companies have also been effective in using this approach to address workforce issues, develop and adopt new technology, and share information. Additionally, government agencies must provide more technical assistance to support innovative methods and practices. The agencies must also go beyond their minimum required performance in regulating, developing technology, and providing information.

The recent adoption of more sophisticated risk management approaches by both industry and regulators to address environmental and health and safety issues is a good example of exceeding the minimum standards and requirements of current regulatory programs, allowing for better performance and potentially leading to a greater societal acceptance of coal production and utilization. A number of coal producers are involved in “beyond compliance” practices such as supporting local economic development, strengthening social and infrastructure capacity, and practicing environmental protection, restoration, and post-mining land use. These companies have corporate sustainable development policies and guidelines in place that provide guidance for operations and community involvement. Management leadership must establish higher environmental performance standards and actively pursue engagement with all stakeholders and interested parties within the community to ensure that coal mining is conducted in a responsible manner.

Companies noted for beyond compliance mine health and safety approaches have enjoyed better reputations with the workforce and the public. Mining companies must go beyond mine safety regulations, conduct thorough assessments of risks, and identify methods to eliminate risks inherent in systems and processes involved in mining operations. In addition, promoting a safety culture as the top priority of senior management and setting truly ambitious health and safety goals has positive impacts throughout the organization.

4. ECONOMIC AND BUSINESS CHALLENGES

The coal mining sector must address economic uncertainty, avoid supply interruptions, and promote production stability. If coal is to remain a significant part of the energy mix in the United States, past economic and business practices that resulted in boom and bust cycles must be avoided. Supply-demand dynamics and the lucrative export market are important considerations in market stability. Many of the large coal producers are publicly traded companies and must answer to their stockholders for their business performance. Investments in new production capacity for these companies must be made on the basis of accepted business practices. Because of the need for a secure domestic energy supply, the government and coal consumers also have a vested interest in ensuring that supplies are uninterrupted and stable.
Historically, periods of increased coal prices and production (boom cycles), similar to the one currently experienced in the United States, have been followed by downturns (bust cycles), due to a short-term business focus and failure of the coal mining industry to address longer-term challenges of sustaining production capacities. This up-and-down cycle promoted instability that impacted investment, markets, coal development, infrastructure improvements, labor uncertainty, and even public trust. It was difficult to justify large-scale investment in reserves that would not be in the supply chain for several years.

In contrast, during the extended period of high coal prices in 2007 and 2008, several factors have made short-term production increases difficult. Among the causes are the long lead time needed for reserve acquisition and environmental permitting, transportation issues, lack of a skilled workforce, and shortages of mining equipment and consumable materials such as off-road tires. In the longer term, however, these factors must be addressed if coal production capacity is to meet projected future needs.

Uncertainties about health and safety and environmental laws and regulations, public acceptance of coal production and utilization facilities, and the threat of carbon legislation also make capital decisions on production expansion and equipment replacement or upgrades difficult. Opposition to coal usage has mobilized community involvement in coal mining development and permitting. The contribution of coal mining to greenhouse gas generation (methane during mining and carbon dioxide from burning coal) and, therefore, to global warming, must be critically assessed. Unless the uncertainty with regard to carbon dioxide emission control is resolved, through policy or by technological developments such as carbon capture and storage, greenhouse gas emissions from coal-fired power plants will remain a major factor impacting private and public investment in coal mining.

Additionally, the federal government should address the role of coal in the domestic energy portfolio through explicit policy. Because of the widespread availability of domestic coal resources, clarifying its importance in a safe and secure domestic energy supply will help alleviate business and economic concerns about the production and use of coal.

5. WORKFORCE CRISIS

If the coal mining sector is to remain viable, it must address a potentially significant shortfall in the workforce at all levels. Retirement of the Baby Boom Generation and the entry of new generations into the workforce in the United States and around the world will contribute to a significant shortage of an available, qualified coal mining workforce at all levels and expertise. The coal mining sector will be in competition with many other sectors for new employees and must adopt new approaches for recruiting and retention. Even if these efforts are successful, a large labor shift will have significant impacts on coal mine productivity and health and safety and this transition must be carefully managed. Although industry will be most impacted by this shortage, both government and academia must also address this looming crisis.
The coal mining sector will face significant challenges in meeting its needs for workers between now and 2030 because of retirements, migration to and from the coal sector and coal mining areas, and the potential for increased coal production. This significant workforce swing will impact all types of jobs in all areas of the coal mining sector, from coal producers to the coal community at large, and from entry-level miners to management and professional positions, and will include suppliers and service providers, educational and training institutions, and government agencies. The impending turnover in the labor force will have inevitable consequences for productivity, safety, demand for training, and corporate structure and culture.

The development of a corporate culture that is positioned to adapt to the new and changing workforce is a critical aspect of meeting the workforce challenges. The career and personal development focus that some coal mining companies have implemented has resulted in lower turnover rates and greater job satisfaction. The commitment from the top echelons of a number of companies to a corporate culture that is dedicated to safety and to nurturing workforce development is also apparent. In addition, programs focused on work life and personal growth will be critical to developing long-term loyalty and to enhancing the ability to recruit staff from locations distant from coal mining operations. Companies must adopt approaches for workforce development that include: emulating the industry leaders and benchmark practices; dealing with local issues, such as housing shortages; providing competitive salary and benefit packages; addressing perception issues by being open with local communities; developing mentoring and personal development opportunities; changing the corporate culture to build brand loyalty to the company; and developing resources for effective community recruiting, both from the region near the coal mine as well as from more remote communities with larger potential labor pools.

6. EDUCATION AND TRAINING NEEDS

_Education and training resources are not in place to ensure an adequate supply of professionals and workers and their continued development within the industry and the broad coal community_. Education and training resources need to be reinforced to address employee development at all levels related to the upstream coal sector.

Government and industry will be called upon to finance and support training and education to produce sufficient expertise to maintain the performance level of the sector. Globally and nationally, there is a severe educational crisis in the engineering and scientific disciplines related to the upstream coal mining cycle. Major problems include undergraduate recruitment and enrollment, support and sustainability of graduate students and programs, and faculty succession and development of the future professorate in mining-related fields. Resources are needed to enhance student and program support and to provide research funding opportunities that are necessary for the sustainability and growth of any coal-related discipline and professional field within the higher education environment, including engineering, geology, reclamation science, and others.
In addition, institutions providing educational opportunities in the broad mineral disciplines will not be able to expand without significant industry investment.

Building a workforce that supplies a sufficient number of skilled employees will require enhancing and expanding training centers and facilities. Companies, unions, private training vendors, federal and state agencies, and institutions should work together on this effort. Traditionally, this training has been provided by mining operators and equipment manufacturers, or through vocational programs. However, many of these programs have been discontinued. The few programs that are in place today appear to be developed by the largest mining companies for their own benefit; companies at the other end of the spectrum (smaller companies, contract mining operations, and contractors performing mining activities at coal mines) may have minimal internal training capabilities. Without additional training resources, these companies may have difficulty in staffing operations with an experienced and well-trained workforce.

A network of community colleges and vocational schools is required to train workers regionally. Traditional training must be supplemented with new training options offered by advanced simulation and virtual reality. On-the-job training and apprenticeship programs for tradespersons need to be enhanced. Development of distance learning opportunities, including interactive, Internet-based training and satellite television courses, may become necessary to meet training and vocational educational needs, particularly in remote areas.

7. **Societal Acceptability**

*It is imperative to address the societal acceptability of coal mining and utilization.* Coal is a vital energy resource today and will likely remain so for the foreseeable future. Yet, there is little appreciation of the role that domestic coal production plays in meeting the nation’s current and future energy demand in a safe and secure manner. As a result, coal production and utilization face both real and perceived challenges in societal acceptance. Therefore, for coal to remain a viable part of the domestic energy portfolio, the entire coal sector, including industry, government, academia, and nongovernmental organizations, needs to work collaboratively to disseminate factual information about the availability, importance, and impacts of coal production and use.

Much of the past information about coal production has been disseminated through the media, with varying degrees of accuracy and completeness. Often, the most readily available information has been about problems and challenges rather than advances and successes. To ensure that accurate, complete information is available for all parties, the coal industry and government agencies must directly engage local communities and citizens to share information, receive meaningful input, discuss the importance of coal with regard to domestic energy security, demonstrate environmental and health and safety performance, and share decision-making power. Unless the coal sector successfully engages the public and demonstrates its importance as an energy resource and meets the challenges identified above, the social acceptance of coal production becomes unlikely.
and coal mining and utilization may lose their social license. Given the global nature of the modern coal industry, sustainable development requirements and practices promoted in other parts of the world and even mandated by a number of major global financial institutions, will have a positive impact on the U.S. coal industry by reinforcing practices and cultures that address community and societal issues.

Some of the most serious issues facing the coal industry in the next few years are related to environmental concerns and social and community acceptance of the mining and use of coal. As a result, development and deployment of the best upstream technologies and practices and the wider acceptance and utilization of downstream advanced coal and carbon management technologies will have a significant impact on the environmental performance of coal, its acceptance, and its future sustainability and growth. Government regulators will have to increase efforts to adopt clear, science-based regulations and risk assessment protocols to assure a skeptical public that the production and utilization of coal is regulated and conducted in a manner that poses acceptable risks to human health and the environment.

It is important for the coal industry to create opportunities for engagement of all stakeholders and local communities. The coal industry, along with the rest of the mining sector, has traditionally addressed community engagement from a compliance and legal framework, and has focused on information and consultation via media releases, newsletters, websites, public meetings, and discussion groups. Most participants in the mining industry today clearly understand that local communities and local people impacted and affected by a mining operation must be openly engaged at a much higher level and in a process based on respect and ongoing dialogue. In essence, the entire industry should transition from an information-sharing, crisis, and defensive mentality to one that promotes pro-active dialogue, transparency, and public participation.

8. SUMMARY

Coal will continue to play an important role in the U.S. energy portfolio, at least until 2030, which is the scope of this study. The discussion presented in this report on upstream issues is, therefore, appropriate and much needed to identify potential challenges and recommended areas of improvement. There are also issues of safety and security with regard to meeting the nation’s energy demands from domestic sources such as coal. A cooperative effort should be established among coal producers, coal suppliers and equipment manufacturers, government agencies, academic institutions, and other nongovernmental organizations to examine system-wide economic contributions and to analyze costs and benefits to society and the environment that are created by all facets of coal operations. Elements to be addressed in such a life-cycle analysis may include factors associated with the extraction, processing, transportation, and utilization of coal. Worker health and safety issues, positive and negative environmental impacts, and contributions to the public wellbeing need to be fully assessed so that policymakers can make intelligent decisions regarding the role of coal in meeting the nation’s future energy needs.