COAL FIRED POWER PLANTS & CO2 EMISSIONS

While there have been many arguments for and against man-made climate change, it is now clear that the balance of power shift from a Republican Presidency to a Democratic controlled Presidency and congress has certainly ended that debate for the foreseeable future.

Now that the Democratic Party has taken control of both houses of Congress and the Executive Branch, there is hope amongst senior Democrats that they will be able to convince the president that caps on greenhouse gases are needed as well.

"We have an opportunity to put an emphasis on issues of clean energy, renewable energy, global warming, climate change, in a way that wasn't possible during the last several years," says the incoming Democratic Party head of the Senate energy committee, Jeff Bingaman.

Mr. Bingaman supports set federal limits on greenhouse gases. He recently co-authored a letter to President Bush urging him to work with the Democrats to develop solutions to the global warming problem.

And, according to many publications, the largest contributor to global warming is carbon dioxide (CO2), and a push will likely be made to curb these emissions.

Coal Fired Power Plants & CO2 Emissions

The world meets 25% of its primary energy demand with coal, a number projected to increase steadily over the next 25 years. With respect to carbon dioxide (CO2), the most prevalent greenhouse gas, coal combustion was responsible for 41% of the world's CO2 emissions in 2005 (11 billion metric tons). Coal is particularly important for electricity supply. In 2005, coal was responsible for about 46% of the world's power generation, including 50% of the electricity generated in the United States, 89% of the electricity generated in China, and 81% of the electricity generated in India. Coal-fired power generation is estimated to increase 2.3% annually through 2030, with resulting CO2 emissions estimated to increase from 7.9 billion metric tons per year to 13.9 billion metric tons per year.

For example, during 2006, it is estimated that China added over 90 gigawatts (GW) of new coal-fired generating capacity, potentially adding an additional 500 million metric tons of CO2 to the atmosphere annually.

Many in Congress now believe that developing a means to control coal-derived greenhouse gas emissions is an imperative if serious reductions in worldwide emissions are to occur in the foreseeable future. Developing technology to accomplish this task in an environmentally, economically, and operationally acceptable manner has been an ongoing interest of the federal government and energy companies for a decade, but no commercial device to capture and store these emissions is currently available for large-scale coal-fired power plants.

Background: What Is Carbon Capture Technology and What Is Its Status?

Major reductions in coal-fired CO_2 emissions would require either precombustion, combustion modification, or post-combustion devices to capture the CO_2. Because there is currently over 300 GW of coal-fired electric generating capacity in the United States and about 600 GW in China, a retrofittable postcombustion capture device could have a substantial market, depending on the specifics of any climate change program. The following discussion provides a brief summary of post combustion technology under development that may be available in the near-term. It is not an exhaustive survey of the technological initiatives currently underway in this area, but illustrative of the range of activity.

Post-Combustion CO_2 Capture

Post-combustion CO_2 capture involves treating the burner exhaust gases immediately before they enter the stack. The advantage of this approach is that it would allow retrofit at existing facilities that can accommodate the necessary capturing hardware and ancillary equipment. In this sense, it is like retrofitting postcombustion sulfur dioxide (SO_2), nitrogen oxides (NO_x), or particulate control on an existing facility.

Post-combustion processes capture the CO_2 from the exhaust gas through the use of distillation, membranes, or absorption (physical or chemical). The most widely-used capture technology is the chemical absorption process using amines (typically monoethanolamine (MEA)) available for industrial applications. Pilot plant research on using ammonia (also an amine) as the chemical solvent is currently underway with demonstration plants announced. These approaches to carbon capture are discussed below. Numerous other solvent-based post-combustion processes are in the bench-scale stage.

<u>Monoethanolamine (MEA)</u> - The MEA CO_2 carbon capture process is the most proven and tested capture process available. The basic design (common to most solvent-based processes) involves passing the exhaust gases through an absorber where the MEA interacts with the CO_2 and absorbs it. The now CO_2-rich MEA is then pumped to a stripper (also called a regenerator) which uses steam to separate the CO_2 from the MEA. Water is removed from the resulting CO_2, which is compressed while the regenerated MEA is purged of any contaminants (such as ammonium sulfate) and recirculated back to the absorber.

The process can be optimized to remove 90-95% of the CO_2 from the flue gas. Although proven on an industrial scale, it has not been applied to the typically larger volumes of flue gas streams created by coal-fired power plants. The technology has three main drawbacks that would make current use on a coal-fired power plant quite costly.

First is the need to divert steam away from its primary use — generating electricity — to be used instead for stripping CO_2 from MEA.

A second related problem is the energy required to compress the CO_2 after its captured — needed for transport through pipelines — which lowers overall power plant efficiency and increases generating costs.

A recent study by the Massachusetts Institute of Technology (MIT) estimated the efficiency losses from the installation of MEA from 25%-28% for new construction and 36%-42% for retrofit on an existing plant. This loss of efficiency comes in addition to the necessary capital and operations and maintenance cost of the equipment and reagents. For new construction, the increase in electricity generating cost on a levelized basis would be 60%-70%, depending on the boiler technology. In the case of retrofit plants where the capital costs were fully amortized, the MEA capture process would increase generating costs on a levelized basis by about 220%-250%.

A third drawback is degradation of the amine through either overheating (over 205^{o}F) in the absorber or through oxidation from oxygen introduced in the wash water, chemical slurry, or flue gas that reacts with the MEA. For example, residual SO_2 in the flue gas will react with the MEA to form ammonium sulfate that must be purged from the system. This could be a serious problem for existing plants that do not have highly efficient flue gas desulfurization (FGD) or selective catalytic reduction (SCR) devices (or none), requiring either upgrading of existing FGD and SCR equipment, or installation of them in addition to the MEA process.

<u>Chilled Ammonia (Alstom) -</u> An approach to mitigating the oxidation problem identified above is to use an ammonia-based solvent rather than MEA. Ammonia is an amine that absorbs CO_2 at a slower rate than MEA. In a chilled ammonia process, the flue gas temperature is reduced from about 130^{o}F to about 35-60^{o}F.

This lower temperature has two benefits: (1) it condenses the residual water in the flue gas, which minimizes the volume of flue gas entering the absorber; and (2) it causes pollutants in the flue gas, such as SO_2, to drop out, reducing the need for substantial upgrading of upstream control devices.

Using a slurry of ammonium carbonate and ammonium bicarbonate, the solvent absorbs more than 90% of the CO_2 in the flue gas. The resulting CO_2-rich ammonia is regenerated and the CO_2 is stripped from the ammonia mixture under pressure (300 pounds per square inch [psi] compared with 15 psi using MEA), reducing the energy necessary to compress the CO_2 for transportation (generally around 1,500 psi).

Ammonia (Powerspan) - A second ammonia-based, regenerative process for CO_2 capture from existing coal-fired facilities does not involve chilling the flue gas before it enters the absorber. Using higher flue gas temperatures increases the CO_2 absorption rate in the absorber and, therefore, the CO_2 removal. However, the higher flue gas temperatures also mean that upgrades to existing FGD devices would be necessary.

Ramifications of CO_2 emissions control and mitigation

The most obvious ramification is that the cost of electricity will increase. With 50% of the US electricity supply coming from coal fired power plants, the option of not producing power from coal is nill. For some plants CO_2 trading may mitigate some costs.

While most of the CO_2 captured will likely be sequestered (underground) at a cost, some facilities may be able to offset a portion of the cost by selling to a growing CO_2 market. CO_2 has been increasing used as an enhanced oil recovery technique (rather than using water). However, supply will surely out grow demand in this regard.

To learn more about Venture Engineering's capabilities in this regard, please contact Mr. Bill Slatosky – Manager Process Engineering at 412-231-5890, ext. 305.

Dave Moniot has over 19 years experience Mr. Moniot has over 19 years of experience in the management, coordination, and execution of chemical, energy (including cogen and CHP), petrochemical, refinery, pharmaceutical, healthcare and research and development projects, and metals. He holds a Bachelor chemical engineering degree from the University of Pittsburgh. He can be reached at (412) 231-5890 x301, or at dmoniot@ventureengr.com.