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BEFORE THE
MINNESOTA OFFICE OF ADMINISTRATIVE HEARINGS
100 Washington Square, Suite 1700
Minneapolis, Minnesota 55401-2138

FOR THE
MINNESOTA PUBLIC UTILITIES COMMISSION
127 7th Place East, Suite 350
St. Paul, Minnesota 55101-2147

In the Matter of the Petition of Excelsior Energy Inc. and Its Wholly-Owned Subsidiary MEP-I, LLC For Approval of Terms and Conditions For The Sale of Power From Its Innovative Energy Project Using Clean Energy Technology Under Minn. Stat. § 216B.1694 and a Determination That the Clean Energy Technology Is Or Is Likely To Be a Least-Cost Alternative Under Minn. Stat. § 216B.1693

PREPARED REBUTTAL TESTIMONY AND EXHIBITS OF EXCELSIOR ENERGY INC. AND MEP-I LLC

DOUGLAS H. CORTEZ

OCTOBER 10, 2006

EXCELSIOR ENERGY, INC.

BEFORE THE MINNESOTA PUBLIC UTILITIES COMMISSION

PREPARED REBUTTAL TESTIMONY OF

DOUGLAS H. CORTEZ

Q Please state your name, current employment position and business address.

A Douglas Cortez. In February of 2006 I retired from Fluor Corporation ("Fluor") after 36 years experience in the electric power, petroleum and petrochemical, and related energy industries in research and development, project development and financing, and engineering and construction capacities. I am currently an independent energy consultant advising clients on all aspects of electric power plant planning, development, engineering, design and construction. Because I was one of the Fluor executives working on Excelsior's Mesaba Energy Project, Fluor has agreed that I can continue supporting Excelsior's efforts in my capacity as an independent consultant and that I can testify on Fluor independent engineer's reports filed in this proceeding. My business address is Hensley Energy Consulting LLC, 412 North Coast Highway Suite B346, Laguna Beach, CA 92651. My curriculum vitae is attached as Exhibit ___ (DC-1).

Q For whom are you testifying?

A I am testifying on behalf of MEP-I LLC and Excelsior Energy Inc. (collectively "Excelsior"), the developers of the Mesaba Energy Project (the "Project").

Q Have you previously provided testimony in this proceeding?

A Yes. I submitted Direct Testimony on June 19, 2006 on behalf of Excelsior Energy Inc. ("Excelsior").

Q What is the scope of your rebuttal testimony in this proceeding?

A In response to testimony from a number of witnesses about the general issue of carbon capture ("CC") and new coal fueled plant costs, my testimony addresses the current state of the technology and economics of capturing the greenhouse gas carbon dioxide from supercritical pulverized coal ("SCPC") plants and integrated gasification combined cycle ("IGCC") power plants. In addition, my testimony provides rebuttal comments to the testimony of the Department of Commerce witness Dr. Eilon Amit, Xcel Energy witness Frank Miao, mncoalgasplant.com witness Ronald R. Rich and Minnesota Center for Environmental Advocacy witness J. Drake Hamilton. Finally, I offer testimony in response to comments of other witnesses in this proceeding about (a) the useful life of Mesaba Unit I, (b) whether Mesaba Unit I should be designed to produce 450 MW or approximately 600 MW of electric capacity, and (c) the broader Mesaba Project's potential to contribute to a transition to hydrogen as a fuel source.

Q Have you prepared any Exhibits to support your testimony?

A Yes, I have prepared a summary of recent studies by independent investigators as well as studies that Fluor has prepared for Excelsior addressing the relative cost and performance of IGCC and SCPC power plants including the impact of retrofitting IGCC and SCPC plants for capturing carbon dioxide for sequestration. Those Exhibits are: Exhibit ___ (DC-2) – Summary of IGCC and SCPC Comparative Studies (Newly Built Plants), Exhibit ___ (DC-3) – Summary of Statistical Comparisons of IGCC and SCPC, Exhibit ___ (DC-4) – References of Studies and Reports, Exhibit ___ (DC-5) – List of Referenced Reports, Exhibit ___ (DC-6) – Fluor Independent Analysis of Generation Technologies for a 600 MW Coal-Fired Power Plant in Minnesota, Addendum B –

SCPC Plant Levelized Nominal Cost of Electricity Comparison, and Exhibit ___ (DC-7)– Mesaba Energy Project Partial Carbon Dioxide Capture Case.

Q In preparing these Exhibits, what methods of investigation did you use?

A There have been many studies comparing IGCC with pulverized coal ("PC") boiler power plants in recent years. These studies often compare different coals and different technologies, for facilities constructed during different time frames. For example, some examine subcritical, supercritical and ultra supercritical PC power plants. Some IGCC studies look at water slurry fed gasifiers and others evaluate dry feed gasifiers. Most of these studies are based on high rank coals (bituminous coals). But some evaluate sub-bituminous and lignite coals. As a result, it is difficult to compare results as the selection of technologies and coals has a significant impact on the results.

In preparing these exhibits, I focused on the following:

a. I included only studies prepared by unbiased, independent institutions widely respected in the industry. The most significant and credible studies comparing IGCC and SCPC technology have been prepared by Electric Power Research Institute, National Energy Technology Labs (U.S. Department of Energy), U.S. EPA, International Energy Agency, and several independent engineering consultants, such as Worley Parsons (formerly Parsons Corporation), Jacobs Consultancy, Fluor, and Nexant (formerly part of Bechtel).

b. I included reports where the comparisons between IGCC and SCPC were based on similar coals and technologies and less impacted by the costs of construction in any particular year.

c. I included only data for SCPC power plants since supercritical boilers are the primary competitor for IGCC based power plants today.

Q Were reports prepared by Fluor for the Mesaba IGCC project included in your Exhibits?

A Yes. One of my objectives was to compare the results of Fluor's studies commissioned by Excelsior Energy with other reports by independent investigators.

Q What was your role in preparing the Fluor reports?

A In 2005, I was employed by Fluor and I supervised some of the Fluor engineers that prepared the Fluor reports (listed in Exhibit **___** (DC-5), Reference 1 is included as Exhibit **___** (DC-7)). My role was to supervise the economic analysis. I did not supervise the engineering and cost estimates contained in the Fluor reports but I did review the work and provided advice. I retired from Fluor in January, 2006 and now operate as an independent consultant to Excelsior and other clients.

Q Can you describe the data Exhibit ___ (DC-2)?

A One of the issues of great interest today is the relative cost of capturing carbon dioxide from coal fired power plants to reduce the emissions of global warming gases into the atmosphere. Most of the studies that have been published compare newly built SCPC plants with newly built IGCC plants with and without CC. There are fewer published studies of the cost of retrofitting SCPC and IGCC plants after they have been constructed.

Exhibit **___** (DC-2) summarizes the results of studies of newly built IGCC and SCPC plants with and without CC. To normalize the data, I have listed the key attributes of these plants: COE ("cost of electricity"), construction costs in terms of dollars per kilowatt ("$/kW") and heat rate in terms of British thermal units per kilowatt hour (“Btu/kWh”) higher heating value (“HHV”). Because of the enormous number of case studies involved, I have averaged the results of some studies that examined several gasification technologies and made some adjustments. The construction costs are “engineering and construction costs” and exclude contractor risk premiums, off site infrastructure improvements, future cost escalation, and owners and financing costs.

At the bottom of the table, I have shown percentage differences for SCPC and IGCC without CC and percentage changes for SCPC and IGCC where CC was included. In doing this I am seeking to identify trends that are not impacted by technology choice and the year the plant cost estimates were made.

Q What conclusions do you draw from Exhibit ___ (DC-2)?

A One of the conclusions I draw relates to the relative costs and performance of IGCC and SCPC with and without CC. Since these data come from a large number of studies at various times, I tested the data for statistical significance on relative costs and performance. The results for the two technologies without CC are:

IGCC vs. SCPC (no CC)	90% Confidence Low	Average	90% Confidence High
Increase in COE	-2.5%	3.6%	9.7%
Increase in $/kw investment	4.9%	10.6%	16.3%
Decrease in heat rate	-5.8%	-3.5%	-1.2%
Note: Based on six recent investigations from independent sources.			
(See References 2,6,8,9,11,13 in Exhibit ___ (DC-5))			

The wide range of published study data are in remarkable agreement. Within a 90% confidence range, they show that an IGCC plant based on current technology will cost about 5 to 16% more to construct than an SCPC plant also based on current technology. The IGCC plant will be more efficient by about 1 to 6% (i.e., will have a lower heat rate). Although there were just three studies that estimated COE, they suggest that the COE from an IGCC plant would be lower by about 2% or up to 9% higher. Please note that these data do not include the impact of Federal investment tax credits and financing incentives that are currently available for IGCC power plants. The impact of these incentives is not part of the scope of my testimony. However, I believe that if an IGCC project uses these incentives it will close the gap in construction costs and COE shown in the table above.

Q What does Exhibit ___ (DC-2) say about the relative cost and performance of IGCC and SCPC with carbon capture?

A Applying the same methods of analysis, we obtained the following results for the CC data:

IGCC vs. SCPC (with CC)	90% Confidence Low	Average	90% Confidence High
Decrease in COE	-23.0%	-19.5%	-8.0%
Decrease in $/kw investment	-17.9%	-15.9%	-13.9%
Decrease in heat rate	-24.3%	-18.3%	-12.2%
Note: Based on three recent investigations from independent sources			
(See References 6, 12, 13 in Exhibit ___ (DC-5))			

Although there were fewer studies and the range of uncertainty is higher, the conclusions are clear. If current SCPC and IGCC technologies are constructed with CC equipment, the IGCC technology has clear advantages in terms of a lower COE, a lower plant costs, and a higher efficiency (a lower heat rate). It should be pointed out that most of these studies are based on bituminous coal plants. For lower rank coals, the advantage of IGCC for 90% CC may not be as dramatic. However, the studies that have been done indicate that the advantage would still be significant. If a partial capture retrofit is required, an IGCC operating on sub-bituminous coal, such as Mesaba Unit I, will enjoy a very strong advantage.

Q What is being summarized in Exhibit ___ (DC-3)?

A As I mentioned, very few studies have been published on the cost of retrofitting an IGCC or SCPC plant with CC after the plant has been placed in service. This concept is of interest now since many coal power plants are being planned in the U.S. and utilities, regulators and consumers are very interested in the impact of future carbon controls or regulations on coal power plants.

In Exhibit __ (DC-3), I have summarized the few studies that have been completed — including the recent studies by Fluor for Excelsior.

Q What conclusions can be drawn from Exhibit ___ (DC-3)?

A There are an insufficient number of specific retrofit studies from which to perform a statistical analysis. However, the few data points we have suggest that the cost of retrofitting an IGCC plant or SCPC plant will be similar to the costs of building the improvements into a newly built plant.

Exhibit ___ (DC-3) also summarizes the results of a study Fluor did for Excelsior examining a "partial carbon capture" case where about 30% of the CO_2 is captured at a much lower cost than capturing 90% of the CO_2.

Q Can you explain why a 30% partial carbon capture scenario may be sensible for an IGCC facility?

A Yes. Unlike in an SCPC plant where there is no CO_2 until after combustion, and the CO_2 created during combustion is part of the diffuse, low pressure, high volume stream of flue gas, in an IGCC plant the CO_2 is created in two stages: first in the gasifier itself as part of the pre-combustion syngas stream and second in the combined cycle power plant post-combustion emissions stream. The amount of CO_2 present in the pre-combustion raw gasifier syngas can vary widely depending on the type of coal and type of gasifier being used. For a water slurry gasifier operating on sub-bituminous coal, such as the one Mesaba will be using, the CO_2 can be 15% to 16% of the total dry gas produced. If CC becomes attractive for the Mesaba Project, this high level of CO_2 will provide an opportunity to capture carbon at a low cost. This level of CO_2 in the syngas equates to over 30% of the total amount of combined first and second stage CO_2 produced in an IGCC plant. In order to achieve a 90% CO_2 removal rate in an IGCC plant, the CO in the pre-combustion syngas stream must be converted to CO_2 through a shift reaction, requiring additional processes and equipment as part of the gasification island. Achieving the approximately 30% CO_2 removal rate from an IGCC plant will not require the additional shift reaction equipment, and it is therefore will be less expensive and technically easier to achieve a 30% removal rate than the 90% removal rate at an IGCC plant.

Q Exhibit __ (DC-4) summarizes the results of the Independent Studies of 90% carbon capture and the Fluor Study of 30% carbon capture. Why was this study commissioned by Excelsior Energy?

A When designing an IGCC or SCPC plant for future CC, engineers face many choices. In the case of SCPC plants, there are few options. Most experts agree that amine scrubbing technology (most likely integrated with the plant steam system to reduce efficiency losses) is the only practical technology for scrubbing CO_2 from high volumes of SCPC flue gas containing low concentrations of CO_2 and excess oxygen (the oxygen degrades amine solutions unless special additives are used to suppress its detrimental effects). (*See* Reference 9 on Exhibit ___ (DC-5).)

With IGCC, there are many different approaches to adding CC technology. The key challenge is the trade off between capital costs versus the plant performance (output and heat rate).

As described above, Fluor has suggested that it is possible to retrofit the Mesaba Unit I IGCC plant to remove about 30% of the carbon from the syngas upstream of the turbines without incurring any up front costs and reducing significantly the retrofit costs when CC is required or economic. (*See* Exhibit __ (DC-7).)

Exhibit ___ (DC-4) compares the dramatic results of the Fluor study with the results of the many 90% CC cases published by others. Where 90% CC for IGCC adds up to 39% to the plant costs and 21% to the heat rate, 30% CC adds only about 10% and 6.5% respectively. Fluor's study of the SCPC with only 30% CC shows that this option adds much more to the plant costs and the heat rate penalty. For SCPC there is no attractive "partial CC" approach. This is because scrubbing 30% of the CO_2 from an SCPC combustion plant requires building a smaller scrubber processing 30% of the total flue gas and removing 90% of the CO_2 fed to the smaller scrubber. This is required since an amine scrubber is not efficient if it operates at low CO_2 capture levels. With an IGCC plant, removing 90% of the CO_2 from the fuel gas prior to firing in the combustion turbines is more efficient and cost effective compared to carbon capture for an SCPC plant. This is true for both the 30% case (no shift unit) and the 90% capture case (with shift unit).

Even if the lower 30% CC option is selected, it would not preclude adding more equipment in the future to shift the syngas and add more CO_2 scrubbers to achieve 90% CC.

Q For the cases where 90% of the CO_2 is captured, what lessons can we learn from Exhibit ___ (DC-2) and Exhibit ___ (DC-3)?

A There are enough case studies behind the data for meaningful comparisons of IGCC and SCPC with and without 90% CC. Exhibit ___ (DC-4) summarizes those results.

The with and without CC cases were statistically analyzed to determine the 90% confidence ranges for COE, plant costs and heat rate differences for IGCC and SCPC with and without CC. Exhibit ___ (DC-4) shows the dramatic difference between IGCC and SCPC when CC is the issue. The majorities of the academic and engineering community agree that CC can be added to an IGCC plant at a higher COE of about 26 to 34% compared to a much higher added COE for SCPC of about 51% to 78%. The higher added cost to add CC to SCPC is even more dramatic for plant investments. IGCC requires about 29 to 39% more capital while SCPC requires 72% to 75% more capital. SCPC technology also incurs a steeper heat rate penalty than IGCC (about a 40% rise in heat rate vs. about 20% for the IGCC plants). These data show that the selection of the source (i.e. gasification vs. combustion) can greatly impact future power costs if carbon controls are implemented in the years to come. The choice of the source is more important than the selection of gasification type or boiler type since these data capture every currently commercial technology. As stated earlier, these differences would be less dramatic for lower rank coals capturing 90% of the CO_2, but the clear advantages of gasification over combustion would remain. With partial CC of low rank, IGCC plants should enjoy a strong advantage.

Q Almost everyone investigating carbon capture targets 90% capture and sequestration. Does it make sense to consider a lower carbon capture scheme for IGCC?

A is an issue for policy makers to weigh. But I think it makes economic sense to impose a lower CC scheme for several reasons. If carbon controls include a mandate to capture 90% of the CO_2 from power plant stacks, then this approach would not apply. However, it seems more likely that carbon controls will include a cap and trade system or a carbon tax, or that carbon dioxide will have commercial value for enhanced oil production. Therefore, producers of CO_2 will seek the most economic or lowest cost method to reduce CO_2 emissions. If this more likely scenario unfolds, then for the reasons set forth above, an IGCC plant, such as Mesaba, will have the option of reducing CO_2 emissions by 30% at a much lower cost. Barring an unexpected technology breakthrough, an SCPC plant operator will be left with only one option, the option of adding much more expense amine scrubbers – thus significantly raising the COE for the consumer.

Q If 30% or 90% carbon capture is required during the life of the power plant, which of IGCC vs. SCPC is the lowest cost coal resource?

A IGCC. Currently, the studies summarized in the Exhibits to my testimony show that IGCC today has only a small cost penalty compared to PC units, excluding any credits for environmental and health benefits. However, as my answer to an early question states, the data shows IGCC would clearly rank as the lowest cost resource if the cost of controlling carbon emissions is included.

Q Can you explain the key difference in the technologies that SCPC and IGCC plants would use to capture CO_2?

A. Because the SCPC plant flue gas is at very low pressure, only a "chemical" sorbent can be used to capture the CO_2. Amine solutions are used to chemically bond with the acid gas (CO_2). The CO_2 is released by stripping with steam because elevated temperatures are required to break the bonds with CO_2.

With an IGCC plant just the opposite situation exists. The CO_2 is at high pressure and physical solvents can be used to capture the CO_2 in much smaller equipment. Also, the dissolved CO_2 can be released by dropping the pressure or "flashing" the solution. This does not require application of steam heat and results in a more energy efficient process.

These fundamental differences between IGCC and SCPC CC systems are what give IGCC such a substantial advantage.

Q Can you explain what changes are actually made to an SCPC plant to capture CO_2?

A Although amine scrubbing technology is widely used in the oil and gas industry, it is rarely used in an oxidizing environment such as exists in power plant flue gas. Oxygen causes rapid degradation of the amines and increases corrosion. These problems have been successfully addressed in small plants operating on flue gas from gas fired power plants by using special corrosion inhibitors and corrosion resistant materials.

Commercial application of amine scrubbing to flue gases has been widely practiced on a small scale for production of food grade CO_2. However, very large scale operation of amine scrubbers operating on coal derived flue gas has not been demonstrated. As reported by the U.S. EPA, "the economics and scale up issues associated with a 500 MW or larger power plant are substantial" (*See* Reference 8 on Exhibit ___ (DC-5).)

The developers of flue gas amine scrubbing technology (Fluor, MHI, ABB Lummus, Praxair) are actively working on improving their technologies to address the challenges of cost, performance and efficiencies. If CO_2 capture equipment is added to an existing PC power plant today, the following major equipment would be required:

a. Flue gas blower to pressurize the downstream equipment
b. A large amine absorber to capture the CO_2
c. A steam stripping column to remove the CO_2
d. Amine solution heat exchange equipment
e. Heat exchangers to cool the stripped CO_2 and condense water
f. A glycol drying system to dry the CO_2 to meet pipeline specifications
g. CO_2 compressors to raise the pressure to 1600 to 2500 psi for pipeline transportation

Large scale amine scrubbers operating on coal derived flue gas have not been constructed. However, it is believed that the flue gas must be very low in SO_x and NO_x and particulates before feeding to the amine system. If the coal power plant being retrofitted for CO_2 capture does not meet these requirements, additional capital may be required to modify the plant SO_x, NO_x and particulate removal systems.

Q Can you explain what changes are actually made to an IGCC plant to capture CO_2?

A Because an IGCC plant is custom designed to optimally convert coal to electricity without CC, retrofitting the plant for CC at a later date would involve many trade offs and compromises. The optimal retrofit design has yet to be developed, so my comments are based on preliminary studies.

Assuming the plant is designed for optimal performance without CC (as is the case with the Mesaba Project), the key changes to achieve 90% CO_2 capture would include:

a. Addition of a CO shift unit to convert CO to CO_2

b. Removal of the COS hydrolysis unit (shift accomplishes this step)

c. Addition of a scrubbing tower to the acid gas removal unit to remove CO_2

d. Modification of the combustion turbines to burn hydrogen rich fuels

e. Addition of air compressor and nitrogen compressor capacity to the air separation plant (less air extracted in the power plant and more nitrogen for NO_x controls)

f. Depending on the acid gas removal system technology, CO_2 drying equipment may be needed

g. CO_2 compressors to boost the pressure to required pipeline specifications

These changes, with the possible exception of the gas turbines, would employ commercially proven equipment. Additional plot space would be required for this retrofit to be possible. The Mesaba Energy Project is being designed with the required plot space for future CC.

While these changes are significant, the cost and performance penalties would be substantially less that those that would result if an SCPC plant of the same size and using coal fuel were retrofitted for CC.

Q Can you explain what changes are actually made to an IGCC plant to capture 30% of the CO_2?

A Fluor completed a study for Mesaba which evaluated a lower cost option to capture CO_2 (see Exhibit ___ (DC-7)). The favorable economics of this option, which are discussed above, result from the less severe changes to the plant. The key changes are summarized below:

a. Addition of an additional amine absorber to remove about 85% of the CO_2 in the clean fuel gas

b. Addition of equipment to strip the CO_2 from the rich amine solution

c. Addition of heat exchange equipment to improve cycle efficiency

d. Extraction of steam from the power plant for use as diluent to turbine combustors (loss of CO_2 in the fuel gas will require more diluent for NO_x control)

e. CO_2 drying and compression equipment to meet CO_2 pipe line specifications

Again, the Mesaba Project is being designed with the required plot space for this capture scenario.

Q Assuming IGCC technology has these significant advantages for future carbon capture, won't future technology changes in IGCC and SCPC technology shift the economics to favor SCPC?

A The gap between IGCC and SCPC is so great, I believe that this is highly unlikely to happen.

Significant R&D investment is now being made by the power and hydrocarbon process industries, the U.S. Department of Energy, and research organizations in Europe and Asia to improve the technologies for clean coal power generation including CC and sequestration. As a result of these R&D efforts, improvements in both IGCC and SCPC technology and CC technologies will surely be made and many may eventually find applications in commercial power plants.

Reviewing all of these R&D programs is not part of my testimony. However, I am familiar with some of the programs that have been published. I believe that fundamental benefits of gasification compared to combustion technologies are compelling – especially in the time frame that the U.S. power industry is now planning new coal generation plants, i.e. the next 10 to 15 years. It is my opinion that the race between clean coal combustion technologies and clean coal gasification technologies to produce the least cost "low carbon power" will ultimately be won by the gasification group of technologies, and that over the life of any new coal plant, IGCC is likely to be a least cost resource. Recent reports by U.S. DOE and U.S. EPA come to similar conclusions (*see* References 9 and 13 on Exhibit ___ (DC-5).)

Q Have you read the direct testimony of Dr. Eilon Amit?

A Yes.

Q Do you or Fluor have any observations about the comparative cost analysis contained in Dr. Amit's testimony?

A Yes. Fluor has reviewed the comparative cost analysis contained in Dr. Amit's testimony and prepared a report attached to my testimony as Exhibit ___ (DC-6), Fluor Independent Analysis of Generation Technologies for a 600 MW Coal-Fired Power

Plant in Minnesota, Addendum B – SCPC Plant Levelized Nominal Cost of Electricity Comparison.

Q What is the purpose of this report?

A In December 2005, Fluor prepared an independent report on coal power generation technologies ("Fluor Report") that compares the plant cost and performance of the 600 MW Mesaba Energy Project Unit I with a hypothetical 600 MW grassroots SCPC plant located near Monticello, Minnesota. The Report provides an overview of plant cost and performance data for the two technologies. Dr. Amit did not consider this information in his comparative calculations so we wanted to prepare an addendum to our original report that provides relevant, comparative calculations.

This addendum compares the levelized nominal COE of the hypothetical SCPC plant described in the report with levelized nominal costs reported for Big Stone II, a proposed 630 MW SCPC plant near Milbank, South Dakota, and Sherco 4, a potential 750 MW SCPC plant in Sherburne County, Minnesota. A comparison with the levelized nominal COE reported by the Department of Commerce for the Mesaba Energy Project is also provided.

Q What are the conclusions of the Fluor report attached as Exhibit __ (DC-6)?

We concluded when Big Stone II is compared to the Fluor hypothetical 600 MW SCPC plant on a common basis, the difference in levelized COE is within 7%. Most of the difference is in the much lower O&M cost estimate for the Big Stone II plant. It is noted that the hypothetical 600 MW SCPC plant was assumed to be greenfield and includes an allowance for infrastructure and offsite costs that would presumably be higher than those required for Big Stone II and Sherco 4 (Referenced attached Figures B1 & B2).

Finally, we show that the levelized COE for the Mesaba Energy Project is essentially the same and very competitive to that for Big Stone II.

Q Have you read the direct testimony of J. Drake Hamilton?

A Yes, and I have the following comments.

Ms. Hamilton cites one study that added capital costs for CC from IGCC plants could be as much as 66%. My survey of six of the most comprehensive and independent studies indicates that added capital costs would range from 29 to 39%. If CC is required in the future, IGCC plants will be significantly less expensive to retrofit than SCPC plants.

Ms. Hamilton states that Excelsior is planning only on capturing 30% of its CO_2 emissions in the future. Excelsior can capture any level of CO_2 that might be required in the future depending on the regulations. The Mesaba Project has the unique advantage of beginning capture of CO_2 at the 30% level at a relatively low cost thus increasing the odds that Mesaba will reduce carbon emissions depending on the cap and trade system or carbon tax imposed. This option simply does not exist for SCPC plants.

Ms. Hamilton states that CO_2 capture and transportation entails unacceptable safety and environmental risks. CO_2 has been captured and transported by the oil and gas industry for many years and has an excellent safety record. Kinder Morgan lists 7 CO_2 pipelines on its website, some as long as 500 miles (http://www.kindermorgan.com/business/co2/transport.cfm#co2_pipelines). Encana has been successfully operating a 200 mile pipeline from the Dakota Gasification Co. in North Dakota for the past 10 years and recently announced an expansion of the line. (http://www.encana.com/operations/upstream/weyburn_scope_co2.html). Another example of successful CO_2 pipeline operations is the Denbury Resources operation which moves CO_2 through a 183 mile network connecting the Jackson Dome in Mississippi to EOR users along the Gulf Coast. (http://www.denbury.com/W_Mississippi.htm). CO_2 is widely recovered from refinery and petrochemical plants and transported for use in the food and beverage industry. These are just a few examples of carbon dioxide transportation and use based on natural deposits of CO_2 and manufactured CO_2. Ms. Hamilton states it makes no sense to locate the Mesaba Project 450 miles from the sequestration site in North Dakota. Using the cost guidelines in the EPA Nexant report (*See* Reference 9 in Exhibit ___ (DC-5), a CO_2 pipeline for Mesaba Unit I would cost about $110 mm (excluding rights-of-way). Kinder Morgan now operates profitable CO_2 pipelines as long as 500 miles. Although a closer sequestration site may be better, this distance does not appear to be an economic barrier, and especially considering that the Mesaba cost of capture will be one of the lowest costs of CO_2 based on the studies discussed in my testimony.

Q **Have you read the direct testimony of Ronald Rich?**

A Yes, and I have the following comments.

Mr. Rich sites the DOE FutureGen project as the basis for 90% CC. FutureGen is a non-profit technology demonstration project. The stated goal of FutureGen is to demonstrate the technology for capturing 90% of the CO_2 produced in a gasification based power plant. FutureGen's goal is to sequester about 1 mm tons per year of CO_2. Although FutureGen targets 90% capture on a daily stream basis, the actual amount of sequestered CO_2 could be less than 90% on an annual basis. The FutureGen project is an important project for the clean coal industry but should not be compared to a commercial 600 mw IGCC project.

Mr. Rich states that CC from an IGCC project will decrease efficiency by 10 to 40% and that capturing "33%" as Mesaba proposes is misleading. The survey of independent studies described above shows that heat rate (the inverse of efficiency) will degrade by 17 to 21%. Mesaba has proposed capturing 30% with a loss of less than 10% efficiency. This is proposed only as the first least cost step for the consumer to reduce carbon emissions. Only the Mesaba Project provides this lower cost opportunity to Minnesota ratepayers. If carbon regulations, technology developments or beneficial uses of carbon allow higher levels of CC that offers net benefits to ratepayers, the Mesaba Project will be ready to implement those more expensive options, which will surely be less expensive than retrofitting an SCPC plant.

Mr. Rich describes several "costly steps" that will be required to capture carbon. Some of the steps he describes are not required or are misleading:

a. The water of combustion is not condensed. It is a clean and harmless vapor that leaves the plant stack.

b. CO_2 is not converted to a solid or liquid. In an IGCC plant with CC, the CO_2 is recovered in a clean state, dried and compressed to pressures above the CO_2 critical point. At these conditions, CO_2 acts like a liquid and is pumped at lower specific energy consumptions. This is proven technology practiced for many years as discussed above.

c. The CO_2 would not be transported by rail or truck. Although CO_2 in small quantities is transported by truck and rail today, the large amounts of CO_2 captured from an IGCC plant would be transported by pipeline only. High pressure pipelines operate at over 2000 psi and are highly efficient and safe. The cost to build a pipeline for Mesaba would be about $110 mm (excluding rights of way) assuming 90% capture, and much less if the first phase is 30% capture.

d. The cost of geologic sequestration is not fully known today. The purpose of the FutureGen project is to develop that data and demonstrate its safe operation. FutureGen and other data from the North Dakota program will be available to Excelsior when the time comes to capture carbon at Mesaba.

e. “The volume of CO_2 captured would exceed volume of coal shipped to the plant.” Clearly the carbon fed to an IGCC or SCPC plant largely ends up as CO_2. But to compare the volume of supercritical CO_2 in a pipeline with the volume of bulk coal in a rail car does not make sense.

Q Have you read the direct testimony of Frank Miao?

A Yes, and I have the following comments.

a. Mr. Miao states syngas turbines are "not conventional" technology but the rest of the IGCC plant is. The advanced turbines (F class machines) burning natural gas are conventional turbines in widespread use and the information is readily available from the key suppliers (General Electric, Siemens and MHI). The turbines operating on “E” class machines with syngas are conventional technology and operating in many commercial plants. The Italian oil fired projects are operating in integrated gasification plants with multiple gasifiers and multiple turbines running on syngas. Recently, the ENI IGCC plant in Italy was brought into commercial service and the owner reported that the startup and commission of the plant was accomplished in less than five days. (See Reference 14). The current generation of F class machines operating on natural gas is relatively new. Therefore, an IGCC plant with this equipment has yet to be constructed. However, the Mesaba IGCC design is a combination of "conventional equipment" proven in various large scale applications. GE, Siemens and MHI offer the technology as a fully developed commercial product and back their equipment with standard warranties.

b. Mr. Miao states that the 603 MW Mesaba Unit I is a 2X scale up of Wabash and Polk. Mesaba Unit I is a two train plant. As described in more detail in the Rebuttal Testimony of Thomas A. Lynch from ConocoPhillips, there is not a significant scale up from Wabash for each gasification train. This is a misleading statement.

c. Mr. Miao states incorrectly that CO and CO_2 are "removed" to capture carbon. As described above, the fuel value of CO is reacted with steam and converted to hydrogen and carbon dioxide in a 90% CC IGCC plant.

Q On page 13 of his direct testimony for Xcel Energy, Marvin E. McDaniel testifies that Xcel assumes generation plant lives of approximately 30-40 years, and that he would expect Mesaba I's IGCC technology would substantiate an expected life at the low end of that range. Do you agree with this analysis?

A There is no basis for such a statement. Gasification equipment constructed over 50 years ago is still operating today. Similar petrochemical and refining equipment is operating for 50 years or more. No new refinery has been built in the U.S. for over 30 years. Clearly, many old process plants are operating today because they have been properly maintained and upgraded when the technology dictates. Combustion turbines, like the rotating machinery in a conventional coal plant, may have shorter useful lives. However, with proper maintenance and upgrades, this equipment can also enjoy a useful life of 40 years or more. If components of the Mesaba plant become technically obsolete, they will be replaced with the latest new generation of equipment. Unlike a large single 600-750 mw SCPC boiler and steam turbine, an IGCC plant consists of a series of smaller equipment in multiple trains. As technology changes, an IGCC plant is more amenable to upgrades and betterment projects than an SCPC plant. These cost savings from these technology advancements are not included in Excelsior's cost projections.

Q Can you explain why Mesaba Unit I is being designed to produce approximately 600 MW and not 450 MW?

A The capacity of an IGCC plant is set by the size of the combustion turbines which have a fixed power rating. Today, the state of the art advanced combustion turbine for syngas service is about 230 MW. When integrated into a combined cycle, each turbine with a steam turbine produces about 300 MW net of internal loads. To achieve economies of scale and lowest COE for the ratepayer, a minimum of two trains is required, thus resulting in an IGCC plant rating of about 600 MW.

Prior to the recent commercial introduction of the uprated class 7F combustion turbines, most IGCC plant designs were based on smaller F class or E class machines and were rated at about 450 to 500 MW at sea level. Other than smaller new technology demonstration plants such as the FutureGen Industrial Alliance Project, the Southern Companies KBR transport gasifier "Stanton Project" in Orlando, and the demonstration project announced by Xcel Energy in Colorado (all nominally 250 MW), I am not aware of any new commercial IGCC plants under development in the US 60 Hz market today that are not rated at 600 Mw or more.

Q Is the E-Gas^{TM} technology being used in the Mesaba Energy Project able to gasify coal and produce a large quantity of hydrogen that could potentially contribute to a transition to using hydrogen as a fuel source?

A Yes. Although Mesaba Unit I is being designed for power generation, it is my understanding that the larger Mesaba Energy Project will encompass subsequent units that certainly could produce a large quantity of hydrogen that could potentially be the basis for a broader transition within society to using hydrogen as a fuel source. In fact, most of the gasification plants licensed and constructed in the past few years have been hydrogen producing plants. Over 15 such plants are under construction today in China. These plants produce synthesis gas from coal, shift the syngas to hydrogen, capture the carbon in the form of carbon dioxide and use the resultant products to manufacture nitrogen based fertilizers. Some of the 500 MW IGCC plants in Italy co-produce high quality hydrogen for use in the refining industry.

The hydrogen economy will require large quantities of hydrogen for use in power generation (such as fuel cells) and transportation (primarily cars, buses and trucks. Recently BP and GE announced a business alliance to develop 10 to 15 power plants based on hydrogen fuels. Although bulk hydrogen might be produced someday from nuclear fusion or other non-hydrocarbon resources, such developments are decades away. If the U.S. is to transition to a "hydrogen economy," fossil fuels, primarily coal, will need to be used. The Mesaba Project proposes to use the only technology that can be used to convert coal to hydrogen, i.e., gasification.

The E-Gas technology is an efficient process for converting coal to synthesis gas which is the key raw material for hydrogen production using proven commercial technology. Construction and operation of the Mesaba Project will be an important step towards the hydrogen economy.

Q Compared to SCPC, is IGCC a maturing technology or a young technology that will experience significant improvements in the years ahead?

A As a general matter, IGCC is a relatively younger technology than pulverized coal boiler technology. A 2006 report by the U.S. DOE and National Coal Council (see Reference 15 on Exhibit ___ (DC-5) listed developing improvements as "ultra supercritical" boilers, innovative post combustion carbon capture, and oxy-combustion for easier post combustion capture. These coal combustion technology improvements could be significant. However, they are either pushing the limits of already mature supercritical steam systems or adding on flue gas controls to the back end of the power plant.

IGCC, on the other hand, embodies the integration of several technologies each of which is relatively young compared to PC coal technology. In a recent report by the U.S. DOE/NETL, they presented their forecast for improvements in IGCC technology over the next 10 years (*see* Reference 13 on Exhibit ___ (DC-5). This report listed breakthrough technologies now under development that could dramatically improve IGCC technology costs and efficiency. Improvements, such as pressurized dry feed systems, long lasting refractories, warm gas cleaning, Ion Transport Membranes (for air separation), advanced G and H gas turbines, and gas membrane separations, could drive current IGCC COE of about $70/mwh down to below $45/mwh, with CC.

Many of these improvements in IGCC technology are "subsystem" improvements that could be added to an earlier generation IGCC plant. Most of the improvements being developed for PC plants are for new grassroots plants and will be difficult to incorporate into older plants. Converting a subcritical PC plant to an Ultra SCPC plant would be very difficult.

Not all of the improvements cited by the DOE in its recent report (Reference 13 on Exhibit ___ (DC-5)) are likely to be successful. However, in this observer's opinion, the path of least resistance to significantly improved and lower cost coal power generation technology over the next 10 to 15 years will be the path based on gasification and related technologies.

Q Can you summarize the conclusions of your rebuttal testimony?

A Yes. In my professional opinion based on over 30 years of relevant experience, I believe it is very likely that IGCC will be a least cost resource to ratepayers over the life of a new coal-fueled baseload facility, particularly if any form of meaningful carbon regulation is put into place. The comparative cost testimony provided by Dr. Amit appears to be valid given the data that formed the basis of his analysis, but much of the data that formed the basis of his analysis appears to materially understate the likely actual costs of construction for a new baseload SCPC plant. In contrast, the analysis and data provided in the Fluor Reports originally filed in this proceeding in December of 2005 provide more realistic information concerning the likely costs of a new SCPC plant, and when Dr. Amit's levelized pricing methodology is applied to the Fluor data, the levelized cost of Mesaba Unit I is less than the expected levelized cost of the alternative SCPC plant. Preliminary engineering and design work for Mesaba Unit I has determined that approximately 600 MW is the optimal output for the facility, and in my judgment the expected useful life of Mesaba Unit I would be in excess of 40 years. Also, the E-Gas™ technology being used in the multiple unit Mesaba Energy Project is capable of producing large quantities of hydrogen from coal, allowing the Mesaba

Project to potentially contribute to a transition to hydrogen as a fuel source for the larger economy. Finally, choosing IGCC technology today will afford the rate payer the opportunity to participate in the coming flow of improvements in IGCC technologies that could be used to reduce costs, increase efficiency, reduce greenhouse gas production, and extend plant life for many decades.

Does this conclude your rebuttal testimony?

A Yes.

EXHIBITS

EXHIBIT ____ (DC-1)

Curriculum Vitae

EXHIBIT ____(DC-2)

Summary of Studies Comparing Newly Built IGCC and SCPC Power Plants with and without Carbon Capture

		Reference	1	2	3	4	5	6	7	8	9	10	11	12	13
		Source	Fluor	Fluor	US. DOE/NETL	IEA Foster Wheeler	EPRI Parsons	US DOE / Parsons	Jacobs	US. EPA Nexant	US. EPA Nexant	US DOE Mitretek	EPRI	EPRI	US. DOE/NETL
		Time Frame for Economics	2005	2005	NA	2003	2003	2002	2003	2004	2004	2004	2003	2005	2006
		Coal Basis	Sub Bit	Sub Bit	NA	Bit	Bit	Bit	Bit	Bit	Sub Bit	Bit	Bit	Bit	Bit
Newly Built Data															
IGCC	Newly Built	COE				5.91	4.57	4.77					4.95	4.96	5.25
IGCC w CC	Newly Built	COE				7.58	5.723	6.58						6.12	7.02
PC Coal	Newly Built	COE	5.973	5.973				5.15					4.58	4.59	4.97
PC Coal w CC	Newly Built	COE						8.56						6.61	8.35
IGCC	Newly Built	$/kw	Trade Secret	Trade Secret		1,625	1,158	1,111	1,164	1,430	1,630		1,395		1,522
IGCC w CC	Newly Built	$/kw				2,151	1,522	1,642	1,511						2,021
PC Coal	Newly Built	$/kw	Trade Secret	Trade Secret				1,143		1,261	1,299		1,315		1,355
PC Coal w CC	Newly Built	$/kw						1,981							2,368
IGCC	Newly Built	heat rate	9,390	9,390		8,450	9,653	7,915	8,384	8,167	8,520		8,885		8,721
IGCC w CC	Newly Built	heat rate				10,160	11,550	9,226	10,296						10,835
PC Coal	Newly Built	heat rate	9,450	9,450				8,421		8,900	9,000		8,805		8,865
PC Coal w CC	Newly Built	heat rate						11,816							12,688
IGCC vs SCPC (no CC)															
	Newly Built	COE						-7.4%					8.2%	8.1%	5.6%
	Newly Built	$/kw	9.1%	9.1%				-2.8%		13.4%	25.5%		6.1%		12.3%
	Newly Built	heat rate	-0.6%	-0.6%				-6.0%		-8.2%	-5.3%		0.9%		-1.6%
IGCC vs SCPC with CC)															
	Newly Built	COE						-23.1%						-7.3%	-15.9%
	Newly Built	$/kw						-17.1%							-14.7%
	Newly Built	heat rate						-21.9%							-14.6%
Changes for Carbon Capture															
IGCC	Newly Built	Increase in COE			25%	28.3%	25.2%	37.9%				38 to 40%		23.4%	34.0%
PC Coal	Newly Built	Increase in COE			84%			66.2%						43.9%	68.0%
IGCC	Newly Built	$/kw investment				32.4%	31.4%	47.8%	30.0%			28-30%			32.7%
PC Coal	Newly Built	$/kw investment						73.3%							74.8%
IGCC	Newly Built	increase in heat rate				20.2%	19.7%	16.6%	22.8%			14.5-16.8%			24.4%
PC Coal	Newly Built	increase in heat rate						40.3%		40.3%					43.1%

EXHIBIT ____(DC -3)

Summary of Studies Comparing IGCC and SCPC Power Plants with and without Retrofitted Carbon Capture

		Reference	1	2	3	4	5	6	7
		Source	Fluor	Fluor	US. DOE/NETL	IEA Foster Wheeler	EPRI Parsons	US DOE / Parsons	Jacobs
		Time Frame for Economics	2005	2005	NA	2003	2003	2002	2003
		Coal Basis	Sub Bit	Sub Bit	NA	Bit	Bit	Bit	Bit
Carbon Capture Retrofit Data									
IGCC	Newly Built	COE					4.57		
IGCC w CC	Retrofit	COE					5.932		
PC Coal	Newly Built	COE	5.973	5.973					
PC Coal w C(	Retrofit	COE							
IGCC	Newly Built	$/kw	Trade Secret	Trade Secret			1,158		1,164
IGCC w CC	Retrofit	$/kw					1,596		1,542
PC Coal	Newly Built	$/kw	Trade Secret	Trade Secret					
PC Coal w C(	Retrofit	$/kw							
IGCC	Newly Built	heat rate	9,390	9,390			9,653		8,384
IGCC w CC	Retrofit	heat rate	10,000	NA			11,569		10,395
PC Coal	Newly Built	heat rate	9,450	9,450					
PC Coal w C(	Retrofit	heat rate	10,400	12,300					
Changes for Retrofit CC									
IGCC	Retrofit	Increase in COE	<10%	NA			29.8%		
PC Coal	Retrofit	Increase in COE	>20%	>60%					
IGCC	Retrofit	$/kw investment	9.9%	NA			37.8%		32.5%
PC Coal	Retrofit	$/kw investment	23.7%	>60%					
IGCC	Retrofit	increase in heat rate	6.5%	NA			19.8%		24.0%
PC Coal	Retrofit	increase in heat rate	10.1%	>30%					

EXHIBIT ____ (DC -4)

Summary of Studies Comparing Carbon Capture Costs for IGCC and SCPC Power Plants

Changes for Carbon Capture			90% Confidence Low	Average	90% Confidence High
IGCC	Newly Built	Increase in COE	25.8%	29.8%	33.9%
PC Coal	Newly Built	Increase in COE	51.1%	64.7%	78.3%
IGCC	Newly Built	Increase in $/kw	29.4%	34.1%	38.8%
PC Coal	Newly Built	Increase in $/kw	72.1%	73.3%	74.5%
IGCC	Newly Built	increase in heat rate	16.7%	19.0%	21.3%
PC Coal	Newly Built	increase in heat rate	38.8%	40.3%	41.8%

Fluor 30% CC Study (PRB Coal Mesaba)	
retrofit	<10%
retrofit	>20%
retrofit	9.9%
retrofit	23.7%
retrofit	6.2%
retrofit	10.1%

Note: Based on 7 recent investigations from independent sources
(See References 3,4,5,6,10,12,13 on Exhibit DC-5)

EXHIBIT ____ (DC -5)

List of Referenced Reports

1. Fluor Enter., “Mesaba Energy Project Partial Carbon Dioxide Capture Case,” Oct. 2006.
2. Fluor Enter., “Indep. Analysis of Generation Tech. for 600 MW Coal-Fired Power Plant in Minnesota,” (Dec. 2005).
3. U.S. Dep’t of Energy, Nat’l Energy Tech. Lab., “Carbon Sequestration: CO_2 Capture,” *at* http://www.netl.doe.gov/technologies/carbon_seq/core_rd/co2capture.html.
4. J. Davison, Int’l Energy Agency, Greenhouse Research and Dev. Program, and L. Bressan Foster Wheeler Italiana, “Coal Power Plants with CO_2 Capture: The IGCC Option,” Gasification Tech. Council Annual Meeting, San Francisco (Oct. 12-15, 2003).
5. M. Rutkowski and R. Schoff , Parsons Corporation, and N. Holt and G. Booras, Elec. Power Research Inst., “Pre-Investment of IGCC for CO_2 Capture with the Potential for Hydrogen Production,” Gasification Tech. Council Annual Meeting, San Francisco (Oct. 12-15, 2003).
6. Parsons Energy and Chemicals, on behalf of U.S. Dep’t of Energy, Nat’l Energy Tech. Lab., “Evaluation of Innovative Fossil Fuel Power Plants with CO_2 Removal,” (2002) (*as reported in* Reference 9).
7. J. Griffiths and S. Scott, Jacobs Consultancy, “Evaluation of Options for Adding CO_2 Capture to ChevronTexaco IGCC,” Gasification Tech. Council Annual Meeting, San Francisco (Oct. 12-15, 2003).
8. Nexant, Inc., on behalf of U.S. Envtl. Prot. Agency, “ENVTL. FOOTPRINTS AND COSTS OF COAL-BASED INTEGRATED GASIFICATION COMBINED CYCLE AND PULVERIZED COAL TECHN.,” EPA-430/R-06/006 (Jul. 2006).
9. “Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies”, U.S. Environmental Protection Agency, Prepared by Nexant, Inc., EPA-430/R-06/006 (Jul. 2006)
10. D. Gray, S. Salerno, G. Tomlinson, Mitretek Corp., on behalf of U.S. Dep’t of Energy, “Current and Future IGCC Technologies: Bituminous Coal to Power,” Report MTR-2004-05, (Aug. 2004).
11. N. Holt, and G. Booras, Elec. Power Research Inst., “Pulverized Coal and IGCC Plant Cost and Performance Estimates,” Gasification Techn. Council Annual Meeting, Washington D.C. (Oct. 2004).
12. , J. Phillips, Elec. Power Research Inst., “CO_2 Capture Basics for IGCC,” Coal Fleet for Tomorrow General Meeting, Pittsburgh, PA (Mar. 28, 2006) (Confidential Communications).
13. J. Klara, U.S. Dept. of Energy, Nat’l Energy Tech. Lab., “IGCC: Coal’s Pathway to the Future,” Gasification Tech. Council Annual Meeting, Washington D.C. (Oct. 2-4, 2006).
14. “Eni Refining & Marketing Sannazzaro Gasification Plant: Project Update and Startup Experience,” D. Camozzi (Snamprogetti), Gasification Tech. Council Annual Meeting, Washington, D.C. (Oct. 2-4, 2006).
15. Nat’l Coal Council, “Coal: America’s Energy Future”, Vol. 1 (Mar. 2006).

EXHIBIT ____(DC -6)

Independent Analysis of Generation Technologies for a 600 MW Coal-Fired Power Plant in Minnesota

Addendum B – SCPC Plant Levelized Nominal Cost of Electricity Comparison

EXHIBIT __ (DC-7)

Mesaba Energy Project Partial Carbon Dioxide Capture Case