ORIGINAL

BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

DOCKET NO. 070098-EI
FLORIDA POWER & LIGHT COMPANY

IN RE: FLORIDA POWER & LIGHT COMPANY'S PETITION TO DETERMINE NEED FOR FPL GLADES POWER PARK UNITS 1 AND 2 ELECTRICAL POWER PLANT

CMP ____
COM 5
CTR Orig
ECR ____
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OPC 1
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DIRECT TESTIMONY & EXHIBIT OF:

STEPHEN D. JENKINS

BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

FLORIDA POWER & LIGHT COMPANY

DIRECT TESTIMONY OF STEPHEN D. JENKINS

DOCKET NO. 07____- EI

JANUARY 29, 2007

Q. Please state your name and business address.

A. My name is Stephen D. Jenkins. My business address is URS Corporation, 7650 West Courtney Campbell Causeway, Tampa, Florida 33607.

Q. By whom are you employed and what is your position?

A. I am employed by URS Corporation ("URS") as the IGCC Technology Leader.

Q. Please describe your educational background.

A. I received a Bachelor of Science in Chemical Engineering from the University of South Florida in 1976.

Q. Please describe your work and professional experience.

A. I have over 30 years of experience in the power industry, primarily in the design, permitting, and operation of large coal-fired and oil-fired power plants, emission control systems for coal-fired power plants, and Integrated Gasification Combined Cycle ("IGCC") power plants. Prior to joining URS, I worked for TECO Energy, as well as several of its subsidiaries, including Tampa Electric Company and TECO Power Services. I worked in a number of areas in these companies, including power plant operations, power plant engineering, fuels, environmental planning, finance, governmental affairs and regulatory affairs. I also served as the

Deputy Project Manager for the Polk Power Station IGCC project, one of the two operating IGCC power plants in the U.S.

Q. Where are you currently employed?

A. I am employed by URS in the Tampa, Florida office.

Q. What do you do in that job capacity?

A. I am responsible for leading our IGCC and gasification business in the power industry, across the U.S. My job responsibilities include business development, as well as managing large projects in related technical areas. This includes a number of projects where we are providing environmental permitting, planning, feasibility and engineering services. I personally have been involved in the feasibility engineering, permitting or design of ten different coal gasification and IGCC projects.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to show that Florida Power & Light Company's ("FPL") selection of ultra-supercritical pulverized coal ("USCPC") technology for the proposed FPL Glades Power Park ("FGPP") is a more prudent one than had they selected IGCC technology. This is based on an overall analysis and comparison of factors that include technology maturity, efficiency, reliability, power generating capability, operational history and environmental performance.

Q. What is IGCC technology?

A. IGCC is a developing technology for generating electricity using coal or other similar feedstocks. Unlike conventional pulverized coal ("PC") fired power plants where the coal is combusted in a boiler, and steam is produced, turning a turbine generator to produce electricity, the IGCC process converts coal into a synthetic gas, or syngas, which, after cleaning, can be burned in a gas turbine generator. An IGCC facility combines gasification technology from the chemical industry with combined cycle power generation technology from the power industry. Air, steam, nitrogen and other streams are integrated between the gasification and combined cycle "islands"; hence, the name Integrated Gasification Combined Cycle, or IGCC.

Q. **How much of your background is involved in IGCC technology?**

A. I have worked with IGCC technology for 15 years, about half of my career.

Q. **How much of your current job is spent working on IGCC issues?**

A. About 75% of my current work applies directly to IGCC technology.

Q. **Have you written any articles, or done any presentations, on IGCC technology?**

A. Yes. I have written articles and made many presentations on IGCC technology over the past 15 years.

Q. **Do you consider yourself an expert in IGCC technology?**

A. Yes. As I noted, I was the Deputy Project Manager for the Polk Power Station IGCC project, one of the two operating IGCC power plants in the U.S. Since then, I have been directly involved in a number of IGCC and gasification projects across the U.S. This includes providing environmental permitting, technical feasibility, and engineering services for a number of these modern IGCC and gasification plants that are in development at this time. In addition, I serve on the

Electric Power Research Institute's CoalFleet for Tomorrow Program IGCC Experts Group.

FGPP SITE

Q. Can you please describe the technology that FPL is proposing to use at FGPP?

A. The technology to be used at FGPP is USCPC technology. In this kind of a power generation technology, coal is crushed to a fine powder, and blown into a boiler with air. The coal-air mixture burns at temperatures of over 2,500 °F. Heat from the combustion is transferred to the water that is pumped through the boiler tubes, turning it to steam at very high temperatures and pressures. The operating pressure of coal-fired power plants is classified as either subcritical pulverized coal ("SPC") or supercritical pulverized coal ("SCPC"). SPC and SCPC refer to the state of the water and steam that is used in the steam generation process. SPC power plants utilize pressures below the critical point of water in which there is a distinct difference in the state of the water and the steam. The critical point of water is 3,208 psia and 705 °F. At this "critical" point, there is no difference in the density of water and steam. At pressures above 3,208 psia, heat addition no longer results in the typical boiling process in which there is an exact division between steam and water. The fluid becomes a composite mixture throughout the heating process. The majority of the boilers in the U.S. utilize subcritical technology, typically with steam temperatures up to 1,050 °F and pressures up to

2,400 psia. These units utilize a steam drum and internal separators to separate the steam produced in the boiler from the water circulating in the boiler tubes. Supercritical units do not utilize a steam drum, since there is no way to separate steam from the steam-water mixture.

In SCPC boilers, all of the water introduced into the boiler is turned into the supercritical steam-water mixture. Operation at the higher supercritical pressures is more efficient than for subcritical boilers. The U.S. Department of Energy ("DOE") has defined USCPC steam cycles as operating pressures exceeding 3,600 psia and main steam superheat steam temperatures approaching 1,100 degrees F. This is even more efficient than conventional SCPC technology. FGPP plans to utilize the more efficient USCPC technology.

The high pressure steam is then piped to the steam turbine, where it turns the turbine blades at high speed. The turbine is connected on a shaft to a generator, which produces the electricity. The steam is condensed to water, and then pumped back to the boiler to be turned into steam again.

In the boiler, the ash in the coal is converted primarily to fly ash, with some falling to the bottom of the boiler; it is called bottom ash. The bottom ash is cooled in a water bath and removed for re-use in industry or it can be safely stored in a lined landfill. The fly ash is removed in the emission control system. In the boiler, low-NOx burners, with overfire air, are an industry-standard design for minimizing the formation of NOx during combustion. The emission control system for a coal-fired power plant typically includes a selective catalytic reduction ("SCR") system for reducing emissions of nitrogen oxide ("NOx") emissions, a sorbent injection system for capture of mercury, a fabric filter for removal of the fly ash and captured mercury from the exhaust gas stream, a flue gas desulfurization ("FGD") system for removal of the sulfur dioxide ("SO_2") produced when the sulfur inherent in the coal is also combusted, and a wet ESP for removal of fine particulates. These are all included in the design of FGPP. Following the emission control system, the cooled, cleaned exhaust gas exits through a stack.

Q. Is the technology that FPL is proposing to use a proven and reliable technology?

A. Yes. The USCPC technology that FPL is proposing to use is proven worldwide and is a reliable technology for power generation.

Q. Are other facilities in the United States and around the world using this technology?

A. Yes. There are approximately 160 supercritical generating units in operation in the U.S., with over 500 operating worldwide. This number includes 17 plants worldwide using the more advanced USCPC technology proposed for FGPP. Several have been operating almost nine years, and operating data shows that these units have been very reliable.

Q. Are you a proponent of IGCC technology?

A. Yes. I am. Although IGCC is still in the development phase of, I think that it will be able to significantly reduce emissions and provide low cost electricity, once it is proven at a large, commercial scale.

Q. Has IGCC been used successfully for other power plants in the United States and around the world?

A. Yes. Although its application was not initially successful due to difficult start-ups and low plant availability, these IGCC facilities can now be considered as successful.

Q. Please describe some of the currently existing IGCC plants in the United States and around the world.

A. There are four coal-based IGCC plants in operation worldwide. They include Tampa Electric Company's Polk Power Station near Mulberry, Florida; SG Solutions' Wabash River Generating Station in West Terre Haute, Indiana; Nuon's Willem-Alexander Centrale Station in Buggenum, The Netherlands; and the Elcogas Puertollano Plant in Puertollano, Spain. There was a fifth plant, in the U.S., but it is no longer in operation.

Q. How big are those facilities?

A. All four of these are single train gasification plants, each with a net output in the range of 250-260 MW.

Q. Has anyone built a 1,960 MW facility using IGCC?

A. No.

Q. What is the largest facility that has been built using IGCC?

A. The largest coal-based IGCC plant is sized at 260 MW (net).

Q. Do you know of any proposed 1,960 MW or larger IGCC facilities?

A. No. I do not.

Q. What is the largest size IGCC plant that is commercially available?

A. The largest size being commercially available is called the 600 MW net "reference plant." This size is being offered by five different IGCC technology providers, although the specific commercial and environmental guarantees are not publicly available. This 600 MW net size incorporates several gasifiers to produce two to three times the amount of syngas produced at each of the demonstration facilities, which is sufficient to fully load two of the modern gas turbines being commercially offered for syngas service. Integrated together, the net output is about 600 MW. It will first be very important to prove the coal gasification technology at this larger scale, as well as proving these new types of syngas-fired gas turbines at commercial scale. Once that has been done successfully, and I believe that it will be, these companies will begin to offer large designs. That is likely to happen about six to eight years from now after this next generation of IGCC plants has gone into service.

Q. Have the current IGCC facilities been funded by their governments?

A. Yes. All four of the operating plants received significant amounts of co-funding from their respective federal governments. This is because both private industry and the governments were very interested in developing IGCC and demonstrating it at commercial scale, but neither was able to bear the entire costs of these plants. In the case of Polk Power Station, the DOE funded 20-25% of the capital cost of the plant, as well as some of the operating costs during the demonstration period.

Q. What has been the track record of these facilities?

A. The initial start-up at all of these plants was very difficult and the overall plant availability for each of these plants was low for the first several years. Since then, many operational problems have been solved, some equipment has been removed or modified, and many of the "bugs" have been worked out.

Q. Are all these facilities still online and functioning?

A. No. Only four of the five are in operation.

Q. Is the facility in Nevada still online and functioning?

A. No. The gasification facility at the Piñon Pine IGCC demonstration plant in Nevada is no longer functioning, although the power block is operating using natural gas as a fuel.

Q. Why is the Nevada facility not online and functioning?

A. This IGCC plant was developed as part of the DOE's Clean Coal Technology Program, as were the Polk Power Station and Wabash River IGCC facilities. The gasification technology used at the Piñon Pine IGCC demonstration plant was not successful, and was shut down following initial start-up and operation.

Q. How reliable are IGCC facilities?

A. The four operating IGCC plants described previously had significant start-up and initial operation problems. Reliability in the first three to four years was much lower than planned. Since then, many of the design and operation issues have been successfully resolved. Availability values are much higher, although none of these plants have achieved sustained reliability values of 85%, as planned. In its ninth year of operation, Polk Power Station achieved 82% availability of the overall IGCC plant. Wabash River reached about 78% availability in its seventh year of operation. The Nuon IGCC plant reached about 78% availability in its eleventh year of operation, and Puertollano's availability peaked at about 60% during its fifth year of operation.

Q. Why do IGCC plants have problems with reliability?

A. The four IGCC plants all have single-train gasification islands. Whenever a single train is removed from service due to operational problems, there is no syngas available for combustion in the gas turbines. At that point, unless a back-up fuel is used, the power plant must be shut down. The use of a single train in these demonstration plants is a major contributor to the low reliability of IGCC plants. Other reasons for low reliability include corrosion and erosion of gasifier refractory, requiring an outage for replacement, corrosion of process piping, plugging of syngas heat exchangers that leads to outages for cleaning, corrosion of process piping, slurry pump problems, and miscellaneous power block problems that can occur in any combined cycle plant. A reliability issue that is somewhat unique to syngas use relates to high rotor torque. Gas turbines are designed to handle the combustion of natural gas. Since syngas has a much lower heating value, a much greater amount of syngas is required to fully load the gas turbine. This additional rotational stress has had negative impacts on syngas-fired gas turbine reliability.

There are many gasifiers operating successfully worldwide. They are typically used for producing a syngas that can be further processed to produce hydrogen for refineries or to make ammonia for fertilizer manufacture, not to produce electricity. Some of these facilities, particularly those with spare gasifier trains, reach availability values in the high 90% range. Some of the successful gasifiers also use refinery bottoms, like asphalt, as a feedstock. Such liquid feedstocks require little handling and preparation, versus the coal handling and coal grinding systems required in a coal-based IGCC plant. Operating a gasifier by itself is significantly less difficult and complicated than when using a gasifier as an integrated part of a complex IGCC plant that produces electricity. It is important to note that the "integration" part of IGCC is very difficult to design for and to operate. All of these components in the gasification and power block islands must be operated interdependently. The failure of one system often leads to the entire plant being shut down. It is very different from having to operate only a gasifier. That is why the reliability of gasifier-only facilities is greater than those of IGCC facilities.

Q. Has there been an effort to improve the performance of IGCC?

A. The next generation of IGCC plants is being designed using the lessons learned from the four operating plants. Some of the key design enhancements to improve reliability include using two 50% sized gasification trains (instead of one 100%-sized train), and even adding a third gasifier train as a spare, better integration between the gasification island and the power block, better gasifier refractory materials, design without convective syngas coolers, and upgraded gas turbine burners and materials for syngas service. These design improvements, along with other lessons learned, are expected to provide for easier initial start-up, as well as higher availability. Use of a spare gasification train is expected to provide up to 90-92 % availability, but adds to the cost of the facility. Moreover, these design enhancements will not be placed into service until the 2011-2013 timeframe, so that it will be six to eight years from now (allowing for start-up and initial operation) before we see whether IGCC reliability can be improved to levels greater than 85%.

Q. Is IGCC technology progressing as quickly as you would like?

A. No. It is not. The first generation of IGCC plants went into service between 1994 and 1998. The second generation will not go into service until 2011-2013, a time delay of about sixteen years. When we designed and built Polk Power Station, it was our expectation that the technology would be embraced by the industry, and that by now we would have had the critical second generation of IGCC plants already in operation, in order to prove the technology on a large, commercial scale.

Q. Does IGCC need more investment in research?

A. Yes. IGCC still requires a significant amount of investment in research and development. That is why individual power companies, the Electric Power Research Institute ("EPRI"), and the U.S. DOE are still planning and funding such research and development ("R&D") to support further IGCC technology development. In the Coal Technology Roadmap developed by EPRI and Coal Utilization Research Council, a total of $5.2 billion of R&D and demonstration of promising improvements is still needed to provide for the needed IGCC enhancements. These include basic system development, efficiency improvements, use of new air separation technology, improvements in gasifier refractory materials, new types of particulate removal devices, slurry pump enhancements, gasifier skin temperature monitoring systems, more efficient emission control systems, and gas turbines that can handle high hydrogen concentration syngas. Of this $5.2 billion, about 60% would be needed from the federal government. In addition, the Energy Policy Act of 2005 provides for additional IGCC and gasification R&D through the U.S. DOE's Clean Coal Power Initiative, as well as tax incentives and loan guarantees to promote further demonstration of IGCC and gasification technology. This legislation specifically recognizes the continuing need for R&D and co-funding or economic incentives for IGCC technology to succeed at large, commercial scale.

Q. When do you think IGCC will be commercially available?

A. IGCC is commercially available from IGCC technology suppliers at this time, based on a 600 MW net IGCC "reference plant" design. However, the plant would not be able to be started up for five to six years from the time you began the IGCC project. For example, if you began a 600 MW net IGCC reference plant project today, it would be late 2012 to 2013 at best before the plant was ready for startup. Any changes to the basic reference plant design would take longer to design, and may not even be commercially available.

If IGCC technology were to be selected for this project, FPL would likely use the largest size plant available, in order to take advantage of economies of scale, just as it has already done in choosing large 980 MW (net) USCPC units. For IGCC, the closest match to meet the 1,960 MW (net) value would be to use a 3x3x1 configuration such as the one referenced in the study jointly conducted by FPL and Black & Veatch. This study is noted as Document No. DNH-2 in the testimony provided by Mr. Hicks of FPL. However, as I noted previously, the largest size IGCC facility that is being offered by the IGCC technology suppliers is the 600 MW (net) reference plant. Therefore, a non-standard 3x3x1 configuration, if commercially available, would take even longer to be designed and constructed.

IGCC technology suppliers, in alliance with engineering firms and power block suppliers, are offering the technology today with limited guarantees on performance and emission limits. Although about a dozen power companies are going forward with IGCC projects, none have yet finalized a contract for a complete reference plant, so that such terms and conditions, as well as the guarantees, have not yet become publicly available. Due to the higher cost of IGCC compared to SCPC technology, many of these projects are counting on the financial incentives provided by state and federal legislation in order to help make the projects commercially feasible.

Q. Do you think that IGCC technology is commercially ready?

A. Although IGCC is commercially <u>available</u>, it will not be commercially <u>ready</u> or <u>proven</u> on a large scale for at least another six to eight years, once this next generation of IGCC plants has gone into service and had an opportunity to work through initial start-ups and reach steady operation.

Q. Do you have concerns regarding the use of IGCC technology at FGPP?

A. Yes. I would have some concerns with the use of IGCC technology at this site.

Q. What are some of your concerns with the use of IGCC technology at the site?

A. First, I would be concerned with the potential for reliability problems. FGPP is being designed for 92% reliability, which is commercially available and proven with SCPC technology. As noted previously, such high reliability levels have not yet been demonstrated by existing IGCC power plants, and it will be six to eight years before the presently planned IGCC plants are able to prove whether the intended design enhancements can provide for improved reliability.

Second, FGPP is being designed to produce 1,960 MW net, using two USCPC generating units. As noted previously, IGCC is only commercially available, but not yet "ready" or "proven," at the 600 MW net size. It would take more than three IGCC reference plants to do the job of the two USCPC units. At the present time, the three IGCC technology supplier alliances are at their busiest ever. I am concerned that the supplier alliances would not be able to support the engineering, procurement, and construction of three concurrent 600 MW IGCC reference plants.

Third, it takes five to six years to design, permit, and construct an IGCC plant. If FPL were to start now, it would be late 2012 or 2013 at best before the first IGCC plant could be ready for operation.

Q. Do you have reliability concerns with an IGCC plant?

A. As I noted previously, the existing IGCC power plants demonstrated poor reliability in the initial years of operation, with only medium reliability values at maturity. Even though designs are including information from lessons learned, it will still be another six to eight years before we know whether IGCC can provide the high reliability values that are presently being demonstrated by SCPC plants worldwide.

Q. Why do you have reliability issues with an IGCC plant?

A. These concerns are based on the historical poor to moderate performance of the four operating IGCC plants worldwide, and the fact that the potential for higher reliability will not be known for another six to eight years.

Q. Why is the plant that FPL is proposing more reliable than an IGCC plant?

A. PC technology has been in commercial operation worldwide for about 100 years. IGCC has only been in commercial operation worldwide for about 13 years. There are more than 300,000 MW of PC capacity in the U.S. There are only 510 MW of IGCC capacity in the U.S. PC technology is proven at a large scale in thousands of applications. PC units (whether SPC, SCPC or USCPC) have demonstrated high reliability. The operation of a PC unit does not require the interdependent operation of a multitude of individual chemical and mechanical processes as does IGCC. IGCC plants take several days for a cold start, due to limitations in the rate of heating up of the gasifier (to protect the refractory from thermal cracking), as well as cooling the air separation "cold box" to well below freezing temperatures. Together, these have significant negative impacts on the total number of days per year that the IGCC plant can operate at full load. IGCC plants have suffered from these problems and have exhibited reliability problems. PC plants require several days for a cold start, but these would typically occur two or three times per year. IGCC plants also have a history of many warm or hot starts. While these startups do not take as long, they still impact negatively on IGCC unit reliability. Two of the IGCC plants being planned at this time for operation in the 2011 to 2012 timeframe have noted in their air permit applications the potential for over 60 startup and shutdown events per year, far more than what is normal for PC units. Taking into account all of these reasons, PC units are expected to continue to provide higher reliability than IGCC units.

Q. Is there a proposed IGCC facility in Orlando?

A. Yes. An IGCC plant is being planned in the Orlando area.

Q. Can you compare that facility to the proposed FGPP?

A. The Orlando Gasification Project ("OGP") is being developed by the Orlando Utilities Commission ("OUC") and Southern Power Company ("Southern"), a subsidiary of the Southern Company, which is a large utility holding company. OGP is planned to start up in 2010. The OGP proposes to demonstrate the Kellogg Brown and Root ("KBR") transport gasifier in IGCC configuration. The KBR technology has been developed from technology used in catalytic crackers in the refinery industry. OUC and Southern expect this new IGCC technology to provide for higher efficiencies, especially when applied to low quality coals. The KBR technology has been pilot tested at the approximately six MW scale at the Power Systems Development Facility in Wilsonville, Alabama, adjacent to

Alabama Power Company's Gaston Steam Plant. The KBR technology is an air-blown gasification technology, unlike the oxygen-blown gasification technology being commercially offered by GE Energy, ConocoPhillips and Shell (although it can operate in oxygen-blown mode). In addition, OGP will use Powder River Basin subbituminous coal railed in from Wyoming, unlike the higher quality bituminous coal planned for FGPP.

OGP will be sized for a net output of only about 285 MW. This is about one-sixth of the power generation capacity to be produced by the USCPC generating units planned for FGPP. Overall, OGP will be much smaller in scale than FGPP, and will use a power generation technology that is not yet proven at large commercial scale.

Q. Can you compare the efficiency?

A. The efficiency of OGP will not be known until it has been in operation for at least a year, meaning some time in 2011. For comparisons of SCPC and IGCC efficiency, I refer you to the study jointly conducted by FPL and Black & Veatch. This study is noted as Document No. DNH-2 in the testimony provided by Mr. Hicks of FPL.

Q. Can you compare the Capital Cost?

A. Comparisons of the capital costs of different projects are difficult, due to differences in what each estimate includes or excludes. According to the DOE, the cost of the OGP will be $557 million. However, I understand from Southern that this amount only includes the gasification portion of the project, and not the combined cycle power block. Therefore, it is not possible to make a comparison of capital costs with FGPP. For comparisons of SCPC and IGCC cost, I refer you to the study jointly conducted by FPL and Black & Veatch. This study is noted as Document No. DNH-2 in the testimony provided by Mr. David Hicks of FPL.

Q. Can you compare the technology status?

A. As noted previously, USCPC technology is proven on a large commercial scale. IGCC technology is still in development, and is not yet mature. OGP will only demonstrate the KBR technology at about half of the IGCC reference plant size and one-seventh the size of FGPP.

Q. Can you compare the scale-up required?

A. The USCPC technology proposed for FGPP will not require any technology scale-up, as it is already in commercial operation worldwide at the proposed scale. The capacity of the KBR gasifier will need to be scaled-up over fifty times.

Q. Has the Orlando facility received government funding?

A. OGP is receiving co-funding under Round two of the DOE's Clean Coal Power Initiative.

Q. How much funding will it receive under this program?

A. According to the DOE, it will be providing $235 million in co-funding for OGP.

Q. How effective is the plant that FPL is proposing in reducing emissions?

A. The emission control systems planned for the USCPC power generation technology proposed for FGPP will be designed to provide state-of-the-art emission reductions.

Q. Can you please discuss each of the emissions, such as nitrogen oxides, sulfur dioxide, mercury and other emissions in terms of how they would be handled at an IGCC plant versus the proposed FPL plant?

A. As I noted previously, an IGCC facility converts coal to a syngas, which is then cleaned and combusted in the gas turbine. The reduction of emissions from an IGCC plant occurs pre-combustion, so that pollutants are removed or reduced before the syngas is burned. This is different from a PC plant, where most of the emission reductions are achieved post-combustion, meaning that emissions are removed from the exhaust gas after the coal is burned. The table below describes the typical emission control methods for the USCPC technology proposed for FGPP and for IGCC.

	FGPP	**IGCC Plant**
NOx	Low-NOx burners and overfire air to reduce formation of NOx, along with Selective Catalytic Reduction (SCR) to remove NOx from the flue gas	Syngas humidification and injection of diluent nitrogen (for oxygen-blown IGCC systems) into syngas just prior to the gas turbine or in the burners
SO_2	Wet Flue Gas desulfurization (FGD) system	Removal of hydrogen sulfide from syngas reduces SO_2 emissions when the syngas is combusted in the gas turbines
PM/PM10	Use of fabric filter to remove fly ash from the flue gas, along	System can use wet carbon scrubber, hot gas cyclone, and/or

	with minimizing fine particulate through removal of SO_3 droplets in a wet ESP	high temperature, high pressure candle filter
CO	Good combustion practices	Good combustion practices
VOC	Good combustion practices	Good combustion practices
SAM	FGD system and wet precipitator	Fuel sulfur specification and SO_2 emission control
Mercury	Co-benefits removal in ESP or fabric filter, and in FGD system, along with sorbent injection upstream of the fabric filter	Removal in slag, carbon scrubber, pre-sulfided activated carbon bed, and acid gas removal system recirculating solvent

Q. Does reliability affect emissions? In other words, if you have to start up a plant more frequently, does that affect emissions?

A. Yes. Overall plant reliability can affect overall emissions. When a PC power plant starts up, the boiler is fired with coal at a very low throughput, and then it gradually ramps up to a higher throughput. When the proper steam conditions are reached, the steam is routed to the steam turbine for power generation, although at a minimum load. Then the coal throughout, steam production and power generation are gradually ramped up to full load.

During the time a plant is starting up, coal is being consumed without any power generation, until steam conditions are right for sending it to the steam turbine. Power plants operate at their most efficient point at high loads. During the start-up process, the unit operates at a lower efficiency. This means that more coal is used for a unit of power generated than it would at a high load. Since more coal is being consumed, more emissions are produced per unit of power generated. Fortunately, PC units have a fairly short start-up time period. In starting up a coal-fired unit, steam requirements are typically met using a small, auxiliary boiler. These boilers use fuel oil or natural gas, and contribute to the unit's overall emissions.

IGCC units have a different start-up profile. As noted previously, a cold start-up on an IGCC power plant can take several days. During this time, large amounts of coal can be consumed in the gasification process while the emission control systems are being started up. Clean or partially cleaned syngas is flared. Emissions from the flare can be substantial, depending on the state of operation of the emission control systems and the total time of flaring. Combining these technical issues with a somewhat lower reliability of IGCC versus PC technology, an IGCC plant could actually produce more emissions on an annual basis than a PC unit, even though it may have a lower emission rate on a lb/MWh or pounds per million Btus of heat input basis.

Q. Based on the technology today, do you believe that the emissions would be better for an IGCC facility versus the proposed FPL power plant?

A. Not necessarily. The proposed emission rates for some of the pollutants for proposed IGCC units are lower than those proposed for FGPP. However, due to the impacts of all of the start-up and shutdown cycles inherent with IGCC facilities, there can be some substantial overall increases in overall emissions from an IGCC facility that are not accounted for in these proposed emission rates. URS analyzed the emission data in the air permit applications for several proposed IGCC facilities, as well as similar data for FGPP. We looked at the proposed emission rates in lb/MWh and then calculated what those values would be when incorporating the emissions from the start-up and shutdown cycles. What we found was that for FGPP, the emissions from start-up and shutdowns increased the overall emission rates by no more than five %. However, it was very different for the IGCC units. We saw that the emission rates for the IGCC units could actually be increased by an average of 38%, if all of the potential start-up and shutdown emissions are accounted for. Based on that analysis, it is possible that an IGCC unit with an emission rate lower than that for a PC unit may actually have an equal or greater potential emission rate, due to the differences in the start-up and shutdown issues. I would not expect that in actual operation, that all of these start-up and shutdown cycles would occur. The air permit applications were written in a way so as not to constrain the units' operation, so that the number of start-up and shutdown cycles was maximized. For an actual comparison, each unit's characteristics would have to be analyzed to determine the overall impact of start-ups and shutdowns.

Q. Is IGCC "CO_2 Capture Ready"?

A. When discussing IGCC technology, the term "CO_2 capture ready" means that the IGCC plant is technically ready to be converted to produce a concentrated stream of CO_2 (through the water shift reaction), and that the CO_2 can be easily captured and removed from the syngas stream. An IGCC plant is not capture ready unless it has been designed from the beginning to provide for these significant modifications. IGCC by itself is not "CO_2 capture ready."

Q. What changes are needed to make an IGCC plant CO_2 capture ready?

A. First, the IGCC technology being used, as well as the physical plant itself, must be capable of the addition of a water shift reactor. This is the primary process where the syngas is processed and converted to a stream with high concentrations of both hydrogen and CO_2. Since the water shift reaction is exothermic, steam is typically produced for use elsewhere in the process. The IGCC plant design must account for the addition of this water shift reactor and to have a proper place to route this low pressure steam.

Then there must be room for the addition of a very large CO_2 capture/removal system. While the acid gas removal systems typically used for H_2S removal can also be used to absorb some of the CO_2, they are much more selective for the H_2S. This means that it is much more difficult to remove the CO_2 than the H_2S from the syngas. The H_2S removal system is much too small to also remove a large portion of the CO_2. It must be able to be scaled up considerably, with much additional equipment required. The CO_2 removal system requires a significant amount of high pressure steam to strip (remove) the CO_2 from the solvent, so that it can be concentrated. Therefore, the steam turbine must be designed from day one with steam extractions at the right temperatures and pressures for CO_2 stripping.

Significant additional power is required for the CO_2 removal system to operate. With the extraction of steam noted previously, and the increased internal power use, the IGCC plant's net output falls considerably, and this deficit must be made up by other sources of generation.

Once the CO_2 is removed from the syngas, a hydrogen-rich syngas stream remains. While gas turbines have the ability to burn syngas and other fuels that contain some hydrogen, gas turbines for the combustion of concentrated hydrogen streams are not yet commercially available at large scale. Gas turbine manufacturers are doing R&D on their products to see how high a concentration of hydrogen can be safely combusted (the burning profiles of natural gas, hydrogen and syngas are all very different, and the burners must be specifically designed to provide for safe, controlled combustion, especially with hydrogen). Large, commercially-available gas turbines for hydrogen-rich syngas are not expected until 2014.

Therefore, IGCC is not inherently CO_2 capture ready without significant additions, modifications and impacts to its efficiency and output. I have heard many people apply the term "CO_2 capture ready" to IGCC without really understanding what is involved, both technically and financially, to implement these significant changes. Just because people call it CO_2 capture ready does not mean that it is.

Q. Have CO_2 capture technologies been applied to IGCC?

A. Yes, but only on a test basis.

Q. Are EPRI and the DOE funding R&D on CO_2 capture technologies?

A. Yes. A significant amount of design development is underway, in order to qualify and quantify the modifications described previously. CO_2 capture for IGCC is not yet a commercially available technology. Similar R&D is proceeding for CO_2 capture technology that could be applied to PC plants. Applying CO_2 capture to a PC plant is presently much more difficult and expensive than for an IGCC plant. This is primarily because the CO_2 must be removed from the flue gas after combustion. Since air is used in combustion, the flue gas stream from a PC unit has a high concentration of nitrogen (from the air), and the CO_2 is at a very low concentration. It is much more difficult to remove CO_2 from a weak stream than a concentrated stream. The CO_2 capture system must be much larger, more expensive and more energy intensive. EPRI and the DOE are funding R&D for CO_2 capture for both PC and IGCC.

Q. Would inclusion of CO_2 capture technology reduce output at the plant?

A. Yes. As I noted previously, a considerable amount of steam must be extracted from the steam turbine for the CO_2 stripping process. This steam would otherwise have been used for power generation. In addition, the CO_2 capture system has large internal power requirements for pumps and other equipment. All of these reduce the plant's net output in a significant way. A recent study by the EPA shows that the addition of a CO_2 capture system would reduce the output of an IGCC plant by 14% and a SCPC plant by 28%. The result of this is that the plants would become very inefficient, and would be unable to meet their intended load requirements.

Another option would be to size the plant to be much larger in the beginning, so that the net output, after all of the steam extraction and additional internal power ruse, results in the required net output. Of course, this would require the expenditure of a significant additional capital cost to build the plant.

Q. Would CO_2 capture technology raise the cost of electricity?

A. Yes. It would. The equipment required for CO_2 capture is both extensive and expensive. The plant would be more expensive, and the cost of electricity, which would include a component to account for this additional capital expenditure, would be higher.

Q. Can you say that IGCC is "CO_2 capture ready" today?

A. It is not. Once the R&D is completed over the next decade, as described previously, IGCC is expected to be CO_2 capture ready.

Q. Is IGCC currently effective at removing CO_2 and then providing an appropriate storage location?

A. No. It is not. There is no experience with the capture and sequestration of CO_2 from the four operating IGCC plants. To date, only pilot testing has been done on IGCC plants for CO_2 capture. No sequestration of the CO_2 captured from those tests has occurred.

Q. Are you aware of any other power companies that have investigated the use of IGCC?

A. Yes. I am aware of many power companies that have investigated, or are presently investigating, the use of IGCC.

Q. Has AEP investigated the use of IGCC?

A. Yes. It has investigated the use of IGCC.

Q. Who is AEP and what did it conclude about the use of IGCC?

A. AEP is the American Electric Power Corporation. It is the largest generator of electric power in the U.S. AEP conducted a major study of IGCC technology. The conclusions of that study, as presented by Mr. Michael Mudd of AEP, were as follows:

- IGCC technology is not yet mature;
- IGCC efficiency is worse than advertised;
- IGCC costs are higher than advertised;

- It is difficult to get a fixed price and guarantees for an IGCC facility;
- IGCC startup is long and complicated; and
- More R&D is needed for IGCC to be proven for commercial use.

Initially, AEP found that the IGCC suppliers were not able to provide a "wrap" of guarantees. As business alliances were formed among gasification technology suppliers, power block suppliers, and engineering firms, AEP eventually felt comfortable in expecting to obtain reasonable guarantees, and proceeded with the Front End Engineering and Design ("FEED") phase for a 600 MW net IGCC reference plant.

Its IGCC plant will be developed in either Ohio or West Virginia, depending on which state will allow it to recover the additional costs of building an IGCC plant instead of an SCPC plant. This is a critical part of making the project financially feasible for AEP. Once this initial design phase is completed, AEP will also have a more accurate cost estimate for the plant, and will be able to determine whether to continue with the project. AEP was planning for the capital cost premium of IGCC over PC to be no greater than 20%.

In late December, 2006, AEP noted that its FEED study showed that the cost would exceed this 20% premium. Because of that, AEP has instructed their technology supplier team to re-evaluate and modify the design to find ways to reduce the cost to meet this goal. It will likely be another six months before this re-design and revision of the cost estimate are completed. AEP will need the new cost estimate before it goes before the public utility commission to request approval for the costs of detailed design and construction.

In addition to going forward with this IGCC project, AEP has continued to rely on SCPC technology. In August of 2006, AEP announced the development of a 600 MW USCPC plant to be sited near Fulton, Arkansas, scheduled for operation in the summer of 2011. In announcing this new PC plant, the company's president noted that "we believe that a coal- or lignite-fueled plant is the best choice for new base load generation to economically fuel the future growth of the economies in our region, allow us to remain a low-cost provider, and prevent over-reliance on natural gas for electricity generation as domestic national gas supplies are diminishing."

Q. Overall, how would you compare the plant efficiency for IGCC technology to the proposed FPL plant?

A. The "promise" of IGCC technology included much higher efficiencies than PC units. In practice, neither Polk Power Station nor Wabash River Generating Station has met its efficiency goals. It was expected that through process and technology improvement, this next generation of IGCC plants would meet the goal of 40% efficiency. Unfortunately, it does not look like that will happen. Of all of the coal-based IGCC plants being planned, not one has a planned efficiency of over 38%. The highest efficiency values, according to information provided by the power companies in their public documents and especially in their air permit applications, will be ERORA Corporation's planned IGCC plants in Kentucky and Illinois, with efficiencies of 36.8%. These efficiency values are typically provided in the industry at "new and clean" conditions; performance typically degrades over time as equipment ages and wears. Earlier this year, Tampa Electric Company announced that it was planning to build a second IGCC plant at Polk Power Station. Polk Unit #6 will be a 600 MW (net) plant. Its efficiency, as noted in Tampa Electric Company's Ten Year Site Plan submittal, is planned to be only 36.6%.

FGPP is being designed for an efficiency of 38.8%, which is higher than that for the next generation of large, commercial-scale, coal-based IGCC power plants.

Q. How would you compare the emissions between an IGCC plant and the proposed FPL plant?

A. They are very similar for many of the primary pollutants.

Q. How would you compare the reliability between an IGCC plant and the proposed FPL plant?

A. FGPP is being designed for an availability of 92%. This is much higher than what the four existing IGCC plants have been able to achieve. As I noted previously, design improvements and the addition of spare equipment are expected to provide for 85-90% availability on the planned IGCC units. It is possible that the availability of IGCC and SCPC could be comparable, but we will not know what IGCC availability will be for another six to eight years.

Q. How would you compare the cost certainty between an IGCC plant and the proposed FPL plant?

A. At the present time, the cost of IGCC is not known in anywhere near the detail or accuracy as that of PC units. Since there are hundreds of SCPC units around the world, these costs are much more certain. Once one of the companies planning an IGCC plant actually signs a contract for the purchase and development of its IGCC plant, the industry will have a much better idea of what IGCC will really cost. At this time, the range for IGCC cost is very wide and uncertain. It has also been difficult to obtain guarantees or risk sharing with the IGCC technology suppliers at a reasonable cost.

Q. How would you compare the maturity of the technology between an IGCC plant and the proposed FPL plant?

A. USCPC technology is proven worldwide on a large, commercial scale. IGCC is still in development, and is not yet mature. However, in six to eight years, we will have much more experience with IGCC technology once the units being planned actually go into operation.

Q. In your professional opinion, would you recommend the use of IGCC technology for this proposed power plant?

A. Based on the requirement for a power generation technology that can provide 1,960 MW net in the 2012 through 2014 time period, high efficiency, low cost, high cost certainty, high reliability, and low emissions, I would not recommend IGCC technology for FGPP.

Q. In your professional opinion, in terms of reliability, cost-effectiveness, emissions, and commercial availability, do you recommend the technology being proposed by FPL for the proposed power plant?

A. Yes. I recommend the use of USCPC technology for FGPP. It meets the requirement for a power generation technology that can provide 1,960 MW net in the 2012 through 2014 time period, high efficiency, low cost, high cost certainty, high reliability, and low emissions.

Q. Please summarize your testimony.

A. After comparing the USCPC technology proposed for use at the FGPP with IGCC technology, I have found that USCPC technology is more technologically mature, more efficient, and higher in availability than IGCC technology. It also provides for a similar environmental emission profile as IGCC technology, and more cost certainty than IGCC. I conclude that the selection of USCPC technology for FGPP would be a prudent decision by FPL.

Q. Does this conclude your direct testimony?

A. Yes. It does.