A Vision for Achieving Ultra-Low Emissions from Coal-Fueled Electric Generation

The Coal Based Generation Stakeholders Group
January 2005

Preface

This long-term vision of coal-fueled electricity in the United States represents the consensus of Chief Executive Officers from our nation's largest coal consumers, rail carriers and producers, and the Presidents of the Associations that represent them.

As our most abundant domestic energy resource, coal is vital to ensuring low-cost electricity and providing for an economically prosperous future.

In an era of rising energy costs, low-cost electricity from coal improves the quality of life, strengthens the economy, protects national security, and offers the best potential for increasing energy independence.

These goals can all be accomplished while working toward continuous improvement in emissions, with an ultimate goal of ultra-low emissions from coal fueled electricity.

Introduction

Coal is a fuel of the present. In 2005 a record 1.143 billion tons of coal will be mined in the United States. Most of this coal will be used to generate approximately 52 percent of the electricity that our nation uses to light, heat and cool our homes, schools, hospitals and other community facilities and to run our factories.[1]

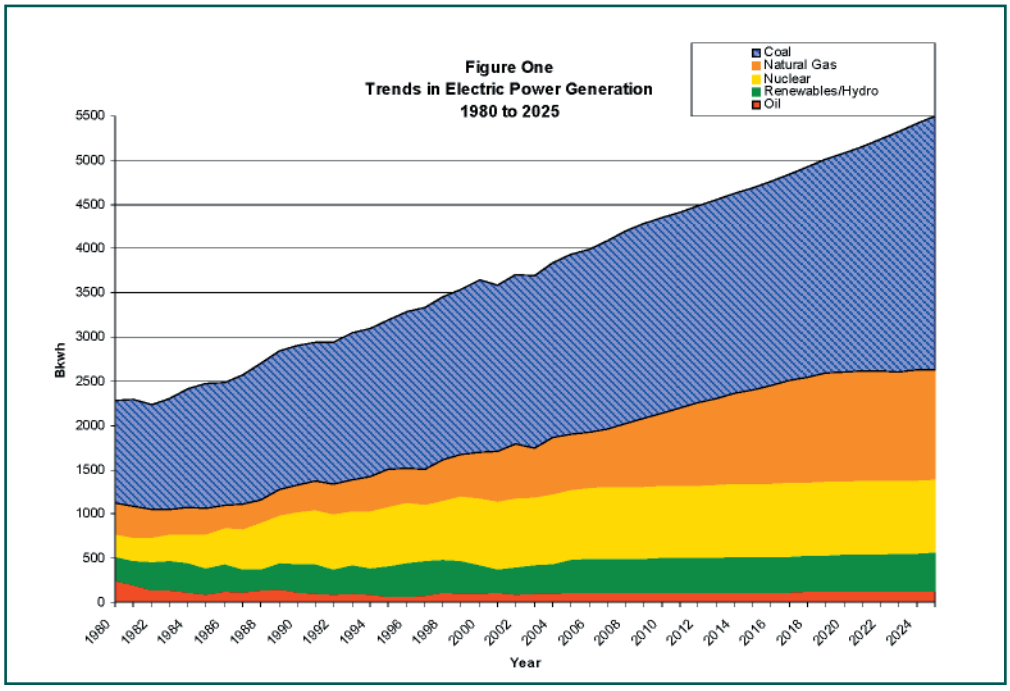
Coal is and must remain a fuel of choice in the future. Coal is our most abundant domestic fossil fuel resource, both in the United States and world wide. By 2025, 1.5 billion tons of coal will be produced in the U.S. with the majority used to produce 52 percent of the electricity that powers our nation.[2] By 2025 small amounts of coal could be used to make liquid fuels and/or hydrogen. According to the International Energy Agency, global coal use will continue to increase over the next 20 years. In 2025, coal will be the basis of over 42 percent of electricity produced globally with a higher dependence on coal in the developing world, including China (78 percent) and India (70 percent).[3]

How can coal-fueled electric generation increase while addressing the concerns about the environment? As this paper will discuss, our nation will need to rely both on the existing coal-fueled fleet and on new advanced clean coal-fueled capacity to meet growing electricity demand. To date, great strides have been made in developing technologies that produce electricity from coal while reducing emissions of sulfur dioxide (SO_2), nitrogen oxide (NO_x), particulate matter and other air pollutants such as mercury. The suite of advanced technologies that will comprise the new coal-fueled fleet will continue this trend. And work is underway to develop and commercialize technologies that are expected to achieve ultra-low/near zero net emissions from new coal-fueled generating plants. This includes technologies to address emissions of carbon dioxide (CO_2). **The United States' coal-fueled electric generators, coal producers and coal-hauling railroads believe that continuous improvement in reducing emissions from coal-fueled plants is not only desirable, it is necessary.**

Rising Coal Use and Declining Emissions

Coal has always been an important part of the United States energy mix and an integral part of our increasingly electrified economy. Coal is a domestically abundant energy reserve. The United States has recoverable coal reserves of approximately 275 billion tons, enough to last over 200 years at current recovery and usage rates. This is a significant advantage compared to domestic reserves of petroleum and natural gas. Globally, coal is an equally important resource.

Since 1980 coal use for power generation in the United States has increased by over 75 percent from 570 million tons per year to just over 1 billion tons annually. Projections show that the rate of growth in electricity demand in the U.S. will remain strong through 2025 and beyond, as illustrated in Figure One. This will be accompanied by nearly a 50 percent increase in coal fueled electricity generation.[4]



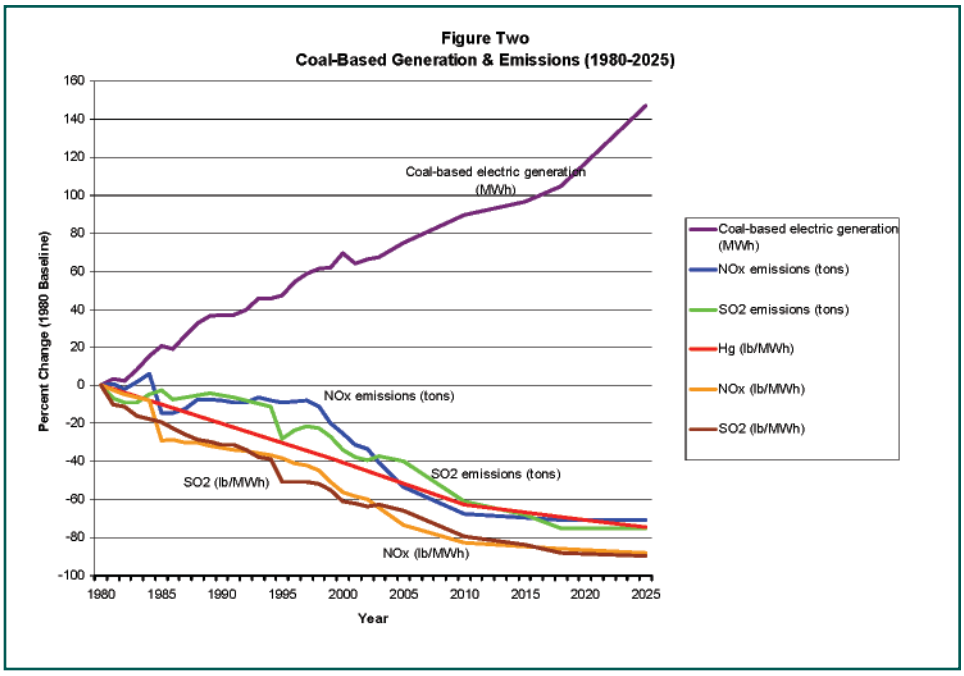
Source: EIA: Historical data: MER, December 2004; Projections: Annual Energy Outlook, 2005.

Historically, electricity demand has paralleled national GDP and population growth, and these upward trends are expected to continue as the U.S. economy, population and energy needs grow. Low-cost electricity has been shown to drive economic prosperity and a better quality of life. Coal has been a major contributor to low-cost electricity. In 2003, the average cost of coal delivered to the electric generator was 76 percent less than that of natural gas.[5] This differential is forecast to stay approximately the same through 2025 in constant dollars.[6] Sources of electricity generation other than coal – hydro, nuclear, natural gas, oil, and renewables – are limited by cost, availability of fuel, or siting constraints. Thus, coal, which now fuels more than half of electricity generated, is expected to maintain or increase its share of the electricity market.

The projected increase in coal use will come with a continued improvement in air quality. The aforementioned 75 percent increase in coal use since 1980 was accompanied by an equally impressive decline in emissions of SO_2, NO_x and particulate matter. Collectively, emissions of SO_2 and NO_x declined by 40 percent over this time period. At the same time, existing pollution controls reduced mercury emissions by some 40 percent below uncontrolled levels.

As Figure Two shows, air emissions and emission rates for NO_x and SO_2 and the emissions rate for mercury are expected to continue to fall[7] even as coal use increases.

As shown in the table below, the proposed Clean Air Interstate Rule (CAIR) and the proposed Clear Skies Act would both impose more stringent caps on power plant emissions. With continuous development of technology, and retrofitting existing plants with today's technologies, there is no doubt the industry will be able to meet the 2018 goals of the Administration's multi-emissions legislation (The Clear Skies Act) as proposed in late 2003 and re-introduced in 2005.



Source: Historical Data from EPA, Projections, AEO 2005.

U.S. Coal Plant Annual Emissions

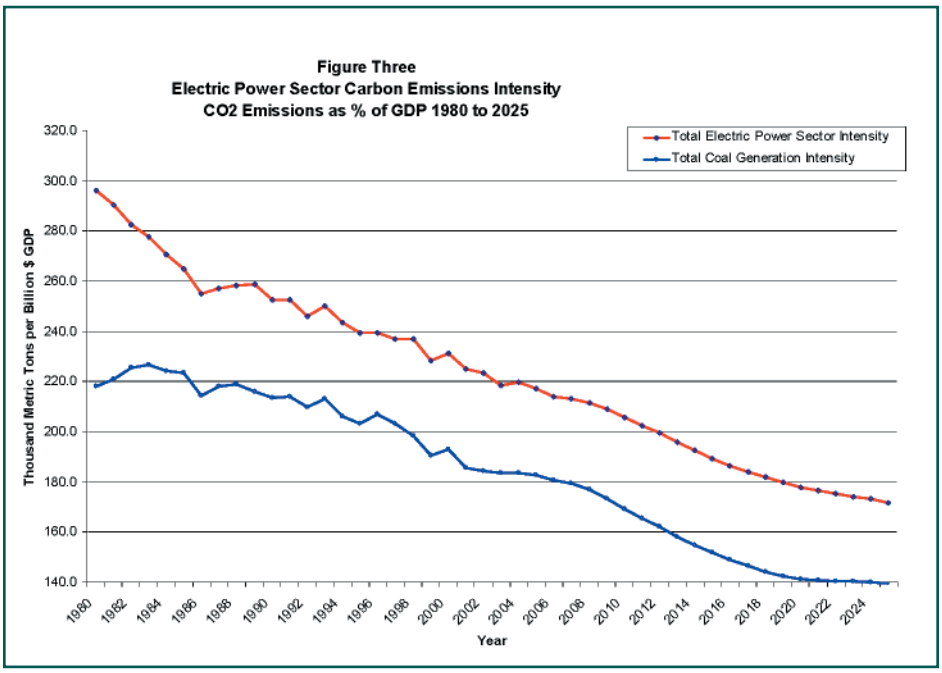
(In Million Tons)

	2003 actual emissions	2010 Clean Air Interstate Rule Cap	2015 Clean Air Interstate Rule Cap	2010 Clear Skies Act Cap	2018 Clear Skies Act Cap
SO_2	10.6	4.5	3.1	4.5	3.0
NO_x	4.4	1.8*	1.5*	2.1	1.7

* Clean Air Interstate Rule applies only to 28 Eastern States and DC for SO_2, plus Connecticut for NO_x

Emissions reductions are not limited to SO_2, NO_x, particulate matter, and mercury. Both power sector carbon intensity (as measured as the ratio of CO_2 emissions to GDP) and coal-fueled generation carbon intensity are expected to continue their downward trends due to greater efficiencies in combustion technologies and, ultimately, the ability to capture and sequester carbon cost effectively. (See Figure Three.)

Achieving continuous improvement in the environmental performance of our coal-fueled generating fleet will require that the nation pursue an agreed-upon, aggressive, and sustained technology development program. This will require billions of dollars in new investments shared by the public and private sector.



Source: EIA: Historical data: Annual Energy Review; Projections are based on the forecast included in AEO 2005

The Need for New Capacity Employing Multiple Technologies

The nation will continue to rely on the existing 876.3GW[8] generating fleet (including 303GW of coal-fueled capacity) to meet electricity demand. But that is not enough to generate the 50 percent increase in electricity that will be required by 2025. Between now and 2025, at least 263GW of new electric generating capacity must be built to meet new demand and to replace the very small amount of capacity that will be retired in this period. As coal generation is expected to increase by nearly 50 percent, the nation must rely on both the existing coal-fueled fleet and nearly 100GW of new coal capacity that must be built during this time.[9]

As discussed below, new coal-fueled capacity will need to incorporate advanced generating and emissions reduction technologies. **No one technology will dominate; rather, a suite of technologies will be needed.** These will include advanced pulverized coal and integrated gasification combined cycle (IGCC) technologies developed to use the range of coals produced in the United States.[10] Importantly, not only are these advanced coal technologies being designed and demonstrated to achieve ultra-low emissions from coal-fueled plants, they are being developed to ensure reliability from coal use and continued low cost electricity to the consumer.

Ultra-low Emissions Defined

It is important to note that emission levels that are achievable and commercially available today would have been viewed as ultra-low by designers of the current fleet of coal-fueled plants that were built in the 1970s. The 100 or more new coal-fueled power plants that are currently proposed for construction will, according to publicly announced plans, achieve extremely low emissions through the use of both pulverized coal and IGCC. These plants will have higher efficiencies than the existing fleet, which will also assist in lowering CO_2 emissions. And tomorrow's energy plants, fueled by coal and constructed on a commercial scale within the next 20 to 30 years, will have an even greater ability to convert coal cost-effectively to electricity and prevent or capture emissions.

A new long-term definition of "ultra-low emissions," plants that could be constructed on a commercial scale in the 2025 to 2035 time period, would feature:

- A greater than 99% removal of SO_2, NO_x and particulate matter;
- 95% removal of mercury;
- 50% to 60% thermal efficiency; and,
- The capability to capture and sequester CO_2.

Construction and operating costs of these new plants would not force a material increase in the cost of electricity.

These goals outlined above build upon the more than 25 years of steady emission improvement made by the coal-fueled electricity generating community (illustrated in Figure Two above). The new advanced technologies that will be put on line in the next decade will provide for even more dramatic reductions in emissions of SO_2, NO_x, particulate matter, and mercury. These low emissions levels would have been considered "ultra-low" emissions even 15 years ago. And, as defined above, the definition of "ultra-low" implies even lower emissions in the technologies of tomorrow.

Strategy for Achieving Ultra-low Emissions

The electricity generating industry, working in conjunction with the Department of Energy (DOE), is developing the next generation of coal-fueled generating technologies though basic R&D, the Clean Coal Power Initiative (CCPI), and the FutureGen[11] project. It is vital that these programs, jointly funded by industry and DOE, continue to receive long-term funding so that the goal of moving promising technologies along the R&D path to full-scale commercial demonstration is achieved in a timely manner. Industry, alone, is unable to assume the financial risks of demonstrating the technological advancements envisioned in these projects. The government must play a significant role in accelerating technology development to meet the low-emission, low-cost energy needs of all Americans, and ultimately the needs of the world's fastest growing developing countries.

The table below shows the path coal-fueled electricity's performance has taken and performance goals we aspire to meet through R&D, the CCPI program, and FutureGen. Provided these programs are adequately funded over the long term, and are successful, these technologies would be available for widespread deployment within the next two to three decades.

Significant progress is being made in emissions reduction. Ultra-low emissions could potentially include CO_2, if Congress in the future determines that CO_2 reductions are needed and timely R&D is completed. Achieving meaningful CO_2 reductions would require significant technical advances.

EPA has determined that CO_2 is not a pollutant within the meaning of the Clean Air Act (CAA). In so concluding EPA noted that the effect of CO_2 emissions on the environment is the subject of continuing and unresolved scientific debate.

While there is still considerable debate about the need to reduce CO_2 emissions, no matter how the issues are resolved, it is essential that the federal government support R&D efforts that will allow coal to be burned cleanly well into the future. The possible need to reduce CO_2 emissions should be balanced by a respect for economic impacts and from a perspective that does not result in the displacement of coal for electric power generation with expensive alternatives in either the short or the long term, especially imported fuels from politically unstable areas of the world. Because this issue is likely to remain a concern, we must focus on developing coal-fueled technologies that are amenable to cost-effective capture and sequestration of CO_2 emissions.

Because affordable electricity from coal is essential for the economic growth of the United States and the health of its citizens, two criteria must be met if it is determined that CO_2 emissions should be reduced:

1. New technologies must be developed that allow cost-effective capture of CO_2 emissions; and,
2. Reliable and cost effective methods of sequestering (i.e. the permanent storage of) CO_2 must be demonstrated at the scale necessary to manage billions of tons of power plant CO_2 emissions.

The most effective way to accomplish these objectives is through significant government support of carbon capture and sequestration technologies.

Coal Vision Goals for New Power Plants

Performance Target	Typical Plant, 1990	Range of New Plant Air Permit Applications (2001-2004)	Range of DOE-CCPI Award Winners 2004	DOE/CURC/EPRI Roadmap Goals 2020
SO_2 Removal, %	80-90	95-98	99+	>99
NO_x lb/MMBtu	0.5	0.05-0.10	0.01 or less	0.01
Mercury Removal %	30-70 Co-Benefit*	50-80 Co-Benefit*	95+	95
CO_2 Removal, %	N/A	N/A	N/A	90

* A limited amount of mercury removal is possible from the "co-benefit" of controls that are installed to reduce SO_2, NO_x and particulate emissions.

A Technology Pathway to Meet our Goals

Technologies for the use of coal to generate electricity fall into two general categories: combustion-based processes and gasification-based processes. The most common combustion-based processes are pulverized-coal (PC) and atmospheric fluidized bed combustion (AFBC) systems. In gasification-based systems, coal is converted into a gas that is burned in a combustion turbine to generate the steam necessary to drive a steam turbine, hence the term "integrated gasification combined cycle" (IGCC) to describe the overall process. Gasification systems also afford the opportunity to convert part of the coal-derived gas into hydrogen, into other fuels including transportation fuels, and chemicals.

A joint effort[12] between industry and DOE over the last several years has led to the creation of a common coal technology roadmap that defines the status of existing coal-fueled generating technology, establishes goals for future technology, and describes the technology research, development, and deployment paths that are needed to reach this ultimate goal. **The roadmap does not rely on a single technology or single technology path to reach the goals.**

The table below describes technology used in new plants today and compares the current technology with the goals for future development in terms of environmental and process performance, and cost. As the table indicates, current new plant technology (i.e. plant performance typical of new technology today, not typical of the existing operating fleet) achieves low emissions of SO_2, NO_x, primary particulates and significant reductions of mercury emissions initially through co-benefits. The roadmap envisions further incremental improvement. Proven commercial technology for increased mercury control does not yet exist, but the roadmap targets technology for that includes substantial mercury control in the future, at least in new plant applications.

An important aspect of the roadmap is the recognition that future technology must meet both cost and environmental performance goals to be acceptable for broad application. **Importantly, the goals outlined in the table below will not be met without sufficient federal government and industry funding as described in the details of the roadmap** (www.coal.org).

We have a substantial understanding of the technology that must be developed to ensure that coal-fueled power plants meet future environmental objectives, as the roadmap demonstrates. There is broad agreement on the next and subsequent steps needed to realize the goal of ultra-low/near-zero net emissions from coal-fueled power plants. Achieving the roadmap goals will require a coordinated program of research, development, demonstration, and commercial deployment.

DOE/CURC/EPRI Roadmap Goals

Environmental Performance Goals	New Plant Technology of Today	New Plant Technology of 2020
Air Emissions	98% SO_2 removal	>99%
	0.10 lb/MM Btu NO_x	<0.01
	0.01 lb/MM Btu PM	0.002
	Hg "Co-Benefits"	95%
	CO_2 removal - N/A	90%
By Product Utilization	30%	Near 100%

Process Cost and Performance Goals**	New Plant Technology of Today	New Plant Technology of 2020
Efficiency (HHV)	38-40%*	50-60%
Availability	>80%	~90%
Capital Cost, $/kW	1000 - 1300	800 - 900
Cost of Electricity, $/MWh	$35	<$30

* At least 38 percent with 40 percent more likely, dependent on coal type

** These goals do not reflect cost and performance impacts of carbon capture and sequestration, which remains a major R&D goal.

The Roadmap and Carbon Capture

These roadmap goals do not reflect the cost and performance impacts of carbon capture and sequestration, which remain a major research and development goal. Nevertheless, achieving the roadmap goals will reduce the carbon intensity of coal-fueled electricity by increasing its generating efficiency. As described in a recent National Coal Council Study.[13] if more substantial reductions are desired, it will be necessary to develop economical technologies for the capture and storage of CO_2. These goals also assume continued research, development, and demonstration funding at levels identified in the roadmap.

Current technologies for CO_2 capture are too costly (capital and operating costs) and energy-intensive for widespread commercial application in power plants even before considering costs for carbon sequestration (storage). New technologies such as membrane separation and oxygen-based combustion are under development to reduce the cost and energy penalties, but the development of capture technology depends on the design of the generating system. For gasification-based systems, CO_2 can be removed ahead of the combustion turbine, affording potential capital and operating cost advantages relative to combustion-based systems. Membrane technology also may be attractive for CO_2 separation in gasification-based systems, and promising technologies such as water hydrates, pressure swing adsorption, and solid sorbents, are under investigation.

Once the carbon has been captured, regardless of the technology used, the ultimate goal is to sequester, or permanently store, CO_2 to prevent its emission into the atmosphere. This is likely to be the most challenging aspect of implementing a carbon management policy if society determines it is needed. To a limited extent, the technology for carbon sequestration is in commercial use. For example, CO_2 is injected into oil and gas formations to stimulate production. However, these are small applications compared to volumes of CO_2 that need to be sequestered worldwide in order to reduce global emissions significantly. Large-scale and long-term demonstrations of carbon sequestration technologies over a geographically and geologically diverse range of candidate sequestration sites are needed before making any policy decisions concerning carbon management. The DOE's current program of Regional Carbon Sequestration Partnerships is directed at identifying the opportunities and obstacles to carbon sequestration throughout the United States. Similar assessments need to be conducted internationally, and the DOE has established the Carbon Sequestration Leadership Forum to organize global activities.

The FutureGen Project is a presidential initiative to accelerate the development of near-zero net emissions technology by building and operating a prototype coal-fueled power plant of the future. The FutureGen facility will be a gasification-based system capable of capturing and storing one million tons-per-year of CO_2 and producing electricity and hydrogen with near-zero emissions of the conventional pollutants. The FutureGen facility also will serve as a research platform for the testing and scale-up of promising technologies, such as new CO_2 separation methods, as they emerge from the ongoing R&D and CCPI demonstration programs.

Conclusions

Dramatic and continuous reductions in emissions from coal-fueled electricity generation using advanced technologies can be a reality. The alternatives – regulation through litigation, unbalanced policymaking, and over-reliance on foreign energy sources – threaten economic and national security, and constrain our potential contributions to global emissions reductions through our technological leadership. Industry and government can and must agree on reasonable milestones that enable significant environmental progress, greater investment certainty, energy security, and the low-cost electricity that drives economic prosperity and a better quality of life.

A portfolio of clean coal technologies, including advanced pulverized coal and IGCC along with CO_2 mitigation options (including geologic and terrestrial/biologic sequestration) will be needed to achieve ultra-low/ near-zero net emissions from coal-fueled power plants in the near and long term. Achieving these technology goals will require a commitment to continue coordinated investment by government and private industry in all elements of research, development, demonstration, and deployment of clean coal technology including carbon capture and storage at levels consistent with those recommended in the industry/government roadmap.

Footnotes

[1] *Short Term Energy Outlook*, January 2005. Energy Information Administration, www.eia.doe.gov.

[2] *Annual Energy Outlook 2005* – Early Release, December 2004. Energy Information Administration.

[3] *World Energy Outlook, 2004*. International Energy Agency.

[4] *Annual Energy Outlook, 2005*.

[5] *Monthly Energy Review*, December 2004. Energy Information Administration.

[6] *Annual Energy Outlook, 2005*.

[7] The declining mercury emissions rate is based on EPA's assumed reductions as a co-benefit of SO2 and NOx reductions under implemention of the proposed Clean Air Interstate Rule (CAIR).

[8] Existing net summer capacity for electricity generators and independent power producers on January 1, 2004. This capacity does not include combined heat and power plants, or generating capacity used for commercial and industrial uses only. Source: EIA, Electric Power Annual 2003.

[9] *Annual Energy Outlook, 2005*.

[10] *Clean Coal Technolgies Roadmaps*, IEA Clean Coal Centre, October 2003.

[11] FutureGen is a presidential initiative to build a facility that will produce electricity and hydrogen from coal with near zero emissions. The plant will include demonstration of carbon dioxide capture and sequestration.

[12] The roadmap is the product of a collaborative effort by the Department of Energy (DOE), the Coal Utilization Research Council (CURC), and the Electric Power Research Institute (EPRI). The roadmap, which can be found on the CURC (www.coal.org) and DOE (www.netl.doe.gov) websites includes details on the specific technology advances, associated research, development and demonstration needs, and costs to achieve the proposed goals.

[13] *Coal Related Greenhouse Gas Emissions*, National Coal Council, May 2003.

The Coal Based Generation Stakeholders Group

The Coal-Based Generation Stakeholders Group is a diverse group of investor-owned utilities, rural electric cooperatives, public power companies, coal producers and coal-hauling railroads. The group believes that the option to generate electricity from coal – which remains America's most abundant energy resource – must be preserved and enhanced because it strengthens our economy, ensures the generation of affordable and reliable electricity, maintains a diverse fuel supply, and provides secure jobs for American workers.

The members of the Coal-Based Generation Stakeholders Group believe that continuous improvement in reducing emissions from coal-fueled plants through the use of advanced technologies is not only desirable it is necessary.

The electric Power, coal, and railroad industries have total revenues of almost $300 billion and directly employ almost 800 thousand workers.

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