OFFICE OF FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY • DOE/FE-0215P-40 ISSUE NO. 40, SUMMER 2000

CLEAN COAL TODAY

A NEWSLETTER ABOUT INNOVATIVE TECHNOLOGIES FOR COAL UTILIZATION

PROJECT NEWS BYTES

SGI International (SGII), owner of the **ENCOAL Clean Coal Technology Demonstration Project** located near Gillette, Wyoming, and developer of the project's Liquid-From-Coal (LFC®) technology, has signed an agreement to sell its entire output of cresylic acid feedstock to Merisol, a division of Merichem-Sasol USA, LLC. Cresylic acid is used in a wide range of applications, including cleaners and disinfectants, magnet wire enamel solvent, and vitamin E intermediates. SGII now has two of the five products from the ENCOAL project under long-term agreements, and is completing contract negotiations for the other three. The ENCOAL project has demonstrated viability of upgrading low-rank coals by significantly reducing their moisture content and improving their heating

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LPMEOH™ DEMONSTRATION PROJECT CONDUCTS PRODUCT-USE STUDY

With the recent successes of the Liquid Phase Methanol (LPMEOH™) process, the market for clean-burning, storable liquid fuel from coal is more promising than ever. The LPMEOH™ Process Demonstration Plant, located at Eastman Chemical Company's chemicals-from-coal complex in Kingsport, Tennessee, began its fourth year of operation on April 2, 2000, and has produced in excess of 58 million gallons of methanol from coal-derived synthesis gas or "syngas." Since demonstration operations began in April of 1997, overall availability of the plant has exceeded 96 percent, while in calendar years 1998 and 1999, availabilities in excess of 99.7 percent were achieved at a production rate of 260 tons per day of methanol. The LPMEOH™ process uses a slurry bubble column reactor to convert syngas (derived from gasification of high-sulfur bituminous coal) directly to methanol. Largely as a result of this success, the project was recently extended an additional 15 months (from December 28, 2001, until March 31, 2003) to allow for the opportunity to perform new tests that are considered to be of significant commercial interest.

A GTC-85-72 gas turbine airplane engine was used in the LPMEOH™ study, and demonstrated environmental benefits of the stabilized methanol.

The LPMEOH™ technology was developed by Air Products and Chemicals, Inc. during the 1980s with the financial support of the U.S. Department of Energy (DOE). The concept was proven in over 7,400 hours of test operation in the DOE-owned, 10 tons-per-day Process Development Unit located at LaPorte, Texas. Air Products and Eastman formed the Air Products Liquid Phase Conversion Co., L.P. partnership to execute this project under the DOE Clean Coal Technology (CCT) Program. As part of the CCT project, a product-use test program has been developed to enhance the early commercial acceptance of this type of clean coal technology processing facility. The objective of this testing program is to demonstrate commercial market application for the "as produced" (stabilized) methanol as a replacement fuel and as a fuel supplement.

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...LPMEOH™ continued

In the LPMEOH™ process, methanol derived from syngas yields a high quality product (generally greater than 97 percent purity and only 1 percent water by weight). In contrast, gas-phase methanol synthesis, which must rely on hydrogen-rich syngas, yields a crude methanol product with 4–20 percent water by weight. As a result, the LPMEOH™-produced methanol would be suitable for many applications with substantial purification cost savings.

Economically, the methanol from the LPMEOH™ process, when coproduced with electric power in an integrated gasification combined-cycle (IGCC) plant, is four to eleven cents per gallon lower than gas-phase produced methanol. Through coproduction in the IGCC plant, the syngas manufacturing equipment is already in place. Further, methanol storage and transport costs are minimized because methanol is usually marketable locally. Competing methanol is typically shipped from the U.S. Gulf Coast, which can add significant freight costs.

PRODUCT-USE TEST PROGRAM

Stabilized methanol from the LPMEOH™ project has been made available for seven tests (see the table below). These tests will determine its feasibility as a feedstock in transportation and power generation applications. If successful, methanol as a product can enhance the flexibility of, and revenue from, IGCC plants. Fuel economics have been evaluated for the use of stabilized methanol as a fuel supplement for gasoline, diesel, and natural gas, and in municipal, industrial, and utility applications.

Transportation Systems

A total of five vehicle types have been tested on fuel blends made from stabilized methanol produced at the LPMEOH™ Demonstration Project. These tests, which have been performed at three different locations, were designed to determine if there are any differences in fuel economy, maintenance, or exhaust emissions when compared to performance with fuels made with chemical-grade methanol. In bus and fuel-flexible vehicle (FFV) trials, stabilized methanol has been shown to provide the same environmental benefits as chemical-grade methanol with no associated penalty on performance or fuel economy.

FFVs tested at the Florida Institute of Technology experienced average fuel economies ranging from 10.88 miles per gallon (mpg) to 14.68 mpg for M-85 fuel blends (85 volume percent methanol/15 volume percent gasoline). The vehicles operated well on the fuel blends and experienced only routine repairs that were not related to fuel type.

The ARCADIS Geraghty & Miller FFV averaged approximately 16 mpg on M-85 for both stabilized methanol and chemical-grade methanol.

Product-Use Test Program

	Program Participant	Application	Testing
Transportation Systems	**Florida Institute of Technology**	1988 Chevrolet Corsica FFV 1993 Ford Taurus FFV Jacksonville Transit Authority bus	Fuel economy, maintenance, exhaust emissions as compared to chemical-grade methanol
	ARCADIS Geraghty & Miller	1996 Ford Taurus FFV	Fuel economy and hydrocarbon, non-methane hydrocarbons, methane and formaldehyde emissions as compared to chemical-grade methanol
	West Virginia University	Transportable laboratory facility which tested three Transit Motor Corporation buses in New York	Hydrocarbon and particulate matter emissions as compared to diesel fuel and chemical-grade methanol
Power Generation Systems	**West Virginia University**	GTC-85-72 gas turbine	Turbine emissions (CO, CO_2, NO_x, O_2) and performance
	ARCADIS Geraghty & Miller	Water-emulsion fuel for use in aircraft ground support equipment	Generator emissions (NO_x, CO) and performance
	ARCADIS Geraghty & Miller	Distributed power generation	Generator emissions (in particular NO_x)
	University of Florida	Hydrogen source for phosphoric acid fuel cells	Comparisons of reformation products, extent of conversion, and catalyst life between chemical-grade methanol and stabilized methanol

The vehicle exhibited higher emissions for total hydrocarbons, carbon monoxide (CO), carbon dioxide (CO_2), and methane for the stabilized fuel blend. Emissions of non-methane hydrocarbons and nitrogen oxides (NO_x) were higher for the M-85 fuel blended with chemical-grade methanol. For each of these parameters, emissions for both fuels were within the standards established by the state of California.

The West Virginia University transportable laboratory facility, which specializes in the measurement of emissions from heavy-duty vehicles, determined that emissions of hydrocarbons and particulate matter increased slightly when stabilized methanol is used to replace chemical-grade methanol as a bus engine fuel. However, stabilized methanol offers substantial advantages in lower emissions of NO_x (nearly 83 percent lower) when compared to diesel fuel.

Power Generation Systems

Four projects were selected to study the use of stabilized methanol in both central power (as a supplement in peak power demand periods) and distributed power generation systems.

Initial tests in a gas turbine and a diesel generator have shown that levels of nitrogen oxides in the exhaust air can be lowered when stabilized methanol or methanol emulsions are used instead of conventional oil fuels. At one of the test sites, a low-NO_x stationary gas turbine, was operated with stabilized methanol. NO_x emissions as low as 1 ppmv, corrected to 15 percent oxygen (O_2), were achieved at acceptable combustor CO emission levels. As with the chemical-grade methanol, lubrication additives will likely be required when stabilized methanol is fed to a gas turbine. During testing at the West Virginia University, potential lubrication additives were assessed, and NO_x emissions were reduced by 75 percent when compared to liquid hydrocarbon fuel.

Initial testing of stabilized methanol as the source of hydrogen to a phosphoric acid fuel cell is also underway. A reformer test apparatus has been constructed for this purpose. Operating conditions for the reformer are presently being evaluated for different catalysts.

Moving Forward

Successful demonstration of the LPMEOH™ technology, and the application of stabilized methanol to these transportation and power systems, will add significant flexibility and dispatch benefits to IGCC electric power plants. The facilities traditionally have been viewed as strictly baseload power generation technology. Now, central clean coal technology processing plants, making coproducts of electricity and methanol, can simultaneousy meet the needs of local communities for dispersed power and transportation fuel.

The LPMEOH™ Process provides competitive methanol economics at small methanol plant sizes, and a freight and cost advantage in local markets. Methanol coproduction studies show that methanol can be produced at economically competitive levels from an abundant, non-inflationary local fuel source, such as coal. The coproduced methanol may be: an economical hydrogen source for small fuel cells; used as a transportation fuel; and an environmentally advantaged fuel for dispersed electric power.

Power Plant Hall of Fame

Power magazine launched the Power Plant Hall of Fame in Cincinnati, Ohio on April 5, 2000. Selection into the Hall of Fame is based on "demonstrated leadership in the application of new technologies and business practices resulting in optimized competitive performance, energy efficiency, and environmental protection." Inductees must be previous winners of *Power* magazine's "Power Plant of the Year Award." Six Clean Coal Technology (CCT) projects were inducted to date. This special recognition once again highlights the DOE CCT Program, and demonstrates the overall effectiveness of the program in bringing new and environmentally acceptable coal technologies to commercialization. Sponsored by Myplant.com, of Phoenix, Arizona, the Hall of Fame is an online publication that profiles over 150 plants recognized by *Power* magazine. Descriptions of each inductee can be found at http://www.myplant.com/default_Power.asp, then scroll and click on "Hall of Fame."

On hand for the first induction ceremony and to accept awards on behalf of their plants were Paul King, Wabash River Generating Station, PSI Energy Inc., and Craig Cameron, Polk Power Station, Tampa Electric Co. The other CCT project inductees are: Pure Air on the Lake, Tidd PFBC, LIMB, and CT-121 FGD.

ALBANY RESEARCH CENTER SUPPORTS FE MISSION

The Albany Research Center (ARC), located in Albany, Oregon, was established on June 2, 1942, as part of the U.S. Bureau of Mines. Its purpose was twofold: to find methods for using the abundant low-grade resources in the Pacific Northwest, and to develop new metallurgical processes using electrical energy from the newly commissioned Bonneville Dam in the Pacific Northwest. During the early years, one of the ARC landmark achievements was the research and development leading to a commercial process for producing zirconium. As part of the U.S. Bureau of Mines, the ARC continued to be involved in a variety of metals and minerals related research areas, including atmospheric corrosion, wear, vitrification of wastes, sulfur concrete, liquid emulsion membranes for waste water cleanup, thermodynamics, cold-wall induction melting, and titanium casting. Albany Research Center scientists have been granted several hundred patents, and have contributed extensively in the fields of metals and minerals research over the years. In 1985, the Center was named an historical landmark by the American Society for Metals.

In 1995, Congress closed the parent U.S. Bureau of Mines, but as part of that process, the ARC was transferred into the U.S. Department of Energy's Office of Fossil Energy (FE). Albany fits into the FE mission thanks to the center's unique materials-related competencies, which were developed during 54 years of service to the nation, and are relevant to several aspects of technology, namely:

- Materials development and characterization;
- Melting, casting, and joining of metals;
- Materials performance in severe applications;
- Minerals beneficiation and characterization; and
- Hazardous waste cleanup/beneficiation.

Research at ARC provides vital data to FE on the performance characteristics of materials for current and future power systems. Next generation systems, such as the Vision 21 powerplex, require cost-effective, high-temperature, and pressure-resistant materials. Vision 21 facilities are being designed to use various fuels (coal, biomass, petroleum coke, and other wastes) to produce electricity, steam, clean fuels, or chemicals with near-zero polluting emissions and extremely high efficiencies.

ARC research programs emphasize industrial partnering through cooperative research and development agreements (CRADAs). In addition, research teams are formed with National Energy Technology Laboratory (NETL) and other national laboratories. The synergy of ARC and its various partners is meeting ARC objectives through research programs in several areas.

Advanced Casting Technologies are being developed for energy applications. These include TiC-reinforced *cast* austenitic stainless steels, as well as thin-wall cast ductile iron and thin-wall steel castings for the transportation industries. TiC-reinforced castings will allow for significantly different carbide content (for creep resistance) and aluminum and silicon contents (for oxidation and corrosion resistance) than conventionally wrought stainless steels.

Thin-wall castings of both steel and ductile iron for the transportation industry offer an opportunity to improve the fuel economy of future vehicles at little or no cost penalty (a weight reduction of 125 lbs. can be equated to a 0.5 mpg improvement in fuel economy). ARC is developing evaporative pattern casting (EPC) technology and techniques to predict general mechanical behavior and specific monotonic and dynamic mechanical properties of thin-wall castings for the transportation industry.

Advanced Coating Techniques are intended to produce unique oxidation and sulfidation resistant coatings based on layered inter-metallics. These coatings would have the same properties as bulk iron-aluminide materials, without associated joining/fabrication problems. The coatings would utilize conventional deformation processing techniques (such as extrusion or rolling) to bond the foils to the substrate. The advanced coating effort effectively combines ARC's processing and materials development capabilities.

Service Life Prediction activities are solving critical wear, erosion, and corrosion problems found in the operation of current and future fossil energy systems. Materials and procedures can be developed to reduce effects of wear, erosion, and corrosion through an understanding of how these phenomena impact performance in severe service environments.

Materials and techniques in **Advanced Refractory Technology** will extend the lifetime of refractory liners (primary or repair) for slagging coal gasifiers, biomass gasifiers, and other critical systems by shortening system downtime caused by refractory maintenance, and by developing improved thermocouples that will withstand the molten slag attack of coal ashes.

Research in **Advanced Titanium Processing** is designed to reduce the overall cost of titanium and titanium alloys for certain oil and gas production materials. The ARC-developed process for continuous casting of titanium using a cold-wall induction furnace represents a breakthrough that can substantially reduce fabrication costs of titanium in non-aerospace applications.

Emission and Waste Reduction activities are targeted at reducing environmental impacts from the production of electrical power in coal fired/coal gasification plants. This includes solids disposal/waste stream vitrification research, waste water handling, and CO_2 sequestration by direct mineral carbonation, whereby CO_2 is converted to solid form and cannot escape into the atmosphere.

RECENT MILESTONES

Microtechnology-Based Energy and Chemical Systems (MECS) — The ARC, University of Oregon, and Zess Technologies, Inc. are developing unique technologies to produce miniaturized heat exchangers, recuperators, microchannel reactor-based fuel processors, filters, and chemical reactors for gas separation and chemical processing. MECS take advantage of the extraordinary rates of heat and mass transfer associated with micro-structures and utilize ARC's foil lamination technologies.

CO_2 Minerals Sequestration Research Program — A team consisting of ARC, NETL, Los Alamos National Laboratory, and Arizona State University is investigating the mineral carbonation of CO_2. Recent breakthroughs at ARC have shown the conversion rate for capture of CO_2 as a carbonate is 75 percent in 30 minutes at 185 atmospheres. Modifying the reaction to develop a fast rate of reaction is one of the keys to an industrial process.

ALBANY RESEARCH CENTER FACILITIES

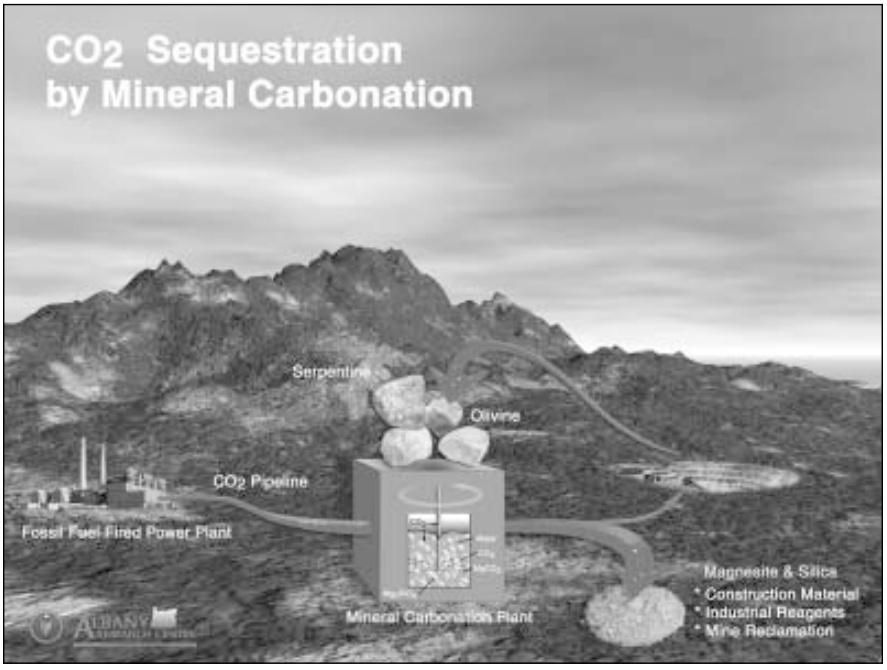
The *Fabrication Facility* offers a wide variety of services from heat treating to thermo-mechanical processing, including rolling, forging, swaging, and wire drawing.

The *Materials Evaluation Facility* includes: universal test machines with capacities to 220,000 lbs and temperatures to 1,000 °C; stress-rupture and creep rupture under air, purge gas, or vacuum; instrumented impact testers; various micro-hardness test instruments; and a state-of-the-art metallography laboratory.

ARC's *Melting and Casting Facility* is a one-of-a-kind unit that has capabilities to melt and cast materials including: electric arc melting furnaces suitable for either smelting or melting; two ARC-patented induction slag ingot and casting furnaces for use with reactive metals; vacuum arc/electroslag remelting consumable-electrode furnaces; and induction furnaces capable of vacuum casting and vacuum melting. This equipment can be used to produce ferrous and nonferrous castings ranging from grams to 300 lbs.

The *High Temperature, High Pressure Corrosion/Erosion Test Facility* will have the capability to duplicate the severe corrosive and erosive atmospheres of the Vision 21 powerplex facilities in both static and dynamic modes.

A fully-equipped *Corrosion Test Laboratory* has: numerous computer-controlled testing systems and a range of specialized corrosion cells; autoclaves and high-pressure chambers for elevated-temperature electrochemical and corrosion studies; a variety of wear-corrosion test systems with electrochemical control; and an environmentally-induced cracking system to evaluate stress corrosion cracking, hydrogen embrittlement, and corrosion fatigue.



Schematic of DOE's process to reduce the greenhouse gas effect on the atmosphere by capturing CO_2 using a mineral carbonation reaction.

SUCCESSFUL DEMONSTRATION OF SNCR AT AEP'S 600-MWe CARDINAL PLANT

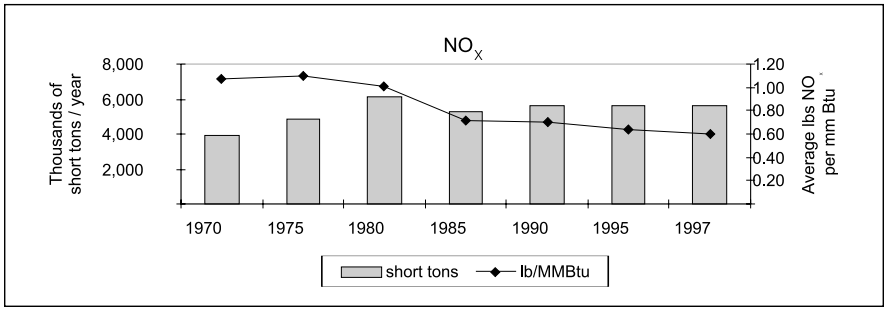
The U. S. Department of Energy (DOE) has established a set of national priorities through its Strategic Plan that includes the goal to promote secure, competitive, and environmentally responsible energy systems that serve the needs of the public. The Innovations for Existing Plants (formerly the Advanced Research and Environmental Technologies) Program, managed by the DOE Office of Fossil Energy (FE), develops advanced environmental control technology for both existing and new coal-fired power plants. The program involves research and development (R&D) on technologies to capture mercury, air toxics, acid gases (e.g., H_2SO_4), nitrogen oxides (NO_x), and carbon dioxide. In addition, research is being carried out to expand the use of coal by-products. The program also provides high quality scientific information on present and emerging environmental issues for use in regulatory and policy decision-making.

An important component of the program is the research and development on advanced nitrogen oxides (NO_x) control technologies. This effort is focused primarily on systems capable of controlling NO_x emissions to a level of 0.15 lb/million Btu at a cost significantly lower than state-of-the-art technology. The research is driven by continuing pressure for further reductions in NO_x emissions from coal-fired utility boilers to address ground-level ozone and related environmental issues such as ambient fine particulates, visibility, eutrophication, and climate change. FE is currently managing a portfolio of NO_x control technology R&D projects ranging from modeling to full-scale demonstration. These efforts include the recently completed installation and operation of a selective non-catalytic reduction (SNCR) system at American Electric Power's 600-MWe Cardinal Plant in Brilliant, Ohio.

PARTNERING WITH INDUSTRY

The success of the FE NO_x technology research is intimately tied to close coordination and cooperation with industry and other key stakeholders, and builds on success achieved through the DOE Clean Coal Technology Program in this area. The research program has a strong history of assisting industry in the development of useful commercial products, such as low-NO_x burners (LNBs). As shown in the table below, NO_x emissions on a ton-per-year basis have increased since 1970 due to an increase in coal-based power generation. However, on a pound-per-million-Btu basis, NO_x levels have been nearly cut in half. Much of this reduction can be attributed to the application of LNB technology to coal-fired utility boilers.

Net NO_x Reductions from LNB Application



The benefits of government-industry collaboration have been more recently demonstrated through a project involving the full-scale testing and evaluation of SNCR technology. This $6.5-million effort was completed in April 2000 in partnership with American Electric Power (AEP), the Ohio Coal Development Office, and the Electric Power Research Institute. A consortium of electric utilities including GPU, GENCO, Allegheny Energy, Illinova, Ameren, Louisville Gas and Electric Company, Baltimore Gas and Electric, New England Electric System, Buckeye Power, Southern Company Services, Cinergy, Tennessee Valley Authority, East Kentucky Power Cooperative, WEPCO, and FirstEnergy, also participated in the program. FE provided $500,000, some 8 percent of total project costs.

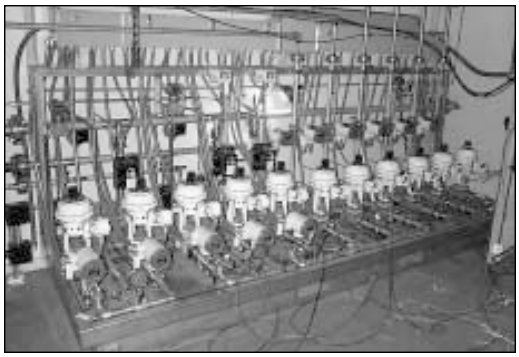
NO_x regulations have been important drivers in the Cardinal project. Industry anticipates that any new NO_x rule will allow for system-wide averaging of emissions, so AEP was interested in evaluating the maximum NO_x reduction that could be achieved by coupling SNCR with combustion controls such as LNBs. Title I of the Clean Air Act Amendments of 1990 addresses six priority pollutants, including ozone (a NO_x precursor). In September 1998, EPA announced a final rule for reducing regional transport of ground-level ozone. The final rule requires 22 states and the District of Columbia to submit State Implementation Plans (SIP) to address ozone transport through reductions in NO_x emissions. Under the NO_x SIP Call, states will have the flexibility to choose which sources to regulate. However, it is most likely that fossil-fuel-fired electric utilities will be targeted. In fact, EPA established state NO_x allowances based on a NO_x emissions rate for electric power plants of 0.15 lb/

million Btu during the five-month "summer" ozone season (May through September). Although delayed by court action, the SIP Call is proceeding. EPA estimates that its implementation will reduce annual NO_x emissions by 1.2 million tons.

SNCR involves injection of a solution of ammonia (NH_3) or urea into the furnace in a temperature window between 1,800 °F and 2,200 °F to react with and remove NO_x. Conceptually, SNCR is a simple process. The nitrogen-based reagent reacts selectively in the presence of oxygen to reduce the NO_x to molecular nitrogen (N_2) and water (H_2O).

The test program was carried out at the AEP Cardinal Plant Unit 1, a 600-MWe opposed-wall, cell-fired, dry-bottom, pulverized coal-fired boiler located in Jefferson County, Ohio. Equipped with LNBs, Unit 1 was in compliance with the Title IV emission limit of 0.68 lb/million Btu. The specific objective of the SNCR project was to reduce NO_x by an additional 30 percent, while maintaining ammonia concentrations in the flue gas, known as "slip," at or below 5 ppm. This level of control, when combined with the reduction from the LNBs, would achieve an overall reduction from the plant's baseline NO_x level of about 67 percent. Thus, the project would demonstrate that integration of LNBs and SNCR could provide a cost-effective level of NO_x control beyond that mandated by Title IV, allowing for the generation of NO_x credits.

The project was significant because it addressed two critical SNCR technical issues — unit size and coal-sulfur content. The Cardinal Plant demonstration represents the largest-scale application of SNCR technology to a coal-fired boiler in the United States. The previous largest



Metering pumps for the Cardinal Plant SNCR system's urea injection

American Electric Power's 600-MWe Cardinal Plant in Brilliant, Ohio.

SNCR installation was on a 321-MWe unit. Also, Unit 1 burns an eastern bituminous coal with a sulfur content of about 3.7 percent. An important SNCR operating issue is the potential formation of ammonium sulfate and bisulfate due to the reaction of sulfur trioxide with ammonia that has "slipped" through the SNCR system. Ammonium bisulfate can condense in the heat transfer sections of regenerative air heaters. In addition, ammonia can adsorb on flyash, and ammonium salts can create a potential plume opacity problem. The amount of ammonium sulfate and bisulfate formed is a function of the sulfur content in the combustion gases.

Fuel Tech provided and installed SNCR equipment at the Cardinal plant. Provision was made for urea (ammonia) injection at three zones in the furnace. Optimization of the SNCR unit was carried out between March 16, and April 27, 1999. The testing was performed at loads of 600, 450, and 350 MWe. The tests included a wide variety of configurations, differing the zones in service, injectors in service at each zone, chemical biases, amounts of urea injected, and other injection parameters.

NO_x reduction and NH_3 slip data for the test runs at 600 MWe show that NH_3 slip below the 5 ppm target can be achieved at NO_x reductions of 20–25 percent on a consistent basis. Several tests were also performed where NO_x reductions between 25 and 35 percent were achieved with an NH_3 slip at or below 5 ppm. At intermediate load (450 MWe) and mid-load (350 MWe), the corresponding NO_x reduction versus NH_3 slip data show that multiple-level injection provided the best combination of high NO_x reduction and low ammonia slip. Data at these loads show that NO_x reductions between 30 and 35 percent can be achieved with NH_3 slip levels less than 5 ppm.

Based on the results of the optimization program, long-term testing of the SNCR system at the Cardinal Plant was carried out between September 20, and November 19, 1999. During this time, the unit was held at various load points to verify that SNCR could successfully perform at full, intermediate, and minimum loads. The system provided approximately 30 percent reduction in NO_x across the load range while minimizing slip.

The most significant balance-of-plant equipment and operating concerns, air heater pluggage, flyash contamination, and excessive opacity levels, did not materialize during the long-term test program. A longer test period would be needed to fully evaluate the effect of SNCR operations on these factors.

UPCOMING EVENTS

August 21-23, 2000
Energy 2000
Sponsors: FEMP, DOE/NETL, Florida Solar Energy Center, and others
Location: Pittsburgh, PA
Contact: JoAnn Stirling
Phone: (321) 638-1014

September 19-21, 2000
Air Quality II: Mercury, Trace Element, and Particulate Matter
Sponsors: DOE and Energy & Environmental Research
Location: Tysons Corner, VA
Contact: Anne Fiala
Phone: (701) 777-3119
*E-mail:*afiala@eerc.und.nodak.edu

September 30 - October 5, 2000
11th International Conference on Coal Science
Sponsors: DOE/NETL, IEA, and IEA Member Countries
Location: San Francisco, CA
Contact: Karen Lockhart
Phone: (412) 386-4763
E-mail: lockhart@netl.doe.gov

November 13-14, 2000
Coal Tech 2000: Low-Rank Coal Utilization Conference & Exhibition
Sponsors: DOE/NETL, NEDO (Japan), Energy Technology Laboratory
Location: Jakarta, Indonesia
Contact: Kim Yavorsky
Phone: (412) 386-6044
E-mail: yavorsky@fetc.doe.gov

FE'S MERCURY PROGRAM

QUALITY MEASUREMENTS AND COST-EFFECTIVE CONTROLS

The U.S. Environmental Protection Agency (EPA) 1998 Mercury Report to Congress found a "plausible link" between anthropogenic sources emitting mercury and bioaccumulation of mercury in fish. EPA estimates that coal-fired plants contributed 50 of the 158 total annual tons of mercury emissions reported from all sources in the United States during 1994–1995. Most gas streams from coal-fired electricity generators contain only minute amounts of mercury (a few parts per billion), but the volume of gas emitted is quite large. A court order requires EPA to make a determination by December 15, 2000, about regulating mercury from power plants. Impending regulations and the absence of effective mercury control technologies have been key motivators of the DOE Office of Fossil Energy (FE) program to develop compliance options.

FE has collaborated with the Electric Power Research Institute (EPRI), EPA, and other government agencies to quantify emissions and understand the processes impacting emissions of mercury and other hazardous air pollutants (HAPs), also known as air toxics, in various power plant configurations. Building on this 10-year collaboration, the FE program is providing sound scientific data for a regulatory determination by EPA, and is accelerating development of mercury removal technologies. Currently, there are no such practical, cost-effective removal technologies. The FE mercury program research is being conducted under FE's Innovations for Existing Plants Program, and is the largest funded program in the country for developing an understanding of mercury emissions and control technologies.

MEASUREMENT AND CHARACTERIZATION OF MERCURY EMISSIONS

Measurement of mercury is an enormous challenge because of the extremely low concentrations of mercury in the coal flue gas. Development of a widely applicable characterization model useful to utility planners first requires a sound understanding of the fundamental principles controlling the formation and partitioning of toxic species during coal combustion. Likewise, it is critical that accurate real-time instruments be developed so that reliable mercury concentration and speciation levels can be measured quickly, allowing immediate process changes resulting in a successful removal strategy. To this end, FE is studying the chemical reactions of the various forms of mercury with other flue gas constituents; determining the influence of both combustion conditions and coal type on the various forms of mercury found in the flue gas; and using information from these studies to develop reliable real-time instruments capable of determining concentrations of the various mercury species.

NEAR-TERM, LEAST-COST CONTROL TECHNOLOGY

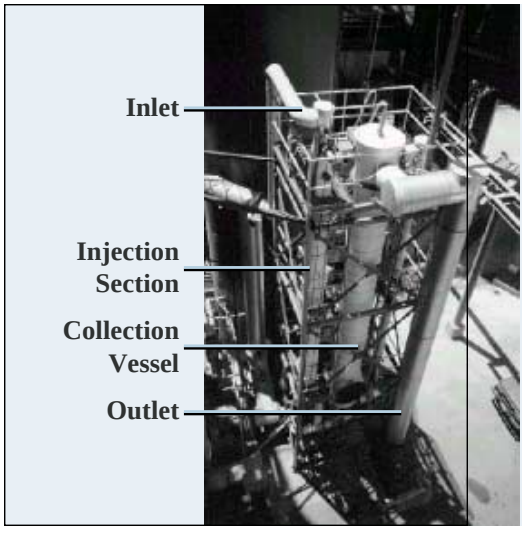
The low mercury concentrations in flue gas represent a challenge in developing cost-effective controls, similar to the challenge of measuring and characterizing small quantities of mercury. The major R&D elements are: (1) optimizing the air toxics removal performance of conventional flue gas cleanup systems (e.g., utilizing additives to enhance mercury capture across particulate matter control devices and/or converting elemental mercury to the

water soluble oxidized form inside scrubbers); (2) developing mercury removal adsorbents for injection, such as activated carbon, fly-ash carbon, and noble metals; and (3) evaluating novel concepts for potential long-term development.

In 1995, DOE initiated an Advanced Emissions Control Technology Program ("Mega PRDA Program"), which will be ending this year. These research projects encompass years of bench- and pilot-scale testing and evaluation of several approaches for controlling the emission of mercury from coal-fired utility boilers.

Under the Mega PRDA program, DOE, Public Service Company of Colorado, and EPRI are funding work at pilot- and full-scale to evaluate carbon injection as a mercury control technology. ADA Technologies, Inc. performs the fabrication, pilot operation, and reporting. One such project is illustrated in the figure below, which shows a 600-acfm (actual cubic feet per minute) slipstream test rig located at Public Service of Colorado's 350-MWe Comanche facility. Flue gas is drawn from either the inlet (high particulate loading) or the outlet (essentially particle free) of the station's reverse-gas baghouse. In addition, the rig can be configured for an electrostatic precipitator (ESP), a pulse-jet fabric filter, or EPRI's TOXICON pulse-jet fabric filter. Research shows that mercury retention on native fly ash is a major effect, and that flue gas temperature greatly influences the rate of capture, with lower temperatures being more conducive to retention.

FE's 600-acfm Slipstream Test



Although costs remain high, R&D to date has provided a 50 percent reduction (from $6.5 billion per year to $2.5 billion per year) in the estimates made three years ago of the cost of a 90-percent mercury reduction from all U.S. coal-fired boilers. While the program is generating impressive scientific information, the high cost of removal is driving the need for further studies.

Beginning in late FY 2000, the FE mercury program will continue research with a solicitation aimed at acquiring field test data for promising mercury control technologies, and pilot-scale testing of novel mercury removal concepts. Specific objectives include: measuring mercury removals of promising control technologies at large scales and documenting control costs; identifying possible negative and positive impacts of retrofitting with mercury control technologies; and assessing the applicability of the control technology to a significant portion of the utility boiler population. Ultimately, the goal is to demonstrate mercury control options at a scale large enough to allow utilities to adequately assess operational, environmental, and economic performance.

BEST AVAILABLE MERCURY CONTROL TECHNOLOGY

Policy makers have recognized that a number of issues still remain, and that regulations must be based on sound science. If regulations controlling mercury from coal-fired power plants are necessary, the regulatory process will have a fixed timetable with a proposed regulation due no later than December 15, 2003, and utility industry compliance by December 2007. The FE Mercury Program is working with EPA and EPRI to provide reliable and current data for mercury emissions from coal-fired utilities and removal capabilities of various control technologies.

DOE has supported the regulatory development process in a number of important ways. FE disseminated mercury emission data for 16 coal-fired boilers that formed the basis of the EPA's 1997 Mercury Report to Congress. In December 1998, under the guidelines of Section 114 of the 1990 Clean Air Act Amendments, EPA issued an "Information Collection Request" (ICR) for more sampling and measurement of mercury in coal and in flue gas, and asked FE to add mercury testing to its existing projects and to help develop its Quality Assurance and Quality Control Plan. As part of this effort, FE analyzed ICR data to determine removal trends, and integrated ICR data with pilot scale test results into a cost performance model to verify earlier cost estimates. The ICR effort is to be completed in June 2000, and results will be available this fall.

DOE will continue to collaborate with EPA throughout the regulatory process and provide updated information as the understanding of mercury emission chemistry improves and cost and performance data becomes available from DOE's latest solicitation.

REGULATORY UPDATE

Operators of coal-fired electricity generators are monitoring a number of evolving environmental regulations. In addition to mercury (as explained on pages 8-9), the U.S. Environmental Protection Agency (EPA) continues to regulate NO_x, soot and smog, haze, coal combustion wastes, and cooling water intake structures. The following is a brief regulatory status summary.

NO_x—In response to recommendations issued in June 1997 by the Ozone Transport Assessment Group (OTAG) Policy Group, EPA issued a State Implementation Plan (SIP) Call to 22 states and the District of Columbia. The SIP Call (effective December 28, 1998, as EPA's Ozone Transport Rule) required these 23 jurisdictions to submit emission reduction plans by December 30, 1999, on how to cut NO_x emissions 85 percent below 1990 rates or to achieve a 0.15 lb/10^6 Btu emission rate by May 2003. Although delayed by a legal challenge, action on the SIP Call is proceeding. EPA also acted on Section 126 petitions from four northeastern states (Connecticut, Massachusetts, New York, and Pennsylvania) calling upon EPA to impose NO_x controls on power plants and large industrial combustion sources in 12 upwind states.

On the national level, EPA tightened New Source Performance Standards (NSPS) for NO_x emissions from electric utility and industrial steam plants built after July 9, 1997, requiring an emission limit of 1.6 lb/MWh regardless of fuel type. This action places coal at a disadvantage because of the high nitrogen content of the fuel relative to natural gas. The revised NSPS included provisions limiting NO_x emissions to 0.15 lb/10^6 Btu for existing plants modified after July 9, 1997. However, the Court of Appeals vacated the provisions applying to modified plants.

Soot and Smog—In July 1997, EPA issued final rules revising National Ambient Air Quality Standards (NAAQS) for particulate matter (PM) and ozone (referred to as soot and smog regulations). The standard for inhalable particles (PM_{10}) remained essentially unchanged, while a new standard for respirable particles ($PM_{2.5}$) was established at an annual limit of 15 micrograms per cubic meter, with a 24-hour limit of 65 micrograms per cubic meter. The Court of Appeals found the PM_{10} rules deficient and vacated the provisions, and the U.S. Supreme Court has agreed to hear the case.

The revisions to NAAQS for $PM_{2.5}$ could also impact SO_2 control because sulfates, which are formed upon release of SO_2 from the stack, are in this size range. If a relationship is established between fine sulfate emissions and ambient $PM_{2.5}$ concentrations, coal-burning facilities could face serious repercussions. A five-year period is estimated as needed to monitor for ambient air $PM_{2.5}$ levels and composition, to evaluate the data, and to determine attainment/non-attainment. SIPs are required three years after a non-attainment designation, with attainment required within 10 years of the designation.

For ozone, the standard was tightened from 0.12 parts per million (or 120 parts per billion) of ozone measured over one hour to a new standard of 0.08 parts per million (or 80 parts per billion) measured over eight hours. SIPs are required by July 2003 to address hydrocarbons and NO_x emissions, the principal precursors of ozone, with final compliance by December 2003 to July 2010, depending on current air quality. Interim NO_x reductions will come from the EPA SIP Call discussed above.

Regional Haze—In July 1999, EPA published a new rule calling for long-term protection of and improvement in visibility in 156 U.S. national parks and wilderness areas. During 2003–2008, states are required to establish goals for improving visibility in each of these areas and to adopt emission reduction strategies through 2018. Congress required EPA to link these actions with $PM_{2.5}$ compliance. Coal-fired power plants are likely targets for new controls to reduce regional haze.

Coal Combustion Wastes—In April 2000, EPA issued a final rule to continue to classify coal ash as non-hazardous, and therefore not regulate its handling, use, and disposal under Subtitle C of the Resource Conservation and Recovery Act (RCRA). However, additional comments on the rule will be accepted until September 2000. Such wastes, which have a variety of beneficial uses, will continue to be regulated under Subtitle D of RCRA, which governs non-hazardous wastes. In March 1999, EPA had issued a Report to Congress concluding tentatively that low volume wastes, and mixed high- and low-volume wastes were not hazardous.

Cooling Water Intake Structures—As a result of a Consent Decree, EPA is developing regulations under Section 316(b) of the Clean Water Act for cooling water intake structures for both new and existing sources, to be final in August 2001. The proposed new source rule is to be signed in July 2000. These regulations will affect electric utilities and refineries, and other manufacturing industries. Since earlier regulations were withdrawn in 1979, states adopted their own cooling water intake regulations on a site-specific basis.

INTERNATIONAL INITIATIVES

U.S. AND CHINA SIGN TECHNOLOGY PROTOCOL

From left: Jay Braitsch, DOE/FE; Peter Jodoin, DOE/IA; Sun Chun, DOE/FE; Robert Kripowicz, DOE/FE; Liu Zhaodong, Chinese Embassy; Vice Minister Xu Guanhua; Shi Dinghuan; Jin Xiaoming; and Li Baoshan.

Representatives from the U.S. DOE Office of Fossil Energy (FE) and the Ministry of Science and Technology for the People's Republic of China (PRC) signed a new protocol in April for cooperation in R&D on fossil energy technology. The new protocol covers areas of mutual interest in coal, oil, and gas, whereas the previous protocol, signed in 1985, applied only to coal. Chinese ministerial responsibilities have also shifted since 1985, necessitating a new agreement. It is anticipated that 10 or more Chinese organizations will participate in the various work areas under the new protocol.

The protocol envisions cooperation such as technical information exchanges and visits by technical experts, equipment and materials exchange, technological demonstration and seminars, and joint cost-shared projects. Initial tasks will be discussed in June when FE's Principal Deputy Assistant Secretary, Robert S. Kripowicz, will head a U.S. delegation to the first meeting of the Permanent Coordinating Group, of which he is co-chair. The group includes individuals from the U.S. and PRC who will be responsible for planning work to be performed under the protocol. These cooperative efforts will be in the areas of power systems, clean fuels, oil and gas, environmental technology, and regional climate change.

Increased cooperation with China and other key countries is strongly supported by recommendations made by the President's Committee of Advisors on Science and Technology in their June 1999 report, "Powerful Partnerships – the Federal Role in International Cooperation on Energy Innovation." This report was the basis for the Administration's International Clean Energy Initiative, under which DOE requested $46 million in FY 2001, including $13 million for five FE initiatives.

FE ASSISTS SOUTH AFRICAN UTILITY IN EVALUATING CCTS

Komati Power Station's cooling towers and electrostatic precipitators

ESKOM, South Africa's national utility, is considering repowering a 125-MWe unit at the mothballed 1,000-MWe Komati Power Station with circulating fluidized-bed combustion (CFBC) technology. The plan is to burn "discard" coal, the high-ash residue from coal washing. Located near Middelburg, South Africa, the project would be the first utility-scale CCT installation in South Africa. The Komati project represents up to $25 million in potential U.S. goods and services exports.

The DOE Office of Fossil Energy's involvement with ESKOM began in 1998, when its representatives facilitated meetings with U.S. engineering firms and technology vendors, arranged CCT site visits, and encouraged attendance at DOE coal-related conferences. ESKOM has visited a number of U.S. power plants, including JEA's Northside Station in Jacksonville, Florida, where the Large-Scale CFB Combustion Demonstration Project is being conducted. ESKOM has also visited the three major vendors of CFBC technology in the United States: ABB-Ahlstom, Babcock & Wilcox, and Foster Wheeler.

In recent years, South Africa has produced 250 million tons of coal annually, and currently is the world's second largest exporter with 62 million tons exported in 1999. Discard coal is the country's largest volume industrial waste, with 55 million tons of fresh discards generated annually. This comprises 20 percent of the total mined product. By 2002, it is estimated that the inventories of accumulated discard coal in South Africa will reach 1 billion tons. These inventories are primarily located in the Mpumalanga area.

See "International" on page 12...

..."International" continued

ESKOM presently generates some 90 percent of its electricity using conventional, pulverized-coal technology with an overall operational capacity of 30,000 MWe. ESKOM's long-term planning calls for adding 1,000–2,000 MWe of new generation capacity annually starting in 2007. Clean coal technologies like CFBC would allow that power demand to be met with state-of-the-art technology. In addition, CFBC plants could use the vast quantities of discard coal that otherwise would have to be landfilled.

A preliminary investigation has indicated that sufficient discard coal inventories exist within a 10-km radius of the Komati power station, both in term of accumulated product and future streams, to support 400–500 MWe of capacity for 30 years. The Komati demonstration would prove CFBC in South Africa and could lead to repowering of additional mothballed conventional pulverized-coal units. If all 3,800 MWe of ESKOM's mothballed units are repowered, the U.S. export potential could be as high as $800 million. Large deposits of discard coal could also make CFBC greenfield units more attractive.

In August 1999, as a commitment under the U.S.-South Africa Binational Commission, the U.S. Trade Development Agency approved $500,000 for a repowering feasibility study of ESKOM. With results of the feasibility study in hand, ESKOM will assess joint venture possibilities with technology vendors and local investors. To meet the projected demand for new power, ESKOM will likely need to commit to the Komati demonstration project within the next year.

PRESIDENTIAL MISSION TO INDIA UNVEILS ENERGY EFFICIENCY INITIATIVES

In March, President Clinton spent a week in India and Pakistan addressing environmental, economic, health, and other issues of joint concern. During his stay in India, the President announced several initiatives to protect the environment, develop clean energy sources, and combat climate change, some of which could have potential for clean coal technology applications.

One initiative was a Joint Statement on Energy and the Environment, signed by U.S. Secretary of State Madeleine Albright and India's Minister of External Affairs Jaswant Singh. Of particular relevance to the DOE Office of Fossil Energy (FE) is a provision for improvements in power plant efficiency, an area in which the efforts of FE in India have long been focused. The goals are a 15 percent improvement in generating efficiency by 2008, along with a 10 percent increase in use of biomass and other renewables by 2012. Since most of India's power is supplied by low-grade coal burned in aging and inefficient facilities, it is likely that much of the improvement will have to come from modification of existing coal-fired plants or installation of new ones. The agreement notes that India is making fossil fuel energy use cleaner and more efficient, and intends to further improve energy efficiency in the electric power sector by focusing on renovation and modernization to include repowering of older plants to improve plant load factors, upgrading, and strengthening sub-transmission and distribution systems as well as to reduce transmission and distribution losses. The agreement expands upon an earlier Joint Statement of last October. A Joint Consultative Group on Clean Energy and Environment will be created to promote collaborative projects and cooperation.

While in India, the President announced a $45-million energy efficiency/clean energy package that includes a second, five-year phase of the Greenhouse Gas Pollution Prevention Project headed by USAID with technical support from FE. Current activities are directed toward reducing the amount of greenhouse gas (GHG) emissions produced per unit of electricity generated. Over the past five years, more than a dozen teams led by FE have provided technical assistance to India's power stations and training to power plant engineers. FE also helped the National Thermal Power Corporation, the sixth largest utility in the world, to establish the Centre for Power Efficiency and Environmental Protection (CenPEEP), a national resource for training and technology demonstrations. In the second phase, termed the Climate Change Supplement, FE will assist in building local capacity to sustain GHG reduction in existing plants. FE will also introduce more efficient and lower cost GHG technologies for new power plants and improve the utilization of existing assets.

NEW IEA CLEAN COAL CENTRE STUDY AREAS

In April 2000, representatives from the Office of Fossil Energy (FE) participated in the Executive Committee Meeting, held in London, for the International Energy Agency's Clean Coal Centre. Barbara McKee, Director of FE's International Office of Import/Export, is Committee Vice Chair. New study areas were selected in general agreement with U.S. priorities defined at a March 2000 meeting in Washington, D.C., sponsored by the National Mining Association and the Gasification Technologies Council. In the coal utilization area, studies will be undertaken in hybrid biomass, waste, and coal energy; cost reductions in plant operation; coal quality assessment; fuel cells using coal or waste fuels; petcoke use; and instrumentation and control. In the environmental area, studies will focus on the potential for economic CO_2 reduction; market mechanisms for greenhouse gas reduction; air pollution control costs; and an update of the flue gas desulfurization handbook. Other studies selected include coal mining restructuring and coal selection for high quality coke production. In the past year, the Clean Coal Centre has produced 17 reports. To order reports, check directions at http://www.iea-coal.org.uk_.

..."News Bytes" continued

value, while producing commercially useful products. The sale of cresylic acid further demonstrates the economic benefits of using advanced clean coal technologies.

Since successfully completing demonstration operations at the **Healy Clean Coal Project** in central Alaska, in December 1999, the **Alaska Industrial Development and Export Authority** (AIDEA) has

issued topical reports describing the key technical activities carried out during the project's two years of demonstration operations. The following topical reports describing various aspects of the project have been issued recently: *Combustion System Operation, Spray Dryer Absorber Performance Testing, Boiler Performance Testing, Air Emission Compliance Testing,* and *AIDEA's Perspective on the 90-Day Commercial Operation Test and Sustained Operations Report*. The topical reports are available on the Clean Coal Technology Compendium at http://www.lanl.gov/projects/cctc.

JEA, of Jacksonville, Florida, sponsor of the **JEA Large-Scale CFB Combustion Demonstration CCT project**, has signed an innovative three-year safety partnership with the Occupational Safety and Health Administration and the Florida Department of Labor. Because of its excellent safety record (a 25 percent annual reduction in workplace injuries over the past three years), JEA will be allowed a freer rein at all of its sites, and will be evaluated by OSHA only annually. This will allow OSHA to concentrate its efforts elsewhere in Florida where construction-related fatalities have been rising, with last year being the second highest in the nation. JEA also has promised to hire only contractors with high safety ratings. The OSHA program is an offshoot of the "Construction Accident Reduction Emphasis" program.

A public environmental scoping meeting for the **Kentucky Pioneer Energy Integrated Gasification Combined Cycle Demonstration Project** Environmental Impact Statement was held on May 4, 2000, in Trapp, Kentucky, with 32 registered guests in attendance. Members of the public provided comments regarding possible impacts on road systems, schools, property values, power plant design and fuel source, and jobs that may be needed during construction and operation of the plant. Comments from the scoping meeting will be considered during preparation of the draft environmental impact statement.

CLEAN COAL TODAY

Published quarterly by:
The Office of Fossil Energy
U.S. Department of Energy (FE-24)
Washington, DC 20585

Editor: Phoebe Hamill

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STATUS OF ACTIVE CCT DEMONSTRATION PROJECTS

ENVIRONMENTAL CONTROL DEVICES

Southern Company Services, Inc. – *Demonstration of Advanced Combustion Techniques for a Wall-Fired Boiler.* All testing on the original project has been completed and reported. Phase 4 has been extended 19 months to evaluate the use of additional plant equipment for NO_x and LOI control and on-line efficiency optimization techniques using GNOCIS. (Coosa, GA)

ADVANCED ELECTRIC POWER GENERATION

City of Lakeland, Department of Water & Electric Utilities – *McIntosh Unit 4A PCFB Demonstration Project and McIntosh Unit 4B Topped PCFB Demonstration Project.* Lakeland Electric is re-evaluating its options to meet future power demand. (Lakeland, FL)

JEA – *ACFB Demonstration Project.* In September 1997, DOE signed an agreement with JEA to cost-share refurbishment of the first (Unit 2) of two units at the Northside Generating Station. Unit 2 is scheduled for operation in early 2002, to be followed by two years of demonstration. (Jacksonville, FL)

Kentucky Pioneer Energy, L.L.C. – *Kentucky Pioneer Energy Projec*t. Kentucky Pioneer Energy, L.L.C. has replaced the Clean Energy Partners, LP as the project participant and has moved the site to a new location in Trapp, Kentucky. An Environmental Scoping Meeting was held on May 4, 2000. (Trapp, KY)

Sierra Pacific Power Co. – *Piñon Pine IGCC Power Project.* In the first quarter of 2000, Sierra Pacific began to make additional repairs and improvements so that sustained operation of the gasifier can be achieved. Improvements include increasing the diameter to the annulus section of the gasifier to address the problem of high temperatures of the limestone and ash leaving the gasifier. Also, the refractory in the gasifier grid area and 18 feet into the fluid bed region will be replaced with a single castable layer on a revised anchoring pattern, to provide improved resistance to low cycle fatigue of the refractory lining. Sierra expects to restart the plant in July 2000. The project will end January 1, 2001. Sierra continues to operate the plant normally in the gas combined-cycle mode. (Reno, NV)

Tampa Electric Co. – *Tampa Electric Integrated Gasification Combined-Cycle Project.* Tampa's Polk Power Station has completed three years of successful commercial operation. The gasifier has operated 18,500 hours, and the combustion turbine has operated 20,500 hours producing over 7,000 MWh. Testing of petcoke is currently being performed. (Mulberry, FL)

Wabash River Joint Venture – *Wabash River Coal Gasification Repowering Project.* The Wabash River Cooperative Agreement expired on 1/1/00. The participant is currently working on the final report. (West Terre Haute, IN)

Alaska Industrial Development and Export Authority (AIDEA) – *Healy Clean Coal Project.* Demonstration operation under the Cooperative Agreement was completed in December 1999, and final reporting is under way. A 90-day commercial operation test was completed on November 15, 1999. Based on the findings by the independent engineer who witnessed the test for the purpose of commercial operation acceptance, Golden Valley Electric Association, Inc. (GVEA) did not accept the plant for commercial operation and stated that the Power Sales Agreement was terminated. Subequently, in March AIDEA and GVEA reached a settlement and AIDEA turned the plant over to GVEA for custodial care in April. GVEA is now seeking regulatory approval for conversion of the plant to a conventional low-NO_x burner and lime spray dryer emission control system. GVEA has engaged a consultant to determine the technical, regulatory, and economic feasibility of the retrofit. The plant will not operate until this determination is complete. (Healy, AK)

Arthur D. Little, Inc. – *Clean Coal Diesel Project.* Preparatory work is under way for a preliminary performance checkout of the diesel engine. Fuel oil will be used to ensure that the diesel engine is in running condition. Work is continuing to install the coal slurry fuel system and support equipment. Preliminary performance checkout should begin by the summer of 2000. Upon completion, work will begin to modify the engine so it can operate on coal slurry. (Fairbanks, AK)

COAL PROCESSING FOR CLEAN FUELS

Western SynCoal LLC (formerly Rosebud SynCoal® Partnership) – *Advanced Coal Conversion Process (ACCP) Demonstration.* Rosebud SynCoal Partnership has been reorganized and merged into a new entity, Western SynCoal LLC. The ACCP Demonstration Project in Colstrip, Montana has processed over 2.5 million tons of raw sub-bituminous coal. Over 1.7 million tons has been supplied to customers, including industries (primarily cement and lime plants) and utilities. The first year of testing the supplemental fuel system at Colstrip Unit 2 has been completed. The system has been performing well. Colstrip Unit 2 has experienced significant benefits in improved heat rate, reduced auxiliary load, and reduced slag related limitations. Work is on-going to learn how to optimize the application of supplemental fuel use. (Colstrip, MT)

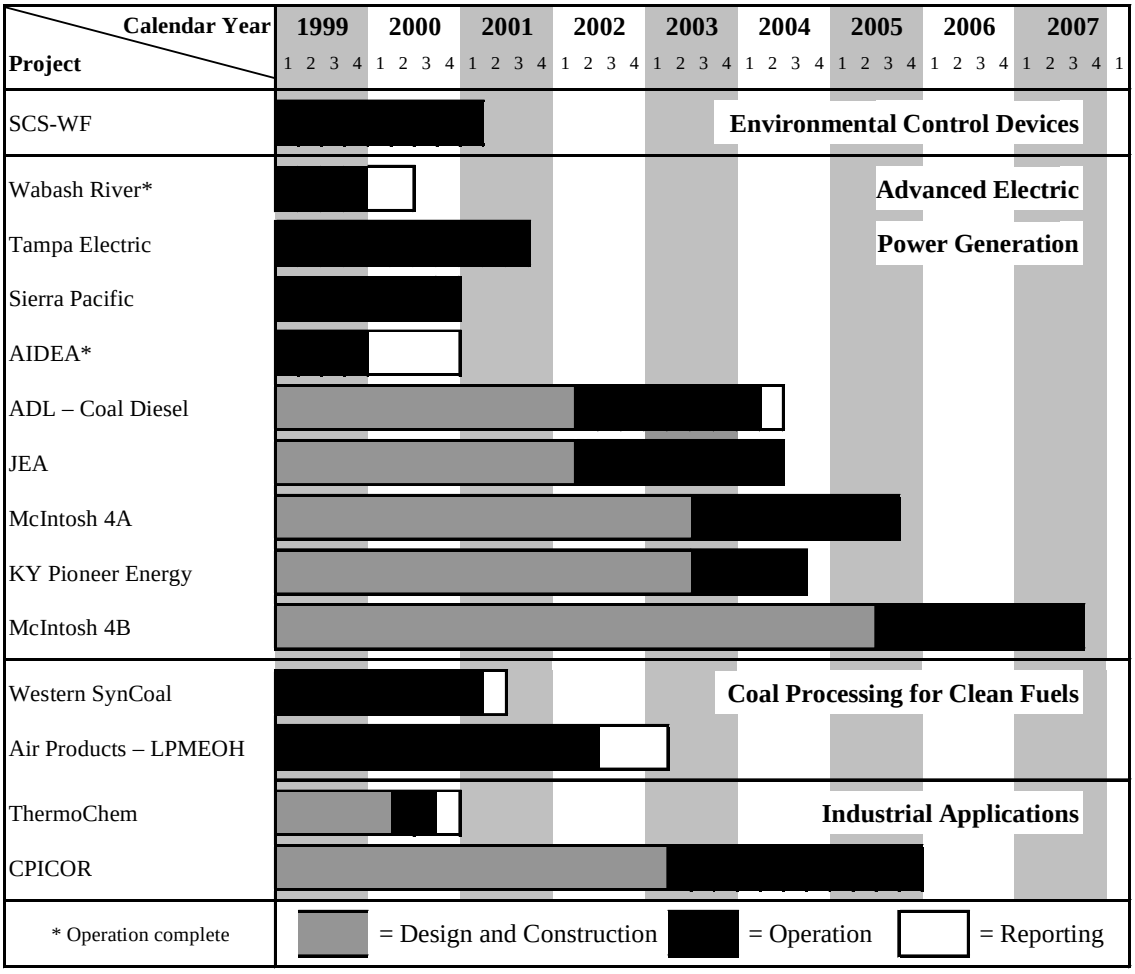
Air Products Liquid Phase Conversion Company, L.P. – *Liquid Phase Methanol Process Demonstration Project.* The Liquid Phase Methanol (LPMEOH™) Process Demonstration Facility continues to experience stable operation on coal-derived synthesis gas. The project recently was extended an additional 15 months (from December 28, 2001, until March 31, 2003). Since being restarted with fresh catalyst in December 1997, the demonstration facility has operated at greater than 99 percent availability, and since April 1997, has produced over 58 million gallons of methanol, all of which was accepted by Eastman Chemical Company for use in downstream chemical processes. As a result of the successes achieved, the project was extended an additional 15 months (through March 31, 2003) to allow for the opportunity to perform new tests considered to be of significant commercial interest. The monitoring of all potential catalyst poisons, and methods for their removal and control continue to be an important part of the ongoing plant operation. (Kingsport, TN)

INDUSTRIAL APPLICATIONS

CPICOR Management Company, L.L.C. – *Clean Power From Integrated Coal/Ore Reduction.* DOE has continued its environmental analysis for preparing an Environmental Impact Statement for this project. The CPICOR Management Company (CMC) continues to perform baseline environmental monitoring and preliminary engineering and design in support of the NEPA process. CMC also continues to work closely with the Australian developers of the HIsmelt® Process to establish a process and mechanical design database for this project. This project will be designed to produce 3,300 tons per day of liquid iron and approximately 160 MWe from the by-product gases. (Vineyard, UT)

ThermoChem, Inc. – *Pulsed Combustor Design Qualification Test.* Installation of the steam reformer 253-tube pulse combustor test vessel and structure is in progress. Installation is scheduled for completion in August 2000. Testing of the 253-tube pulse combustor will begin in late August 2000. Shakedown tests of the Process Data Unit (PDU) using Black Thunder, Wyoming subbituminous coal were completed in April 2000. The PDU is being modified to improve operability and testing resumed in July 2000. (Baltimore, MD)

TIMELINE OF ACTIVE CCT PROJECTS



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FE-24