Office of Fossil Energy, U.S. Department of Energy • DOE/FE-0524 • Issue No. 77, Fall 2008

CLEAN COAL TODAY

A Newsletter About Innovative Technologies for Coal Utilization

News Bytes

The U.S. Department of Energy (DOE) has issued a Funding Opportunity Announcement (FOA) under the third round of the Clean Coal Power Initiative. The FOA, dated August 11, 2008, is targeting coal-based systems and subsystems that capture, sequester, or put to beneficial use, at least 300,000 tons per year of CO_2. Capture efficiencies must be at least 90 percent. Projects must show significant progress toward carbon capture and sequestration, with < 10 percent increase in electricity costs. Electricity must represent at least 50 percent of a project's gross energy product. Proposals are due January 15, 2009. The FOA is available at www.grants.gov. ◆

The DOE, in September 2008, announced a solicitation for up to $8.0 billion in federal loan guarantees for projects that employ advanced technologies that avoid, reduce or sequester emissions of

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Inside This Issue

Advanced Sensors for Next Generation Power Plants

The performance of tomorrow's advanced fossil-fueled power generation systems depends greatly on R&D advances in novel sensors and advanced process control methods for high-performance, near-zero emission power systems such as Integrated Gasification Combined-Cycle (IGCC) in combination with carbon capture and storage (CCS). Under the Office of Fossil Energy (FE) of the U.S. Department of Energy (DOE), the National Energy Technology Laboratory (NETL) is leading the effort to develop sensing and control technologies and methods to achieve seamless, integrated, automated, optimized, and intelligent power systems.

Sapphire sensors packaged into a probe (shown here) were installed and tested at Tampa Electric's Polk Power Station

As R&D enhances the understanding of these systems, it is clear that new, robust sensing approaches, including durable materials and highly automated process controls, are needed to optimize plant operation and performance. Efforts by NETL and its partners have focused on suitable sensor materials, designs, and packaging for harsh environments. Process control advances include highly automated, state-of-the-art, integrated digital control systems for an entire plant, or a central control system having the flexibility to interface with a variety of vendor-supplied component controls via network protocols. Much of the work is taking place through NETL's Advanced Research Program, with additional efforts by NETL in-house researchers (see box on page 3).

Technical Challenges

The performance of advanced power systems is limited by the lack of sensors and controls capable of withstanding operation under harsh conditions including high temperatures and pressures, erosive and corrosive atmospheres, and changes in fuel composition found in, for example, combined coal and biomass operations. Harsh environments are inherent to new systems that aim to achieve high efficiency with low emissions. Coal gasifiers and combustion

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... *"Sensors" continued*

turbines undergo the most extreme conditions with temperatures reaching 1,600 °C, and pressures near 800 psi. Slagging coal gasifiers are highly reducing, erosive, and corrosive. Combustion turbines have an oxidizing combustion atmosphere.

Active control of plant processes requires online monitoring of critical plant parameters in areas where measurement of temperature, pressure, and gas species cannot be made with current commercial instrumentation. Physical measurements include temperature, pressure, and strain/stress under extreme conditions. Gas and solid measurements determine fuel/combustion gas constituents, such as oxygen, hydrogen, carbon monoxide, and methane. Exhaust gas constituents are nitrogen oxides, sulfur oxides, and trace contaminants. Condition monitoring includes those parameters to assess equipment condition and maintenance requirements, as well as algorithms that support the efficient management of power plant assets.

PROGRAM SUCCESSES

Through its workshops, NETL has engaged industry, academia, and other stakeholders to review and identify the measurement and control needs for advanced power generation systems. Focus is on critical online measurement capabilities with sensor materials and designs that can withstand up to 1,600 °C for temperature measurement and nearly 500 °C for online gas composition sensing. These sensors must be durable enough to survive in service between plant outages, in some instances for two years or more. Substantial progress has been made, evidenced by the number of extramural R&D projects demonstrating the viability of novel sensors, resulting in patents, licensing, and commercialization of the technology. Following are highlights of achievements.

OPTICAL SENSORS

Optically based sensors are used to measure both physical operating parameters and gas species concentrations. Optical sensing relies on the interaction of light with a process variable, and numerous optical and spectroscopic approaches exist for tightly controlling gas stream conditions. Innovation in this area has been oriented towards the utilization of optical materials that can withstand high temperatures, and designs of online spectroscopic sensors that take advantage of new detection schemes and miniaturized optical components.

Optically based sensors offer advantages over commonly used resistance-based devices because of their inherent immunity to electromagnetic force (EMF) interferences and resistance to corrosion. High-temperature optical materials include sapphire, silicon carbide, and silica.

Single-Crystal Sapphire Temperature Sensor – To withstand the extreme conditions of a coal gasifier, researchers from the Center for Photonics Technology at the Virginia Polytechnic Institute and State University (Virginia Tech), with NETL support, developed a single-crystal sapphire optical fiber sensor that has been demonstrated in the laboratory to measure temperature up to 1,600 °C with good resolution and survivability. The sensor consists of a sapphire fiber with a sapphire wafer attached to the end. When the end of the fiber is exposed to extreme temperatures, the reflection of the light from the front and back faces of the wafer are used to infer temperature of the system.

Sapphire sensors were packaged into a large probe, which was installed and tested at full scale in the gasifier section of Tampa Electric Company's Polk Power Station in Florida. The sensor survived for seven months before it was cleaved by shifting refractory material, causing premature failure. In contrast, comparable instrumentation, including precious metal thermocouples, was replaced twice during the same test period. Work is under way to re-engineer the sensor packaging for another full test in a coal gasifier. Given its initial success, this optical sensor is being considered for use in the combustion section of a power turbine.

Optical Fiber Gas Sensors – Silica fiber sensors are commercially available for the measurement of temperature, pressure, and strain for low-temperature industrial applications. NETL is supporting research to expand the capabilities of these sensors to include gas sensing. NETL has teamed with Virginia Tech, GE, and other institutions to develop low-cost "holey" fibers and nano-crystalline gratings that are applied to silica fibers to create high-temperature optical fiber gas sensors. Holey fibers are produced with a nano-porous cladding structure around the core of the fiber, where light is launched and reflected. The novel feature of these fibers is their porous structure and radial orientation of the pores to allow gas to diffuse quickly in and out of the fiber structure. The use of controlled wavelengths enables the

light to interact with the gas-filled pores, so that the instrument can infer both the identity and quantity of a gas mixture.

Other work sponsored by NETL has focused on mixtures of metal oxide-based nano materials that can be applied to a grating on a fiber to permit selective gas interaction with the fiber's light, and subsequent inference of gas concentration. Current research focuses on the development of high-temperature (500 °C) gratings that will enable rapid, simultaneous, and online detection of hydrogen and carbon monoxide. The first laboratory demonstrations of this technology were recently completed.

Micro Sensors and MEM Devices

Micro sensors are small electronic devices using conductive materials that are targeted to interact with gases present in the process stream. These, and Micro Electro-Mechanical devices using silicon, have been the center of much R&D. NETL's research is oriented towards the development of micro devices that can function at 500 °C. These sensors are intended to be low cost and replaced annually. They would be in widespread use throughout a plant, and coupled with intelligent algorithms for monitoring, would enable low-cost networking for plant optimization.

Work to date has resulted in multiple patents and licenses for micro gas sensor arrays for the detection and monitoring of typical exhaust gases. Portions of this work—performed with funding from NETL by The Ohio State University and GE Reuter Stokes, among others, were awarded prestigious R&D 100 awards by *R&D Magazine*. The technology also is being examined for military, automotive, and medical applications.

Progress in sensors and control technology – through improved fuel utilization and more precise control of plant operations – has had profound positive impacts on system efficiency of advanced power systems. ■

NETL's Combustion Sensor Offers New Diagnostic Capability

NETL has developed and patented an innovative combustion control and diagnostics sensor (CCADS) for continuous flow combustion applications, such as gas turbines. At the time of its fabrication in the laboratory, CCADS was considered a breakthrough technology for its capability to detect flashback. With additional research, it has been shown that the sensor is able to monitor flame properties such as fuel/air ratio, flame stability, combustion dynamics, incipient lean blowout conditions, and equivalence ratio estimation. Gauging these parameters within a combustion turbine will enable close control of instabilities and developing events. In addition, monitoring the system in this way will contribute to higher efficiencies and lower emissions.

NETL has licensed this technology to an industrial partner, Woodward. NETL onsite researchers have worked with the licensee under a series of cooperative research and development agreements (CRADAs) to test the technology at full scale and make the sensor commercially available.

CCADS sensor inserted into the center body of a fuel nozzle

NETL's in-house development of fundamental laboratory experiments and computational fluid dynamics models has supported CCADS development by providing physical insight into flame ionization and ion transport processes. Computer modeling of combustor design and simulation of combustion processes also are expected to help improve the design of CCADS for use in commercial combustion applications.

Industry adoption of CCADS will open the door to more efficient, lower emission turbines in advanced energy systems through smarter control of combustion. CCADS technology will enable advanced energy systems to make more efficient use of natural gas, petroleum-based fuels, coal, and biomass.

NETL, USDA Design Coal-Stabilized Biomass Gasification Unit

Coal, poultry litter, contaminated corn, rice hulls, moldy hay, manure sludge—these are representative materials that could be tested as fuel feedstocks in a hybrid gasification/combustion concept studied in a recent U.S. Department of Energy (DOE) design project. DOE's National Energy Technology Laboratory (NETL) and the U.S. Department of Agriculture (USDA) collaborated to develop a design concept of a power system that incorporates Hybrid Biomass Gasification. This system would explore the use of a wide range of biomass and agricultural waste products as gasifier feedstocks. The plant, if built, would supply one-third of electrical and steam heating needs at the USDA's Beltsville (Maryland) Agricultural Research Center (BARC). It could save an estimated $2 million annually in utility costs, while providing BARC with an important research platform to study the applicability of bio-syngas to agricultural operations. DOE would gain knowledge of the application of bio-syngas to utility and industrial operations.

DOE's Office of Fossil Energy (FE) has long supported the demonstration of new technologies to convert solid fuels into electric power, process heat, and higher-value gaseous or liquid feedstocks. More recently, FE has been focusing on increased use of coal with biomass. Six awards were made in September 2008 for projects to address challenges to large-scale production of hydrogen from coal and coal-biomass mixtures (see www.fe.doe.gov, FE Techline dated September 3, 2008).

While the proposed Hybrid Biomass Gasification system would use a number of proven technologies to generate 1,665 kWe of electric power, the system configuration is new and untested. Additionally, coal combustion has not previously been used to stabilize overall gasifier/combustor operations. Previous systems have all used biomass in both gasifier and combustor, with moisture variation in biomass adversely affecting operations and efficiency.

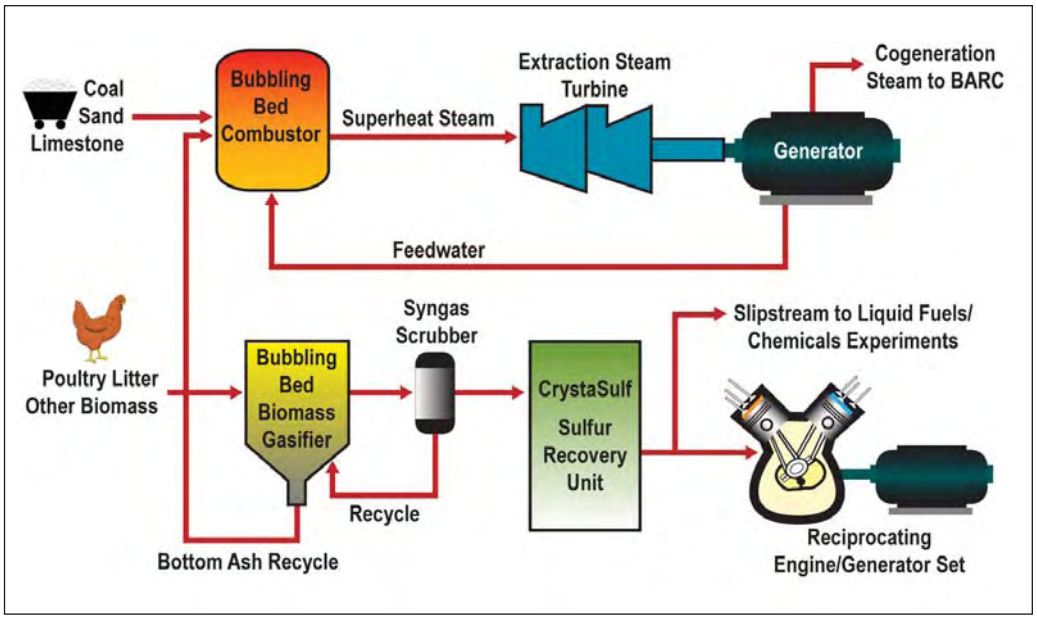
USDA's Beltsville Agricultural Research Center has been in operation since 1910

As seen in the schematic, the proposed hybrid system integrates a bubbling bed biomass gasifier, a bubbling bed combustor fueled by coal, a bio-syngas fired diesel (reciprocating) engine, a coal combustion-based extraction steam turbine, and various clean-up components (not all depicted). The gasification reactor converts the biomass feedstock into syngas and residual char. The combustion reactor utilizes coal and char to produce heat for the gasification process. It may later burn biomass if determined to be practical. Sand, limestone, char and ash circulate between the gasifier and combustor. The combustor heats sand to 910 °C (1,675 °F). The sand is then fed to the gasification reactor where it envelops the biomass particles, quickly turning them into gas. Residual sand, ash and char are recycled to the combustor where the sand and ash are reheated and char consumed.

Electricity production is accomplished from two generating elements within the power system. The gasification reactor produces a medium Btu bio-syngas fuel (~500 Btu/cf) that powers a modified diesel engine. This reciprocating engine is used to generate 825 kWe of electricity directly from the bio-syngas, with some bio-syngas left over for research purposes. The second generating element, the extraction steam turbine, generates electricity from the combustion reactor's waste heat, and also supplies steam to the BARC facility. At full firing, the turbine could supply 18,943 lb/hr (2.39 kg/s) of steam, while delivering 1,235 kWe of electric generation. Steam extraction for heating or cooling automatically adjusts for seasonal demand. When less steam is extracted, more electricity is generated for use

by BARC. At minimum steam extraction of 12,000 lb/hr (1.51 kg/s), the plant would generate 1,665 kWe.

As part of the plant design, up to half of the syngas going to the modified diesel could be drawn off as a slipstream for R&D needs. When this happens, the reciprocating engine would operate at reduced electrical output. Liquid fuels R&D would include F-T liquids, methanol, ethanol, and dimethyl ether (DME). Other USDA/DOE research opportunities include creation of new products for fertilizer and other ash-based soil amendments. Still other work could evaluate syngas-fueled engines, syngas cleanup, and CO_2 capture. Oxygen-based gasification studies are also possible.



Coal-stabilized biomass gasification concept

Researchers have also evaluated potential emissions from the hybrid gasifier, based on operating data from similar units. Sulfur dioxide removal is expected to be better than 90 percent (less than 0.32 lb/million Btu). Limestone in the combustor bed is effective in collecting sulfur, and the CrystaSulf unit removes all sulfur from the bio-syngas. Since a consistent low bed temperature minimizes NO_x, those levels are expected to be below 0.12 lb/million Btu. Additionally, selective non-catalytic reduction would treat the post-combustion NO_x. A baghouse will be effective in removing particulate matter to levels of 0.029 lb/million Btu. Trace elements (chlorine and mercury) can be removed by sorbents in the combustor, and by the baghouse.

The proposed unit is estimated to cost a little over $47 million to build, and would be a government-owned facility. As such, the government would evaluate this first-of-a-kind project on its merit as a combined heat and power generator as well as a flexible biomass research facility to justify its initial investment cost. While the test facility's estimated capital cost and the positive operating revenues from the ~3MWth plant are economically viable in the USDA research setting, operation would not pay off the investment if this were a commercial project. A commercial project would need to be at least six times as large.

Researchers believe that experience gained with Hybrid Biomass Gasifier would provide the flexibility to test a wide range of feedstocks, research their unique handling and equipment-related problems, and establish boundaries of operation. ■

... "News Bytes" continued

air pollutants or greenhouse gases. Projects eligible for support include IGCC with carbon capture; combined coal- and biomass-to-liquids, ultra-supercritical pulverized coal plants, coal-to-chemicals, and coal-to-methane gas. Part I of the application is due December 22, 2008, and Part II by March 23, 2009. These loan guarantees are authorized in Title XVII of the Energy Policy Act of 2005. ◆

Also in September, DOE announced the award of six projects to address challenges of large-scale hydrogen production from coal and coal-biomass. Projects will deal with methods for optimal pre-treatment and feeding into coal gasifiers, development of a data base on raw syngas composition, and effects of syngas contaminants on Fischer-Tropsch and Water-Gas-Shift processes. For further information, see the Techline at www.fe.doe.gov/news/techlines/2008/. ■

LARGE EDDY SIMULATION FOR ADVANCED POWER SYSTEMS

Researchers at the National Energy Technology Laboratory (NETL), together with their counterparts in academia, have recently made strides in Large Eddy Simulation (LES), an advanced type of computational fluid dynamics (CFD) modeling. Today's greater computing power at reduced cost allows for modeling and simulating variations in flow of fuel through advanced power systems, reducing the need for actual hardware testing of a range of coal fuels. Advanced models allow the designer or plant operator to evaluate the financial and environmental tradeoffs with different fuel types and carbon capture approaches. Overall, improved modeling and simulation decrease trial and error and reduce costs, factors key to widespread adoption of ultra-efficient advanced clean coal technologies, such as integrated gasification combined cycle (IGCC).

LES: THE LATEST CFD MODELING APPLICATION

Although LES has existed in some form for almost 40 years, simulations could take months and were limited to academic use for relatively simple simulations, such as non-reacting flows (e.g., isothermal flow over an airfoil). A modern LES simulation, on the other hand, can be performed in a matter of days, making it a computational tool practical for solving engineering problems on industrial timescales.

SimVal combustor and team with the pressure vessel in the background

The fundamental equations that govern fluid dynamics are known as the Navier-Stokes equations. The idea behind LES is to solve these equations in a filtered form that directly simulates the large scale unsteadiness in a flow. This flow is very much geometry dependent, or specific to each combustor. At the same time, LES can model – using algebraic stress type models – the smaller turbulent scales that tend to be more isotropic and homogeneous. Currently, the majority of CFD simulations are done with steady-state, time-averaged approaches such as Reynolds-Averaged Navier Stokes (RANS) simulations. Though adequate for predicting heat transfer, or flow through a compressor or turbine blade passage, RANS approaches are not as well suited for predicting the flow in a combustor, with its complex interactions between chemistry and turbulence. RANS models the entire spectrum of turbulent motions and must usually be "tuned" to a specific combustor's geometry through the adjustment of parametric constants in the turbulence model. The benefit of LES is in the reduction of the number of modeling constants that must be tuned in order to accurately simulate the flow-field in a particular combustor. LES is suited for simulating transient phenomena like flame flashback, blowout, or acoustic interactions between the flame and the combustion chamber.

The use of LES as a computational tool for chemically reacting, or combusting flows, began in earnest in the mid-1990s. Although much progress has been made, the remaining barrier to widespread use is the lack of well-validated combustion sub-models robust enough to be valid over a wide range of combustor operating conditions and fuel types. NETL's in-house Simulation Validation (SimVal) combustor is addressing this problem by generating experimental datasets that can be used to validate LES models at conditions relevant to gas turbine operating conditions. NETL is also collaborating with various universities on the development of new, computationally efficient and accurate combustion models that will allow for simulation times that are reasonable for combustor development on an industrial scale.

NETL'S SIMVAL TEST COMBUSTOR

The intermediate-scale (3 MW), high-pressure, optically accessible SimVal combustor is a key component of NETL's High Pressure Combustion Facility, and provides the capability to observe high-pressure combustion processes at realistic gas turbine conditions. The overall goal is to promote the development of novel, ultra-low emissions, fuel-flexible combustors. One important activity under way at SimVal is providing combustion data sets for LES (and other CFD) code development. In SimVal, fuel composition, operating pressure, inlet air temperature,

and combustor geometry are varied to study the effects of these parameters on flashback and lean extinction limits, dynamic stability, and pollutant emissions. The combustor can be operated over a wide range of pressures (up to 20 atmospheres), inlet air temperatures (up to 900 °F) and flow rates (up to 3 lb/s). The effects of fuel composition are studied by adding controlled quantities of hydrogen to the baseline natural gas fuel. Researchers are attempting to simulate the range of fuel chemical timescales that might be encountered in different syngas compositions produced by IGCC plants. These timescales could vary according to type of coal and gasification technology used. Further, the modular combustor design enables the combustor to be reconfigured to study geometric effects, such as fuel injector and swirl vane design and position.

Experiments at SimVal are conducted with precise control of the thermal, acoustic, and flow boundary conditions since well-defined boundary conditions are central to providing useful validation data sets and accurate LES codes and models. Heat loss and combustor liner temperature profiles are measured through water-cooled test sections and thermal imaging. The combustor acoustics are controlled by adjusting the flow field at the combustor inlet and outlet using choke plates, and controlling fuel-air mixing at the combustor inlet. A unique feature is full optical access to the combustion region using a quartz liner and quartz windows on the pressure vessel, allowing direct observation and detailed imaging of the flow field in the flame region as well as flame structure at all operating conditions. While the SimVal combustor was designed specifically for collecting model validation data, the flexibility of the design allows for studying a wide range of combustor geometries and operating conditions for conducting more applied research, such as assessing new combustion technologies.

University and Contract Research

The development of new computationally efficient sub-models is being explored through collaborations with various universities in activities such as DOE's University Coal Research Program. In one effort, NETL is working with Stanford University to assess current LES capabilities for predicting transient phenomenon such as flashback and blowout. NETL and Virginia Tech are assessing the sensitivity of acoustic boundary conditions on CFD simulations of thermo-acoustic instabilities. NETL also has several projects with West Virginia University (WVU) and the University of Pittsburgh to validate current RANS and LES combustion modeling approaches using data generated in SimVal. Currently, the group at Pittsburgh is working on the application of LES using a Filtered Density Function (FDF) combustion modeling approach to lean premixed combustion. The group at WVU is assessing the LES capabilities of the commercial code FLUENT in predicting emissions of NO_x and CO in lean premixed combustion systems.

NETL is also working with the commercial CFD company ANSYS to assess the capabilities of LES in predicting flashback common with high-hydrogen fuels. Collaborative efforts with ANSYS also involve new LES combustion models applicable to lean premixed combustion of high-hydrogen fuels.

NETL is already recognized for its contribution to CFD modeling, having developed one of the most advanced codes to date, the MFIX (Multi-phase Flow with Interphase eXchanges) for transient modeling of transport gasifiers with dense solid phases. With the current effort, NETL and its partners are advancing the state-of-the-art in LES combustion modeling while simultaneously providing the much needed experimental data for validating these models over a wide range of conditions. ■

Upcoming Events

November 16 – 20, 2008
9th International Conference on Greenhouse Gas Control Technologies
Sponsors: DOE, MIT, IEA GHG
Location: Washington, DC
Contact: Mary Gallagher
Phone: 617-258-0307
E-mail: ghgt9@mit.edu
Web site: http://mit.edu/ghgt9/

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Washington, DC 20585

Editor: Phoebe Hamill
Phone: 202-586-6099
Fax: 202-586-7085
E-mail:
phoebe.hamill@hq.doe.gov
Web site:
http://www.netl.doe.gov/technologies/coalpower/cctc/newsletter/newsletter.html

Comments are welcome and may be submitted to the Editor.

INTERNATIONAL INITIATIVES

FOSSIL R&D COOPERATION WITH ISRAELI UNIVERSITY

A delegation led by NETL Director Carl O. Bauer visited Israel in early May at the invitation of the U.S.-Israel Binational Industrial Research and Development Foundation to discuss strategic energy cooperation between the United States and Israel, as stipulated in the U.S.-Israel Energy Cooperation Act signed into law December 2007. Bauer and Professor Uriel Reichman, President, Diplomacy and Strategy, of the Interdisciplinary Center (IDC) Herzliya, signed a Memorandum of Understanding for cooperation on fossil fuels. The MOU allows for technology cooperation and assessments of options (including technology economics) in a variety of areas. Specifically, areas of possible joint effort include: carbon management; power plant water use; power grid efficiency and reliability; hydrogen energy and fuel cells; hybrid energy systems using turbines; alternative fuels; and advanced materials.

The algae tank at the Ashkelon coal-fired power plant cultivates algae for pills, a diet supplement common in Japan. A similar process could be used for sequestration, and is being developed by Arizona Public Service for its Redhawk Plant

Despite its limited energy resources, Israel is the most developed country in the Eastern Mediterranean region, and boasts the most developed and technologically advanced economy. The Israel Electricity Corporation (IEC), the national utility that generates nearly all of the country's power, maintains and operates 17 power stations with a total capacity of 11,323 MW. In 2007, the Company sold 49,323 GWh of electricity. From 1997 to 2007, demand for electricity in Israel grew at an average annual rate of 4.8 percent, exceeding the average annual growth rate of the country's gross domestic product of 3.8 percent during the same period. In 2007, nearly 70 percent of the electricity generated by IEC was based on coal, with an additional 20 percent from natural gas. IEC operates two coal power plants at Hadera and Ashkelon with a combined capacity of 4,840 MW. A new 1,100-MW coal-fired plant is being constructed at Ashkelon and is expected to begin supplying electricity around 2012. Israel imports over 13 million metric tons of bituminous coal to fuel its power plants.

The delegation met with the Ministry of National Infrastructures, to discuss possible cooperation on a number of coal-related topics, such as preparation of a national geologic carbon sequestration atlas, similar to that developed by NETL for North America, and flame stability in gas turbines. Other meetings took place with researchers at the Weitzman Institute (a leading Israeli university), Algatech (a rapidly expanding international biotechnology company), and the Arava Institute for Environmental Studies (a regional center for environmental leadership) to discuss using CO_2 to accelerate the growth of algae for productive uses, such as biofuels that could displace fossil-based transportation fuels. The group visited Seambiotic's prototype algae farm at IEC's coal-fired 2000-MW Ashkelon power plant, where a quarter acre of shallow pools are filled with the same seawater used to cool the power plant. A small percentage of the flue gas from the plant is "siphoned" from the power plant and injected into the algae ponds, where the CO_2 is captured. The delegation also discussed advanced coal gasification, and other cooperation, with representatives from Ben Gurion University.

IDC Herlizya was established in 1994, and presently has 3,600 graduate and undergraduate students – about 15 percent of them overseas students from 44 different countries. Throughout the entire week, Dr. Isaac Berzin of IDC Herlizya served as the delegation's host. Dr. Berzin is a world authority on the application of algae-based technology for production of biofuels, and founder of GreenFuel Technologies Corporation, headquartered in Cambridge, Massachusetts. Dr. Berzin was recently named by Time magazine to their fifth annual list of the world's most influential people. With support from NETL, APS and GreenFuel Technologies are working together to coproduce substitute natural gas (SNG), biofuels, and electricity with near-zero CO_2 emissions at Arizona Public Service's Redhawk Power Plant, about 50 miles west of Phoenix.

As the first follow-on activity to the NETL-Israel MOU, a research professor from Ben Gurion University visited the United States to discuss cooperation on coal gasification. Subsequently, two officials from the Geological Survey of Israel visited NETL in early August to discuss potential R&D cooperation in coal and power. Israel is considering U.S. coal-based technologies such as IGCC and carbon capture and storage as part of a clean energy strategy to meet future electricity demand. In addition to touring the sequestration-related research facilities at NETL, the delegation visited the University of North Dakota Energy and Environmental Research Center, Lawrence Berkeley National Laboratory, and FE-supported enhanced coalbed methane project sites near Navajo City, New Mexico, and in Marshall County, West Virginia.

NETL Signs Agreement with Poland

In June 2008, the Office of Fossil Energy's National Energy Technology Laboratory (NETL) signed a Memorandum of Understanding with Poland's Central Mining Institute (CMI) and Institute for Chemical Processing of Coal (ICHP) for RD&D cooperation across a broad range of technologies for clean coal power generation and advanced coal conversion. The agreement was signed by NETL's Director Carl O. Bauer, Professor Jozef Dubinski, CMI's Director General, and Dr. Marek Sciazko, ICHP's Director. Cooperation will focus on advanced coal combustion, gasification, and emission control; carbon capture, storage, and transport; coal conversion to produce hydrogen, chemicals, chemical feedstocks, and liquid fuels; underground coal gasification; chemical looping; and advanced materials. The agreement also provides for consultation on the formation of a Polish Clean Coal Technology Center.

Both CMI and ICHP have been in existence for over 50 years. CMI is an R&D organization that serves the needs of Poland's industrial enterprises, including the mining industry. Services range from research planning and small-scale R&D to advanced coal technology development, economic impact analyses, and full-scale project implementation. CHP is focused on delivering innovation and knowledge to make Poland's carbochemistry, energy, mining, and waste processing sectors more energy efficient and to improve their competitive position. ICHP is striving to be recognized throughout the European Union (EU) as a center of technological innovation for coal processing.

Coal accounts for well over 90 percent of Poland's primary energy production. In 2006, Poland produced 171 million short tons – which ranked it eighth among coal producers worldwide – and consumed 155 million short tons. As member of the European Union (EU), Poland has been reducing its pollutant emissions and increasing the contribution of renewable energy to its energy portfolio according to EU schedules. Poland has adopted a number of measures in the past few years to help lower its energy and carbon intensities to Western levels, including various energy-saving initiatives at the local level. Cooperation with NETL under this agreement is an integral component of the warm bilateral relationship that the United States and Poland have enjoyed since 1989, and should help Poland further progress towards EU environmental regulatory compliance.

Active PPII and CCPI Project Status

PPII Status

CONSOL Energy Inc. – *Greenidge Multi-Pollutant Control Project*. Several series of tests were conducted to measure the performance of the unique combination of emissions control systems installed in Unit 4 of the AES Greenidge plant. Analysis and reporting of the results of those tests are in progress. Preliminary reports have been excellent, and it is expected that the project will be completed by the October 18, 2008 end date of the cooperative agreement. (Dresden, NY)

CCPI Status

MEP-I LLC (Excelsior Energy Inc.) – *Mesaba Energy Project*. Excelsior's application for pre-construction site environmental permits continues to proceed through the Minnesota Public Utilities Commission (MPUC) approval process. The application includes requests for a large electric power generating plant site permit, routing permits for a high voltage transmission line and natural gas pipeline, and air and water appropriation permits. The U.S. DOE and the Minnesota Department of Commerce are currently addressing comments made on the draft Environmental Impact Statement (EIS). Minnesota has an EIS-equivalent requirement associated with the site environmental permitting process under its Power Plant Siting Act. The final EIS is expected before the MPUC site decision. The MPUC is separately considering Excelsior's petition for approval of a Power Purchase Agreement (PPA) with Xcel Energy, under the MN Innovative Energy Project and Clean Energy Technology statutes. The MPUC has not issued a final ruling, but has directed Excelsior and Xcel to enter into a dialogue with other Minnesota utilities to determine, by May 2009, their interest in participating in the PPA. (Itasca & St. Louis Counties, MN)

NeuCo, Inc. – *Integrated Optimization Software*. NeuCo has successfully completed its operational phase. Project goals included reducing NO_x emissions and increasing efficiency and availability. NO_x emissions and ammonia consumption have been reduced to a point significantly below the target values. Substantial heat rate and availability benefits were also attained. The final technical report and post project assessment are complete and posted on the NETL website. (Baldwin, IL)

We Energies – *TOXECON™ Retrofit for Mercury and Multi-Pollutant Control*. Mercury removal average for 2008 has been greater than 90 percent. This level of removal has been obtained by using both neat and halogenated powdered activated carbon (PAC) at injection rates nominally between 1.0 and 1.5 lb/mmacf. The Trona injection report has been completed by ADA. The goal of 70 percent SO_2 removal was achieved. Further, a Trona injection rate capable of removing 74 percent of the incoming SO_2 required a three-fold increase in PAC injection rate to maintain 90 percent mercury removal. The report is available on the NETL website. The continuous emission monitoring system for mercury is performing well, routinely passing daily calibration checks with very few maintenance issues. Searching for additional markets for TOXECON ash has ADA-ES looking at conductive concrete applications as well as to advanced concrete additives. A conductive concrete pad will be installed at the Presque Isle Plant to evaluate structural integrity. Several polymer-based air entrainment additives have been recently tested that show promise to allow high LOI concrete to be used in transportation-based applications. WE Energies and United Conveyor Corp. continue to investigate the potential for further reduction in fugitive dusting during the ash unloading process. The level of dusting has decreased dramatically since project inception. (Marquette, MI)

Western Greenbrier Co-Generation (WGC), LLC – *Western Greenbrier Co-Production Demonstration Project*. DOE's involvement in Western Greenbrier Co-Production Project ended effective June 14, 2008. WGC had been unable to generate private sector funds for its share of the Phase 2 project construction and demonstration costs. In an effort to allow the project to move forward, DOE had granted several amendments to Phase 1 (Project Definition) providing 33 months of additional time and over $2 million of additional DOE funding. (Rainelle, WV)

Great River Energy (GRE) – *Lignite Fuel Enhancement*. GRE is installing four dryers on Unit 2, and four more on Unit 1 with its own funds. Thus, the entire Coal Creek Station is being retrofitted with lignite coal dryers. GRE has completed fabrication of the eight full-scale dryers for both units. Dryer shells have been assembled on the ground and lifted to the respective dryer floors. Dryer baghouses have also been installed. GRE completed lifting and placing four fans for Unit 2 dryers. Installation of the coal dryer system control room for both units was initiated. (Underwood, ND)

NeuCo Inc. (formerly Pegasus Technologies) – *Mercury Specie and Multi-Pollutant Control*. The project team has begun neural net development for combustion optimization using the CombustionOpt module. Initial results indicate that mercury is

correlated with NO_x, CO, burner tilt, and SO_2. Development of a mercury optimizer contained within the CombustionOpt module will begin once sufficient neural network knowledge is obtained. The neural network optimizers will automatically tune plant-wide systems for mercury capture optimization. Multi-variable process controller testing continues with all manipulated variables in service. Ready Engineering has modified the coal feeders and scales to improve coal rate and coal quality control. With all instruments and devices in place, the plant will be able to select coal and coal blends, and accurately meter and characterize the coal. (Jewett, TX)

Southern Company Services, Inc. – *Demonstration of a Coal-Based Transport Gasifier*. DOE has agreed to relocate the demonstration project. Southern Company, through its affiliate Mississippi Power, plans to develop an air-blown Integrated Gasification Combined Cycle (IGCC) power plant demonstration project utilizing a coal-based transport gasifier. The demonstration plant will be built in Kemper County, Mississippi, and generate electricity using Mississippi lignite. An Environmental Impact Statement will be prepared for this new site and the Public Scoping Meeting was scheduled for Tuesday, October 14, 2008, in DeKalb, Mississippi. (Kemper County, MS)

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1000 Independence Avenue
Washington, DC 20585-1290

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