The IGCC Process: From Coal To Clean Electric Power

Outlook on Integrated Gasification Combined Cycle (IGCC) Technology

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Good morning, Mr. Chairman and members of the Subcommittee. My name is Ed Lowe. I am the Gas Turbine-Combined Cycle Product Line Manager for GE Power Systems. I appreciate the opportunity to testify this morning.

I am pleased to be here today to share with you our views about the benefits that Integrated Gasification Combined Cycle (IGCC) technology can deliver. IGCC can cost effectively produce power from solid fuels, such as coal, with substantial environmental benefits over other coal power generation technologies. If IGCC is adopted as the preferred coal based power generation technology, it will help the country and our customers meet the environmental goals of reducing NOx, mercury and other air pollutants, while also advancing sound energy policy goals of retaining a secure and diverse mix of fuels for electric power generation and improving the efficiency of coal based power generation.

OVERVIEW OF IGCC TECHNOLOGY

IGCC is a process that converts low value fuels such as coal, petroleum coke, orimulsion, biomass, and municipal wastes into a high value, low Btu, environmentally friendly natural gas-type fuel, also called “synthesis gas” or simply “syngas”. When used to fuel a combined gas turbine and steam turbine plant, known as a combined cycle system, coal based syngas fuel produces electricity more efficiently and with lower emissions than traditional direct fire coal boilers.

Coal gasification is not new, although there have been many technological improvements over its development cycle. The first mention of using coal gasification in the United States to produce "Town Gas" was by the Baltimore Gas Company in 1842, and by the 1910s,

commercial coal gasification was commonly used in the United States and Europe to provide cities with gas for streetlights and domestic consumption.

However, the combination of gasification with gas turbine power plants – the IGCC concept - had to wait until gas turbine combustion technology had advanced to the point that it was ready to accept the significant technical challenge of combusting low Btu IGCC fuels. Gas turbines for IGCC are markedly different from the vast majority of gas turbines that are fueled by natural gas. IGCC gas turbines must be specifically engineered to achieve highly efficient and reliable service on syngas. These design enhancements relate primarily to the combustion and fuel systems, but also encompass special safety, packaging, and controls modifications.

IGCC's roots trace back to GE's Global Research Center in Schenectady, NY. In the early 1970's pilot testing demonstrated poor fuels could be converted to clean syngas, and that it was possible to integrate a gas turbine and a chemical gasification plant. Further work, at GE's Schenectady laboratories, continued in the early 1980s on gas cleanup and with full-scale combustion development. This work led to the first large commercial coal IGCC Plant, the 120 MW Cool Water Plant located in California. This was a partnership funded project with EPRI and other participants that utilized GE's innovative gas turbine combustion technology. Commissioned in 1984, Cool Water demonstrated the technical feasibility of IGCC.

In the 1990's commercial IGCC plants were successfully built and operated with steady improvements in reliability, efficiency and cost. Two examples of current coal IGCC plants are Tampa Electric Company's Polk 250 MW IGCC plant in Florida, commissioned in 1996, and the Public Service of Indiana's (now Cinergy) Wabash River 250 MW IGCC plant in Indiana, commissioned in 1995. These two plants, utilizing GE gas turbines, have successfully logged over 50,000 operating hours on coal synthesis gas.

Since GE pioneered IGCC nearly three decades ago, we have developed a broad IGCC product line of gas turbines with matching steam turbines spanning the 100 to 400 MW module range. GE has sold over 23 IGCC gas turbines and attained over 400,000 gas turbine operating hours on syngas. GE is committed to developing new and improving existing IGCC gas turbine designs. New York continues to serve as the central hub of our efforts to advance this technology. The development of concepts for further improvement in emissions is continuing at our Global Research Center in Schenectady, and we recently strengthened our commitment to advance IGCC technology with the commissioning of a new combustion development facility in Greenville, South Carolina.

ENVIRONMENTAL ADVANTAGES OF IGCC

IGCC is inherently less polluting and more efficient than any other coal power generation technology. In IGCC, harmful pollutants are removed from the syngas before they reach the gas turbine; therefore, end-of-pipe/stack cleanup is not necessary. IGCC efficiently removes ash, sulfur compounds, ammonia, mercury, other metals, and any particulate matter to reduce air pollution. Emissions of SO_x, NO_x, mercury, heavy metals, and particulate from an IGCC plant are fractions of the emissions from conventional, coal power plants.

For example:

- IGCC NO_x emissions are approximately half those of modern pulverized coal steam-boiler plants. About 0.07 lb/million Btu NO_x emissions can be achieved through IGCC. This is approximately a 60% reduction in NO_x emissions from the average coal plants operating today. Since 1980, the can-annular combustors employed by GE have been continuously improved to handle a wide variety of fuels and to reduce NO_x emissions. Beginning with the Cool Water Coal IGCC test program, NO_x emission performance was demonstrated at less than 0.125 lb/million Btu using "E" class gas turbine technology. The recent TECO Polk and PSI Wabash plants, have achieved similar NO_x values (less than 0.1 lb/million Btu), using higher efficiency "F" class technology. Similarly, full pressure and temperature laboratory test programs using various process diluents, including N_2, H_2O, and CO_2, lead us to believe that the challenging target of single digit NO_x emissions (0.04 lb/million Btu) may be possible. GE is evaluating whether to implement a development program with the goal of achieving this challenging target, and the support of EPA, or legislative changes, would encourage our initiation of such a program.

- 95% mercury removal is being achieved by a gasification plant in Kingsport, Tennessee. Similar mercury removal systems can be used to economically and reliably remove mercury for new IGCC plants.

- Sulfur can be recovered from the syngas either as elemental sulfur or sulfuric acid in pre-combustion cleanup. Both elemental sulfur and sulfuric acid are marketable industrial by-products depending on local economics. With little sulfur remaining in the syngas stream that enters the gas turbine, the emissions of SO_x for an IGCC plant are less than half of those of even state-of-the-art direct combustion coal boiler plants.

GE's emphasis on improving turbine and combined cycle efficiencies has directly benefited IGCC emissions performance. High IGCC efficiencies yield CO_2 greenhouse gas emissions that are 12% lower than those of state-of-the-art coal steam-boiler plants. These emissions are approximately 30% lower than those of average coal plants

operating today, for comparison purposes. Additionally, in the gasification process carbon can be removed from the syngas to create a hydrogen-rich fuel that can further reduce CO_2 greenhouse gas emissions. In our combustion development programs, GE has successfully demonstrated combustion of 90% hydrogen syngas fuel to demonstrate the technical feasibility of power plants with ultra low CO_2 emissions.

Let me emphasize this key point: In the IGCC process harmful pollutants are removed from the syngas stream before combustion, rather than in post combustion flue gas treatment. The pressurized syngas stream represents less than 1/100 of the volume of flue gas from direct coal combustion and the contaminants in syngas are concentrated. Therefore, IGCC pre-combustion clean-up is far more effective and much lower cost than the post-combustion clean-up employed in direct combustion coal steam-boiler plants.

And there is another important environmental benefit: In IGCC coal ash is converted in the gasifier into a solid, vitreous slag which is chemically inert. This non-leaching slag can be employed in the construction industry as road fill or as strengthening aggregate for building concrete. IGCC does not require secure landfill sites for ash storage and ash-landfill pollutant leaching into the groundwater is not an issue.

ENVIRONMENTAL REGULATION SHOULD NOT BE A BARRIER TO IGCC DEPLOYMENT

In spite of these significant environmental benefits, we are concerned that permitting bodies may burden IGCC with duplicative and reliability reducing end-of-pipe controls for NO_x, such as SCR (selective catalytic reduction). These systems cannot work as reliably on IGCC as they do on natural gas fired units. The pollution prevention combustion technology on GE's IGCC gas turbines delivers NO_x emissions below that of alternative coal technologies and we strongly believe that IGCC must be evaluated as a coal technology with consideration given for its total environmental benefits when setting emission targets.

OPTIMAL USES OF IGCC

Gasification is a steady state chemical process and therefore IGCC plants perform best in base-load applications. IGCC gas turbines require natural gas or distillate as a start-up fuel; so that all IGCC gas turbines must be dual fuel capable. As a consequence, IGCC plants can switch to the backup fuel when syngas is unavailable or co-fire when syngas is limited. With the availability of backup fuels and combustion

design flexibility, IGCC plant power availability can approach that of natural gas combined cycle plants.

IGCC must be optimized based on the design requirements, which is primarily defined by the fuel characteristics — there is no universal IGCC design that will satisfactorily meet all expectations. A myriad of technical possibilities must be balanced for each gasifier type and each syngas fuel to optimize IGCC systems for specific fuel type and site conditions. Through cycle optimization studies and by incorporating lessons learned from successful operation of many IGCC units, GE has optimized system configurations for all major gasifier types and most GE heavy-duty industrial gas turbine models.

GE is conducting continuous improvement programs, which endeavor to further enhance the overall performance level of IGCC plant designs. Working with various process technology suppliers, GE is helping to facilitate, define and develop lower cost and higher efficiency IGCC plant designs.

FAVORABLE ECONOMICS

The cost to build large IGCC plants has steadily decreased over the last 25 years; the installed turnkey Engineer Procurement Construct (EPC) price is now projected to be $1200 per kW. This makes the superior IGCC technology cost competitive with other modern coal power plant options such as Circulating Fluid Bed, or super critical and ultra-super critical pulverized coal boiler plants with state of the art emission control systems.

Continuous gas turbine technology improvements raise the prospect for further economic improvements as output power and plant efficiencies increase. As additional IGCC plants go operational, improvements in system performance and plant design cost can be expected from a growing and maturing technology experience base.

CONCLUSION

IGCC clearly becomes the superior coal technology option when its higher plant efficiency – 5 percentage points above other coal technologies – and significant environmental advantages are considered.

Coal IGCC offers superior environmental performance while projected to produce electricity at prices competitive with modern direct-fired coal power plants. IGCC also provides an inherent capability to cost effectively meet future environmental needs because contaminates are removed in a low volume, high

concentration, pre-combustion fuel gas steam. We look forward to exploring options with you and with regulatory agencies to ensure that appropriate laws and policies are in place to allow IGCC's environmental and efficiency benefits to be achieved.