Coal-Fired Power Generation *and the* 1990 Clean Air Act Amendments

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More than half the electricity used by American consumers today is produced from coal burning power plants. The reserves of coal in the U.S. far exceed equivalent domestic supplies of oil and gas and account for nearly 30 percent of world reserves. Furthermore, coal is an energy bargain, remaining the least expensive fossil fuel in the U.S. With the unlikely availability of new nuclear units this decade, or the near term development of other significant power sources, coal will continue to play a major role.

The problem with coal has always been its impact on the environment. Unabated coal burning produces ash particulates and emissions associated with acid rain, namely sulfur dioxide (SO2) and nitrogen oxides (NOx). The recently enacted Clean Air Act Amendments of 1990 are the most comprehensive step to date to reduce overall emissions from the entire power plant inventory. The new provisions on acid rain adopt a radical new market-based approach to reducing emissions. The goal of the plan over the next 10 years is to reduce overall SO2 emissions to less than 50 percent of the emissions produced in 1980.

The Clean Air Amendments should produce a significant environmental improvement in the design, retrofit and new construction of coal-fired power plants. In particular, increased attention will be given to the older, higher emitting units which have thus far avoided extensive regulation. This article addresses how the new law affects coal-fired power plants and summarizes some of the technologies that permit environmentally acceptable use of coal for power in the future.

History of the Clean Air Act

In 1970, the Clean Air Act was passed to "protect and enhance" the nation's air quality. As a result of the Act, the Environmental Protection Agency (EPA) set "New Source Performance Standards" for emissions of SO2, NOx and several other pollutants. These standards put a limit on new coal-fired power plants for emission of no more than 1.2 lbs. of SO2 per million Btu of coal burned. Many utilities, especially in the West, were able to meet these

Photo by Ed Malles

requirements simply by burning low-sulfur western coal.

Amendments to the Act were passed in 1977 which retained the original emissions cap on SO2 but further required that all plants built or altered after Sept. 18, 1978, reduce SO2 emissions by 70 to 90 percent from the levels that would be emitted if no sulfur controls were installed. The 1977 amendments created two classes of coal burning power plants: (1) pre-1978 plants with little or no pollution control equipment and (2) post-1978 plants which are equipped with flue gas scrubbers.

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In November of 1990, President Bush signed into law The Clean Air Act Amendments of 1990. Title IV of the amended Act addresses acid rain deposition control and the goal of reducing annual emissions of sulfur dioxide and nitrogen oxides. The ultimate goal of Title IV is to reduce by the year 2000, overall emissions of SO2 nationally by 10 million tons per year from a 1980 level of 18.9 million tons. The 8.9 million tons permitted by 2000 would then become a cap for the future. The law does not displace the normal permitting process but rather superimposes a new market-based approach on the existing regulatory process. All utilities will receive a limited number of "allowances" in order to emit SO2. An allowance is basically a permit to emit one ton of SO2 in a single calendar year.

1990 Title IV: Acid Deposition Control Through the Allowances Program

In order to "throw on the switch" at any fossil-fueled power plant, a utility owner/operator must first control enough allowances to cover the amount of pollutants the unit will emit. Temporary increases and decreases in emissions within utility systems or power pools do not require allowance transfers or recordation so long as the total tonnage emitted by the utility system in any year matches its allowances for that year. Thus, utilities must "true up" at year end to ensure that allowances match emissions for each unit.

The allowance program applies to both existing and new utility units to ensure the cumulative annual emission of SO2 from utility units does not exceed the established ceiling. Prior to operation, new units must acquire from existing utility plants sufficient allowances to cover their emissions. In this regard, utilities have four basic options:

1. Shut down or cut back operations at an existing unit plant and use its allowances for the new plant;

2. Reduce emissions at existing unit to a greater extent than otherwise might be required in order to free up some allowances for the new unit;

3. Buy allowances on the open market or from the EPA reserve for auction every year at a price of $300 to $1,500 per allowance; or

4. Implement conservation and renewable energy projects and thereby earn bonus allowances.

Title IV divides the allowances program into two phases. Phase One will go into effect Jan. 1, 1995, and run to the end of 1999. This phase will cover the largest and highest emitting units in the nation.

There are currently more than 100 plants totaling about 90,000 megawatts of high emitting coal burning units which will have to reduce emissions or stop operating by the beginning of Phase One. Most of these units are located in the Midwest. However, the Southeast states have a small percentage of these units within their borders.

Phase One will involve switching to low sulfur coal and/or retrofits of conventional post-combustion pollution control technology such as the flue gas scrubbers used on many plants built during the 1980's. The limit on Phase One emissions and allowances will generally be based on 2.5 lbs. of SO2 per million Btu's. (lbs./mmBtu).

The goal is to reduce NOx emissions by two million tons, below 1980 levels. New emission limits will become effective for coal-fired units in 1995. Tangentially fired boilers and dry bottom wall-fired boilers (other than units applying cell burner technology) will have NOx limits of .45 and .50 lbs./mmBtu, respectively. Other types of boilers will be regulated in 1997 under regulations yet to be developed by EPA. Low NOx burner or equivalent technology must be utilized to achieve these results.

Phase Two goes into effect in the year 2000 and will cover all units, including those previously addressed by Phase One. Allocation of allowances will be based on the units' primary fuel emission rate (not to exceed 1.2 lbs. of SO2/mmBtu's), and previous operations. When Phase Two begins, annual national allocation of allowances for all utility units will not exceed 8.9 million tons. This level of 8.9 million tons will become the annual cap for emissions in the future.

Bonus allowances will be distributed to accommodate growth by units in high growth states (such as Florida) and in clean states with statewide average SO_2 emissions below 0.8 lbs./mmBtu. Also, plants that use energy conservation technology or renewable energy will receive special incentive allowances for making early reductions in SO_2 emissions.

Clean Coal Technology

The challenge for the 90's is to achieve high environmental performance with minimal degradation of the power plant's efficiency. Over the last two decades, the most common means of reducing emissions of coal combustion has been by the use of the flue gas scrubber developed during the 1960's.

Until recently, the flue gas scrubber was the only commercial technology capable of achieving the 70 to 90 percent SO_2 reduction required under the 1977 Clean Air Act Amendments. According to the Department of Energy, a little over 20 percent of currently operating U.S. coal-fired power plants have installed scrubbers. Due to the time frame in meeting Phase One requirements, scrubber installation could double by 1995.

However, the future of clean coal burning for power generation will have to go beyond the scrubber technology available today. Today's scrubbers are expensive to build and consume 5 to 8 percent of a power plant's thermal energy in order to operate. Additionally, the current scrubber technology does not reduce the emissions of NOx.

The Clean Coal Technology Program began in the late 1980's as a government and industry cofunded effort to demonstrate a new generation of innovative processes that improve environmental performance with accompanying improvements to plant efficiencies. Almost $3 billion has been earmarked for this program. If these clean coal technologies can be made economical at commercial scales, the nation's interests in energy security, economic growth, and a cleaner environment can all be fostered with our abundant supplies of coal.

A brief discussion of some of these technologies can be addressed by reviewing how coal can be cleaned at several points in the fuel chain.

1. Precombustion Cleaning—An estimated 40 percent of the coal bound for U.S. utility boilers receives some cleaning before it is burned. The Electric Power Research Institute has estimated that wider use of coal cleaning processes could reduce total SO_2 emissions by 10 percent nationwide. To achieve greater reductions, improved coal cleaning techniques need to be developed including chemical and biological cleaning.

One of the new chemical techniques being pioneered in precombustion cleaning is a molten-caustic leaching, a chemical process in which coal is exposed to a hot, sodium- or potassium-based chemical which leaches sulfur and mineral matter from the coal. Researchers have also identified naturally occurring bacteria that can biologically desulfurize coal much the same way that oil spills are being handled biologically. Scientists are improving the sulfur-removing characteristics of this bacteria, particularly their speed in "eating" organic sulfur.

According to DOE, chemical or biological coal cleaning appears to be capable of removing as much as 90 percent of the total sulfur in coal. Some chemical techniques also may remove 99 percent of the ash.

2. Cleaning During Combustion—In fluidized bed combustors, crushed coal is mixed with limestone and the mix is suspended on jets of air. As the coal burns, the limestone acts like a chemical "sponge" to capture the sulfur before it enters the exhaust system. More than 90 percent of the sulfur released from coal can be captured this way and turned into solid dry waste. Also, since combustion temperatures can be kept to around 1400 to 1600 degrees F, or almost half the temperature of a conventional boiler, much less nitrogen pollutants form. Thus, fluidized bed combustors can meet both SO_2 and NOx standards without any additional pollution control equipment.

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The "cyclone" combustor concept also combines high combustion efficiency with pollutant removal. In contrast to conventional boilers, coal is burned in cyclone combustors in a separate chamber outside the furnace cavity. The hot combustion gases then pass into the boiler.

The advantage of this concept is that ash is kept out of the boiler where it accumulates and lowers heat transfer efficiency. This is accomplished by very high temperatures which cause the mineral impurities to melt and form slag which is forced to the outer walls of the combustor by the vortex of air (the "cyclone"). The problem with current cyclone combustor technology is its production of unacceptable levels of NOx resulting from the high temperatures.

3. Post-Combustion Cleaning—Advanced post-combustion SO_2 controls include in-duct sorbent injection systems inside the ductwork leading from the boiler to the smokestack. Sulfur absorbers (such as lime) are sprayed into the center of the duct. Fifty to 70 percent of the SO_2 can be removed as the reaction produces dry particles that can be collected downstream. This technique will be particularly attractive for retrofiting smaller, older plants where space is limited.

Advanced scrubber technology is being developed to make these devices more economical and to remove both SO_2 and NO_x. The addition of adipic acid in the process can achieve as much as 97 percent SO_2 removal. "Jet bubbling reactors" are also being developed, in which the flue gas is bubbled through a sulfur absorbing slurry which greatly improves the process efficiency when compared to today's wet scrubbers.

Post combustion nitrogen oxide controls are also being developed using the concept of selective catalytic reduction (SCR). Ammonia is mixed with fuel gas which then passes through a reaction chamber separated from the scrubber vessel. By use of a catalyst, ammonia converts the NO_x to molecular nitrogen and water. This process is projected to reduce nitrogen emissions by 50 to 80 percent.

A drawback with the SCR system, however, is that problems occur when used with high sulfur coal. High sulfur coal by-products can cause corrosion and plugging of downstream components. The Clean Coal Technology Program plans to test techniques to overcome this and other problems with SCR.

The Clean Air Act Amendments of 1990 attracted a great deal of attention and participation in the legislative process and will receive even more attention upon implementation. The rulemaking process by EPA is likely to take two to four years and could result in additional significant debates. However, the fundamental principles of this market-based approach to pollution control of coal-fired power generation appears to be sound. The result should be an improvement in energy security and environmental quality while maintaining economic growth.

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