

# Coming Clean on Coal

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The most important environmental challenge of our times may well be reducing man-made carbon output, and thus avoiding tipping the earth into potentially uncontrollable climate changes. And since 25% of global man-made carbon emissions come from the power generation industry, it is clear that reducing them is key to achieving reductions. Yet in many cases, reducing carbon outputs flies in the face of our competing desire for low-cost electricity fueled by a plentiful resource. Thanks to robust resources, one of the lower-cost sources of electricity in many regions is coal-fired generation. In fact, in the three countries that will likely have the largest electric demand growth in the next decade (China, India and the U.S.) coal reserves are plentiful. So it would seem inevitable that coal-fired generation will continue to grow<sup>1</sup>, even though its emissions are responsible for a large percentage of the total carbon contributed by the power sector.

If continued development of coal facilities is inevitable, can the competing forces of reducing carbon and keeping costs low ever be rationalized? Or are we ultimately forced to choose between low carbon output and low-cost electricity? Current technology development initiatives suggest the potential for rationalization. Possibilities include improving power plant efficiency so that less carbon is emitted per MWh of output, removing carbon prior to combustion using coal gasification technology, and removing carbon from the emission stream after combustion.<sup>3</sup> Our focus here will be technologies under development

that remove carbon from the emission stream after combustion. These technologies have the potential for use in new unit construction as well as certain retrofits to existing units.

Many power plant manufacturers are currently working with utilities, generation companies and government and industry research agencies to develop and prove post-combustion carbon capture technologies. The goal of much of this research is 90% carbon capture, meaning that for each unit of carbon used to generate electricity only 10% will ultimately be released into the atmosphere. Manufacturers involved in this

development include Alstom, Powerspan, Siemens, Mitsubishi, and Fluor. Technology approaches include CO<sub>2</sub> capture by ammonia, solvents and amines. Key development issues include system cost, the required parasitic loads (which is the amount of electricity required to run the process), and environmental side effects.

## Additional Ways to Reduce Coal Carbon Emissions

- Improved Efficiency – By improving power plant efficiency, society gets more MWh per unit of carbon emission. One key way to increase efficiency is raising the temperature of combustion through use of super-critical boilers. These raise unit efficiencies to higher than 40% as compared to 33-34% which is typical in existing U.S. units. This process reduces carbon output by about 20% per unit of energy. Such units are already commercially available and many European utilities are using this technology as a means of meeting carbon reduction requirements.
- IGCC – Coal gasification technology converts solid coal to gas that can then be combusted in a gas turbine. If desired, carbon can be removed from the gas stream prior to combustion.<sup>2</sup>

Let's take a closer look at each of the post-combustion carbon capture technologies being developed based on methods of separating CO<sub>2</sub> from gas streams. This has been done for many years in the natural gas industry where CO<sub>2</sub> is removed from raw natural gas to boost its heating value. This process uses an organic compound called amines, which absorb CO<sub>2</sub> and remove it from the gas stream. Unfortunately, using amines in this way is not practical for removing CO<sub>2</sub> from coal emission streams

<sup>1</sup>Worldwide, over 1.4 million MW of coal unit capacity exists today and this is expected to grow to 1.7 million MW in 2011 and to 2.7 million MW by 2030 (Source: McIlvaine Company, [www.mcilvainecompany.com](http://www.mcilvainecompany.com))

<sup>2</sup>For more information on IGCC see the 7/24/06 edition of *The Energy Insider*.

<sup>3</sup>Also being developed is a process called Oxy-Coal combustion which would concentrate carbon during combustion, thus making it easier to capture in the waste stream.

## Carbon Storage Techniques

While carbon capture is all well and good, its value is greatly diminished without a means of permanently keeping it out of the atmosphere. Carbon that is removed from fuel or emission streams is generally liquefied, compressed and injected into a pipeline where it can be transported to its ultimate destination. Based on experience from oil well injections, researchers believe that it will be possible to inject excess CO<sub>2</sub> into stable underground formations where the carbon will be permanently trapped (this process is called carbon sequestration). Test development projects whose goal is to demonstrate commercial viability are currently under way.

There are also limited opportunities to reuse carbon as an input to commercial processes. These include use of CO<sub>2</sub> for carbonated drinks and for refining and other industrial processes, as well as injection of CO<sub>2</sub> into oil wells to increase production. Once injected into the well, the CO<sub>2</sub> remains trapped in the underground reservoir. Both uses are proven, but the potential for commercial use is estimated to be less than 1% of total carbon emitted by coal units.

due to the cost of amine, the energy required for the process, and the fact that another by-product of coal combustion, SO<sub>2</sub>, degrades amines. Thus researchers continue to look for more effective solutions.

### Ammonia Systems

Under the right conditions, ammonia will also absorb CO<sub>2</sub> from the emission stream. The ammonia can then be separated from the CO<sub>2</sub> and reused. Powerspan is developing a process that uses ammonia at stack temperatures. Another approach using chilled ammonia is being developed by Alstom. The Alstom technology is already being field tested at a WeEnergies site in Wisconsin with further tests planned with AEP in West Virginia and Oklahoma. Meanwhile Powerspan will soon begin field testing with NRG in Texas and Basin Electric in North Dakota.

### Solvent Systems

Siemens is developing a system in which a solvent interacts with post-combustion coal emissions, causing the CO<sub>2</sub> to become a solution which can then be captured. The makeup of the solvent is still proprietary information. Siemens plans a pilot installation at an E.ON power plant in Germany by 2010.

### Advanced Amines Systems

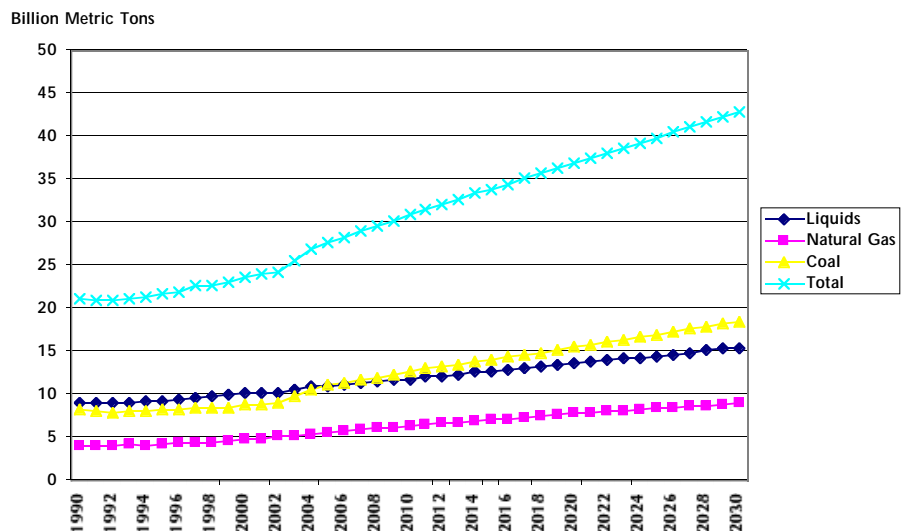
Companies such as Mitsubishi, Fluor and

Alstom are also working with amines in the hopes that the current amine systems can be adapted for use in coal units. Mitsubishi is currently operating a small demonstration facility in Japan and others hope to announce projects in the near future.

### What Does This All Mean?

Clearly a critical factor in reducing carbon emissions will be the development of technologies that use coal as a fuel source, but significantly reduce the associated CO<sub>2</sub> emissions. Post combustion carbon capture from emissions streams offers a promising opportunity to reduce coal-based carbon emissions by 90%. But there is still a long way to go from demonstration projects to commercial viability and the efforts of numerous researchers and developers will be critical. Also important, of course, are development of regulatory and market mechanisms to value carbon reductions that provide power plant owners with revenue streams to pay for the necessary technology. While governments, regulatory agencies, and market makers develop these value mechanisms, technology companies will hopefully be bringing new solutions to market that will be ready to respond to market opportunities. If they are successful, a new wave of coal-fired generation may well be a key component of future energy supply without increasing carbon outputs.

## World Energy-Related CO<sub>2</sub> Emissions<sup>4</sup>



<sup>4</sup>Source: History: EIA, International Energy Annual 2004. Projections: EIA, System for the Analysis of Global Energy Markets (2007).