Grant Application
for a
Lignite Coal Test
at a
Transport Reactor Gasification Facility
in
Wilsonville Alabama

Presented to:

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ABSTRACT

Coal gasification is the latest advanced technology being researched and developed by the Department of Energy to demonstrate that coal can be used as a fuel in electric generation in an environmentally enhanced manner.

The advance Integrated Gasification Combined Cycle (IGCC) system is designed to gasify coal, use the synthetic gas (syngas) produced to fuel a gas generation turbine. The captured waste heat from the gas turbine goes through a heat exchanger to produce steam, which in turn drives a steam generation turbine. This advanced process improves the plant efficiency while reducing plant emissions significantly.

The objective of the proposed grant is to evaluate the performance of lignite fuel in a nominal 4 MW to 8 MW pilot scale advanced coal gasification system at the Department of Energy's Power System Development Facility (PSDF), located in Wilsonville, Alabama. To date, two 250-hour tests of lignite have been conducted with very promising results with low sodium lignite, but with a deposition issue identified for high sodium lignite. The specific technical issues include determining the effects of the coal gasification operating conditions using high sodium lignite on the carbon conversion and quantity & quality of synthetic gas production. The PSDF gasification technology, unlike other current IGCC designs, has a dry feed system to the gasifier and operates at favorable operating temperatures that work well for high moisture lignite.

It is proposed to run a 250-hour test after making some test facility mechanical changes to ensure that disposition issues have been resolved. Then a proposed 1000-hour run on high sodium lignite to examine variable operating conditions. The results of the test will define the operating conditions that provide acceptable performance and identity various operating problems for high sodium lignite.

PROJECT SUMMARY

Today coal currently provides over 50% of the electricity consumed in the United States and will remain a necessary part of our energy mix for some time to come. One of the technologies being developed for advanced coal-based electric power-generating systems is an integrated gasification combined cycle (IGCC) system. The IGCC process converts coal to a combustible gas, cleans the pollutants from the gas, and combusts it in a gas turbine to generate electricity. The exhaust from the gas turbine is used to generate steam to generate more electricity in a steam turbine.

Exploring how lignite coal performs in an advanced gasification process could have a significant economic impact on the North Dakota power industry. The construction of new power plants and the re-powering of existing North Dakota plants using this advanced gasification process could lead to new development of cost-competitive, environmentally acceptable coal-based power generation in the state.

Specific Department of Energy program 2010 goals for baseload IGCC systems using lignite include attaining a net electric system efficiency of 40%, reducing sulfur dioxide (SO_2) by 97% emitting no more than 0.08 lbs of Nitrous Oxide (NOx) emissions per million British Thermal Unit (BTU) and achieving substantial reductions in mercury (Hg) reductions.

One of the most recent IGCC gasification concepts to be investigated by the Department of Energy and Southern Company is the “transport reactor” gasifier (Figure 1, page 10). The transport reactor functions as a circulating fluid-bed while operating in the air-pressure transport system of solid-particle flow. The gasifier concept provides excellent solid-gas contacting of relatively small particles to promote high gasification rates.

The advantages of an advanced transport reactor IGCC for electricity production from lignite need to be demonstrated through gasification tests at Wilsonville, Alabama and include:

- Testing the transport reactor gasifier, part of an advanced high-efficiency IGCC system, will ultimately result in less carbon dioxide (CO_2) emissions/greenhouse gases per unit of power output.

- Low sulfur and nitrous oxide emissions – IGCC emissions of sulfur dioxide and nitrogen oxides, gases linked to acid rain, are a small fraction of allowable limits under the Clean Air Act.

- Transport reactor gasifier can handle coal fines – no coal fines separation necessary.

- High fuel reactivity results in higher conversion of lignite to fuel gas at temperatures low enough to prevent ash deposit problems.

- Use of hot or warm gas cleanup before combustion in a gas turbine results in little negative impact on cycle efficiency from high moisture coal.

- Oxygen-blown operations generate CO_2 capture readiness. Oxygen-blown IGCCs are well suited for application of future technologies to capture, sequester or recycle CO_2.

- The design of the transport reactor is applicable for lignite use with possible scale up commercialization possibilities. There are other gasification technologies, such as the Shell, Texaco and E-GAS™ (formerly Destec), however, none of these technologies will work satisfactory with lignite because of their design. The transport reactor's circulating fluidized bed design with a dry feed system appears to offer a better solution for gasification of high moisture lignite without the production of problematic tars and oils.

- The successful use of lignite in a IGCC system will benefit North Dakota lignite industry by demonstrating the technical and economic viability of lignite fuel in a high efficient gasification power plant. Clearly, this technology could provide lignite-based options for new generation plants, as well as for re-powering existing plants.

The participants include Basin Electric Power Cooperative, Montana-Dakota Utilities Company, Otter Tail Power Company, SaskPower, The North American Coal Corporation, Westmorland Coal Company, BNI Coal, Great River Energy and Great Northern Power Development L.P.

Based on the previous cost of shipping 700 tons to Wilsonville, Alabama, the total estimated cost of 3700 tons of coal and shipping expense is $250,000. Grant applicants are requesting a $125,000 match from the North Dakota Industrial Commission.

PROJECT DESCRIPTION

The objective of the proposed test is to evaluate the performance of high sodium lignite fuel in a high-efficient advanced transport reactor gasification system. Specific technical issues include determining the effects of the transport reactor's operating conditions on carbon conversion and gas yields and quality while monitoring for the increased ash agglomeration and deposition potential of the high sodium lignite.

Two exploratory 250-hour runs using Falkirk and Freedom coal have been conducted at the Power Systems Development Facility in Wilsonville, Alabama with the transport reactor with promising results but with some unanswered questions. The results of two 700-ton tests using Falkirk and Freedom lignite in the transport reactor in both air and oxygen blown modes:

- Good operation and successful gasification of Falkirk and low sodium Freedom
- Acceptable gas heating values
- Excellent carbon conversions
- No tar or oil at high or low temperatures

At low temperature and high sodium, no agglomerations were formed. However, there was reduced carbon conversions and lower gas heating values. At high temperatures and high sodium lignite, agglomerations deposits formed. The next step in advancing and determining the transport reactor's ability to utilize high sodium lignite coal is a preliminary 250-hour short-term test to address deposition problems followed by a 1000-hour test. The 1000-hour test should determine advanced operating and design modifications that could lead the transport reactor's technology toward a future commercial application with lignite coal.

Additional testing (1000 hours) of the Wilsonville’s transport reactor using high sodium lignite coal is necessary to better understand the benefits and challenges of using lignite with this technology. The test would be "continuous" and conducted at optimum operating conditions. The objective of the extended operation of the Wilsonville transport reactor will be to solve blockage problems within the loop seal, feeding problems associated with high moisture lignite, ash handling concerns, sygas recycle ability and determination of the long-term ability of the transport reactor to utilize higher sodium based lignite coal. The extended operation should allow expanding the operating envelope of the transport reactor with higher sodium lignite while still providing acceptable carbon conversion and gas heating values without agglomerations.

The Power Systems Development Facility staff at Wilsonville recommends additional tests where the operating envelope can be expanded for high sodium lignite to achieve acceptable carbon conversion and gas heating values without agglomerations.   The test is needed to better understand the effects of high sodium coal on the transport reactor and determine changes in operation and design to alleviate the agglomerations. Specifically the test will:

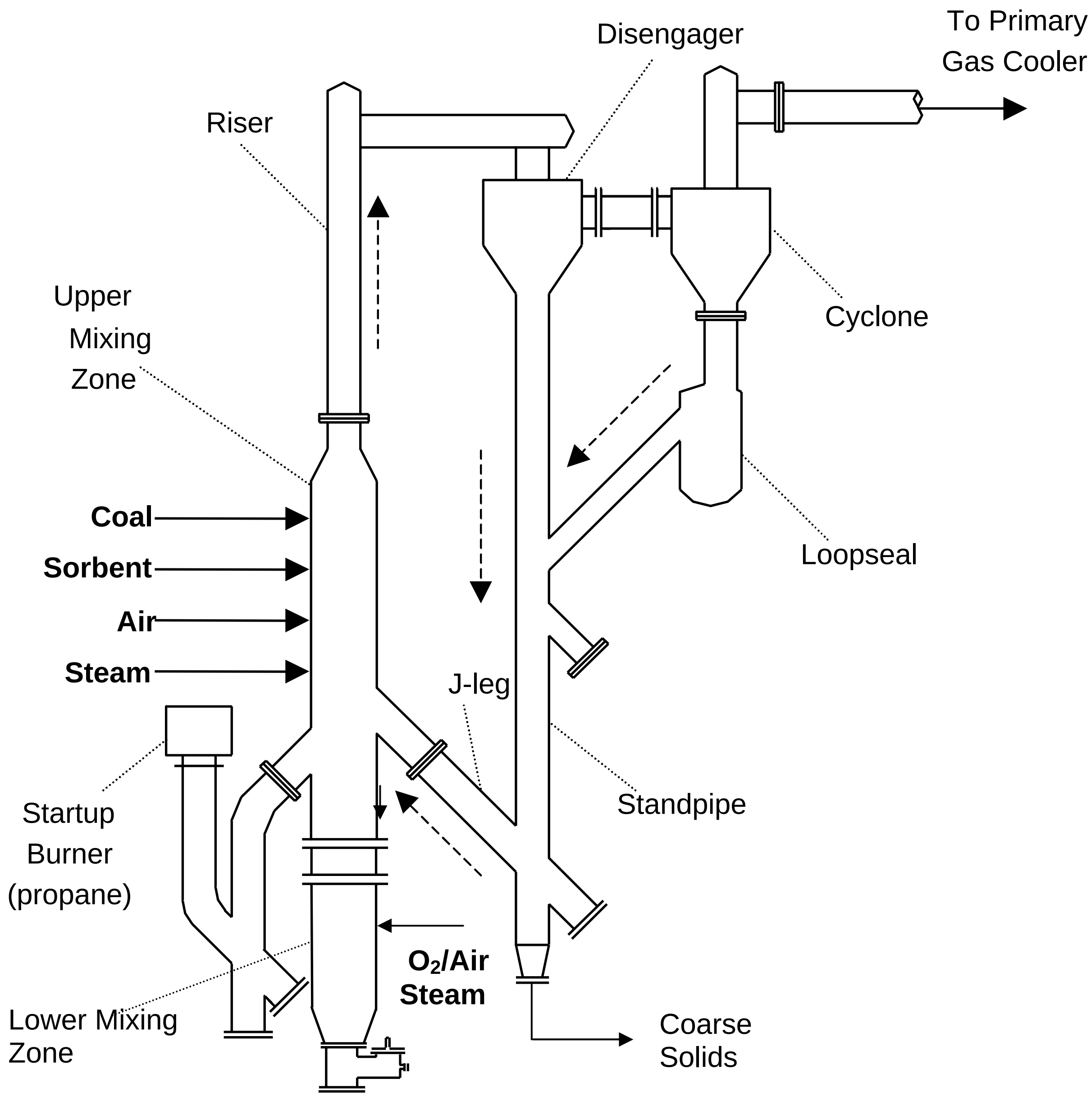
- Have an 1000 hour duration test exclusive of start-up conditions, if needed additional lignite could be provided for shakedown and operational startup producedures.

- Represent commercial operation with continued operations to expel added bed material (sand) to achieve commercial like mass and energy steady state.

- Operate at the maximum feed rate. Characterize reduced load (turndown) operation and performance.

- Resolve high sodium related disposition and or agglomeration issues in a 250-hour test. Demonstrate deposition and agglomeration free operation during long-term 1000-hour continuous operation.
- Increase carbon conversion and fuel energy value by eliminating nitrogen use by recycling syngas to the reactor and demonstrate syngas recycling.
- Operate the reactor at maximum feed coal rate and minimize char loss due to carry-over and capture by the particulate control device.
- Operate reactor to minimize energy value of ash-char products.
- Verify long-term stable combustion of low BTU syngas in the combustion turbine without propane calorific enhancements.

Figure One: Transport Reactor
Air or Oxygen Blown



Standards of Success

The use of lignite as a fuel in the transport reactor gasifier will be considered a success if four criteria are met. First, the transport reactor must exhibit stable operation without significant ash deposition or agglomerations during the 1000 hours of operation. Second, the fuel gas heating value must be acceptable for commercially available gas turbine operation with carbon conversion exceeding 85%. Third, the system emissions should be 10% of New Source Performance Standards (NSPS). Fourth, the hot-gas filters system should show stable operation with only a small increase in filter baseline differential pressure.

If these criteria are met, the technical advantages of using lignite in the transport reactor gasifier will have been demonstrated. Successful testing of the transport reactor gasifier using lignite could lead to acceptance of the IGCC technology with possible commercialization in the future.

Background

POWER SYSTEMS DEVELOPMENT FACILITY
TEST RUN TC13: GASIFICATION RUN
OPERATING SUMMARY FOR 9/31/03 – 11/02/03

- The Transport Gasifier operated for 501 hours in TC13 using Powder River Basin coal and two different types of lignite from the Freedom Mine in North Dakota. The two types of lignite differed primarily in sodium content. The raw high-sodium lignite contained over 6% sodium (ash mineral analysis), whereas the raw low-sodium lignite possessed a sodium content of around 1.5%. The gasifier operated on PRB coal to commission the new syngas-to-turbine system and to test the Piloted Syngas Burner (PSB) with syngas.

- The majority of the test run was air-blown (432 hours), with around 47 hours in enriched-air mode and over 22 hours in oxygen-blown mode. All of the oxygen-blown testing occurred while feeding high-sodium lignite. About 10 hours of enriched-air operation occurred during low-sodium lignite feed. Of the 47 hours of enriched-air gasification, 21 hours was co-feeding high-sodium lignite with low-sodium lignite, and 26 hours was feeding high-sodium lignite.

- The test run experienced stable air-blown operation using PRB as well as the two lignite fuels. Gasifier operating temperatures mostly varied from 1750 to 1775°F during PRB operations, from 1640 to 1750°F during low-sodium lignite operations, and from 1400 to 1700°F during high-sodium lignite operations. The gasifier exit pressure ran between 90 and 180 psig during air-blown operations and between 110 and 130 psig in oxygen-blown operations.

- Despite operating at lower temperatures with the high-sodium lignite, the gasifier produced a syngas free of oils and tar.

- Typical riser velocities ranged from 35 to 50 ft/s during air-blown operations, and were around 40 ft/s during air-blown operations. Standpipe differential pressures were smaller, and the reactor temperature profile was more uniform when the riser velocity was above 35 ft/s.

- For Powder River Basin coal in air-blown mode, the raw lower heating values were between 50 and 60 Btu/SCF resulting in projected heating values for large-scale operations of between 80 and 95 BTU/SCF. PRB lower heating values were slightly lower than previous PRB lower heating values at similar operating conditions due to low coal feed rates.

- In air-blown mode, the Freedom Mine high-sodium and low-sodium lignites achieved raw lower heating values of up to 45 and 61 BTU/SCF, respectively, resulting in projected heating values of up to 85 and 94 BTU/SCF. Higher coal feed rates can improve the lower heating values.

- Using oxygen-enhanced air, the Freedom Mine high-sodium and low-sodium lignites achieved raw lower heating values of up to 60 and 64 BTU/SCF, respectively, resulting in projected heating values of up to 120 and 109 BTU/SCF for the two coals.

- The lower heating values of syngas generated from the Freedom Mine lignite in air-blown mode were consistent with those of syngas generated from Falkirk lignite at comparable coal feed rates, while the syngas lower heating values for the Freedom Mine lignite in oxygen-blown mode were slightly higher than those of the syngas derived from Falkirk lignite.

- Powder River Basin coal carbon conversions were between 94 and 98.5%.

- The carbon conversions for the low-sodium Freedom lignite were between 93 and 98.5% for air-blown testing.

- The carbon conversions for the high-sodium Freedom lignite were between 75 and 99.5% for air-blown testing and were about 98% during oxygen-blown testing. The lower air-blown carbon conversions were during periods of operating at lower temperatures.

- The low-sodium lignite portion of the test run was smooth. Although some deposits occurred while feeding high-sodium lignite at gasifier operating temperatures above 1650°F, lower reactor temperatures (1400 to 1575°F) allowed for steady high-sodium lignite operations for long periods of time without any detectable signs of deposits in the reactor system.

- The coal grinding system showed promise in drying the lignite from a moisture content of 35% to a moisture content of 25%. The coal feeder experienced no difficulties in feeding the lignite to the gasifier.

- The primary gas cooler performed well, exhibiting no signs of oils or tar deposits.

- PCD operations were stable throughout TC13, which included the use of the three types of coal and the transitions to each type. Also, no problems were encountered with PCD operations during operation of the PSB. During most of the coal run, the baseline pressure drop was about 50 to 75 inH_2O. During steady state operations, the inlet temperature was about 600 to 800^oF, and the face velocity was maintained at about 3 to 4.5 ft/min.

- During the run, backpulse pressures of 320 psid on the top plenum and 400 psid on the bottom plenum were used. As in recent runs, the backpulse timer was varied from 5 to 20 minutes in an effort to further optimize backpulse parameters.

- The fines removal system operated fairly well during most of the run. However, during the run, the FD0520 lock vessel Everlasting valve failed to operate several times, presumably due to solids in the valve. The lock vessel Spheri valve was operated successfully during the times when the Everlasting valve was not functioning. Also, the drive end seal on the FD0502 screw cooler failed and caused a short delay in the run while it was repaired.

- Outlet loading samples indicated good sealing of the filter vessel. All the measurements showed outlet concentrations below the sampling system lower limit of detection of 0.1 ppmw except for two samples indicating loading of 0.25 and 0.11 ppmw.

- In the development of reliable level indicators in the FD0520 lock hopper system, evaluation of new resistance probes was continued. For this run, a new probe and transmitter were installed and tested with reliable results.

- The PCD was shut down “clean,” in that backpulsing was continued for over half a day after coal feed stopped. The residual cake was thin and comparable to that seen from recent runs. There was no indication of patchy cleaning on any of the filter elements.

- A preliminary inspection of the PCD internals revealed no obvious problems. No g-ash bridging was present, and there were no apparent filter element failures. In addition, there was no plugging found in the Westinghouse inverted filter element assemblies.

- Unlike previous test runs, the gasifier bed material changed rapidly during TC13, as process-derived materials replaced the sand present at startup. Standpipe samples taken during the test run consist of small particles that preliminary analyses show have a mean diameter (D_{50}) of about 250 to 350 µm. The process-derived solids created during the high-sodium lignite portion of the test run appear to be agglomerates of fine ash particles. Most of the agglomerates are spherical and either hollow-centered or have a glassy solidified silica core. The bulk density of the agglomerates is around 60 lb/ft^3.

- The solids circulation rate remained high as the process-derived bed material replaced the startup sand. The riser differential pressure was above one inch of water per foot of riser length.

- Both the coarse and fine ash depressurization systems worked well. Since the gasifier accumulated process-derived materials in the bed, the intermittent removal of coarse solids from the gasifier was more frequent than in past test runs. Almost one-half of the solids removed from the gasifier loop were coarse solids, resulting in a time-averaged removal rate of about 120 pph of coarse solids.

- For the first time, the combustion turbine at the PSDF ran on syngas, using the PSB (piloted syngas burner). The syngas used in the PSB came from PRB coal. Establishing/increasing syngas flow to the PSB, as well as decreasing/terminating syngas flow, exhibited smooth behavior, and neither caused any fluctuations in gasifier operations.

- To ensure safe operation of the PSB, several new interlocks were commissioned. All performed as expected during the interlock trials. When interlocks tripped the process gas to the PSB, valves diverted the flow to the flare to avoid causing reactor pressure upsets. Once the syngas flowed to the flare, logic controls restored the flow through the main pressure letdown valve to the atmospheric syngas burner (thermal oxidizer)—slowly, to avoid swings in reactor pressure. In practice, the gasifier pressure changed less than 2.0 psig during each trip.

- PSB operations were mostly steady with the generator producing a steady 1.2 MW. As the syngas flow to the PSB increased, the supplemental propane flow to the PSB decreased from 1200 to 400 pph and could have decreased further had the PLC logic not prevented the controller from reducing flow below 400 pph. A future goal for the system is to reduce the propane flow to zero, while maintaining the generator output.

- The PSB flame remained steady throughout testing. Process variances, such as the PCD back-pulse, did not affect PSB operations. PSB testing on syngas was completed after about 6 hours. Upon restarting the following day, the hydraulics on the cranking motor failed. Once the repairs to the hydraulic system are complete, plans call for the PSB to run on syngas as often as possible in the future.

- During the test run, extractive gas samples were taken for determining the amounts HAPS trace metals present in the syngas. The lab is currently analyzing the samples, and the results should be available soon.

- The deposition of naphthalene and three-member ring compounds hindered much of the extractive gas analysis that occurred in previous test runs. A new recently tested crystal knock-out pot should assist in future extractive gas testing and could provide stable, uninterruptible syngas flow to online gas analyzers and other processes that require low temperature syngas.

- The test run was interrupted twice when deposits formed in the loop seal and once when deposits formed in the standpipe. Although aeration flows dislodged the standpipe deposit, each loop seal deposit forced a complete system shutdown and depressurization to clear the material. The deposits were small, around 2-3 inches in diameter, and very easily broken by hand. By interlocking with each other, however, the deposits were able to form an obstruction that would not dislodge on their own. The exact cause of the deposits is not clear, but none formed toward the end of the test run, when gasifier temperatures were significantly lower (1400 to 1575°F). Although the deposits were below the bed level in the loop seal, they seem to have formed somewhere else and traveled there from another part of the gasifier.

- The carbon conversion with the low-sodium lignite was about 98%. However, with high-sodium lignite, the carbon conversion was lower (about 80 to 90%) than in past test runs. The capacity of the spent solids systems limited the coal feed rate to around 3500 pph. Studies are underway to determine whether higher high-sodium lignite feed rates (and higher syngas heating values) are possible. Future tests to address the low carbon conversions include increasing the reactor temperature and recycling the char solids back to the gasifier.

- The atmospheric syngas burner ran well during the test run, easily combusting the syngas derived from the PRB and lignite fuels.

- Most of the gas analyzers were online for the majority of the test run, presenting good gas composition data. The dry gas compositions added up to between 98 and 100% on a consistent basis.

- For PRB coal the sulfur emissions were 200 to 300 ppm (air blown).

- For the low-sodium (high sulfur) lignite from the Freedom Mine, the sulfur emissions were 1,400 to 1,800 ppm during air-blown operation and 2,000 to 2,500 ppm during oxygen-blown operation.

- For the high-sodium (low sulfur) lignite from the Freedom Mine, the sulfur emissions were 500 to 1,800 ppm during air-blown operation and between 1,500 and 2,500 ppm during oxygen-blown operations. The high variation in air-blown sulfur emissions was due to the wide range of coal rates.

- Unlike PRB coal, minimal sulfur capture occurred without limestone injection. The sulfur emissions decreased about 20% during one period of limestone injection.

- During air-blown mode, PRB coal had ammonia emissions between 1,000 and 1,500 ppm in air-blown operation, while the low-sodium Freedom lignite had 500 to 1,000 ppm emissions with a 3,000 pph coal rate and about 1,300 ppm emissions with 5,500 pph coal rate. The high-sodium Freedom lignite had ammonia emissions varying between 750 and 2,300 ppm while in air-blown mode. The ammonia emissions from the high-sodium lignite were a strong function of the coal feed rate.

- During oxygen-blown operations, the low-sodium Freedom lignite had 2,000 to 2,500 ppm ammonia emissions.

- During air-blown operations, the high-sodium Freedom Mine lignite had ammonia emissions varying between 1,500 and 2,500 ppm.

- The solids obtained from the standpipe sampling system had a mass mean particle diameter of between 250 and 350 microns and an LOI typically below 1%. Solids obtained from the spent fines feeder possessed a mean particle diameter of around 20 microns and an LOI varying from under 15% to over 70%.

- The sulfator ran relatively smooth during the test run, generating large quantities of high quality superheated steam for use in the gasifier. The bed level stayed fairly constant and only occasionally required additional sand. Whenever solid fuel was unavailable, the fuel oil system worked well at maintaining sulfator temperatures. During the test run, a spot of high skin temperature developed near one of the steam coil bundles where some of the refractory had apparently been damaged. Future inspections will reveal the degree of damage the sulfator refractory has experienced.

- The new FD0530 feeder fed gash at a rate that much steadier than that seen in previous test runs, although it still fed over a relatively narrow range of feed rates. The feeder needs to be capable of handling higher and lower feed rates. The carryover rate and carbon content in the FD0530 solids was large during the low temperature testing, thus the sulfator had difficulty combusting the material at a rate sufficient to keep pace with the solids collected. The FD0530 conveying line continues to develop leaks and will be replaced soon.

- The test run ended as scheduled on the afternoon of November 2, 2003. The shutdown was smooth, leaving no transient cake on the PCD filter candles. The post-run inspections showed that no further deposits made their way into the loop seal.

Qualification

Power Systems Development Facility

The Power Systems Development Facility (PSDF), located near Wilsonville, Alabama, is a flexible test facility designed to provide an engineering-scale demonstration of advanced coal-fueled power systems and key components at sufficient scale to provide data for commercial scale-up. The U.S. Department of Energy (DOE) has jointly developed the PSDF, with Southern Company and other industrial partners including Electric Power Research Institute (EPRI), Siemens Westinghouse, Kellogg Brown & Root, Inc. (KBR), and Peabody Holding Company. The purpose of the PSDF is to lead America's development of cost-competitive, environmentally acceptable coal-based power generation.

The PSDF started operations in 1996 accumulating about 5,000 hours of combustion testing with the Transport Reactor and Siemens Westinghouse Particulate Control Device (PCD). In 1999 the Transport Reactor was modified to operate as an air-blown gasifier (Transport Gasifier) and again in 2001 to operate as an oxygen-blown gasifier. The Transport Gasifier has operated over 2,900 hours and over 500 hours in air- and oxygen-blown modes respectively. In gasification mode with subbituminous coal more than 95% carbon conversion can be achieved with little tar formation. The PCD outlet loading is normally below the lower limit of detection of 0.1 ppmw.

The Department of Energy conceived the PSDF as the premier advanced coal power generation R&D facility in the world and work there thus far has fulfilled this expectation. DOE's vision is that: "The Wilsonville PSDF will serve as the proving ground for many new Advanced Power Systems and Vision 21 Technologies…. The Wilsonville Power Systems Development Facility gives U. S. industry the world's most cost-effective flexible test center for testing tomorrow's coal-based power-generating equipment…. Capable of operating at pilot to near-demonstration scales, the facility is large enough to give industry real-life data, yet small enough to be cost-effective and adaptable to a variety of industry needs." A key feature of the PSDF is its ability to test new systems at an integrated, semi-commercial scale. Integrated operation allows the effects of system interactions to be understood that are typically missed in unintegrated pilot-scale testing and to advance the development of the proposed technology towards commercialization. The semi-commercial scale allows the maintenance, safety, and reliability issues of a technology to be investigated at a cost that is an order of magnitude below the cost of testing at commercial scale.

The PSDF has developed testing and technology transfer relationships with over 50 vendors to ensure that test results and improvements developed at the PSDF are incorporated into future plants by the systems suppliers. Major subsystems tested and some highlights of the test program at the PSDF include:

- **Transport reactor:** An air-blown, fast circulating-bed reactor called a transport reactor was originally selected because of its flexibility in providing a variety of combustion gases and synthesis gases for testing various downstream subsystems. The transport reactor has been operated successfully as a pressurized combustor (5,000 hours) and as a gasifier (3,400 hours) in both oxygen- and air-blown modes and, as a result has exceeded its primary purpose of generating gases for downstream testing. It is now projected to be the lowest capital cost coal power generation option while also providing the lowest cost of electricity with excellent environmental performance.

- **Advanced particulate control:** Two advanced particulate removal devices and 28 different filter elements types have been tested to clean the product gases, and material property testing is routinely conducted to assess their suitability under long-term operation. Based on the material testing results, an understanding of the filter element properties required for reliable operation in a commercial power system has been developed. Filter elements have been identified that can withstand the expected level of upset conditions and the material requirements have been shared with vendors to aid their filter development programs.

- **Filter safe guard device:** To further enhance reliability and protect downstream components, a “safe guard” device was successfully developed that reliably and completely seals off the filter element upon failure, thus preventing damage to the combustion turbine. Particulate levels of <0.1 ppm have been achieved, well below gas turbine specifications.

- **Coal feed and ash removal subsystems:** The key to pressurized operation is reliable operation of the feed system to the pressurized reactor and ash removal system from the pressurized reactor and filter vessel. Modifications developed at the PSDF and shared with the equipment supplier have increased the reliability of these systems to a level that is acceptable for commercial operation in either the combustion or gasification mode.

- **Syngas cooler testing:** Syngas cooling is of considerable importance to the gasification industry. Ferrules made of several different materials were tested at the inlet of the gas cooler with varying degrees of success. One ceramic material has been shown to perform well in this application.

- **Direct Sulfur Recovery Process (DSRP)**: The DSRP, provided by RTI, was operated on a synthesis gas slipstream from the transport gasifier.

- **Electronic data collection, management, and dissemination system:** A system was installed to allow vendors to view data from their equipment at the PSDF from their home office.

- **Instrumentation:** Several instrumentation vendors have worked with the PSDF to develop and test their instruments under realistic combustion and gasification conditions. Instruments tested include: 1) Nuclear-based solids flow-measurement, 2) Several types of gas analyzers, and 3) Real-time high-temperature/high-pressure particulate monitors, 4) Solids level-measurement probes, 5) Thermographic phosphor high-temperature measurement in reducing atmospheres, and 6) Combustion turbine ignition detection and flame analysis.

- **Highly experience staff:** In addition to this physical infrastructure, a highly experienced staff has been created that has a demonstrated ability to solve complex technical problems and rapidly move new technologies to commercial applications.

Lignite Coal – Transport Reactor:

The transport reactor's successful demonstration using lignite coal with its low Btu content, high moisture, high alkali and high ash qualifies it as a possible technology for future lignite-based power plants or for re-powering existing power plants in North Dakota.

Basin Electric Power Cooperative

Basin Electric Power Cooperative is a consumer-owned, regional cooperative headquartered in Bismarck, North Dakota. We produce clean energy for a healthy economy, based on the Ecowatts® concept. Our history as an electric cooperative is rooted in the beginnings of the electrification of rural America.

Basin Electric operates electricity-generating power plants with a total capacity of 3,373 megawatts. We serve 124 rural electric member cooperative systems that in turn serve approximately 1.8 million consumers in the nine states of North Dakota, South Dakota, Montana, Wyoming, Minnesota, Nebraska, Iowa, Colorado and New Mexico.

Basin Electric has several subsidiaries, including Dakota Gasification Company, which produces natural gas from the coal gasification process and products such as chemicals and fertilizers; Dakota Coal Company, which purchases lignite for our power plants and owns a lime processing plant.

Basin Electric and its subsidiaries employ about 1,700 people.

Basin Electric's subsidiary: Dakota Gasification Company (DGC)

Basin Electric has extensive institutional knowledge of coal gasification with its ownership and operation of DGC.

The Great Plains Synfuels Plant is the only commercial-scale coal gasification plant in the United States that manufactures natural gas. The synfuels plant is owned and operated by Dakota Gasification Company (DGC), a subsidiary of Basin Electric Power Cooperative (BEPC).

The $2.1 billion plant began operating in 1984. Using the Lurgi gasification process, the synfuels plant gasifies lignite coal to produce valuable gases and liquids. The average daily production is 150 million standard cubic feet of synthetic natural gas(SNG), the majority of which is piped to Ventura, IA, for distribution in the eastern United States. The plant capacity is 170 million standard cubic feet. Many byproducts and alternate products are produced and marketed in the United States and worldwide. A portion of the plant's gas output is directed to manufacture 1100 tons per day of anhydrous ammonia.

The synfuels plant daily consumes about 18,500 tons of lignite supplied by the nearby Freedom Mine. The mine is owned and operated by the Coteau Properties Company, a subsidiary of the North American Coal Corporation.

Value To North Dakota

The successful use of lignite in a transport reactor IGCC system will benefit North Dakota lignite industry by demonstrating the technical and economic viability of lignite fuel in a high-efficient gasification power plant. Clearly, this technology could provide lignite-based options for new generation plants, as well as for re-powering existing plants.

The Department of Energy's goals of the transport reactor gasification project include the development of a high-efficient power system attaining a net electric system efficiency of 40% or more, reducing sulfur dioxide (SO_2) by 97%, emitting no more than 0.08 lbs of Nitrous Oxide (NOx) emissions per million British Thermal Unit (BTU) and achieving substantial reductions in mercury (Hg) reductions.

Demonstrating that the highly reactive lignite fuels will produce gas without deposition and agglomerating related problems during the operation of the advanced transport reactor gasifier will help market North Dakota's low cost lignite reserves as a viable fuel for the future. The high reactivity of the lignite provides a market advantage against other coals for this IGCC technology, and the impact of high moisture is minimized.

These coal gasification systems also offer the best potential competition to natural gas-based generation and the future vision of coal-based generation. IGCC systems are being developed and promoted under DOE's Vision 21 program, which should help facilitate market acceptance.

Management

Mike Paul will coordinate the project. Mr. Paul is a registered Professional Engineer in the State of North Dakota with over 25 years of electric utility experience. He is also project coordinator for the Leland Olds re-powering study. Mr. Paul has the responsibility for the technical review of projects related to the gasification technology performance and determining if the IGCC technology is applicable to a re-powering effort.

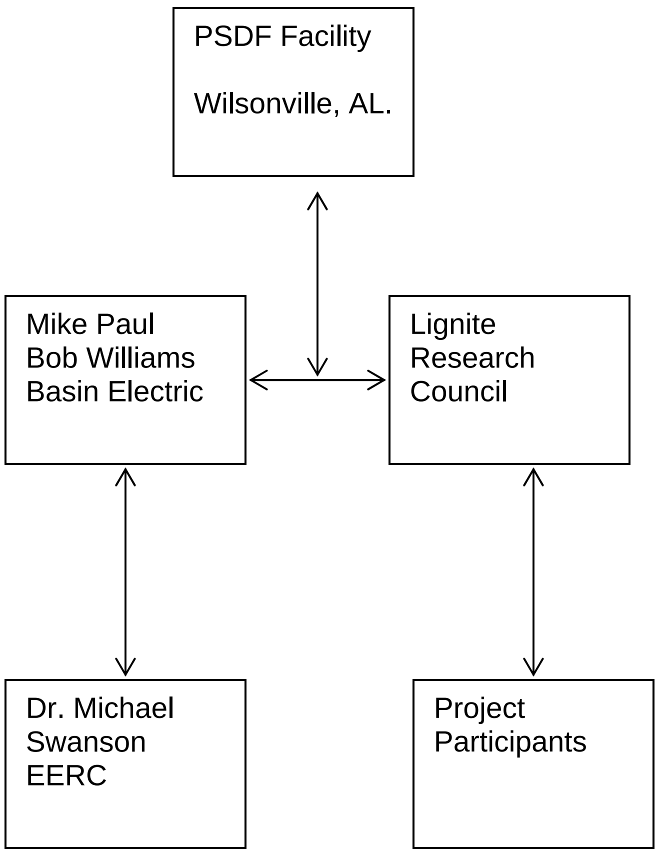
Additional, Bob Williams, will provide engineering support for the project. Mr. Williams is a registered Professional Engineer in the State of North Dakota with over 22 years of electric utility experience, eight of which he was stationed at the Laramie River Station, a 1650 MW coal-based generation plant.

Dr. Michael Swanson, Senior Research Manager, Energy and Environmental Research Center (EERC), will provide consultant expertise for the project. Dr. Swanson is currently involved with the demonstration of advanced power systems such as the integrated gasification combined cycle and pressured fluid-bed combustors, with an emphasis on hot-gas cleanup issues. He is currently project manger on a U.S. Department of Energy funded project testing a pilot-scale advanced transport reactor gasification system. Dr. Swanson's principle areas of interest and expertise include pressurized fluid-bed combustions, integrated gasification combined cycle, hot-gas cleanup, coal reactivity in low rank coal combustion supercritical solvent extraction, and liquefaction of low-rank coals.

Communication:

Communications are essential for a successful project. In an effort to accommodate project participants with planning, scheduling and facilitating discussion on the project the following communication flow will be followed.

Communications Flow:



Timetable

After the funding is in place and the lignite fuel can be selected and scheduled for delivery to the PSDF in Wilsonville, Alabama, the preliminary 250-hour test can be conducted in October 2004. This assumes that the PSDF test facilities modifications are in place.

A likely timetable scenario for 250-hour test:

Shipping coal to Wilsonville	September 2004
250 hour test	October 2004
Project participants test witness	October 2004
Evaluation of data	January 2005

Assuming success in the first short-term run, the 1000-hour run could be conducted in the second quarter of 2005 (April-June) time frame.

A likely timetable scenario for the 1000-hour test:

Shipping coal to Wilsonville	March 2005
1000 hour test	April-June, 2005
Project participants test witness	April-June 2005
Evaluation overview – Wilsonville	August 2005
Final Report	December 2005

Budget

This proposal requests a base amount of $125,000 from NDIC to allow additional testing of North Dakota lignite in the PSDF transport reactor gasifier in Wilsonville, Alabama. This extended test will further demonstrate the practicability of lignite as a fuel for the advanced high-efficient IGCC concept. If successful, lignite may be viewed as a viable fuel for use in this advanced technology for new North Dakota power plants or re-powering existing power plants. Coal gasification may be one option to help lignite remain competitive as a fuel for power generation in the deregulated wholesale power market and help industry and the state achieve the strict regulatory environment being administered by the Environmental Protection Agency (EPA).

Budget itemization:

3700 tons coal @ $10/ton	$3700.00
Shipping 500 tons for 250 hour test	$25,000.00
Shipping 3200 tons for 1000 hour test	$160,000.00
Consultant Fees	$5,000.00
Coal transfer (nearest load out to test facility)	$50,000.00
Misc. (additional coal, shipping, transfer)	$6300.00
Total	$250,000.00

Matching Funds

Based on discussions with the interested participants, this proposal assumes a match of $125,000 for the cost of the project. The matching funds commitment would be subject to the North Dakota Industrial Commission approval for this project, the Board of Directors approval of the participating organizations (as required) and successful negotiations of a PSDF test plan that meets the project participant’s needs. These organizations include Basin Electric Power Cooperative, Montana-Dakota Utilities Company, Otter Tail Power Company, Great River Energy, SaskPower, The North American Coal Corporation, Westmorland Coal Company, BNI Coal and Great Northern Power Development L.P. These organizations have expressed an interest in participating in a review board to evaluate the viability of the transport reactor for possible commercial development.

Tax Liability

I, Clifton T. Hudgins, certify that Basin Electric Power Cooperative does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

________________________ ___________

Clifton T. Hudgins
Senior Vice President
Chief Financial Official

Date

Confidential Information

All data will be placed in the public domain as part of the PSDF gasification test with lignite coal.

The final report summarizing the project and its findings will be public information.

References

1. From Power Systems Development Facilities Website at http://psdf.southernco.com
2. Department of Energy Fossil Energy Website at http://fossil.energy.gov
3. TC 13 Lignite Test Review Meeting held at PSDF facility in Wilsonville, Alabama

APPENDIX A

Resumes of key personnel

Letters of Support

MICHAEL W. PAUL, P.E.
Basin Electric Power Cooperative
1717 E. Interstate Avenue
Bismarck, N.D. 58503-0561
(701) 355-5691
mikepaul@bepc.com

Qualifications

- B.S., Mechanical Engineering, University of North Dakota
- Registered Professional Engineer, North Dakota
- Over 25 years of electrical utility experience with six years stationed at three coal-based power plants

Professional Experience

May 2001 to present

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND
Manager, Mechanical and Performance Engineering
Manage the Mechanical and Performance Section of the Generation Department, Engineering and Construction Division to provide professional engineering support for Basin Electric's existing operating facilities, members, and subsidiaries. Also conduct studies and planning for future generation resources as well as options for meeting future needs at existing facilities. Served as Project Coordinator for the Wyoming Distributed Generation Project and currently assigned as Project Coordinator for the Leland Olds Station Repowering Project Study.

March 1987 to May 2001

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND
Mechanical/Performance Engineering Supervisor
Supervised the Mechanical/Performance Section of the Operations & Engineering Department, Engineering Division to provide professional, cost-effective and timely mechanical design and performance engineering activities for each of our coal-fired plants, as well as for our members and subsidiaries. Activities focused on coal-based power plant operations, performance, and maintenance activities to help ensure safe, reliable, and efficient operation. Assigned as Project Engineer for the Wyoming Distributed Generation project and was actively involved in the future coal-based generation and Leland Olds Station future options studies.

January 1986 to March 1987

Minnkota Power Cooperative, Milton R. Young Station, Center, ND
Engineering Superintendent
Managed the overall generation engineering needs of Minnkota including supervision of professional staff and employees represented by a bargaining agreement. Established and directed the overall plant performance program, coordinated design changes and procurement of equipment and systems, monitored plant water management and chemistry programs, conducted economic and technical feasibility studies, provided technical support and recommendations on plant operations, prepared budgets, and directed plant documentation and drafting efforts. Responsibilities also included working with Minnkota headquarters departments and the other Square Butte project participant.

August 1983 to January 1986

Basin Electric Power Cooperative, Antelope Valley Station, Beulah, ND
Results Engineer
Monitored and reported performance of plant equipment and systems, ensured proper chemistry control of all plant systems, directed plant water management including environmental concerns, supervised lab technicians, assisted in design and operational modifications of plant equipment and systems, and monitored coal quality.

September 1982 to August 1983

Basin Electric Power Cooperative, Antelope Valley Station, Beulah, ND
Mechanical Engineer
Involved with initial Unit 1 start-up, including design changes, supervised boil-out and boiler chemical cleaning, prepared and supervised equipment testing for a full American Society of Mechanical Engineers turbine test, participated in water balance and vibration monitoring, and provided technical support to plant operations and maintenance. Worked closely with design, construction, and start-up groups.

October 1979 to September 1982

Basin Electric Power Cooperative, Production/Design Division, Bismarck, ND
Mechanical Design Engineer
Monitored and directed the design and purchase of mechanical equipment and systems for the Antelope Valley and Laramie River Stations.

May 1978 to October 1979

Basin Electric Power Cooperative, Wm. J. Neal Station, Velva, ND
Mechanical Engineer
Engineering and supervision of a plant upgrade to 50 MW, compliance testing of retrofit precipitators, monitored progress of a Babcock & Wilcox pilot dry scrubber, engineering and initial test burns of sunflower hulls in the main boilers, and operating plant engineering and supervision as required.

September 1977 to May 1978

Engineering Experiment Station, University of North Dakota, Grand Forks, ND
Student Engineer
Involved in the engineering of several solar energy and heat pump projects.

June 1977 to August 1977

Clark Equipment Company, Melroe Division, Gwinner, ND
Summer Engineer
Quality control for welding, fabricating, machining, and assembling various models of the Bobcat skid steer loader.

Professional Memberships, Certifications, Organizations

- American Society of Mechanical Engineers
- Registered Professional Engineer in the State of North Dakota
- North Dakota State Department of Health, Certification as a Class II Water Treatment Plant Operator
- Energy Generation Conference Executive Committee – five years

Robert T. Williams
Mechanical Engineering Supervisor
Basin Electric Power Cooperative
1717 East Interstate Ave.
Bismarck, ND 58503

High School – Grand Island, Nebraska - Graduated May 1971

Military – US Navy Nuclear Power Program – Machinist Mate – Oct. 1971 to Oct. 1977

VA Hospital Boiler Plant Operator – Nov. 1971 to July 1978

College - University of Nebraska, Lincoln – Aug. 1978 to July 1981 - BSME

Professional Experience

Basin Electric Power Cooperative – Laramie River Station – Wheatland Wyoming – Project/Design Engineer – Aug. 1981 to July 1989

> Focused on power plant and environmental systems design, retrofit and maintenance projects

Basin Electric Power Cooperative – Bismarck North Dakota - Project/Design Engineer – July 1989 to July 2001

> Focused on power plant and environmental systems design, retrofit and maintenance projects
>
> Project Engineer for Dakota Gasification plant ammonia based sulfur dioxide removal system for the boiler exhaust gases.
>
> Project Engineer for Wyoming Distributed Generation Project. Installed nine simple cycle gas fired combustion turbines with remote operating capabilities.

Basin Electric Power Cooperative – Bismarck North Dakota – Mechanical Engineering Supervisor – July 2001 to Present

> Supervision of Project/Design Engineers working on power plant, coal systems, water treatment systems and environmental systems design, retrofit and maintenance along with new power systems projects.

DR. MICHAEL L. SWANSON
Senior Research Manager
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone (701) 777-5000 Fax (701) 777-5181
E-Mail: mswanson@undeerc.org

Principal Areas of Expertise
Dr. Swanson's principal areas of interest and expertise include integrated gasification combined cycle (IGCC), pressurized fluidized-bed combustion (PFBC), hot-gas cleanup, coal reactivity in low-rank coal (LRC) combustion, supercritical solvent extraction, and liquefaction of LRCs.

Qualifications
Ph.D., Energy Engineering, University of North Dakota, 2000. Dissertation: Modeling of Ash Properties in Advanced Coal-Based Power Systems.
M.B.A., University of North Dakota, 1991.
M.S., Chemical Engineering, University of North Dakota, 1982.
B.S., Chemical Engineering, University of North Dakota, 1981.

Professional Experience
1999 – Senior Research Manager, EERC, UND. Dr. Swanson is currently involved with the demonstration of advanced power systems such as PFBC and IGCC, with an emphasis on hot-gas cleanup issues.

1997 – 1999 Research Manager, EERC, UND.

1990 – 1997 Research Engineer, EERC, UND.

1986 – 1990 Dr. Swanson supervised a contract with the U.S. Department of Energy (DOE) to investigate the utilization of coal–water fuels in gas turbines. He has designed, constructed, and operated research projects that evaluated the higher reactivity of LRCs in short-residence-time gas turbines and diesel engines.

1983 – 1986 Dr. Swanson's responsibilities included the design, construction, and operation of supercritical fluid extraction (SFE) and coal liquefaction apparatus; characterization of the resulting organic liquids and carbonaceous chars; and preparation of reports.

1982 – 1983 Associated Western Universities (AWU) Postgraduate Fellowship, DOE Grand Forks Energy Technology Center. Dr. Swanson's responsibilities included the design and construction of a SFE apparatus.

1981 – 1982 Graduate Teaching Assistant, Department of Chemical Engineering, UND.

Summer 1982 Research Assistant, Department of Civil Engineering, UND.

1980 – 1981 AWU Student Participant, DOE Grand Forks Energy Technology Center.

Professional Memberships

- American Institute of Chemical Engineers
- American Chemical Society, Fuel Chemistry Division

Publications and Presentations

- Has authored or coauthored over 80 publications