

CLEAN COAL TODAY

A NEWSLETTER ABOUT INNOVATIVE TECHNOLOGIES FOR COAL UTILIZATION

NEWS BYTES

The Office of Fossil Energy (FE) has a new Assistant Secretary. Dr. James J. Markowsky was confirmed by the Senate on August 7, 2009. In November, James F. Wood was named the new Deputy Assistant Secretary for Clean Coal ([see box on page 5](#)). Other new key staff are Christopher A. Smith, Deputy Assistant Secretary for Oil and Natural Gas, and Michelle Dallafior, Senior Policy Advisor. ♦

FE's progress under the American Recovery and Reinvestment Act of 2009 (ARRA) is summarized on page 5 of this issue. The most recent accomplishment is the selection of three major projects under the Clean Coal Power Initiative, announced by Secretary of Energy Steven Chu on December 4, 2009. Projects are the Mountaineer CCS Demonstra-

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SEQUESTRATION REGIONAL PARTNERSHIPS REVIEW YEAR-END PROGRESS

The Regional Carbon Sequestration Partnerships annual review meeting, held November 16–19, 2009, in Pittsburgh, drew 170 participants to discuss progress by the seven Partnerships over the past year. The Department of Energy-led Partnerships encompass more than 350 organizations and span 43 states and four Canadian provinces. Since 2003, they have been engaged in developing region-specific answers to carbon capture and storage (CCS) issues and have identified a variety of storage opportunities. Over the four days, partners provided status reports on over a dozen completed injection projects throughout the United States and Canada. A half day was spent on specific plans of new teams awarded sequestration training grants under the American Recovery and Reinvestment Act of 2009 (ARRA). The National Energy Technology Laboratory (NETL) reported progress in outreach, including Best Practice Manuals, and a new, user-friendly mapping website.



Gerald Hill (SECARB) discusses the Regional Partnerships' first commercial-scale project

The Regional Partnership activity is part of DOE's overall sequestration program, designed to achieve 90 percent capture at the source with the least possible increase in cost of electricity, and 99 percent storage permanence. Phase III (development) follows earlier efforts in site characterization (Phase I) and validation/field testing (Phase II). At the Program Review, three of the nine Phase III projects were able to report on substantial progress. The Southeast Regional Carbon Sequestration Partnership's (SECARB) Cranfield project reached 1 million tons of CO₂ injection in August 2009, joining four other projects worldwide categorized as commercial-scale. Eighty percent of the Phase II field tests are complete, including seven enhanced oil recovery (EOR) projects, five saline reservoir projects, and four projects storing CO₂ in coal seams. Eleven terrestrial projects were also completed, with promising results. All partnerships emphasized rigorous Monitoring, Verification, and Accounting (MVA) programs incorporated into a risk management strategy.

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... "Partnerships" continued

COMMERCIAL-SCALE PROJECTS

Gerald R. Hill, Technical Coordinator for SECARB, outlined progress at the Cranfield EOR site in southwest Mississippi. The first phase of the project, to last 18 months, is injecting CO₂ into an oil field at a rate of 1.6 million tons per year. Injection is taking place both into the depleted oil reservoir and the downdip saline formation, at depths of two miles. Successful field testing of this "stacked storage" concept took place during Phase II. The CO₂ being injected at the Cranfield site comes from Jackson Dome, a natural source.

SECARB is currently working on a second large-scale injection project at the Citronelle field, which will inject CO₂ from an anthropogenic source — captured flue gas from one of Southern Company's coal-fired power plants near the injection site. The anthropogenic test is on track to begin in 2011 and last four years. The Citronelle and Cranfield injection sites are situated in the Gulf Coast wedge. It is estimated that the formation could be used to store 50 percent of CO₂ produced in

the SECARB region for the next 100 years. Hill emphasized SECARB's innovative "toolbox" of MVA techniques for the extreme depths. The network of pressure sensors will be used to optimize the CO₂ injection for storage and oil recovery, as well as serve as an early warning system if CO₂ migrates through the thick caprock. Real-time data collected since July 2008 has demonstrated that pressure-response monitoring techniques are cost-effective and can be deployed at a variety of sites.

Another project, described by the Midwest Geological Sequestration Consortium (MGSC), involves storage of 1 million tons of captured CO₂ from Archer Daniels Midland's ethanol plant in Decatur, IL. The target storage formation is Mt. Simon Sandstone, the thickest and most widespread saline reservoir in the Illinois Basin. Injection will begin in late 2010 and continue until 2013, at a rate of 367,000 tons of CO₂/year. According to Robert Finley of the Illinois State Geological Survey, the project is expected to confirm that the Illinois Basin and Mount Simon Sandstone formation could host future commercial-scale storage projects. The injection well has been completed

to a depth of more than 7,200 feet, together with a network of monitoring wells. A geophone array has been permanently installed in a monitoring well and the first Vertical Seismic Profiles (VSPs) will be acquired concurrent with a baseline 3D seismic survey.

Later, VSPs will be used for plume monitoring.

The Plains CO₂ Reduction Partnership (PCOR) reported on its project in British Columbia, which enjoys significant provincial support. Plans are to inject CO₂ from the Ft. Nelson gas processing plant into a brine-saturated carbonate formation. Edward N. Steadman of PCOR and the Energy and Environmental Research Institute, noted that there are 1,300 natural gas processing facilities in the U.S. and Canada, and many are candidates for CCS. CO₂ capture is at little or no cost, he said, since many of these plants are already removing CO₂ and hydrogen sulfide from the natural gas as part of their regular operation. PCOR has drilled a characterization well and will be drilling an injection well this winter. Plans are to inject CO₂ at a rate of 1.8 million tons/year, starting in late 2011. A second PCOR Phase III project would transfer success of Gulf Coast CO₂ EOR to the Rockies. At Bell Creek Field, Montana, 14 million tons of CO₂ are to be sequestered, and 35 million incremental barrels of oil produced. According to Steadman, the project is on track for 2012 injection.

PHASE II NEARS COMPLETION

The Phase II projects have produced valuable results in terms of validating that CO₂ storage is possible in different basins and geologic structures, oil reservoirs, saline formations, and coal seams throughout the United States and Canada.

In one project in Williston Basin, PCOR injected CO₂ into a depleted oil field in a huff n' puff operation. Test results indicated that large-scale injection of CO₂ in deep carbonate



The Midwest Geological Sequestration Consortium's Illinois Basin-Decatur site injection well during logging operations (Photo by Daniel Byers for the MGSC)

reservoirs can be safe and economic. Another PCOR project at Zama Oil Field in Alberta is combining EOR with storage of CO₂-rich acid gas in pinnacle reefs.

Injection of CO₂ into saline formations also advanced. One project discussed was the Midwest Regional Carbon Sequestration Partnership's Cincinnati Arch project, in which CO₂ was injected into the Mt. Simon sandstone formation, on the site of Duke Energy's East Bend Power Plant in Kentucky. Other saline formation injection projects, completed in the Michigan Basin and along the Gulf Coast, also demonstrated commercial potential.

Unmineable coal seams can be another excellent storage location for CO₂, especially with added value of coal bed methane production. The Southwest Regional Partnership on Carbon Sequestration (SWP) completed an 18,000-ton injection project at the Pump Canyon Test Site in New Mexico's coal bed methane-rich San Juan Basin. This project, along with others completed in North Dakota, Illinois, and Virginia, point to potential commercial opportunities.

One field test sequesters CO₂ in a unique and not-well-understood resource, the basalt formations of the Pacific Northwest. The Big Sky Carbon Sequestration Partnership's Grande Ronde Basalt project will inject 1,000 tons of supercritical CO₂ in the spring of 2010 and study rates of mineralization. Estimates are that a large percentage of injected CO₂ can be completely mineralized over 100 years. Project sponsors have undertaken a community outreach program, including an internship program, which has been effective in gaining support.

SEQUESTRATION TRAINING

The program review also functioned as the "kick-off" meeting for the seven awardees, who received approximately \$7 million in funding under the ARRA to conduct regional sequestration technology training projects. These projects are intended to train professionals and students in the growing field of CCS. The goal is to become self-sustaining after three years of DOE funding. To this end, participants are devising business plans and working to attract sponsors.

The training will utilize some common elements, including teaching modules, seminars/webinars, web sites, and newsletters. However, there are a variety of approaches being taken. The New Mexico Institute of Mining and Technology would start with elementary education through middle and secondary school, and include teaching modules for community colleges. The Southern States Energy Board plans "CCS Camps" for students. The University of Texas at Austin would target professionals already in the workplace, or the unemployed possessing the required skills. Professional society meetings could be one of many venues for training. Texas would also emphasize teacher professional development and train-the-trainer systems to maximize exposure to CCS. The University of Wyoming's program targets scientists and engineers, with a combination of formal classroom and distance learning techniques.



L to R at poster reception: Barbara Altizer of the Eastern Coal Council, Cathy St. Clair, Consol Energy/CNX Gas, and Kathryn Baskin, Southern States Energy Board

NEW OUTREACH

Best Practice Manuals are key to disseminating knowledge gained by DOE and its partners from Regional Partnership activities and other domestic and international research and development (R&D) programs. In 2009, Manuals were published on MVA, as well as Public Outreach and Education. A Manual on Site Characterization is due out in 2010. Presentations also featured the latest developments in NETL's Atlas, which is based on the NATCARB database. The third edition of the Atlas is being developed, and is transitioning to a Google Earth-viewer format in order to make the data more user-friendly. A new NETL website http://www.netl.doe.gov/technologies/carbon_seq/natcarb/ makes the Atlas easy for non-GIS users. Users would be able to download layers to create their own maps, or contact natcarb.maps to ask for a custom map.

Proceedings for the annual program review can be found at <http://www.netl.doe.gov/publications/proceedings/09/RCSP/> ■

NETL LEADS SCIENCE-BASED RISK ASSESSMENT FOR CCS

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) is cooperating with other DOE labs on the National Risk Assessment Program (NRAP), a new effort building on prior industry and laboratory risk assessment experience and applying it to the new field of carbon capture and storage (CCS). The goal is to integrate scientific insight being developed across the sequestration research community, and ensure development of the science base necessary for risk assessment (including strategic monitoring) in support of successful large-scale storage projects. NRAP leverages the broad experience of the DOE national labs to provide a base for integration of multi-organizational research efforts, identify key technical gaps, and provide technical assessments of critical issues. This NETL-led effort includes researchers from Los Alamos, Lawrence Berkeley, Lawrence Livermore, and Pacific Northwest National Laboratories.

Experience with CO₂ enhanced oil recovery efforts in the Permian Basin of West Texas since the early 1970s, along with shorter-duration, large-scale sequestration operations under way internationally, suggest that a well-characterized geologic site can be engineered to store CO₂ indefinitely. Ensuring the efficacy of large-scale CO₂ storage requires accurate predictions of the movement and reactivity of CO₂ in a reservoir, while monitoring each site strategically to verify the predictions of the site's performance. Formal, science-based risk assessment will identify vital data elements and incorporate them into a decision making framework for stakeholders, such as operators, insurance providers, regulators, policymakers, NGOs, and the public.

Through workshops and working groups, NRAP participants have evaluated gaps in current scientific knowledge in order to target specific areas for collaborative research. Tools such as software, including expert elicitation and systems models; instrumentation for monitoring; and best practices, will be adapted for the new field of CCS. Thus far, the NRAP working groups have identified five primary focus areas: wellbore integrity, natural seal integrity, groundwater systems, strategic monitoring for risk assessment, and systems modeling for science-based risk assessment.

One of the topics identified for initial study, closely related to all five focus areas, is the coupled effect of fluid flow (particularly during injection) and geochemical responses in the reservoir. Supercritical CO₂ is more compressible and less viscous than water, ideally allowing it to be injected at higher pressures without fracturing the reservoir. Accurate prediction methods would allow injection at optimum pressure for more efficient operation, without adversely affecting flow paths. Multiphase fluid flow and geomechanical responses have not been traditionally modeled together, except in fairly simple ways, and the new work aims to find better methods of examining these interactions, with the goal of preserving both seal and wellbore integrity.

Fluid flow and subsequent chemical reactions in the reservoir will also be studied to determine whether a pre-existing flow path will open or close over the long term due to changing stress on the fractured rocks, or as a result of

chemical dissolution or precipitation. Some field observations suggest that flow of CO₂-saturated brine along an open pathway in ordinary cement, for example, might have the positive impact over time of sealing a pathway as minerals dissolve and re-precipitate. Research performed by the NRAP will verify this phenomenon and determine which conditions are favorable to precipitation, and which to dissolution.

The NRAP working group ranked improved monitoring techniques as another priority in the ability to assess and reduce risks. Time-lapse 3-D seismic surveys have been able to detect changes in a reservoir that correspond to the displacement of brine by CO₂. However, the deeper the formation, the lower the resolution of seismic images, and the larger the amount of CO₂ required before detection. NRAP researchers will develop and evaluate techniques for quantifying the amount of CO₂ that can be detected and for improving the resolution of seismic detection. They will also develop new strategies for the real-time integration of monitoring data within a model of the sequestration system, the reservoir where CO₂ is injected, reservoir seals, and nearby freshwater aquifers. By incorporating field measurements, individual process models will be updated and verified, helping to improve quantification of the probability of unwanted events.

As the NRAP develops findings and recommendations, the Regional Carbon Sequestration Partnership sites will provide an ideal opportunity for applying and validating the new risk-assessment tools. ■

NEW FE OFFICIALS

Dr. James J. Markowsky is the Office of Fossil Energy's new Assistant Secretary. His long career parallels the development of important clean coal technologies. In the 1970s, he managed the pressurized fluidized bed combustion development program for American Electric Power Service Corporation (AEP). He occupied increasingly senior positions at AEP and served as Executive Vice President from 1996 until 2000. Most recently, Dr. Markowsky was a consultant in energy and electric power, a member of the National Research Council's Committee on America's Energy Future, and a Member and Chair of the National Academy of Engineering's Electric Power/Energy Systems Committee. Markowsky holds a PhD in Mechanical Engineering from Cornell, and a Master's degree in Industrial Management from MIT.

Markowsky and James F. Wood, New Deputy Assistant Secretary for Clean Coal, are colleagues of long standing.

Wood also has over 30 years experience in the power industry. Most recently, he was President and CEO of Babcock Power Inc., a major U.S.-based designer/manufacturer of combustion equipment. Before that, Wood was President of Babcock & Wilcox. He resided abroad for significant periods of time and was responsible for B&W's foreign subsidiaries and ventures in China, Turkey, Egypt and Indonesia. Wood also served as President of WTI International Inc. and Managing Director of Wheelabrator Environmental Systems. Wood was appointed to the National Coal Council by three Administrations, and was a member of the U.S.-Egypt President's Council, an advisory body to Vice President Al Gore. He is also an ASME Fellow and a Trustee of Clarkson University. He holds a B.S. in Chemical Engineering from Clarkson, an MBA with a focus on international economics from Kent State, and a master's and PhD in mechanical engineering from Cornell.



Assistant Secretary Markowsky (left) and Deputy Assistant Secretary Wood (right)



FE TECHLINES PROVIDE STIMULUS FUNDING DETAILS

Techlines (press releases) on the Office of Fossil Energy (FE) website (<http://www.fossil.energy.gov>), as well as FE's American Recovery and Reinvestment Act of 2009 (ARRA) website <http://www.fossil.energy.gov/recovery>, detail progress made in competitive solicitations under the ARRA, for which FE has received \$3.4 billion. ARRA represents an unprecedented effort to jumpstart our economy, create or save millions of jobs, and put a "down payment" on addressing long-neglected challenges so our country can thrive in the 21st century. Below is a list of developments and corresponding Techline dates.

Five Notices of Intent (NOI) to Issue Funding Opportunity Announcements (FOA) were published May 15, 2009. The *Clean Coal Power Initiative (CCPI)* NOI, and later FOA, culminated in the selection of three projects (December 4). ARRA funding was also provided for the Hydrogen Energy California, LLC CCPI project with a cooperative agreement signed (November 6). Another ARRA-supported CCPI project selected for award is Basin Electric Power Cooperative (July 1). The *Industrial CCS* NOI culminated in 12 new project selections (October 2). Separately, ARRA funds were used for two existing projects: Ramgen (August 10), and Arizona Public Service's algae-based project (September 15). The *Site Characterization* NOI resulted in awards for 11 projects (September 16). *Geological Sequestration Training* has been a two-pronged effort (August 27 and September 16). In-depth articles will be available in later issues of *Clean Coal Today*. ■

NEW CARBON CAPTURE CENTER TO CONTINUE PSDF SUCCESSES

The Power Systems Development Facility (PSDF) in Wilsonville, Alabama is a long-standing, successful partnership between the U.S. Department of Energy (DOE) and Southern Company Services, and for almost 15 years has tested new gasification, gas cleanup, and coal feed systems. In May 2009, DOE announced the establishment of the National Carbon Capture Center (NCCC), headquartered at the PSDF. Technology development will include both pre- and post-combustion CO₂ capture.

CO₂ capture represents some 90 percent of total carbon capture and storage (CCS) costs, so development of lower-cost pre- and post-combustion technologies is vital to any strategy to reduce CO₂ emissions. The new carbon capture activity will make use of pilot-scale equipment already in place, as well as new pre-combustion slipstream testing facilities at the PSDF. A new flexible test module for post-combustion testing is to be installed at Plant Gaston, a coal-fired power plant operated by Alabama Power Company that is adjacent to the PSDF. The ultimate goal is to test technologies in commercial scale integrated gasification combined cycle (IGCC) or advanced combustion processes. In addition to the NCCC operator Southern Company Services, partners to date include American Electric Power, Luminant, Peabody Energy, Arch Coal Inc., Rio Tinto, EPRI, and NRG Energy.

AN INTEGRATED TEST BED SINCE 1995

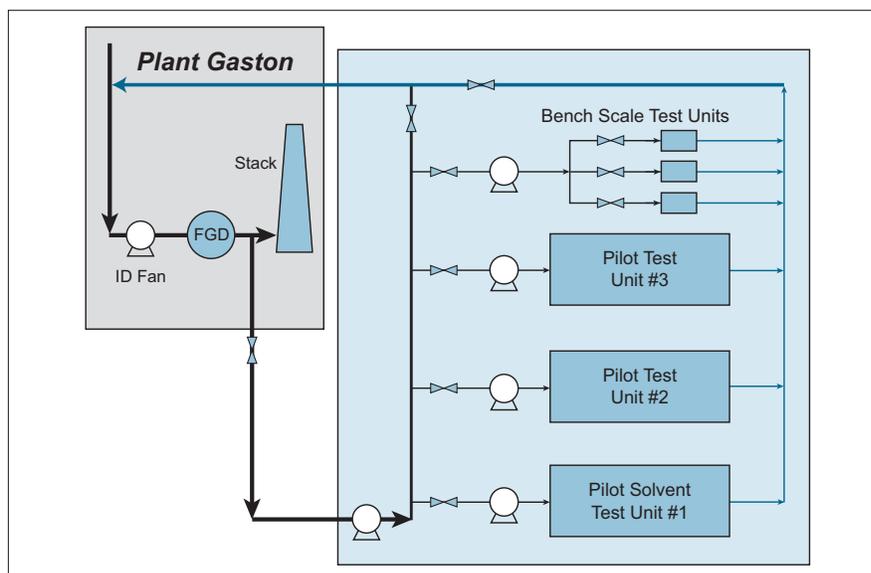
The PSDF is a unique test facility—large enough to produce commercially representative data on the major components required for a commercial plant, but small enough for economic operation. Over the years, major achievements have included a hot gas filtration system to improve energy efficiency, and a gasifier optimized for low-rank coal but suitable for a wide range of coals. The latter has been commercialized as the Transport Integrated Gasification Reactor (TRIG™). The transport reactor can be operated in both combustion and gasification modes, using both oxygen and air as oxidant. The technology holds sufficient promise to have been selected for commercial-scale demonstration at a Clean Coal Power Initiative project in Kemper County, Mississippi.

In addition to developing a new gasifier system, the PSDF has provided test support to a variety of organizations developing coal-based technologies or components. Researchers have examined syngas cleanup techniques, particularly for hazardous pollutants; high-efficiency

filter elements to remove dust from high-temperature, high-pressure syngas and flue gas; and safeguard devices to isolate filters in the event of failure. Additionally, a planar solid oxide fuel cell was operated on syngas, while innovative sensor, gas analysis, and coal feed systems were also developed.

TECHNOLOGY DEVELOPMENT AT THE NCCC

A strategic objective of DOE's Advanced Power Systems program is to create public-private partnerships that develop technology to ensure continued economic production of electricity from the nation's extensive fossil fuel resource, including control technologies that permit reasonable-cost compliance with emerging regulations. The NCCC supports this objective by conducting research and development to advance emerging CO₂ control technologies for effective integration into commercial coal-fired power plants.



A facility for testing post-combustion CO₂ capture technologies is being built to operate on a slipstream from Plant Gaston, a pulverized coal power plant located adjacent to the PSDF in Wilsonville, Ala. Multiple slipstreams will be available for testing a variety of candidate processes.

Component integration exposes new technologies to the requirements and rigors of real plant operating conditions, and allows them to be scaled up with confidence to commercial demonstration. In addition to obtaining performance data, this approach identifies process development needs in preparation for commercial application. Also, the semi-commercial scale of the NCCC allows investigation of the maintenance, safety, and reliability issues of a technology at a cost that is far lower than that of commercial scale testing.

Partners at NCCC are in the process of evaluating available CO₂ capture technology to identify candidates for the test plan. Test equipment at the PSDF includes the engineering-scale KBR transport reactor, a Siemens hot gas filter using candle-type filter elements, syngas cooling, and high-pressure solids-handling systems. For pre-combustion, there is need to test alternative solvents with lower heats of regeneration, and develop more compact, lower cost equipment, as well as provide a test-bed for the scaleup of advanced technologies.

Post-combustion testing at Plant Gaston would be designed to support multiple parallel test bays in order to test candidate processes at the appropriate scale. The test facility will be managed by NCCC personnel, and will investigate the effects on coal-derived flue gas of a wide range of flue gas flowrates and varying process conditions. For research and development projects that have been successfully tested at bench-scale in a research lab, the NCCC will provide a 1,000 lb/hr flue gas slipstream for screening tests. For technologies that have been successfully tested at the screening-scale, the NCCC will provide a flue gas stream for

pilot-scale testing. Two pilot-scale technologies can be accommodated at the same time. Design has begun on the first pilot-scale unit, a versatile pilot solvent test unit (PSTU) designed for a 5,000 lb/hr (0.5 MW equivalent) flue gas slipstream

to test advanced solvents. A second pilot-scale slipstream unit is projected to be available in a couple of years for an advanced process that will be selected through a technology screening process. Advanced solvents, sorbents, and emerging technologies such as membranes are under consideration for testing in the post-combustion module.

WORKING WITH NCCC

Highly trained and experienced NCCC staff members will work with vendors to help develop and improve their technologies. Since technology development is the primary function of the NCCC, testing efforts are not impeded by commercial operating requirements. At NCCC, design engineers develop process and infrastructure modifications necessary to integrate test components into the plant. Operational and maintenance staff members, drawn from the power industry, ensure that the technology is appropriately operated and maintained. Research engineers and scientists collect and evaluate data to develop in-depth understanding of the technology upon which recommendations for design improvements can be made. When necessary, outside specialists are engaged to support data analysis and clarify issues



Plant E.C. Gaston, site for the post-combustion test module

revealed during testing. Vendors' intellectual property is protected by contracts with NCCC.

NEXT STEPS

The major process design is complete for initial infrastructure modifications to provide a test-bed for both post- and pre-combustion capture technology development, and equipment is being ordered. Detailed design of remaining components and balance of plant infrastructure will continue into early 2010. Commissioning of both the pre-combustion testing unit and post-combustion PSTU are scheduled to begin in the third quarter of 2010. Initial operations for both are projected to commence later that year. Technology screening and initial discussions with technology developers are ongoing in collaboration with DOE and private partners. ■

YEAGER AIRPORT HYDROGEN FACILITY

With the goal of making hydrogen a viable energy option, the U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) has sponsored a Hydrogen Fuel Production and Dispensing Facility at the Yeager Airport, in Charleston, WV. The hydrogen is intended for use by airport maintenance vehicles, and by vehicles belonging to the 130th Air Wing of the West Virginia Air National Guard. The facility is the first of three planned along Interstate 79, with the next two facilities planned for Morgantown, WV and Pittsburgh, PA.



Hydrogen Dispensing Facility

The station was designed and built by Parsons in cooperation with NETL. The ribbon-cutting ceremony took place on August 17, 2009, and was attended by congressional and county officials, as well as representatives from the Air National Guard and NETL. Officials had the opportunity to pump hydrogen into a pickup truck, and tour the production and dispensing facilities.

A main goal is to demonstrate the feasibility of hydrogen fuel as a safe and price-competitive alternative to petroleum. With development of hydrogen infrastructure, more hydrogen vehicles could be used, lessening dependence on foreign oil. An environmental plus is the ability for the facility to take advantage of the under-utilized off-peak grid electric power. The Yeager facility is designed as a Research, Development, Test and Evaluation (RDT&E) Platform to deliver hydrogen fuel at petroleum-derived gasoline prices. It is the first openly documented system of its type, and NETL plans a publicly available interactive website for monitoring the facility's performance, reliability and operating costs. Alternative components can also be "swapped in" to the system for testing purposes. Thus, small businesses, universities, and entrepreneurs can validate their innovations in-situ in a fully functional hydrogen energy facility.

The Yeager facility is built with off-the-shelf components to allow for simple facility replication elsewhere. The design is also scalable, with available floor space for a second electrolyzer and other equipment. Three modules are at the site. The first is for hydrogen production, including high pressure hydrogen compression and storage. The electrolyzer uses electricity off the grid, from coal-fired power plants, to split hydrogen

and oxygen from city water. The hydrogen is then compressed up to 6,000 psig. Production capability is 12 kilograms/day (approximately equivalent in energy content to 12 gallons/day of gasoline), with a storage capacity of 50 kg at 6,000 psig. A second module consists of a tube trailer pad for storing hydrogen at medium pressure, i.e. 2,600 psig. The third module is the dispenser pad that utilizes a Krauss hydrogen fuel dispenser (see photo), capable of refueling vehicles at pressures up to 5,000 psig.

The initial vehicles in the three-year test program consist of a Hydrogen Internal Combustion Engine (HICE) Chevrolet Silverado pick-up truck and a hydrogen-fueled fuel cell fork truck. Through financial support provided by NETL, the West Virginia University Research Corporation has agreed to provide and manage four additional hydrogen-fueled vehicles for use by the Yeager airport. Three of these new vehicles will be HICE vehicles that have been converted to operate on either pure hydrogen, or a blend of hydrogen and gasoline. The fourth is planned to be a small utility-

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Major General Allen Tackett of the West Virginia Air National Guard uses a hydrogen fueling pump

HYDROGEN ENERGY CCPI PROJECT

On November 6, 2009, a Clean Coal Power Initiative (CCPI) Round III cooperative agreement was signed by the U.S. Department of Energy's (DOE) National Energy Technology Laboratory and Hydrogen Energy California, LLC (HECA), a venture between BP Alternative Energy, Rio Tinto and Hydrogen Energy International, LLC. The hydrogen-powered project represents the first commercial-scale demonstration of integrated gasification combined cycle (IGCC) technology with carbon capture and storage (CCS).

HECA will design, build and operate a greenfield, commercial-scale, fully integrated advanced IGCC with CCS at a site in Kern County, California. The new plant is anticipated to boost the local economy by creating 1,500 construction jobs and more than 100 permanent operational positions. The project will achieve approximately 90% CO₂ capture efficiency while sequestering some 2 million tons per year for beneficial use in enhanced oil recovery. This is equivalent to taking 350,000 average American cars off the road every year. DOE is providing some \$308 million (just under 11 percent of total costs) with funding from the American Recovery and Reinvestment Act of 2009, toward the sequestration aspect of the project, and total construction costs are estimated at \$2.3 billion. GE gasification technology will be used to generate approximately 250 MW (net) of electricity using a 75% western bituminous coal/25% petroleum coke fuel blend during the two-year DOE Demonstration Phase beginning in 2016.

Captured CO₂ from the IGCC process will be transported via pipeline to the Elk Hills oil field approximately 5 miles away from the HECA site. This beneficial use of CO₂ for enhanced oil recovery (EOR), combined with sequestration, is likely to be a initial model for commercializing IGCC with high levels of CO₂ capture. The Elk Hills oil fields are well characterized fields operated by Occidental of Elk Hills Inc. (OXY). While water/steam floods have been used extensively in California for oil reservoir stimulation, this would be the State's first CO₂ EOR flood.

PROJECT FEATURES

In addition to the advanced IGCC system with CCS, the project employs numerous technological innovations, including hydrogen turbine technology. HECA, in fact, should have the lowest power plant emissions of any commercial solid fuel plant built or under construction. The plant will significantly exceed the emission targets for 2020 established under the Energy Policy Act of 2005,

and would meet stringent air emissions requirements set by California. Plant CO₂ emissions under steady state operations are some 250 lbs/MWh as compared to an average U.S. coal-fired power plant of approximately 2,100 lbs/MWh. This represents a level no commercial coal power plant achieves today. It is also well below California requirements that baseload plants emission rate of greenhouse gases be less than that of a combined cycle natural gas baseload plant (approximately 1,000 lbs/MWh). To achieve these low levels, the Rectisol[®] process has been chosen for acid gas recovery (which removes SO₂ as well as enables CO₂ capture). Rectisol uses cold methanol to physically dissolve acid gases at pressures which match well with the pressures in the gasifier train, so that no energy is lost in decompressing gas for treatment and recompressing it for pipeline transport.

An important environmental plus is the use of local, non-potable brackish groundwater for all process and cooling needs, maintaining area

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Rendition of the HECA Project

... "HECA" continued

freshwater aquifers for agricultural use. HECA will also incorporate a 100% zero liquid discharge system. All project wastewater, including wastewater generated from the IGCC, raw water treatment and cooling tower blowdown will be directed to the zero discharge system, with the recovered water recycled for reuse in the process.

PROGRESS TO DATE

HECA has secured the option to purchase approximately 1,101 acres of land for the project site. The site's location provides close access to utilities and offtake infrastructure. The primary permitting authority, the California Energy Commission (CEC) licenses thermal power plants 50 MW or larger. To date, HECA's application has been found "data adequate," and CEC's final determination is expected in 2011. The National Environmental Policy Act process is also under way and is making use of CEC permitting documentation in order to avoid duplication and drive down costs. The California Public Utilities Commission (CPUC) endorsed Southern California Edison's request for \$30 million funding of a HECA feasibility study. The feasibility study will inform CPUC's decision as to the allowable rate base for the project. HECA has also filed an interconnect request with the California Independent System Operator (CALISO) to provide power to the grid.

The HECA Project Team is composed of professionals sourced from HEI, BP Alternative Energy and Rio Tinto. Fluor Enterprises will act as the engineering contractor for the Project Definition Phase. URS is the

permitting program manager and the site assessment consultant. GE Energy is the supplier of gasification and power generation technology. OXY is the primary CO₂ off-taker and is responsible for EOR operations. ■

... "Yeager" continued

type vehicle that would utilize a fuel cell as the primary power source, or as a means to extend the range of the vehicle. All vehicles will be used to test conversion of traditional gasoline internal combustion engines to hydrogen-fueled engines, promote the awareness of the hydrogen infrastructure, and expand the use of the Hydrogen RDT&E facility. Data on drivability, maintenance, repair, and refueling experiences will be collected from the operator/drivers. Future plans also include the development of training programs for operators, workshops for Fire Marshall code officials, and education and outreach to include hydrogen vehicle demonstrations to government agencies and the general public.

Using West Virginia as a model for other states, the project will educate users, first responders, industry, and the general public, about the safe use of hydrogen and the fossil fuel-to-hydrogen programs, helping to make hydrogen an acceptable energy alternative. ■

... "News Bytes" continued

tion, the Southern Company CCS Demonstration, and the Texas Clean Energy Project. Government share is up to \$979 million, leveraged by \$2.2 billion in private capital. ◆

Clean coal, including carbon capture and storage, will be a research priority under the new U.S.-China Clean Energy Research Center announced on November 17, 2009, by U.S. President Barack Obama and Chinese President Hu Jintao. The Center will be supported by both public and private funding of at least \$150 million over five years. The amount will be split evenly between the two countries. DOE's Request for Information soliciting public input can be found at <http://pi.energy.gov>. DOE intends to issue a Funding Opportunity Announcement in January 2010. ■

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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.



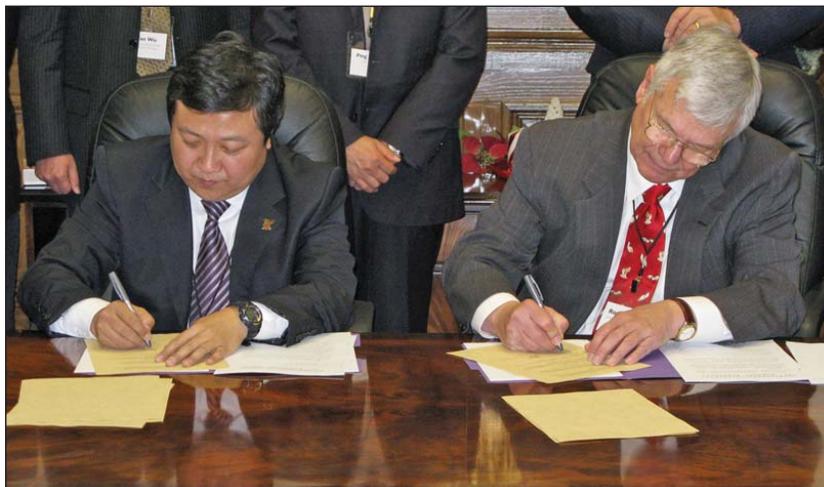
INTERNATIONAL INITIATIVES



WYOMING/SHANXI PROVINCE FINALIZE MOU ON GEOLOGICAL CO₂ SEQUESTRATION

On December 7, 2009, Ronald Surdam, Director of the Wyoming State Geological Survey (WSGS), and Lian Yimin, Director of China's Shanxi Provincial Science and Technology Commission, signed a Memorandum of Understanding (MOU) to undertake joint work reflecting mutual interest in advancing the science and technology of geological carbon dioxide (CO₂) sequestration. The signing was witnessed by Wyoming Governor Dave Freudenthal and Scott Smouse, Senior International Manager at the Department of Energy's (DOE) National Energy Technology Laboratory (NETL). NETL's role stems from participation in the Cleaner Fossil Energy Task Force of the Asia Pacific Partnership on Clean Development and Climate (APP).

The APP is a seven nation public-private partnership designed to build on existing lateral and multi-lateral agreements in order to accelerate deployment of cleaner, more efficient technologies and practices.



Shanxi MOU signing ceremony. Lian Yimin (L) and Ronald Surdam (R)

Both Shanxi and Wyoming are major coal-producing areas. The MOU recognizes that concerns over global climate change could impact coal production and local economies. The MOU calls for selection of CO₂ sequestration sites in Shanxi and Wyoming for

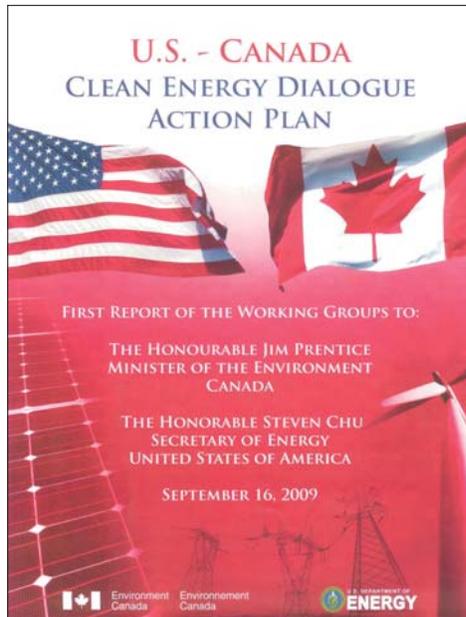
detailed analysis and evaluation. To enhance collaboration and site optimization, the partnership advocates science and technology information exchange through field and site visits. Scientific workshops and other outreach are also envisioned.

One of the cooperative tasks would be delineating the geologic framework, such as stratigraphy and distribution of traps, seals, faults and fractures. Reservoir characteristics, such as porosity and permeability, fluid flow and rock-fluid interactions would also be determined. Scientists will be looking for the value-added potential of enhanced oil or coal bed methane recovery.

WSGS also has an MOU, signed in June 2009, with the neighboring Chinese province Shaanxi, on similar cooperation. That work is headed by the Shaanxi Institute of Energy Resource & Chemical Engineering with the support of the Shanxi Provincial Development and Reform Commission. For that effort, the U.S. Department of State has agreed to provide funding for a prefeasibility study for capturing and storing CO₂ from an existing coal-to-methanol plant in the Ordos Basin.

U.S. – CANADA CCS COLLABORATION

Carbon capture and storage (CCS) is a key area for cooperation under the Clean Energy Dialogue, a cooperative effort launched by President Obama and Canadian Prime Minister Stephen Harper last February in Ottawa. The two leaders met again in September 2009 and received the *U.S.-Canada Clean Energy Dialogue Action Plan*, developed by working groups under Secretary of Energy Steven Chu and Canadian Minister of the Environment Jim Prentice. Focus areas in the Plan include CCS, the electricity grid, and clean energy research and development (R&D) in advanced biofuels, clean engines, and energy efficiency.



The Action Plan recognizes the high degree of integration between Canadian and U.S. economies and energy markets, and the need for aggressive action on climate change. With regard to CCS, increased bilateral cooperation could shorten the timeframe for deployment and encourage cross-border regulatory and policy approaches. CCS technology would also allow both countries to make use of indigenous fossil fuels, enhancing energy security while mitigating effects of climate change.

Joint CCS activities have been under way for some time. The U.S. partners with Canada, the International Energy Agency, and other international partners in the Weyburn-Midale project in Saskatchewan. The provinces of Alberta, British Columbia, Manitoba, and Saskatchewan are participating in the Plains CO₂ Reduction Partnership, one of the DOE-led Regional Partnerships. British Columbia also participates in the West Coast Regional Carbon Sequestration Partnership.

New activities under the U.S.-Canada CCS Collaboration will build on these efforts. The *Carbon Sequestration Atlas of the U.S. and Canada* would be expanded to include the whole of Canada. Separately, DOE is also working to add Mexico to the Atlas database. For next-generation technologies, joint research and research exchanges will take place between the DOE-supported national laboratories, Energy Frontier Research Centers, and Natural Resources Canada Canmet laboratory. Additionally, the projects at Weyburn-Midale and Fort Nelson (British Columbia) will increase their efforts in CO₂ injection and storage testing. Canada and the U.S. will also share information, best practices, and lessons learned from large-scale demonstrations at coal-fired power plants and other sites, such as the oil sands in Alberta. Efforts will be made to develop compatible rules, standards, and monitoring for CCS projects in order to facilitate cross-border activities and minimize business barriers. The plan calls for an annual bilateral CCS conference to provide an opportunity for updates on Plan activities. The U.S. will host the first bilateral conference in May 2010. Also in May, a special track on U.S.-Canada CCS collaboration will be added to the 9th Annual Conference on Carbon Capture and Sequestration being held in Pittsburgh, PA. In 2011, the bilateral conference would meet in Canada.

More details will be emerging to formalize the CCS Collaboration under the Trilateral Energy Science and Technology Agreement with Canada and Mexico. The full text of the September 2009 Action Plan can be found at <http://www.energy.gov/news2009/8019.htm>.

DOE SECRETARY CHU ADDRESSES CSLF MINISTER'S MEETING

In a letter to government ministers at the Carbon Sequestration Leadership Forum (CSLF) meeting in London, UK, Secretary of Energy Steven Chu urged widespread, affordable deployment of carbon capture and storage (CCS) technology. This call to aggressive action, he said, was directed not only to his fellow Energy Ministers at the meeting, but to DOE's own laboratories and to scientist and industry partners around the world. According to Chu, President Obama and the U.S. have already embarked on the largest government investment in CCS of any nation in the world – more than \$4 billion, to be matched by \$7 billion from U.S. industry (see sidebar).

The London meeting, held October 11–14, 2009, was the third Ministerial-level conference of the CSLF since its formation in 2003 by the Ministers of 14 charter members. At the Ministerial meeting, Poland was welcomed as the 24th CSLF member. Ten new projects were added to the CSLF roster of “recognized projects,” bringing the total to 30 worldwide that have been scrutinized and approved by the CSLF Policy and Technical Groups.

Following their meetings, the Ministers in London issued a communiqué which emphasizes the viability of CCS as a key mitigation strategy deserving acknowledgement in international agreements. Ministers urged delegates at the United Nations Framework Convention on Climate Change (COP-15), to recognize the importance of CCS. The communiqué also addressed the importance of deploying CCS in developing countries, as well as globally. Cooperation and knowledge-sharing among countries is crucial, and to that end the communiqué announced the establishment of a formal capacity-building program within CSLF to be led by the Capacity Building Task Force under the CSLF Policy Group.

Capacity building involves developing information and tools to define, evaluate and realize CCS opportunities, and fostering skills to implement and regulate CCS. Part of the activity is ensuring participation of key players: government agencies, industry, financial institutions, academia and research groups, and other stakeholders. For several years CSLF has been aware of the importance of capacity building, especially for emerging economies. In the 2007-2008 time frame, six capacity building workshops were held in the U.S., Brazil, Mexico, and Saudi Arabia. The new, more formal program anticipates more of these outreach activities, with expectation of greater country participation and funding.

For further details, see the website maintained by DOE's Office of Fossil Energy (FE), which acts as the CSLF Secretariat, www.cslforum.org. For up-to-date information on FE's stimulus efforts (American Recovery and Reinvestment Act of 2009), see <http://www.fe.doe.gov/recovery/index.html>.

DOE'S CCS EFFORT

*As outlined by
Secretary Chu,
October 12, 2009 (approximate totals)*



- Commitment of more than \$1 billion for the FutureGen project
- \$1.4 billion for five commercial demonstrations at coal-fired power plants
- \$1.3 billion for five industrial retrofit demonstrations
- \$100 million for innovative concepts for beneficial CO₂ use
- \$50 million for evaluation of geological formations
- \$20 million for training grants to develop highly skilled workforce
- \$400 million for research funding in 2010
- \$500 million continuing investment over 10 years for sequestration science and monitoring
- U.S. China Energy Research Center coordination

ACTIVE PPII AND CCPI PROJECT STATUS

PPII STATUS

CONSOL Energy Inc. – *Greenidge Multi-Pollutant Control Project.* The Final Technical Report for the Greenidge Multi-Pollutant Control Project has been approved. The report is a comprehensive overview of the project, including concept and goals, design, construction, operations, testing, results, and conclusions. This highly successful project concluded on October 18, 2008, having achieved all of its emissions reduction goals. The demonstration project was conducted at the 104 MWe coal-fired AES Greenidge Unit 4. The multi-pollutant control system includes a hybrid selective non-catalytic reduction (SNCR) / in-duct selective catalytic reduction (SCR) system to reduce NO_x emissions, followed by a circulating fluidized bed dry scrubber system to reduce emissions of sulfur dioxide (SO₂), sulfur trioxide (SO₃), hydrochloric acid (HCl), and hydrofluoric acid (HF). Mercury (Hg) removal was also achieved via the co-benefits afforded by the in-duct SCR, dry scrubber, and baghouse. Performance targets included NO_x reduction to ≤0.10 lb/mmBtu, ≥95 percent removal of SO₂, SO₃, HCl, and HF, and Mercury removal ≥90 percent. Actual measured results were a NO_x emission rate of 0.10 lb/mmBtu, SO₂ removal of 96 percent, Hg removal of 94–98 percent, SO₃ removal in the range of 95 to 97 percent, and HCl removal of 97 percent. HF concentrations were typically at or below detection limits. (Dresden, NY)

CCPI STATUS

HECA – *Commercial Demonstration of Advanced IGCC with Full Carbon Capture.* On September 29, 2009, DOE awarded a cooperative agreement to Hydrogen Energy California LLC (HECA) to build and demonstrate a hydrogen-powered electric generating facility, complete with carbon capture and storage, in Kern County, California. HECA, which is owned by Hydrogen Energy International, BP Alternative Energy, and Rio Tinto, plans to construct a fully integrated advanced integrated gasification combined cycle (IGCC) plant that will produce power by converting fuel—a blend of 75 percent coal and 25 percent petroleum coke—into hydrogen and carbon dioxide (CO₂). The hydrogen will be used to fuel a combustion turbine enabling net generation of 250 megawatts of electricity. Approximately 90 percent of the CO₂ produced from the gasification process, or some 2 million tons per year, will be transported via pipeline to the Elk Hills oil field, less than 4 miles away. There it will be sequestered in the same underground formations used for EOR. The estimated capital cost for the project is approximately \$2.3 billion. The federal cost-share is limited to \$308 million, or approximately 10.9 percent of the total project costs. The project consists of three phases: Project Definition (Phase I), Design and Construction (Phase II), and Demonstration (Phase III). Sequestration of 2 million tons per year of CO₂ will begin by 2016. (Kern County, CA)

Great River Energy (GRE) – *Lignite Fuel Enhancement.* GRE has installed four dryers on Unit 2 as part of the Clean Coal Power Initiative project. Due to success obtained in the prototype phase of this project, GRE has installed four more dryers on Unit 1 with its own funds. Thus, the entire Coal Creek Station has been retrofitted with lignite coal dryers. GRE has

completed the dryer construction for each of the two 546-MW units and the common coal crusher building at the Coal Creek Station in North Dakota. GRE has completed checkout testing of dryer equipment and auxiliaries. The functional check-out testing of the equipment includes hydro-testing, water flushing, balancing and vibration testing of fans and motors, loop testing of instruments, checking drives of conveyor belts, bumping motors, checking rotation, and charging water systems to check for leaks. In December 2009, commercial operation of the integrated dryer system for both 546 MW units has been initiated at full load, meeting a major project milestone. The demonstration is scheduled to be completed by March 31, 2010. The individual dryers are operating satisfactorily reducing the lignite coal moisture, and the plant personnel are observing reduced flue gas flows across the downstream equipment. (Underwood, ND)

MEP-I LLC (Excelsior Energy Inc.) – *Mesaba Energy Project.* Excelsior's application for pre-construction site environmental permits—including requests for a large electric power generating plant (LEPGP) site permit, routing permits for a high voltage transmission line (HVTL) and natural gas pipeline, and air permit and water withdrawal permit—continues to proceed through the Minnesota Public Utilities Commission (MPUC) approval process. The Final Environmental Impact Statement (EIS) was released in November 2009. In December 2009, the Administrative Law Judge recommended that Excelsior's application for a power LEPPG Site Permit, a HVTL Route Permit, and a pipeline Route Permit for the West Range Site should be granted by the MPUC. (Itasca & St. Louis Counties, MN)

NeuCo Inc. (formerly Pegasus Technologies) – *Mercury Specie and Multi-Pollutant Control*. The project is in the final budget period (BP3), the demonstration phase. The project host site (NRG Texas Limestone Plant) is operating with all optimization systems in place. HgOpt, which consists of multiple optimizer subsystems, enables plant-wide optimization of mercury and other objectives. A Virtual On-Line Analyzer (VOA) has been successfully validated using collected mercury data. The VOA enables estimation of mercury production and removal rates for occasions when actual mercury measurements are unavailable. Analysis completed during the first quarter of the demonstration phase, including data from before BP3, showed NO_x reductions of 11 percent, with a commensurate reduction in total mercury emissions. Other benefits included a 24 percent reduction in CO and a 0.15 percent boiler efficiency improvement. BP3 is scheduled to end May 31, 2010. (Jewett, Texas)

We Energies – *TOXECON™ Retrofit for Mercury and Multi-Pollutant Control*. The Final Technical Report and the Final Public Design Report were approved. The project concluded on December 31, 2009. During three years of demonstration testing, the technology removed an average of more than 90 percent of the mercury contained in the flue gas from three 90 MW units firing subbituminous Powder River Basin coal. Expectations for annual removal from the Presque Isle plant alone are 97 pounds of mercury and 32 tons of fine particulate matter. The TOXECON™ process resulted from research by DOE, the Electric Power Research Institute (EPRI), and other project partners. It received a 2003 R&D 100 Award as one of the 100 most significant new technologies of that year. Mercury in flue gas exists primarily in elemental form as a vapor insoluble in water and, as such, will pass through most types of

other air pollution control devices. TOXECON™, through its use of activated carbon, can effectively capture both elemental and oxidized mercury. The process is particularly important to Michigan, where a new rule calls for power plants to reduce mercury emissions by 90 percent before 2015. With this successful demonstration, the process is in the position to become the primary mercury control choice for western coals, especially in units with a “hot-side” electrostatic precipitator. In addition, the process is able to maintain “value-added” fly ash as a cement additive. (Marquette, MI)

Southern Company Services, Inc. – *Demonstration of a Coal-Based Transport Gasifier*. 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 generate electricity using Mississippi lignite. This project will incorporate 67 percent CO₂ capture and sequestration via enhanced oil recovery. The Notice of Availability of the Draft Environmental Impact Statement was published in the Federal Register on November 6, 2009, and the NEPA Public Hearing was held on December 1, 2009, in DeKalb, Mississippi. The public comment period ended on December 21, 2009, and the comments are currently being reviewed. Preparation of the Final Environmental Impact Statement is under way. (Kemper County, MS)



U.S. DEPARTMENT OF ENERGY
FE-20
1000 INDEPENDENCE AVENUE
WASHINGTON, DC 20585-1290



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