Summary of Major Points from the Statement of Edward Lowe, General Manager Gasification Market Development, GE Energy before the U.S. House of Representatives Subcommittee on Energy and Air Quality

- Climate change marks a fundamental paradigm shift that will require that we use coal in a different manner for it to be environmentally and economically acceptable.

- The US coal power base in the United States is dominated by pulverized coal combustion, or PC. It is a mature technology.

- IGCC is an alternative, proven coal technology that is fundamentally different than PC in that pollutants are removed pre-combustion versus post combustion. Pre-combustion capture of pollutants has efficiency and cost advantages over post-combustion treatment.

- The first commercial US coal IGCC plants began operation 10 years ago. They validated IGCC's environmental advantages and continue operation today.

- Currently, IGCC has higher capital cost than PC. IGCC is beginning to move down the experience/cost curve, but its deployment and experience is critical to reduce the capital cost gap.

- Pre-combustion CO2 capture with IGCC will incur a reduced impact on capital cost, efficiency, output and cost of electricity than PC with post-combustion capture.

- In terms of readiness, IGCC is ready for carbon capture today. All of the key processes and equipment required for carbon capture in IGCC have been demonstrated in chemical and refinery applications. IGCC is well ahead of combustion coal in this respect.

- IGCC plants that are configured for carbon capture represent a ready hydrogen source that can serve as the catalyst for a hydrogen economy.

- In the area of carbon capture, technology decisions cannot be divorced from policy decisions. Clear policy is needed as an effective catalyst for new technology development, deployment and improvement.

- Favorable federal policy for cleaner coal can take the form of clarity of regulatory policy, incentives, and removal of barriers. The marketplace will then be able to respond with the kind of technology advancements that we benefited from in advanced turbines and wind energy.

Statement of
Edward Lowe, General Manager
Gasification Market Development, GE Energy
Before the United States House of Representatives
Energy and Commerce Committee
Subcommittee on Energy and Air Quality
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Good morning, Mr. Chairman and Members of the Committee. I am Edward Lowe, General Manager for Gasification Market Development at GE Energy. GE appreciates the invitation to participate at this hearing.

GE is a worldwide supplier of advanced power generation technologies that include steam turbines, environmental services and IGCC for coal. Coal is our country's most abundant fossil fuel resource and an important component of the fuel mix necessary for the security and reliability of our nation's electrical power generation Climate change marks a fundamental paradigm shift that will require that we use coal in a different manner for it to be environmentally and economically acceptable. The approaches as to how coal can continue to be a significant part of our energy mix in an economical and environmentally acceptable manner with cleaner coal technology is the focus of my testimony.

Today, the installed coal power base in the United States is dominated by pulverized coal combustion, or PC (Figure 1). The widespread deployment of pulverized coal began in the early 1920's. Since then, steam temperatures, pressures and efficiencies have increased but the basic technology is unchanged. Finely ground coal is mixed with air, burned and heat is extracted from the combustion products to boil water and produce steam that is used in a steam turbine. Pollutants, such as sulfur particulates and mercury are carried as combustion product in a large volume of flue gas. The major physical change that you would see between the early and today's plants is the addition of "end-of-pipe" emission control equipment such as scrubbers to capture sulfur, catalytic reactors to reduce NOx, and precipitators or fabric filters to capture particulates. This control equipment can be larger than the original boiler and a major portion of the plant cost. The approach of merely adding additional boxes to the treatment train as regulations develop continues today with examples being mercury and concepts for achieving carbon capture.

An alternative demonstrated technology for coal power generation is integrated gasification combined cycle, or IGCC (Figure 1). IGCC is fundamentally different than combustion-based PC. The coal-to-power process begins with gasification – a partial oxidation process -- that turns the coal into a natural gas-like fuel called synthesis gas (also known as syngas) primarily consisting of carbon monoxide and hydrogen. Syngas initially contains pollutants such as sulfur, particulate and metals; however, with IGCC these pollutants can be removed pre-combustion, which eliminates the need for adding large, post-combustion treatment boxes. Since syngas is 1/100th of the volume from combustion, pollutants are concentrated and can be more economically and efficiently captured and removed than with post-combustion cleanup. Low volume and high concentration also have beneficial implications for carbon capture which will be discussed later. The cleaned gas is then converted to power in an advanced gas turbine combined cycle plant.

With its pre-combustion cleanup, gasification can be considered as a coal refining process. Compared to current state-of-the-art PC plants, IGCC can produce emissions of sulfur dioxide and nitrogen oxides that are dramatically lower. Compared to an average of recent PC permits and permit applications (Figure 2), an IGCC plant would produce 90% lower SOx, 77% lower NOx and 33% lower particulate matter. IGCC is highly effective at mercury removal and can achieve 90% or higher removal independent of coal type. IGCC consumes 30% less water than PC technology and produces useful byproduct such as elemental sulfur or sulfuric acid for beneficial industrial use such as fertilizer production and vitreous slag for construction use.

So you may ask, if IGCC is so much better, what has been holding up its deployment? A key factor is technology maturity. Compared to 80-90 years of PC experience, the first commercial US coal IGCC plants came into operation 10 years ago through the DOE Clean Coal program. These projects have validated IGCC for coal-to-power. Due to a low variable cost of production, one of these plants--the TECO Polk IGCC plant—is the first TECO plant to dispatch in its fleet, which includes larger PC plants. Owners of both of the early IGCC plants – Duke and TECO – are now pursuing new IGCC projects as recipients of investment tax credit certification under the 2005 Energy Act.

A second key reason is high initial capital cost, although IGCC is beginning to move down the experience/cost curve. Experience provides a flow of design improvements necessary to reduce cost. Design margins incorporated in first-of-a-kind plants can be reduced. Engineering can be re-used and schedules reduced. Recently, inflation has accelerated in basic materials and construction costs to impact all coal projects, both PC and IGCC. For example, the Chemical Engineering Plant Cost Index increased by 29% from 2001 to 2006. IGCC carries larger contingencies due to perceived risk and lack of experience in construction and startup. Today we estimate that the first large-scale commercial IGCC plants to have a 20%-25% premium over PC. As IGCC is deployed, that premium will be reduced to where we believe this gap will be reduced to 10% or less. Savings will be achieved by 1) avoiding one-of-a-kind designs to reduce design and engineering cost and provide a baseline for improvement, 2) optimizing gasification and power generation technology integration, 3) improving design through operating experience, and 4) reducing costs by building a supply chain with greater volume and standard components.

However, with carbon capture and sequestration, we believe pulverized coal will bear a cost premium over IGCC. Carbon capture in an IGCC plant will be performed pre-combustion versus post combustion as would be done in a pulverized coal plant. Pre-combustion capture provides the same fundamental advantages it has with capturing other pollutants -- small volume, high pressure, and high concentration.

In terms of readiness, IGCC is ready for carbon capture today. All of the key processes and equipment required for carbon capture in IGCC have been demonstrated in chemical and refinery applications. The process is flexible and can be configured for a wide range of carbon capture levels. An IGCC plant configured for pre-combustion carbon capture from coal consists of the following four steps:

1. Gasification conversion of coal to syngas. GE gasification technology has 14 units operating on coal and pet coke solid fuels.

2. A chemical process (shift) that reacts carbon monoxide with water to form CO2 and hydrogen. There are 25 units in operation that are using the shift process with GE gasification technology.

3. The CO2 is scrubbed from the syngas using an appropriate solvent and separated into a concentrated stream. The remaining syngas is primarily hydrogen. There are 25 units in operation today that are using scrubbing to produce hydrogen from GE gasification in the chemical industry.

4. The hydrogen is then converted to power in a combined cycle gas turbine. Hydrogen is an acceptable and proven fuel for gas turbines. The capability to use hydrogen fuel has been proven in 22 GE gas turbines operating today with hydrogen content between 50% to 95% -- representative of the range expected from a coal IGCC plant with carbon capture. GE is also providing commercial bids today for hydrogen fueled gas turbines.

All of the key components of low carbon power with IGCC have been proven in large-scale commercial operation and are ready to be integrated into a total IGCC carbon capture power plant. Lessons learned will be drawn from GE's base of over 3GW of global GE IGCC experience and much of this involved with integration of IGCC into refineries (Figure 2). An example of how these pieces are being combined into a commercial IGCC plant with carbon capture is the hydrogen-to-power project that GE is designing with BP and Edison Mission Energy for a refinery at Carson California. In addition to capturing CO2 that will be used for enhanced oil recovery and hydrogen power with 90% carbon capture, this plant will achieve criteria emissions at or better than a natural gas fired turbine and at a fraction of those achievable with a PC using state-of-the-art air quality control equipment. IGCC is also providing a highly beneficial use for petroleum coke – a refinery byproduct.

A key advantage of IGCC with carbon capture that should not be overlooked is the production of hydrogen. IGCC plants that are configured for carbon capture represent a ready hydrogen source that can serve as the catalyst for a hydrogen economy. This cannot be done with a pulverized coal plant. Although the initial primary use will be for power generation, deployment of IGCC with carbon capture and hydrogen generation can serve as both a catalyst and backbone for a hydrogen economy. An IGCC plant that cycles through a turndown of power at night will be able to utilize the gasification plant to generate commercial hydrogen. The net result is that coal can become the source of ultra-clean fuel for transportation or other embodiments of a hydrogen economy and a broadened range of economic and societal environmental benefit from coal. This is in addition to the generation of useful byproducts such as sulfur or sulfuric acid for chemicals and construction material that IGCC provides.

PC plants are currently limited to post-combustion carbon capture. Other approaches such as oxycombustion are just entering early demonstrations and far from being proven. If configured with carbon capture using current commercial technology, a PC plant would be equipped with an additional CO2 scrubber. A physical difference with IGCC would be the larger size of the scrubber required to treat a 100-fold higher flue gas volume than IGCC syngas and at a 5-fold lower flue gas CO2 concentration than IGCC syngas. As referenced in the DOE NETL 2006 Cost and Performance Analysis of Fossil Energy Plants, scrubbing and solvent regeneration requires a large amount of power – approximately 28% of total PC plant output versus approximately 12% for an IGCC plant. The additional capital cost for carbon capture will also be significant - approximately 70%-75% for PC versus 25-30% for an IGCC plant. The net impact is a significant increase in the cost of electricity of approximately 65% for a PC plant versus approximately 25% for an IGCC plant.

Given these costs, and exclusive of a value for CO2 that can be derived from enhanced oil recovery (EOR), which is also a proven technology, there is currently no economic or market motivation to drive implementation or development of carbon capture. If low carbon power from coal is to be deployed, implementation will require policy that establishes a market price for carbon.

Another barrier to deployment is that the US does not have a carbon capture and sequestration regulatory regime. We believe that CO2 sequestration and storage can be done effectively and safely and you will hear about that from another panelist. With respect to transport, currently in the US, there are approximately 3500 miles of CO2 pipelines already in place and 28 MT/year of CO2 injected for EOR recovering more than 55 MM barrels of oil per year. The DOE estimates that there are approximately 550 reservoirs in the U.S. where CO2 could be used for EOR. The use of CO2 for EOR in these reservoirs could result in an increased recovery of nearly 89 billion barrels of oil. Key demonstrations of carbon sequestration are planned by the Regional Carbon Sequestration Partnerships and supported by DOE. GE is working with our customers to fully understand and integrate the requirements that will be placed on CO2 for EOR, deep well or aquifer sequestration and their impact on plant design and tradeoffs.

In the area of carbon capture, technology decisions cannot be divorced from policy decisions. Clear policy is needed as an effective catalyst for new technology development, deployment and improvement. Fortunately, we have positive examples of how this can be done.

- Turbine advancements that increased efficiency from 40% to 60% with a concurrent reduction in NOx emissions by a 8-fold was driven by the Clean Air Act, financial support from the DOE and our own investment.

- Federal Production Tax Credits coupled with state Renewable Portfolio Standards provided the pivotal support to grow a wind energy industry that did not exist 15 years ago to installation of 2,500MW of wind energy and a total installed wind capacity of 12,000MW in the US in 2006. With continued clear policy and support, new global wind energy is expected to maintain an average 13% CAGR until 2030.

These are the kinds of success stories that we should all want for cleaner and low carbon coal power generation. Favorable federal policy for cleaner coal can take the form of clarity of regulatory policy, incentives, and removal of barriers. These are needed to send a message to the marketplace. Early movers need to be rewarded. Long-term liability issues for carbon sequestration need be resolved. Market mechanisms that will define a value for carbon are needed.

Policy options that GE recommends for consideration are

- Expanding the current investment tax credits authorized and funded under the Energy Policy Act of 2005 to offset the current 20% to 25% CAPEX premium of IGCC.
- Incentives or extra credits for early movers with carbon capture
- CO_2 allocations for new low carbon plants
- Low carbon portfolio standard with trading among utilities for low carbon credits
- Carbon capture requirements for new coal power plants phased in over time starting with carbon capture ready, then equivalent to best in class NGCC, and finally with Best Available Control Technology
- EOR and saline aquifer carbon storage demonstration projects
    - Government issued site selection criteria & monitoring requirements
    - De minimis leakage and liabilities for leakage must be addressed

With respect to demonstration projects, IGCC with carbon capture can serve as a CO2 source for large-scale sequestration demonstrations. This should be a deliberate and careful phased approach both in terms of the capture level and the scale of sequestration. As an example, IGCC is capable of modest (3%-10%) carbon capture with a small impact to cost and efficiency. At 10% capture, a

600MW IGCC plant will generate approximately 400,000 tons/year of CO_2 for sequestration or enhanced oil recovery. Government funding for intermediate scale demonstrations would serve to validate the approach, increase confidence, understanding and experience of integrating carbon capture with sequestration and the base for moving to higher levels of capture. Legislation should encourage and reward those who undertake such demonstrations with credit for their early action.

Finally, I would like to thank you and your colleagues the Congress for recognizing the vital role of cleaner coal the 2005 Energy Policy Act. IGCC was a significant beneficiary. Three coal IGCC projects and a petroleum coke hydrogen-to-power IGCC project were awarded investment tax credits. These projects will provide initial experience that is vital to begin closing the cost gap and moving IGCC into wide commercial acceptance and as a platform that brings coal to readiness for a carbon-constrained environment.

Thank you for your attention and I look forward to your questions.

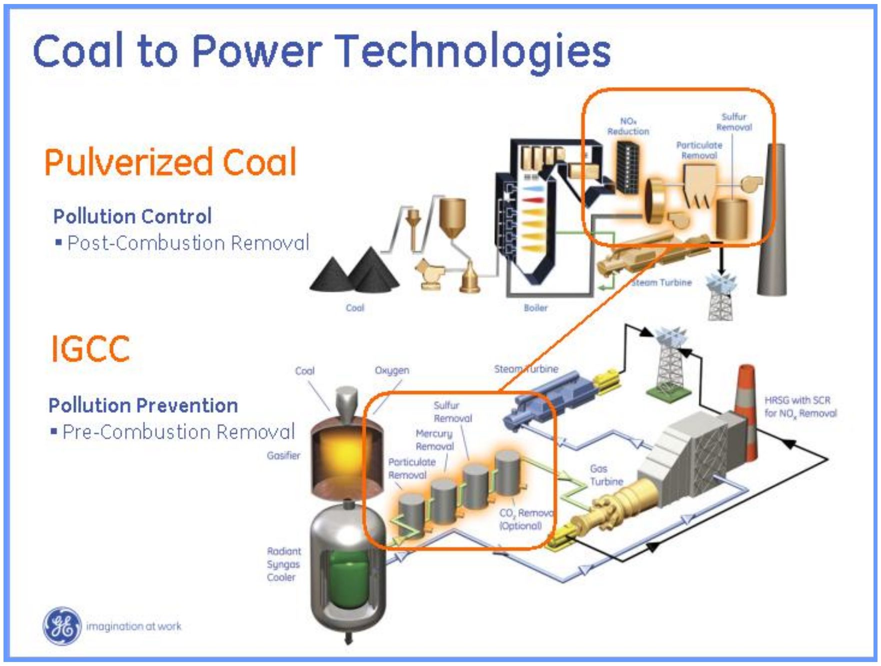


Figure 1

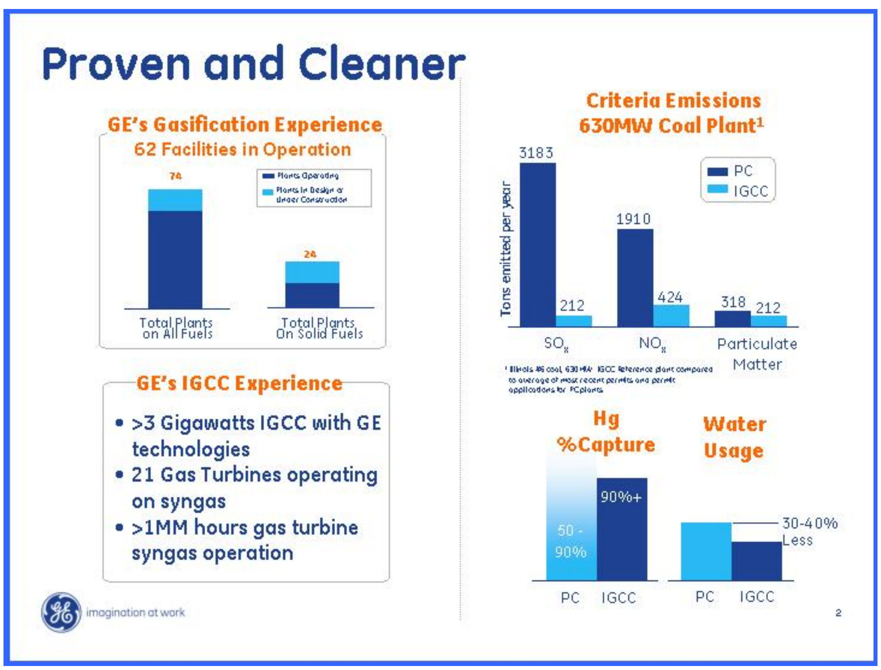
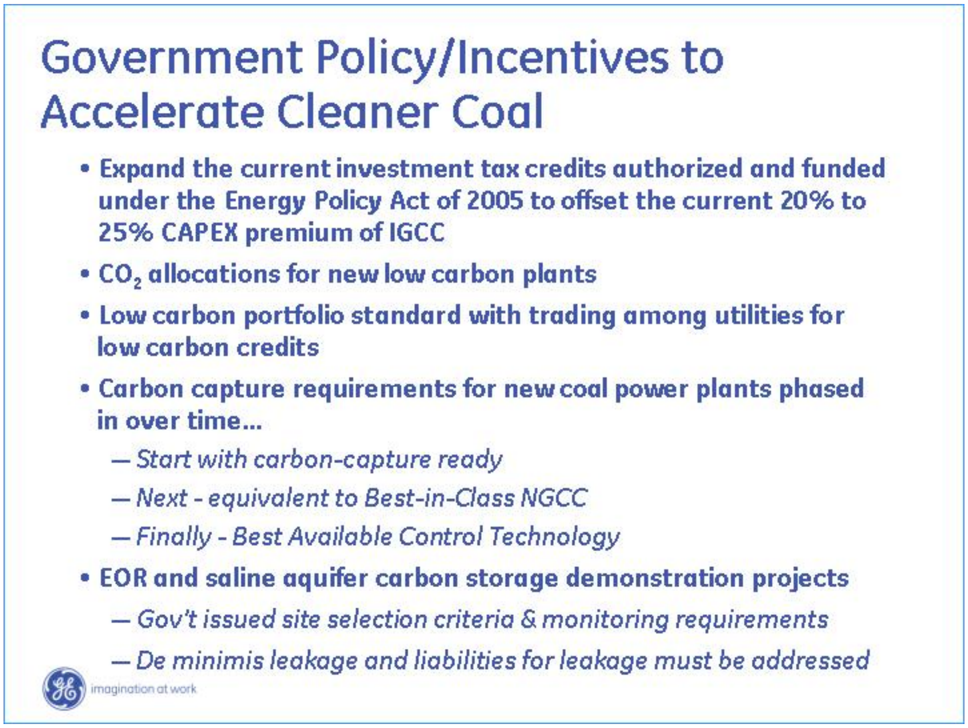


Figure 2


Government Policy/Incentives to Accelerate Cleaner Coal
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imagination at work

Figure 3