COAL-FIRED GENERATION: Proven and Developing Technologies

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INTRODUCTION

The topic of coal-fired generation is appearing more frequently in the media and particularly within energy publications. This is a change from the past decade when most of the energy industry's attention was on natural gas and the inexpensive, clean, and efficient combined cycle electric generators that burn natural gas. The returning interest to coal-fired generation is based on several factors, including:

- U.S. Department of Energy (DOE) funding of new technologies to burn coal more cleanly,
- High prices for natural gas as compared to coal,
- Increase in demand worldwide for natural gas,
- Large supply of coal in the United States, and
- Government instability in some countries providing natural gas and oil resources.

With these events occurring simultaneously, it is not surprising that the energy industry in the United States is once again taking a close look at coal-fired power plants.

In this paper we discuss various technologies that have been developed over the past couple of decades to produce coal-fired energy with fewer air emissions and the clean coal technologies that are under development. We also examine counter-balancing issues behind coal-fired generation. Economic drivers motivating utilities and governments to invest in coal must be balanced with the environmental concerns associated with coal-burning emissions. We also discuss the investment in and use of clean coal technologies in Florida.

CLEAN COAL TECHNOLOGY

The DOE defines Clean Coal Technology (CCT) in general terms as, "technology that when implemented improves the environmental performance and efficiency as compared to the current state-of-the-art in coal-fired power plants."[1] CCT describes a new generation of energy processes that sharply reduce air emissions and other pollutants compared to older coal-burning systems. CCT also involves developing ways to reduce greenhouse gas emissions from coal plants by boosting the efficiency at which they convert coal to electricity or other energy forms. Once a technology has been proven, it is no longer classified as a CCT, and is considered to be a best available control technology (BACT) or best available retrofit technology (BART), which is to be used commercially.

[1] NARUC Web site. <http://www.naruc.org/associations/1773/files/definition.pdf>

Coal Technologies

CCT research has led to new coal-fired generation systems as well as new technologies that can be used to update existing coal-fired generation plants to reduce emissions. The primary focus of the United States' clean coal efforts is to develop innovative designs that can be used to retrofit the roughly 320,000 megawatts of existing base load coal-fired generating capacity in the United States. The nation relies on this generating capacity for over 50 percent of its electricity. Most advances in coal technologies have occurred in two main areas:

- **pollution control systems** to reduce sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions; and

- super-clean, more efficient **advanced power generation systems** for new coal-based power plants.

Pollution Control Systems

The most common post-combustion SO_2 control technology is flue gas desulfurization, also known as scrubbing. Modifications to boilers or particulate emission control devices are not necessary with flue gas desulfurization technology, making this technology particularly useful on existing boilers. The process entails removing sulfur from flue gas with the use of a sorbent, usually lime or limestone. Scrubbers can remove up to 90 percent of the SO_2 emitted at a typical power plant. Another way to control SO_2 is through dry sorbent injection (DSI). In this technology, a reactive calcium- or sodium-based sorbent is injected into the upper part of the furnace to react directly with the SO_2 in the flue gas. Controlling SO_2 can also be accomplished by converting it into sulfuric acid, or SO_3, by passing the flue gas over a catalyst bed.

Controlling NO_x emissions can be accomplished by using many different technologies. NO_x reduction technologies that modify combustion include low-NO_x burners (which are on about 75 percent of coal-based power plants and can remove 37 to 68 percent of NO_x emissions), overfire air, reburning (which can reduce NO_x emissions by 50 to 67 percent), and flue gas recirculation. Post-combustion technologies that reduce NO_x include selective catalytic reduction (which can reduce NO_x emissions by 80 to 90 percent or more and is on order or under construction on 30 percent of U.S. coal-fired generators), selective noncatalytic reduction (which can reduce NO_x emissions by 30 to 50 percent), and hybrid processes that combine the previous two technologies.

Advanced Power Generation Systems

There are three major areas of technology that are considered to be advanced electric power generators. Fluidized-bed combustion, integrated gasification combined cycle (IGCC), and advanced combustion/heat engines are technologies that have high thermal efficiency, low pollutant emissions, reduced carbon dioxide (CO_2) emissions, few solid waste problems, and enhanced economics.[2] ***Fluidized-bed combustion*** allows for greater than 90 percent SO_2 removal and reduces the amount of thermal NO_x formed because plants operate at a much lower temperature than conventional boilers. A circulating fluidized-bed combustion plant reduces

[2] Topical Report Number 18: Environmental Benefits of Clean Coal Technologies. U.S. Department of Energy. April 2001. <http://www.netl.doe.gov/cctc/topicalreports/documents/topical18.pdf>

most of the pollutants inside the furnace as the coal burns. Crushed limestone, when added to the coal as it enters the combustor, captures 90 percent of sulfur pollutants. Fluidized-bed combustion allows for a "slow burn" that reduces the formation of NO_x. ***IGCC*** systems involve the gasification of coal, cleaning the gas, and combusting it in a gas turbine generator to produce electricity. Residual heat in the exhaust gas from the gas turbine is recovered in a heat recovery boiler as steam. Additional electricity can be produced using the steam in a steam turbine generator. IGCC systems are among the cleanest and most efficient of the emerging coal technologies. ***Advanced combustion/heat engines*** include slagging combustors and coal-fired diesel engines. Slagging combustors are designed to remove coal ash as molten slag in the combustor rather than the furnace. Coal-fired diesel engines use either coal-oil or coal-water slurry fuel to drive an electric generation system.[3]

Coal Technology Categories

According to the National Mining Association (NMA), coal technologies can be categorized into three groups:

- ***Combustion*** involves "combining coal with other substances in the boiler to improve efficiency and remove impurities." During basic fluidized-bed combustion, for example, limestone or dolomite is added during combustion to reduce SO_2.
- ***Post-combustion*** technologies use scrubbers, chemical cleaning or precipitators to remove sulfur and other impurities from emissions. Flue gas desulfurization is an example of this technology category and uses scrubbers.
- ***Conversion*** uses heat and pressure to convert coal into a gas or liquid that can be further refined and used cleanly. IGCC is an example of conversion coal technology.

Federal Coal Research

The federal government has been very active in clean coal technology research over the past few decades. The DOE's Clean Coal Technology Program (CCTP) began in 1986. Research focused on commercializing processes that reduced SO_2 and NO_x emissions, and that were more efficient than conventional pulverized coal boilers. From 1986 through 1993 the government and industry selected, funded and conducted 38 technology demonstrations. According to the DOE, clean coal technology research over the past twenty years resulted in more than 20 new, lower-cost, more efficient and environmentally compatible technologies for electric utilities and other industries. Some of the demonstrations, such as JEA's Large-Scale Circulating Fluidized-Bed Combustion Demonstration Project in Florida (which will be discussed more later in the paper), are still ongoing. A significant feature of the CCTP is that the DOE and participant companies share the costs of each demonstration, with the DOE funding up to half of the project costs in some cases. This funding assistance provides a valuable incentive to a company to participate in a demonstration project.

The following section discusses four federal coal technology programs. The first two focus on pollution control, the third deals with advanced power generation systems, and the fourth is comprised of projects that fit into either category -- pollution control systems or advanced power generation systems.

[3] Ibid.

Recent Federal Programs

Clean Coal Power Initiative (CCPI)

The new Clean Coal Power Initiative (CCPI) is an industry/government partnership that is intended to build on the successes of the CCTP by perfecting technologies to reduce mercury and carbon dioxide emissions and increase fuel efficiencies. Future coal research is expected to focus on developing coal-based hydrogen fuels, that when coupled with sequestration will allow for the use of coal with zero emissions.[4]

On January 15, 2003, the DOE announced the first eight projects selected for the initial phase of the CCPI. The eight projects were expected to be awarded approximately $317 million by the DOE. Projects focused on reductions in mercury, SO_2 and NO_x, on increasing efficiency and reducing greenhouse gas emissions, and on using coal waste. Two of the projects have been withdrawn by participants since the announcement.

Of the six remaining projects in the initial phase of the CCPI, one is focused on complying with the Clear Skies Initiative, three are expected to reduce greenhouse gasses, and two are aimed at reducing air pollution through advanced gasification and combustion systems designed to extract the energy potential of waste coal piles as a new fuel source.[5] An example of this type project is the $25.6 million Great River Energy Project, which will test the Lignite Fuel Enhancement System. The DOE announced in June 2004 the testing of the system, "a new process that could dramatically reduce air emissions from certain coal-based power plants while boosting overall generating capacity." The site for the project will be Great River Energy's Coal Creek Station in Underwood, North Dakota. The project's new technology will use waste heat to dry nearly a quarter of the moisture in the high-moisture lignite coal before it enters the power plant boiler. Researchers expect that drying the lignite first will result in greater plant efficiency and lower emissions of SO_2, mercury, CO_2, NO_x, and particulates.[6] Following successful demonstration of the prototype, Great River Energy will perform full-scale, long-term operational testing needed for full power operation of one of the 546 MW units at Coal Creek Station.

On October 22, 2004, the DOE awarded a new $235 million grant to a consortium consisting of Southern Power Company, Orlando Utilities Commission and KBR, a subsidiary of Halliburton. The federal money, awarded under the CCPI, covers approximately 40 percent of the $557 million project, which is to be built at the Stanton power plant in Orlando, Florida operated by the Orlando Utilities Commission. The Consortium will build a 285-megawatt gasified coal power plant featuring a technology developed by the Southern Company called "transport gasifier." This technology is unique among coal gasification concepts in that it is cost-effective when burning low-rank coal and coal with high moisture or ash content. The transport gasifier is capable of both air- and oxygen-blown operation. This flexibility would

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[4] Sequestration is a family of methods for capturing and permanently isolating gasses that otherwise could contribute to global climate change, during the burning of coal based fuel.

[5] DOE NETL Techline. Secretary of Energy Announces First Projects to Meet President's Commitment to New Clean Coal Technologies. January 15, 2003. <http://www.netl.doe.gov/publications/press/2003/tl_ccpi_2003sel.html>

[6] DOE Techline. More Electricity, Lower Emissions from Lignite Plants Are Goals of New Clean Coal Project. June 25, 2004. <http://www.fe.doe.gov/news/techlines/04/tl_ccpi_greatriver.html>

allow it to readily adapt to other applications beyond power generation, including chemical production and possible future carbon dioxide reduction requirements. According to the DOE, this flexibility supports its goal of fostering the development and demonstration of a zero-emissions coal plant that can also provide feedstock chemicals. Teamed with carbon sequestration technology, this plant could allow continued, long-term use of coal to generate electricity.

<u>FutureGen</u>

FutureGen is another project currently being developed by DOE. FutureGen is an initiative to build the world's first integrated sequestration and hydrogen production research power plant. The $1 billion dollar project is intended to create the world's first zero-emissions fossil fuel plant. The DOE envisions the plant to produce 275 MW of electricity output at an undetermined site in the U.S.[7] When operational, the prototype will be the cleanest fossil fuel fired power plant in the world. While the U.S. is taking the lead on this project, other countries will be invited to participate in the demonstration project through the Carbon Sequestration Leadership Forum.

The prototype plant will establish the technical and economic feasibility of producing electricity and hydrogen from coal, while capturing and sequestering the CO_2 generated in the process. The initiative will be a government/industry partnership to pursue an innovative "showcase" project focused on the design, construction and operation of a technically cutting-edge power plant that is intended to eliminate environmental concerns associated with coal utilization. The project will use coal gasification technology integrated with combined cycle electricity generation and the sequestration of carbon dioxide emissions. It will be supported by the ongoing coal research program, which will also be the principal source of technology for the prototype.

The project will require 10 years to complete and will be led by an industrial consortium representing the coal and power industries, with the project results being shared among all the participants, and industry as a whole. Numerous states are currently competing for this project and the industrial consortium has until the end of 2004 to choose the location.

<u>Hybrid Technologies</u>

The DOE is also researching advanced combustion technology that involves new types of hybrid technologies. Hybrid technologies are typically coal-based systems that combine coal combustion and coal gasification into a highly efficient, environmentally clean power generating technology. In a hybrid system, coal is partially gasified in a pressurized gasifier. This produces a fuel gas that can be combusted in a gas turbine. Left behind in the gasifier is a combustible char that can be burned in a fluidized bed combustor or advanced high temperature furnace to produce steam to drive a steam-turbine power cycle and to heat combustion air for the gas turbine. Heat from the gas turbine exhaust also can be recovered to produce steam for the steam turbine.

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[7] DOE Office of Fossil Energy Web site. FutureGen International Prospectus. June 14, 2004. <http://www.fossil.energy.gov/programs/powersystems/futuregen/internationalprospectus06-14-04.pdf>

Hybrid technologies are central to the DOE's Vision 21 Program, which is currently under development. The concept envisions a virtually pollution-free energy plant. The Vision 21 plant would produce multiple products, perhaps electricity in combination with liquid fuels and chemicals or hydrogen or industrial process heat. It would not be restricted to a single fuel type, instead, it would process a wide variety of fuels such as coal, natural gas, biomass, petroleum coke (from oil refineries), and municipal waste. It would generate electricity at unprecedented efficiencies, and coupled with carbon sequestration technologies, it would emit few, if any, greenhouse gases into the atmosphere. Vision 21 builds on a portfolio of technologies already being developed, including low-polluting combustion, gasification, high efficiency furnaces and heat exchangers, advanced gas turbines, fuel cells, and fuel synthesis, and adds other critical technologies and system integration techniques.

2001 Power Plant Improvement Initiative Example

In October 2001, the DOE announced the selection of eight new projects using clean coal technologies to improve the reliability and environmental performance of coal-fired generation plants. Two of the projects have since been withdrawn by their industrial sponsors. The projects were funded under the Power Plant Improvement Initiative (PPII), which was approved by Congress in response to a series of blackouts and brownouts that occurred in 1999 and 2000. The projects focused on lower cost technologies for reducing pollutants, improving the performance and reliability of power plants, and the problem of waste handling from coal-burning plants.[8]

One example of a project funded through the DOE's PPII is at the Birchwood Power Facility in King George, VA (to see information about the other five selected projects, see appendix A). The project is testing a new recycling technology that would turn its coal combustion ash into a lightweight aggregate that can be used to make a variety of construction materials from masonry blocks to concrete to asphalt paving material. In the past, Mirant has had to pay to annually dump 100,000 tons of ash in the municipal landfill. This project pursues new types of recycling technology for coal-burning power plants. The ash is produced as a by-product of the power plant's "spray dryer" scrubber system. Scrubbers are used on many coal-fired power plants in the U.S. to reduce sulfur pollutants, but currently less than 20 percent of the 28 million tons of residue produced annually by these scrubbers is reused and most of that is from wet scrubbers. The Universal Aggregates process is designed to recycle the by-products from either wet or dry scrubbers, thereby lowering the costs of waste disposal while reducing the environmental drawbacks of landfilling. The Birchwood Power Facility project will be the final step to verify that the aggregate manufacturing process and equipment is ready for future commercial use. According to DOE projections, the plant began operations in January 2004 and the project will be complete in February 2005.[9]

[8] DOE Office of Fossil Energy Web site. The 2001 Power Plant Improvement Initiative. August 15, 2003. <http://www.fossil.energy.gov/programs/powersystems/cleancoal/ppii_program.html>

[9] Power Plant Improvement Initiative 2003 Fact Sheet. <http://www.netl.doe.gov/ppii/factsheets/aggregate/aggregate_demo.html>

THE ECONOMIC MOTIVATORS FOR COAL-FIRED GENERATION

As previously mentioned, the United States has a contradictory relationship with coal. On one hand the price and availability of coal is attractive in motivating utilities and governments to investment in coal. On the other hand, the environmental concerns associated with coal-burning emissions are expensive in terms of health impact and clean up. The current economics of building coal-fired generators, including the cost of the fuel source coal versus natural gas, the length of time to build the generator, and the cost components of construction merits discussion.

According to a recent trade journal interest in new U.S. coal plants is strong, with five new plants under construction and progress on proposed plants being reported every week[10]. In addition, there are 94 coal-fired electric power plants currently in the planning stages in 36 states[11]. However, the same article says that experts in the energy industry predict that no more than half of these proposed plants will be built.

A Balanced Fuel Mix

According to Standard & Poor's, the current interest in coal is not because the nation needs additional capacity, in fact the U.S. has a generating capacity surplus that is beyond the 15 to 17 percent capacity reserve margin desired by most utilities[12]. Instead, the interest in coal is caused by the desire to have a more balanced generation fuel mix. Most of the generation plants being built are natural gas fired and, given the increase in demand for natural gas in the international market, this has resulted in an overall increase in the cost of electricity and created price volatility. In contrast, U.S. coal prices have remained stable and inexpensive relative to natural gas prices. Considered the Saudi Arabia of coal, U.S. coal reserves are estimated by the U.S. Geological Survey to be at 230 billion tons, which would last 230 years at the current consumption rates.

The principal market for coal is the electricity generation sector, accounting for approximately 90 percent of domestic sales. Although coal has been and continues to be the primary fuel for electricity generation in the U.S., electricity producers are increasingly turning to natural gas as the fuel source for new generating capacity. The U.S. electricity producers have turned to natural gas because the combined cycle natural gas burning generators can be built quickly and emission levels are relatively low. In contrast, recent efforts to improve air emissions require many older coal-fired plants to be retrofitted with scrubbers and low NO_x burner technology and/or switch to lower sulfur coals to allow them to remain in operation and to maintain their position in the dispatch order.

The Cost of Coal

Historically, the price differential between coal and natural gas has been critical to determining whether new coal projects are built. According to Standard and Poor's, in the past four years the cost of natural gas has roughly tripled from $2 per one million British thermal

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[10] Energy Daily. King Coal Comes Roaring Back. By George Lobsenz. April 26, 2004.
[11] Christian Science Monitor. America's New Coal Rush. By Mark Clayton. March 2, 2004.
[12] Standard and Poor's. King Coal on the Comeback Trail. By Swami Venkataraman and Nancy Hwang. February 26, 2004.

units (mmbtu) of heat generated to over $6 mmbtu. By contrast, coal costs less than $2 mmbtu. Standard and Poor's studies have shown that when natural gas prices stay above $3.50 mmbtu, coal plants are a competitive alternative to natural gas fired plants. The index price of natural gas at Henry Hub (South Louisiana which supplies Florida) for October 26, 2004, according to *Platts Gas Daily* was $7.76 mmbtu. If natural gas prices above $3.50 mmbtu is the threshold for deciding to build coal burning power plants, a natural gas price of $7.76 mmbtu would provide a strong incentive to build coal-fired generation plants.

Standard and Poor's expects that any new coal plants will be built by either regulated utilities, public power entities, or cooperatives. The key motivators for them are: (1) the need to acquire a long-term, reliable, low-cost source of base load generation, and (2) the returns being assured by the inclusion of the plant in the rate base. Coal plants are attractive because they have low variable costs of production, meaning that the fuel needed to power the plant (coal) is inexpensive and readily available. However, because coal plants take approximately two years to permit and 36 to 42 months for construction, building coal plants is not attractive to merchant companies that wish to enter the market rapidly.

According to a recent news article, construction costs for building a state of the art coal-fired power plant are expected to be about $1,200 to $1,400 per kW, compared with $1,000 per kW to build a conventional coal fired power plant[13]. In contrast, a highly efficient natural gas combined-cycle plant can be built for $500 per kW. Thus, while coal is currently cheaper than natural gas and is much more plentiful in the U.S, when utilities are considering whether to build new generation those considerations must be weighed against the higher cost and construction time of building a coal-fired generator.

One of the draw-backs to investing in coal-fired power plants is the risk of new and more stringent laws on carbon dioxide and mercury emissions, requiring additional capital investment. In many states, the environmental issues inherent in building a coal fired plant are as important a consideration in deciding to build as is the economic advantage to using coal over natural gas. When Clean Air Laws are being changed, the risks associated with building coal-fired power plants are greater because the capital expenditures needed to meet the new environmental standards are unknown. Once new Clean Air Laws are passed and the environmental standards are known, the risk of installing new technology coal fired power plants will decrease.

ENVIRONMENTAL CONCERNS

Environmental concerns associated with coal-fired generators and the steps the U.S. has taken to reduce hazardous air emissions are significant issues when deciding what type of generating plant to build. The motivation for the energy industry to develop clean use of coal is the environmental challenge presented by coal-fired power plants, a primary concern being the impact of acid rain on forests and watersheds. Additional concerns are the potential health impacts of trace emissions of mercury, the effects of microscopic particles on people with respiratory problems, and the potential global climate-altering impact of greenhouse gases.

[13] Chemical & Engineering News. Getting to Clean Coal. By Jeff Johnson. C&EN Washington. February 23, 2004.

Coal burning power plants produce more airborne mercury and greenhouse gases than any other single fuel source. Coal-fired power plants are responsible for 60 percent of U.S. SO_2 emissions, 33 percent of U.S. mercury emissions, 25 percent of U.S. NO_x emissions, and more than 33 percent of the nation's CO_2 air emissions[14]. The two pollutants that generate that largest volume of pollution are ***SO_2*** and ***NO_x***. ***SO_2*** is one of six air pollutants identified by the federal Clean Air Act. The largest emitters of SO_2 are coal-based electricity generators. The U.S. concern with damage caused by acid rain prompted the inclusion of SO_2 as a major pollutant. ***NO_x*** is commonly known as urban smog and is a precursor to the formation of ozone. Cars, other transportation vehicles and coal-based power plants are the primary emitters of NO_x.

Environmental Changes

The U.S. Legislature began addressing the concerns of coal-fired pollution in 1970. The original **1970 Clean Air Act** established national standards to limit levels of such air pollutants as SO_2, NO_x, carbon monoxide, ozone, lead, and particulate matter.[15] The Act, and its amendments in 1977, set into motion both public and private sector efforts to develop new environmental control technologies, including new flue gas desulfurization units (scrubbers) that remove sulfur from the exhaust gases of coal-fired power plants. Federal research projects helped improve the reliability of the early scrubbers and the DOE's Clean Coal Technology Program (CCTP) in the 1980's demonstrated new, lower cost and more effective scrubber technologies.

The **1990 Clean Air Act Amendments** contained sweeping revisions to the original Act requiring further reductions in power plant emissions, especially sulfur- and nitrogen-based pollutants that can contribute to acid rain. The amendments put into place a new market-based "cap-and-trade" system that required power plants either to reduce emissions or acquire allowances from others to achieve compliance. To meet the more stringent NO_x standards, many power plants turned to new low-NO_x burners that had been pioneered in the CCTP.

In 2002, the **Clear Skies Initiative** (Clear Skies) was proposed by DOE to reduce three pollutants emitted from coal-fired power plants. While the U.S. Congress has not amended the Clean Air Act to include Clear Skies, the DOE is encouraging utilities to pursue these goals.

- SO_2 emissions would be cut by 73 percent, from current emissions of 11 million tons to a cap of 4.5 million tons in 2010, and 3 million tons in 2018.

- NO_x emissions would be reduced by 67 percent from current emissions of 5 million tons to a cap of 2.1 million tons in 2008, and to 1.7 million tons in 2018, and

- Mercury emissions – never before regulated as a power plant pollutant – would be cut by 69 percent, from current emissions of 48 tons to a cap of 26 tons in 2010 and 15 tons in 2018.

The Clear Skies proposal encourages the use of new and cleaner pollution control technologies that the U.S. EPA believes will reduce compliance costs. The intent is to deliver

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[14] Ibid.
[15] DOE Office of Fossil Energy Web site. <http://fossil.energy.gov/programs/powersystems/pollutioncontrols/>

guaranteed emissions reductions of SO_2, NO_x, and mercury at a fraction of the costs. Also, by setting specific dates in the future to meet the Ambient Air Quality Standards (AAQS), it provides certainty for industry, regulators, and consumers. AAQS are U.S. Environment Protection Agency (EPA) restrictions that limit the concentration of an air pollutant that may be allowed to exist in the atmosphere for any specific period of time. Some standards are established with substantial safety margins to protect the public's health, whereas, other standards are intended to protect property, plant and animal life, visibility and atmosphere clarity. Florida Department of Environmental Protection (FDEP) states that the purpose of air quality analysis is to develop plans to ensure maintenance of acceptable levels of air quality in the face of population or industrial growth and to develop local and statewide strategies for controlling emissions.

One of the major objectives of the Clear Skies proposal is to clean up older coal burning facilities. According to Neville Holt, a technical fellow with the EPRI, most of the coal-fired power plants operating today were built 30 to 50 years ago. Having been paid off long ago, the utilities' costs to generate electricity and to operate these older coal-fired plants are low. The plants are frequently considered must-run units by load serving entities and are heavily relied upon to provide a low cost baseload of energy. These older coal-fired plants produce over 320 gigawatts of electricity, yet less than a third of the power produced (100 gigawatts) by these units have scrubbers to clean up their emissions.

The Clear Skies proposal would require older coal-fired generators to either be retrofitted or retired by 2018[16]. The U.S. EPA estimates that at least 54 units at 30 different coal plants nationwide would be designated as uneconomic and retired at that time. With the strengthening of the AAQS, the U.S. EPA estimates that by 2020, there will be 300 gigawatts of coal-fired units and 81 percent (243 gigawatts) will have one or more of the following: selective catalytic reduction (SCR) for NO_x reductions, flue gas desulfurization (scrubbers) for SO_2 reduction, and activated carbon injection (ACI) for mercury reduction. Thus by 2020, the U.S. EPA estimates that the United States will have less coal-fired generation than it does today and the vast majority of the remaining coal-fired generation will incorporate technologies to reduce the amount of toxic emissions.

COAL AND CLEAN COAL TECHNOLOGY USE IN FLORIDA

Coal Use in Florida

The 2004 Regional Load & Resource Plan produced by the Florida Reliability Coordinating Council (FRCC), states that 30 percent of the net energy generated in Florida was produced from coal-fired generation. The following table illustrates that the percent of coal-fired energy produced in Florida is projected to decline over time as more natural gas fired generators are built. The FRCC estimates that in the year 2013, the amount of coal-fired generation in peninsula Florida will decline to 26 percent. In contrast, over that same period of time the FRCC estimates that the amount of energy generated by natural gas fired power plants will increase from 26 percent in 2003 to 52 percent in 2013. Florida will become more dependent upon natural gas for fuel and the price for energy in Florida will be more closely tied to the price of

[16] EPA Web site. July 2003. <www.epa.gov/air/clearskies/basic.html>

natural gas. As mentioned earlier, the price of coal has been relatively stable over the past decade whereas the price for natural gas has been more volatile.

ENERGY SOURCES IN PENNINSULA FLORIDA SHOWN BY PERCENT as of January 1, 2004 Reported by Florida Reliability Coordinating Council						
Energy Sources	2003 actual	2004	2005	2006	2010	2013
Firm Inter-region Interchange	9.23%	8.94%	9.00%	8.86%	4.28%	1.77%
Nuclear	14.19%	14.06%	13.40%	13.64%	12.39%	11.38%
Coal	28.54%	27.15%	26.98%	26.00%	24.69%	25.93%
Residual (oil #6)	12.83%	11.62%	10.16%	9.02%	6.36%	4.66%
Distillate (oil #2)	0.43%	0.45%	0.55%	0.51%	0.63%	0.71%
Natural Gas	26.47%	32.04%	34.52%	37.14%	47.02%	52.25%
Non Utility Generated	3.67%	2.39%	2.54%	2.42%	2.39%	1.52%
Other (such as waste burners)	4.64%	3.35%	2.84%	2.40%	2.24%	1.78%
Net Energy for Load	100%	100%	100%	100%	100%	100%

There are 27 coal-fired generators in Florida located in 10 counties. The two oldest in-use coal-fired generators are Scholz Units 1 & 2, located in Jackson County. They are owned by Gulf Power Company and were built in 1953. The newest coal-fired generator was built in 2002 by JEA and is located in Duval County. Another new coal-fired generator is in the planning stages in Alachua County and will be built by Gainesville Regional Utilities. Included as Appendix B is a listing of existing coal-fired generation facilities in Florida.

Clean Coal Technology Projects in Florida

Six of the 38 DOE CCTP demonstration projects were to be conducted in Florida. Southern Company Services was involved in two projects, TECO participated in one demonstration, JEA is still conducting a fluidized-bed project demonstration in Jacksonville, and two pressurized circulating fluidized-bed projects to be conducted by the City of Lakeland were terminated in June 2003.

The two Southern Company projects that were both hosted by Gulf Power Company (Gulf) focused on the reduction of NO_x emissions. One of the projects was in Pensacola and the other in Lynn Haven. The Pensacola project was located at Gulf's Plant Crist, Unit No. 5. The objective of the Pensacola project was to evaluate the performance of commercially available selective catalytic reduction (SCR) catalysts when applied to coal-fired utility boilers, while removing NO_x. The SCR technology consists of injecting ammonia into boiler flue gas and passing it through a catalyst bed where the NO_x and ammonia react to form nitrogen and water vapor.[17] The Lynn Haven project took place at the Plant Lansing Smith, Unit No. 2. The project was expected to demonstrate NO_x reduction capabilities when using a technology called Low-NO_x Concentric Firing System.[18] These two projects are finished and classified by the DOE as commercial successes.

From September 1996 through September 2001, TECO conducted a demonstration of a 250 MW advanced IGCC system at Polk Power Station Unit No. 1. During the five-year demonstration period, TECO was able to reduce emissions of SO_2, NO_x, and particulate matter to lower levels than compared to conventional coal-fired plants. The project was the largest of its kind and was initiated after a similar 100 MW IGCC program was conducted in the early 1980s. The project continues to operate commercially and has been the recipient of many awards. Along with successes, the project also exposed some problems, such as refractory liner life, with the IGCC technology.[19] Most of the issues were resolved during the demonstration and the lessons learned should benefit future IGCC projects.

JEA currently is the operator of a 297 MW gross atmospheric circulating fluidized-bed combustor demonstration project. In addition to the demonstration using JEA's Northside Unit 2 plant, JEA also decided to repower its Northside Unit 1 using circulating fluidized-bed technology, bringing the total capacity to nearly 600 MW. According to the DOE, the demonstration's objective is "to verify expectations of the technology's economic, environmental, and technical performance; to provide potential users with the data necessary for evaluating a large-scale atmospheric circulating fluidized-bed as a commercial alternative; to accomplish greater than 90 percent SO_2 removal; and to reduce NO_x emissions by 60 percent when compared to conventional technology." The project was originally sited in York, Pennsylvania, but was moved to Jacksonville after the original participants terminated activities in September 1996. As a result of a commitment to the Jacksonville community, JEA has added several features to the plants to reduce emissions even more than the circulating fluidized-bed technology alone would allow. One such voluntary addition is a polishing scrubber which helps control sulfur and mercury emissions. The polishing scrubber applies a lime slurry to absorb SO_2. JEA was the first company in the U.S. to use a polishing scrubber on a commercial-scale circulating fluidized-bed boiler.[20] The circulating fluidized-bed boiler provides approximately 90 percent SO_2 capture via limestone injection, with the remaining capture from the semi-dry polishing scrubber via injection of lime. The combination results in SO_2 capture above 98 percent.[21] The Northside power station is one of the cleanest burning coal plants in the world. Two demonstration test burns were conducted by JEA in January 2004 and emissions at various

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[17] Clean Coal Technology Demonstration Program 2003 Fact Sheet.
<http://www.netl.doe.gov/cctc/factsheets/scr/selcatreddemo.html>
[18] Clean Coal Technology Demonstration Program 2003 Fact Sheet.
<http://www.netl.doe.gov/cctc/factsheets/tfire/adtangdemo.html>
[19] Clean Coal Technology Demonstration Program 2003 Fact Sheet.
<http://www.netl.doe.gov/cctc/factsheets/tampa/tampaedemo.html>
[20] Coal Cleans Up in Jacksonville. Public Power Magazine. May-June 2004 issue.
<http://www.appanet.org/newsroom/magazine/2004/CoalCleansUp.cfm>
[21] The JEA CFB Demonstration Project: An Update.
<http://www.fwc.com/publications/tech_papers/powgen/pdfs/scottd1.pdf>

load levels were all well below permitted values.[22] In addition to reducing emissions, the circulating fluidized-bed technology has allowed the JEA plants to be 2.5 times more efficient.[23]

Two pressurized circulating fluidized-bed combustor projects were selected for Lakeland Electric's McIntosh Power Station, Unit No. 4. In April 1998, the Lakeland City Council approved a plan that included both projects, but according to the DOE, technical and economic issues could not be resolved and the projects were later terminated. According to an article by the Natural Resources Defense Council, the City of Lakeland abandoned the projects after the price ballooned from $300 million to $450 million.

The projects selected for the Power Plant Improvement Initiative (PPII) included two projects to be conducted by TECO. One project at the Big Bend Power Station in Apollo Beach was to use computer controlled soot blowing technology to clean internal boiler surfaces, allowing for improved plant performance. This project is tentatively scheduled to be completed, and a final report issued, in March 2005.[24] The second TECO project was to demonstrate a laser system that measures the water pattern of the brick liner inside a coal gasifier at the Polk Power Station.[25] According to TECO, the project has not been active for about a year because the additional accuracy offered was not justified by the costs associated with the technology. One critical cost of concern to TECO is that in order to use the technology, the plant must be cooled to a temperature that keeps it out of service for a longer period of time than TECO would like.

Current Coal-Fired Generation Plant Proposals

Gainesville Regional Utilities (GRU) has been engaged in a community outreach effort regarding future electric needs since September 2003. GRU in December 2003, issued a preliminary Integrated Resource Plan (IRP) proposing alternatives to meet Gainesville's electric needs through 2022. The IRP presented options that included building a new coal-fired plant and retrofitting the existing Deerhaven 2 coal-fired plant to reduce NO_x and SO_2 emissions. The Gainesville city commission in March 2004, dismissed two of the options presented in the IRP and ordered GRU to continue researching the option that entails a 220 MW coal-fired circulating fluidized-bed unit. This option includes plans to retrofit Deerhaven 2.

As mentioned earlier, the DOE announced on October 21, 2004 that it had awarded a $235 million grant to Southern Company and the Orlando Utilities Commission (OUC) to build a 285 MW plant that will demonstrate IGCC technology. The project will be built at OUC's Stanton plant in Orlando and commercial operation of the facility is scheduled to begin in early 2010.[26] The grant was awarded as part of the 2002 Clean Coal Power Initiative and will fund approximately 40 percent of the $557 million project.

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[22] DOE Office of Fossil Energy, Clean Coal Today Newsletter. Spring 2004 issue. <http://www.netl.doe.gov/cctc/newsletter/documents/04_Spring.pdf>

[23] DOE Office of Fossil Energy Techline. Clean Coal Power Now Serving Customers in Jacksonville, FL. October 14, 2002. <http://fossil.energy.gov/news/techlines/02/tl_cct_jea.html>

[24] Power Plant Improvement Initiative 2003 Fact Sheet. <http://www.netl.doe.gov/ppii/resources/pdfs/neural/neural.pdf>

[25] DOE Office of Fossil Energy Techline. Abraham Announces Projects to Bolster Electricity Supply from Coal Plants. October 16, 2001. <http://fossil.energy.gov/news/techlines/01/tl_ppii_sel.html>

[26] DOE Taps Southern, Florida Muni For Clean Coal Project. The Energy Daily, ED Volume 32, Number 203. October 22, 2004.

Florida's Environmental Picture

Florida has an air quality monitoring program that measures six pollutants. Those pollutants are: carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone (O_3), particulate matter (10 microns or less in diameter (PM_{10}) and 2.5 microns or less in diameter ($PM_{2.5}$)), and SO_2. Ambient air data is collected by 221 monitors in 34 counties throughout the state.

According to the FDEP's Air Monitoring Report 2002, an essential component of air quality management in the State of Florida is the identification of areas where the AAQS are being violated.[27] If a violation is determined, then plans are developed to reduce pollution concentration levels to allow the areas or entire state to be in attainment with the standards. Areas that meet all AAQS are designated by the U.S. EPA as attainment areas. Also, areas that face anticipated population or industrial growth require the FDEP to develop plans to ensure attainment/maintenance of the AAQS.

FDEP's Air Monitoring Report 2002 states that all areas of Florida are now attainment areas. Florida is one of only two states east of the Mississippi River, and the only highly urbanized state, that currently meets all AAQS. Orange County (Orlando), Duval County (Jacksonville), the Tampa Bay area including Hillsborough and Pinellas Counties and Southeast Florida including Dade, Broward and Palm Beach Counties, continue to be classified by the FDEP as attainment/maintenance areas for the pollutant ozone and Tampa is a maintenance area for lead. Specifically looking at NO_x, all monitors in Florida reported annual concentrations of less than 35 percent of the standard. As reported:

- ***Nitrogen dioxide*** levels have never threatened the standard in Florida. The importance of monitoring nitrogen dioxide is in helping to understand its influence in the formation of ozone and fine particles.
- S***ulfur dioxide -*** the annual average in Florida at all monitors indicated concentrations at or below 35 percent of the standard.
- ***Ozone*** levels in 2002 were exceptionally low. There were only three exceedances of the standard in Florida in 2002. Broward, Orange, and Escambia Counties each had one such event.
- ***Inhalable particulate concentrations*** (PM_{10} or smaller) were usually less than the standard. PM_{10} is more harmful to humans than the larger particles of dust or pollen because it is able to enter the lungs.

Even though Florida meets all U.S. EPA AAQS, and despite the efforts of Florida's utilities to implement the best available control technology to reduce air emissions, Florida's coal-burning utilities release a significant amount of emissions into the air. A May 6, 2004, *St. Petersburg Times* article titled, "Power Plant Called One of Worst," stated that Progress Energy's coal-burning power plant at Crystal River is one of the worst-polluting plants in the nation, according to a report released by an environmental group. The report, called America's Dirtiest Power Plants, evaluated power plants on three emissions: sulfur dioxide, carbon dioxide, and mercury. Crystal River was named on all three lists of the 50 worst offenders. The rankings placed the Crystal River plant in the top 5 percent of pollution-producers among 1,000 plants

[27] FDEP Division of Air Resource Management. <www.dep.state.fl.us/Air/publications/techrpt/amr.htm>

nationwide. Crystal River is one of the largest coal-burning plants in Florida and in the U.S., burning 6-million tons of coal and producing 16.1 billion kilowatt hours of electricity last year for Progress Energy's 1.5-million Florida customers.

It appears contradictory that Florida meets all U.S. EPA air standards, yet, at the same time releases some of the highest levels of emissions compared to other states in the United States. For NO_x emissions, Florida ranked third highest in the nation; for CO_2 emissions, Florida ranked fifth highest; and for SO_2 emissions, Florida ranked ninth highest in the nation as reported by the U.S. Public Interest Research Groups using the U.S. EPA, National Air Quality and Emission Trends Report data[28]. This contradiction can be explained by the geography of Florida. Because Florida is a peninsula it has the advantage of cross winds from the Gulf of Mexico and the Atlantic Ocean blowing across the state and cleansing the air. Thus, while power plants in Florida may release tons of emissions into the atmosphere, the emissions do not remain stationary over the land.

Generally, the older power plants in Florida are the ones that release the most emissions because they predate the current U.S. EPA and FDEP's clean air requirements. Utilities have not been required to retrofit older plants because they were initially built with the BACT at the time and the older plants have not been materially changed in a manner that would increase air emissions. In general, it is difficult to retrofit older power plants because of urbanization, lack of physical space, obsolescence, and it is expensive. With the U.S. EPA's Clear Skies proposal, even those coal-fired generation facilities that had previously been grandfathered would have to meet the new AAQS by 2018. With that in mind, Florida's utilities have taken steps to phase out or retrofit their older coal-fired generators. For example, in 2003, TECO shut down its six Gannon coal-fired units. TECO used the steam turbine portions of four Gannon units to construct a natural gas combined cycle facility at the same site which has been renamed Bayside. Also, for the past four years TECO has invested over $300,000 a year on cleaning up its Big Bend coal-fired units to address acid rain concerns. Gulf Power Company has also addressed acid rain concerns by investing approximately $2,000,000 a year for the past four years in retrofitting its Crist coal-fired generation units. The two sites discussed are among the oldest coal fired generation facilities dating to the 1950's and 1960's.

SUMMARY

Clean coal technology research has been a goal of the federal government and the electric industry in recent years. DOE-sponsored research programs produced many technologies that have been proven effective and are now available commercially. These technologies are reducing emissions of pollutants, including NO_x, SO_2, and particulate matter. Some of the coal technologies are used to retrofit existing coal-fired plants and others are advanced power generation systems for new coal-fired plants. Building on past successes, current clean coal technology research is expected to produce technologies that reduce emissions of NO_x, SO_2, mercury, and greenhouse gases. Current projects will also focus on using coal waste and producing the world's first zero-emissions fossil fuel plant.

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[28] U.S. PIRG. October 2003. <http://uspirg.org/uspirg.asp?id2=11087&id3=USPIRG&>

Coal-fired power plants are a stabilizing component of Florida's and the nation's energy generation fleet. Coal, as a fuel source, is plentiful in the U.S. and its price has been stable for the past decade. Coal-fired generation helps balance out the higher prices of natural gas fired generation. In a state, such as Florida, that has a large percentage of retirees living on a fixed income, it is very important to protect them from large fluctuations in energy prices. Thus, investing in coal-fired generation may help stabilize the prices of energy and those products and services that rely on energy.

Proof that utility companies are considering the economic and environmental benefits of new coal technologies is the announcement by American Electric Power (AEP) in October 2004 that it would build at least one commercial-scale ICGG power plant "with an eye toward developing an economical means of meeting potential greenhouse gas limits."[29] The announcement marked the first time a U.S. power producer publicly pledged to build an IGCC plant. The announcement came in response to a report by a three-member panel comprised of AEP board members who were asked to assess the utility's strategy for reducing its emissions of SO_2, NO_x, mercury and CO_2. "While technology risks, performance uncertainties and capital costs remain formidable at this early stage in IGCC's development, AEP also recognizes sizable operational, policy and economic benefits that this technology potentially could deliver as the next generation of power generation assets," said the panel. "Weighing these costs and benefits, the company has committed to emerging as a leader and first-mover in advancing IGCC into the mainstream of power generation." The location and size of the facility have not been announced. An industry publication reported that the announcement could be a breakthrough for the emerging clean-coal technology.[30]

Florida's utilities are pursuing investment in both the best available control technologies as well as in clean coal technologies. They are also undertaking steps to retrofit older plants with technology to reduce air emissions and in a number of cases, replacing older coal facilities with plants using newer coal technology. The utilities are attempting to replace their grandfathered coal-fired generation with newer, cleaner generation now to address future EPA air emission standards and the health concerns in their communities.

[29] In Industry First, AEP Commits To Clean Coal Plant. By George Lobsenz. The Energy Daily, ED Volume 32, Number 168. September 1, 2004.
[30] Ibid.

Appendix A: Power Plant Improvement Initiative Projects[31]

The DOE announced the selection of eight project proposals for the PPII on September 28, 2001. Details about the Birchwood Power Facility project were reported in the body of this document. Of the remaining seven projects, two were withdrawn by their industrial sponsors. The other projects selected were:

- Arthur D. Little Inc. proposed to outfit a boiler at the Orion Power Company's Avon Lake Power Plant near Cleveland, OH, with a hybrid pollution control system to reduce nitrogen oxides. The system will integrate three exiting NO_x reduction technologies (natural gas reburning, selective non-catalytic reduction, and selective catalytic reduction), which will lower the cost of reducing NO_x.

- CONSOL Energy Inc. proposed to demonstrate a multi-pollutant control system at the AES Greenridge Power Plant near Dresden, NY, to reduce NO_x, SO_2, mercury, acidic gases, and fine particles from smaller coal plants for less money than it costs to control NO_x and SO_2 separately. Innovations CONSOL planned to install at the plant included a catalytic NO_x reduction technology that works inside the plant's ductwork, a low-NO_x combustion technology that burns coal mixed with biomass, and a flue gas scrubber that is less complex and nearly half the cost of conventional systems.

- Otter Tail Power Company proposed to install a technology designed to capture up to 99.9999% of the fly ash particles emitted from a coal boiler. The demonstration will take place at the Big Stone Power Plant in South Dakota and will integrate a fabric filter system with an electrostatic precipitator in a single unit.

- Sunflower Electric Power Corporation proposed to install at it's power plant in Garden City, KS, ultra-low-NO_x burners with other combustion controls to demonstrate a pollution control concept that has never been attempted in power plants that burn western subbituminous coals.

- Tampa Electric Company proposed to apply a neural network system to determine when and how best to dislodge soot that can build up inside a boiler and degrade performance. The demonstration will take place at the Big Bend Power Station in Apollo Beach, FL. Computer controlled sootblowing technology, as opposed to manually activated sootblower, will permit the cleaning of internal boiler surfaces with improved power plant performance.

[31] DOE Office of Fossil Energy Web site. The 2001 Power Plant Improvement Initiative. August 15, 2003. <http://www.fossil.energy.gov/programs/powersystems/cleancoal/ppii_program.html>

Appendix B:
EXISTING COAL-FIRED GENERATION FACILITIES IN FLORIDA
FRCC Form 1.0 as of January 1, 2003

Plant Name	Location (county)	Utility Ownership	Commercial In-Service	Gross Capability – MW		Net Capability - MW	
			Month/Year	Summer	Winter	Summer	Winter
Big Bend Unit 1	Hillsborough	Tampa Electric Company	10/1970	440	447	421	428
Big Bend Unit 2	Hillsborough	Tampa Electric Company	4/1973	430	452	411	433
Big Bend Unit 3	Hillsborough	Tampa Electric Company	5/1976	445	455	428	438
Big Bend Unit 4	Hillsborough	Tampa Electric Company	2/1985	480	488	452	460
Crist Unit 4	Escambia	Gulf Power Company	7/1959	82	82	78	78
Crist Unit 5	Escambia	Gulf Power Company	6/1961	82	82	80	80
Crist Unit 6	Escambia	Gulf Power Company	5/1970	320	320	302	302
Crist Unit 7	Escambia	Gulf Power Company	8/1973	500	500	477	477
Crystal River Unit 1	Citrus	Progress Energy Florida	10/1966	410	410	379	383
Crystal River Unit 2	Citrus	Progress Energy Florida	11/1969	510	515	486	491
Crystal River Unit 4	Citrus	Progress Energy Florida	12/1982	755	770	720	735
Crystal River Unit 5	Citrus	Progress Energy Florida	10/1984	750	765	717	732
Deerhaven	Alachua	Gainesville Regional Utilities	10/1981	249	249	228	228
Lansing Smith Unit 1	Bay	Gulf Power Company	6/1965	172	172	162	162
Lansing Smith Unit 2	Bay	Gulf Power Company	6/1967	201	201	189	189
McIntosh (342/342) Unit 3	Polk	City of Lakeland Orlando Utilities Commission	9/1982	365 146	365 146	205 133	205 136
Northside Unit 1	Duval	JEA	3/1966	297.5	297.5	275	275
Northside Unit 2	Duval	JEA	6/1972	297.5	297.5	275	275
Polk Unit 1	Polk	Tampa Electric Company	9/1996	320	325	255	260
St. Johns River (628/640) Unit 1	Duval	Florida Power & Light JEA	4/1987	666	672	127 501	130 510
St. Johns River (628/640) Unit 2	Duval	Florida Power & Light JEA	7/1988	666	672	127 501	130 510
Scholz Unit 1	Jackson	Gulf Power Company	3/1953	49	49	46	46
Scholz Unit 2	Jackson	Gulf Power Company	10/1953	48	48	46	46

Appendix B:
EXISTING COAL-FIRED GENERATION FACILITIES IN FLORIDA
FRCC Form 1.0 as of January 1, 2003

Plant Name	Location (county)	Utility Ownership	Commercial In-Service	Gross Capability – MW		Net Capability - MW	
			Month/Year	Summer	Winter	Summer	Winter
Seminole Unit 1	Putnam	Seminole Electric Cooperative	2/1984	693	701	658	665
Seminole Unit 2	Putnam	Seminole Electric Cooperative	1/1985	693	701	658	665
Stanton (440/443) Unit 1	Orange	Florida Municipal Power Agency	7/1987	467	470	117	118
		Kissimmee Utility Authority		21	21	21	21
		Orlando Utilities Commission		320	322	302	304
Stanton (446/446) Unit 2	Orange	FL Municipal Power Agency	6/1996	469	469	127	127
		Orlando Utilities Commission		336	336	319	319

ADDITIONAL RESOURCES

U.S. Department of Energy, Office of Fossil Energy, May 2004. http://fossil.energy.gov/programs/powersystems/cleancoal/

U.S. Department of Energy, Energy Information Administration, Coal News and Markets, April 4, 2004. http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html

U.S. Department of Energy, Energy Information Administration, Edward J. Flynn, Impact of Technological Change and Productivity on the Coal Market, 2000.

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U.S. Department of Energy, Office of Fossil Energy, Clean Coal Power Now Serving Customers in Jacksonville, Florida, http://fossil.energy.gov/news/techlines/02/tl_cct_jea.html

Center for Energy and Economic Development, Clean Coal Technology, http://www.ceednet.org/cct_brochure/page02.asp

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Florida Reliability Coordinating Council, 2003 Regional Load & Resource Plan, July 2003

U.S. PIRG Reports, Lethal Legacy: A Comprehensive Look at American's Dirtiest Power Plants, October 2003

Gainesville Regional Utilities, Alternatives For Meeting Gainesville's Electrical Requirements Through 2022: Base Studies and Preliminary Findings, December 2003

Florida Department for Environmental Protection, (July 24, 2003) "Florida Achieves Milestone in Clean Air"

U.S. Environmental Protection Agency, Summary of Clear Skies, http://www.epa.gov/air/clearskies/basic.html

GLOSSARY:

Acid Rain: Rainfall that occurs when atmospheric water vapor combines with oxides of sulfur and nitrogen to form sulfuric or nitric acid. Natural rainfall is slightly acidic due to the presence of carbon dioxide in the atmosphere, which forms a mild carbonic acid. If rainfall becomes too acidic, it may cause environmental damage.

Ambient Air Quality Standards: Standards, authorized by the 1970 Clean Air Act, that establish level of pollutants that can be present in the air without endangering public health and welfare. These standards set maximum levels allowed in a three-hour period and a 24-hour period, and mandate average levels that must be met in a year. An area with air quality superior to the standards for a particular pollutant is classified as an "attainment" area.

Best Available Control Technology (BACT): A pollutant emissions limitation based in the maximum degree of reduction possible, taking into account energy, environmental, and economic impacts and other costs. BACT requirements are intended to ensure that the pollution control systems incorporated into the design of a proposed facility reflect the latest in pollution control technologies used in a particular industry, while taking into account existing and future air quality in the vicinity of the facility.

Best Available Retrofit Technology (BART): A regulatory requirement for utilities to use the best technology available in bringing existing generation equipment into compliance with current environmental regulations. BART applies to technology that is added to existing facilities.

Boiler: A device for generating steam for power, processing, or heating purposes or for producing hot water for heating purposes or hot water supply. Heat from an external combustion source is transmitted to a fluid contained within the tubes in a boiler shell, a close vessel in which water is converted to pressurized steam. This fluid is delivered to an end-use at a desired pressure, temperature, and quality.

Catalyst: A substance that changes the speed of a chemical reaction without itself changing.

Char: A porous, solid, nearly pure carbon residue resulting from the incomplete combustion of organic material. If produced from coal, it is called coke; if produced from wood or bone, it is called charcoal.

Clean Air Act: A specific national law passed in 1963, and amended several times since, giving the U.S. government powers to limit air pollution. The term "Clean Air Act" also is applied loosely to the Air Quality Act of 1967.

Coal: a fossil fuel made up of carbon, hydrogen, oxygen, nitrogen and sulfur. Formed from the remains of trees and plants alive millions of years ago, various types (anthracite, bituminous, lignite, and steam coal) are used as a fuel to generate electricity.

Flue Gas: A mixture of gases resulting from combustion and other reactions in a combustion device. The gas is routed through a chimney or stack into the outdoor air.

Flue Gas Desulfurization (FGD): The process of removing sulfur oxides from power plant exhaust gases. This is done with flue gas desulfurization devices, commonly called scrubbers. Typically, a flue gas desulfurization system can remove 90 percent or more of the sulfur oxides. In an FGD system, the flue gas produced by coal combustion is sprayed with a slurry of water and an alkaline agent – a lime or limestone. The sulfur oxides react with the slurry, forming calcium sulfite and/or calcium sulfate. This is removed as wet sludge. Scrubbers are classified by the type of chemical absorbent used and the waste produced; the process is "throwaway" if the waste has little or no market value and "regenerative" if it can be reused or marketed for some other purpose. A salable product from a "regenerative" system could include gypsum, elemental sulfur, or sulfuric acid.

Flue Gas Recirculation: Technology, in which part of the flue gas is recirculated to the furnace, that can be used to modify conditions in the combustion zone (lowering the temperature and reducing the oxygen concentration) to reduce NO_x formation. Another use for flue gas recirculation is as a carrier to inject fuel into a reburn zone to increase penetration and mixing.

Fluidized Bed Combustion (FBC): A method of controlling emissions during the combustion process. There are two basic types – atmospheric and pressurized. In atmospheric fluidized bed combustion (AFBC), crushed coal is fed into a bed of inert ash mixed with limestone or dolomite. The bed is fluidized, or held in suspension, by an injection of air through the bottom, which causes the mixture to agitate, much like boiling water. As the coal burns, the sulfur released reacts with the limestone or dolomite to form dry calcium sulfate. This solid waste is periodically removed. In pressurized fluidized bed combustion (PFBC), combustion occurs in a similar fashion, but the furnace is maintained at a higher pressure. This compresses the flue gases, allowing a significant reduction in furnace size compared to AFBC. The hot, pressurized gases are used to power a gas turbine, and waste heat from the process is used to produce steam to drive a steam turbine. This is called a combined cycle unit.

Greenhouse Gases: The gases include water vapor, carbon dioxide, methane, ozone, nitrous oxides, fluorocarbons, and particulates among others. They trap heat in the earth's biosphere and affect global heat balances that affect weather and climate.

Lignite: a usually brownish black coal intermediate between peat and bituminous coal; *especially*: one in which the texture of the original wood is distinct – called also brown coal.

Low-NO_x Burner: Technology that is designed to control the mixing of fuel and air to achieve what amounts to staged combustion. This results in a lower maximum flame temperature and a reduced oxygen concentration during some phases of combustion. This results in both lower thermal NO_x and lower fuel NO_x production.

Mercury: mercury is a naturally occurring element that is present throughout the environment. It becomes a toxic air pollutant when released into the air, water and soil by human activity. Reactive, inorganic mercury is emitted to the atmosphere primarily from coal-burning power plants and incinerators that combust mercury-containing wastes.

Natural Gas: a combustible, gaseous mixture of simple hydrocarbon compounds, usually found in deep underground reservoirs formed by porous rock. Natural gas can be found by itself or in association with crude oil. Gas also can be manufactured. Manufactured gas can be obtained from distillation of coal, thermal decomposition of oil or by the reaction of steam passing through a bed of heated coal.

Nitrogen Oxides (NO_x): compounds of nitrogen and oxygen. They are products of automobile exhaust and may be produced by the burning of fossil fuels. They are a contributor to the formation of smog.

Overfire Air: Air that is injected into the furnace above the normal combustion zone. Overfire air is generally used in conjunction with operating the burners at a lower than normal air-to-fuel ratio, which reduces NO_x formation. The overfire air completes the combustion at a lower temperature. Overfire air is frequently used in conjunction with low-NO_x burners.

Particulates, Particulate Matter: discrete particles in a condensed form. Particulate matter emitted from coal combustion is primarily a mixture of carbon, silica, calcium and iron oxide, also smoke and soot may be emitted.

Precipitators (Electrostatic Precipitator): A device for collecting particulate material from waste gases, such as those released by coal burning power stations. The main principle of operation is based on the fact that particulates, moving through a region of high electrostatic potential, tend to become charged and then are attracted to an oppositely charged electrode where they can be collected and removed.

Reburning: Technology where part of the boiler fuel input is added in a separate reburn zone. In this zone, the fuel-rich reducing conditions lead to the reduction of NO_x formed in the normal combustion zone. Overfire air is injected above the reburn zone to complete combustion. Thus, with reburn there are three zones in the furnace: 1) a combustion zone with an approximately normal air-to-fuel ratio; 2) a reburn zone, where added fuel results in a fuel-rich condition; and 3) a burnout zone, where overfire air leads to completion of combustion. Coal, oil, or gas can be used as the reburn fuel.

Retrofit: The process of modifying or updating existing equipment to incorporate advantageous changes or to include current technologies used in newer equipment.

Scrubber: an apparatus for removing impurities especially from gases.

Selective Catalytic Reduction: In this technology, a catalyst vessel is installed downstream of the furnace. Ammonia is injected into the flue gas before it passes over the fixed-bed catalyst. The catalyst promotes a reaction between the ammonia and NO_x to form nitrogen and water vapor.

Selective Noncatalytic Reduction: In this technology, a reducing agent, typically ammonia or urea, is injected into the furnace above the combustion zone, where it reacts with NO_x.

Sequestration: Sequestration is a family of methods for capturing and permanently isolating gasses that otherwise could contribute to global climate change, during the burning of coal based fuel.

Slag: A residue produced by the combustion of coal. Slag is the fused or vitrified matter that accumulates in the bottom of a boiler. It is removed periodically and disposed of according to environmental regulations.

Sludge: Any mixture of solids and liquids resulting in a thick liquid. One example of sludge is the end product of flue gas desulfurization, which is a mixture of water, limestone and calcium sulfite or sulfate.

Smog: a fog made heavier and darker by smoke and chemical fumes; *also*: a photochemical haze caused by the action of solar ultraviolet radiation on atmosphere polluted with hydrocarbons and oxides of nitrogen from automobile exhaust.

Sorbent: a substance that takes up and holds by either adsorption or absorption.

Sulfur Dioxide (SO_2): a heavy pungent toxic gas SO_2 that is easily condensed to a colorless liquid, is used especially in making sulfuric acid, in bleaching, as a preservative, and as a refrigerant, and is a major air pollutant especially in industrial areas.