State Clean Energy-Environment Technical Forum
Integrated Gasification Combined Cycle (IGCC) & Carbon Capture and Storage (CCS)
Part 1: Technology
June 19, 2006
Call Summary

Participants: 51 participants from 23 states and several national organizations (see the participants list at http://www.keystone.org/html/documents.html.)

Key Issues Discussed

- Current state of development of IGCC and CCS
- Barriers to IGCC and CSS
- Environmental and economic costs and benefits of IGCC and CSS
- Implications of IGCC and CSS for companies and existing plants

Summary of Presentations

Note: All of the presentations from this call are available for download at http://www.keystone.org/html/documents.html. Please refer to these documents for additional detail on the presentations.

A. Welcome – Julie Rosenberg, U.S. Environmental Protection Agency (USEPA) Julie noted that this will be the last call until September, when we will resume with another Forum on IGCC policies and programs. This call is intended to review the current state of the technologies and the programs available to assist states that are interested in knowing more about potential deployment of IGCC and carbon capture. She encouraged the call participants to send any suggestions for future topics to EPA or Keystone project staff (see the participant list for contact information) over the summer.

B. Overview of Integrated Gasification Combined Cycle & Carbon Capture and Sequestration – Hank Courtright, Electric Power Research Institute (EPRI)

IGCC Overview

- Clean coal technologies include 1) IGCC plants, which have low emissions and are nearly as clean as natural gas, and 2) **Ultra-supercritical (USC) pulverized coal (PC) generation, which is highly efficient** and has intense back-end clean-up to keep emissions low—though not as low as IGCC.
- Regional differences in coal mean that different options are better in some areas than in others**. IGCC functions best with high-rank bituminous coal**, although newer designs being developed may be better with low-rank coals.
- Most new coal plants in the U.S. are for pulverized coal.
- **Existing coal-based IGCCs** are in Indiana (Wabash), Florida (Polk), the Netherlands (Buggenum), and Spain (Puertollano). These plants are **250 Megawatts or greater capacity** and are currently operating in the production mode.
- There are several **IGCC projects in development**. The most advanced are the AEP, Cinergy, Excelsior, and Steelhead projects. The Soco/Orlando project in Florida is a

Department of Energy (DOE) demonstration facility to test a gasification technology with low-rank coals.

- **Research and development for IGCC** continues. Researchers are currently looking to decrease plant cost and increase efficiency, so IGCC can be more economical.
- European and Japanese companies are **working to increase the efficiency of pulverized coal plants**, hoping to reach 45% efficiency. Their preference for pulverized coal technology is based on their lack of places to sequester carbon dioxide (particularly in Japan). Efficiency improvements hold the promise of reducing costs of pulverized coal over time.
- Currently pulverized coal is less expensive than IGCC, but when carbon management results in a price for carbon dioxide (CO_2)**, IGCC will be cheaper than pulverized coal** at about $40/metric tonnes of CO_2.
- **IGCC should be competitive with pulverized coal by 2020**. Improvements in IGCC technologies (such as elimination of the spare gasifier and building more efficient turbines) will help make IGCC more competitive.
- **Partnerships are leading the way** in IGCC technological developments. **FutureGen is a critical project** that is expected to further lower the cost of IGCC.
- **EPRI's CoalFleet** project is also moving IGCC forward.

Carbon Capture and Sequestration Overview

- **IGCC and pulverized coal plants do not presently use carbon capture**, but retrofitting may make this possible in the future. It takes additional energy and cost to capture and store CO_2.
- **Capture, transport, and storage of CO_2 add 60-70% energy loss to the pulverized coal process.** This cost is what keeps PC from capturing CO_2 today. By comparison, there is only a **30-40% cost increase for IGCC to capture CO_2**. (These numbers are for high-rank eastern coals; they go down somewhat for low rank western coals.)
- There are currently a variety of carbon storage activities around the world, including leading projects in the North Sea (Sleipner), Canada (Weyburn), and Algeria (In Salah). **U.S. companies are learning from these large, successful projects**.
- **The U.S. has great capacity to store CO_2**—similar to Saudi Arabia's capacity to produce oil.
- **Risks that need to be managed in carbon sequestration** include leakage, environmental impacts, permitting, and legal issues.
- **Storage failure mechanisms are also a concern.** Well-bore integrity can be a problem as there is some potential for corrosion and consequent leakage.
- **Storage security should increase with time**, as carbon moves from structural and stratigraphic trapping toward mineral trapping.
- **DOE's carbon sequestration regional partnerships continue to test and demonstrate geologic injection testing.** These are generally small-scale projects, although one is planned for approximately 450,000 Tonnes/year.
- EPRI has its own carbon capture initiative, which is a **multi-phase testing program to develop cost-effective and practical pulverized coal carbon capture technologies**. These technologies have high back-end clean-up in order to achieve emissions similar to those of IGCC. Chilled ammonia has shown some potential to close the cost gap between PC and IGCC.

- **Carbon transport technology is relatively straightforward, but some questions remain** about allowable impurities, pipeline specifications, and permitting outside of rural areas.

C. Overview of Gasification Technologies Council (GTC) Activities and Assistance to States - James Childress, Gasification Technologies Council

- GTC's mission is to promote greater use of gasification technologies in an environmentally superior way.
- Gasification is a commercial technology that is used in a number of applications—not just IGCC. **It reduces dependency on natural gas for electricity generation, opens the way for coal to compete with natural gas in chemicals and fertilizer production and with petroleum in the production of motor fuels, and adds value to U.S. coals by expanding options for their use.** In 2004, there were 117 operating plants with 385 gasifiers.
- **Capacity** for gasification is distributed widely around the world, although the largest **number of plants** is in Europe, North America, and Asia.
- **Based on a 2004 survey, gasification capacity is expected to continue to grow**, more than doubling between 2000 and 2010.
- **Drivers of gasification in the U.S.** include high energy prices, demand for clean electricity and fuel, and federal and state incentives. Strong technology providers, alliances, and guarantees are another driver, and they seem to offer great opportunities for growth in gasification.
- **There are currently scores of gasification projects running in commercial mode worldwide.** The most recent IGCC plant, Negishi, is fully commercial and meets the tough environmental standards in Japan.
- **Gasification offers the least-cost alternative to capture CO_2 for fossil fuel based-power generation and co-production. The Dakota Gasification SNF plant is doing it in North Dakota and selling the CO_2 for enhanced oil recovery.** The Pernis plant in the Netherlands produces hydrogen for use in refineries, creates electricity, and produces CO_2 for greenhouses.
- **Outstanding issues** with sequestration include cost, finding suitable geologic formations, and long-term retention of CO_2.
- **IGCC shows an environmental edge over coal combustion-based power generation**--it produces fewer emissions of criteria pollutants, less creation of solid wastes and wastewater, and lower costs of mercury removal.
- **State agencies, including public utility commissions, environmental regulatory agencies, and economic development offices, are as important as the federal government** in the success of IGCC and sequestration.
- **There are funds available for expense reimbursement for individuals from the public sector who want to attend the Gasification Technologies Workshop (in Bismarck, North Dakota) June 28-2,9 2006,** and there should be at least two of these events in 2007**.** There will be a panel at this workshop on state permitting of IGCC. More information is available at www.gasification.org.

Questions

[Note: Both Hank Courtright and James Childress responded to most questions. Their responses have been combined here to maximize readability.]

Can the use of co-production technologies eliminate the need to capture and sequester carbon?

Even with co-production (producing electricity and other products such as Fischer-Troph fuels or hydrogen), CO_2 is still a by-product. Also, when you are producing something in addition to or instead of electricity (chemical fuels, etc.), you often have to go through chemical shift anyway. However, it is easier to capture with IGCC technology than capturing it after-the-fact in flue gas, where CO_2 is more diluted (ratio is 100-1) and the pressure is lower. Therefore, it takes more energy to capture it in the diluted state.

Hasn't the limitation in ultra-supercritical research been metallurgy at high temperatures and pressures? If so, how do you get around this?

Yes, metallurgy is a key issue. You need materials that can handle high temperatures. Looking at different steels with different alloys has been a key part of the research program. DOE has spent approximately $25 million on research and development over 5 years, and some of these funds have gone to studies of metallurgy for turbines, boilers, etc. We think it can be achieved, but it will not be commercially available for about a decade.

Will increased reduction requirements and values for sulfur dioxide (SO_2), nitrogen oxides (NOx) and mercury (Hg) allowances change the cost considerations for IGCC?

The allowances may have a slight effect on the choice between PC and IGCC, but not a dominant one. IGCC has the advantage of potentially lower SO_2 and Hg emissions. As the price of NOx and Hg allowances go up, there might be some economic value that would favor IGCC, but CO_2 is still the big issue—a value for CO_2 is the potential tipping point for determining competitiveness of IGCC.

What is it about the quality of western coal that makes it difficult for IGCC to handle?

Powder River Basin (PRB) coal has a higher moisture content and lignite has a higher ash content that make it harder to process. If IGCC can deal with western lower rank fuels, then it will make IGCC more viable.

Some IGCC facilities can deal with these, but it increases the cost of electricity a bit. Orlando Utilities is working on a facility that can deal with PRB coal.

Are we spending enough on research to know if carbon capture for supercritical PC can be done in an effective manner?

No. The research funds in the DOE budget are going predominantly to FutureGen. This allocation is appropriate, but it means that there are no other funds available to explore other technologies. Chilled ammonia process, in particular, merits additional funding.

If a utility wants to do IGCC without knowing what CO_2 might cost in the future, and the most economic thing to do is to generate electricity <u>and</u> produce other products, how do you get utilities to work with other partners to make this work?

I am not aware of any regulated utility that is trying to build a polygen plant. The difficulty is with the business model and the operating culture. Utilities know how to "do" electricity and would need to partner with others, which they are reluctant to do. Also, when you get to load-following, the strong preference is to base-load—load following creates more exposure to reliability factors. Another question is how you would structure regulation of such plants.

What are the economic opportunities for co-production? For example, how does the value of alternative products in addition to electricity affect the competitiveness of IGCC and pulverized coal plants?

It may be difficult for utilities to both achieve the economic benefits of co-production and also meet the load-following requirements of electricity demand without jeopardizing reliability. In addition, utilities may not be interested in making chemicals as a sideline when their core business and expertise is producing electricity. They might want to partner with someone who takes on the responsibilities for marketing and delivering any co-products. Some plants are testing burning hydrogen directly, which might provide a viable co-production path, but there are still some technical challenges, including how much hydrogen you can use.

In general, chemical companies are more likely to engage in co-production. One participant mentioned that an Exxon plant is currently producing electricity with petroleum coke – a project developed under old PURPA regulations.

What are the permitting and guidelines issues for IGCC versus permitting for conventional power plants?

The permitting process for IGCC is unclear. Industry has questions about it. In general, there needs to be a more streamlined approach to permitting. There are specific permitting differences between IGCC and PC including the treatment of flare gases and OSHA requirements.

Technologically speaking, is it advisable for utilities to wait to invest in IGCC until FutureGen is completed?

No. Deployment of new technology is important to keeping coal competitive and addressing climate change. Currently, companies have to deal with the additional risks as early deployers of new technologies. To minimize the economic uncertainty that comes from the lack of an IGCC track record, some companies try to get a performance guarantee for the manufacture of equipment and regulatory agreement for cost recovery upfront. It is necessary for companies to be prudent on this—they need to have this kind of safety net. It is critical that the early IGCC plants are done well; otherwise, there is the risk of setting back the overall IGCC movement. We need early plants to serve as test-cases and learning tools, and the regulatory community can help by providing greater cost recovery certainty We think IGCC can be very successful and that it will achieve acceptable performance levels and reliability numbers, but we do not know how long it will take to get there.

How would this technology apply to the wood products industry?

There are gasifiers that are using biomass. Gasifying wood chips with small airborne gasifiers has not been successful. There is greater potential in black-liquor gasification in the pulp and paper industry—this has high-value environmental benefits. There is a company in Sweden that is having some success with this.

What is the status of conversions of natural gas combined cycle plants to coal gasification?
There was a lot of interest in this at first, but technological feasibility and economic concerns have headed off enthusiasm. There are some questions that need to be answered such as whether the site has access for transportation and space for coal stockpiles and whether the facility has the expertise for changes to coal combustion. However, in the last 6 months there has been increased activity in retrofitting old coal plants on the east coast. They cannot get a new coal combustion plant permitted in their areas and already have all the space and other requirements, so it makes sense there.

Although plants that are now being built do not have CO_2-capture technology, could they be retrofitted?
You can add CO_2 scrubbers on the back-end. Some coals plants are physically laying out extra space for scrubbers on new plants just in case. This extra space is necessary, because the scrubbing technology is quite large.

Is anyone looking at storage of hydrogen, which is a byproduct?
I do not think anyone is looking at hydrogen storage. They probably use produced hydrogen in a combustion turbine or transport it immediately by pipeline for use in petroleum or chemical production. Storing hydrogen is very risky.