

CLEAN COAL TODAY

A NEWSLETTER ABOUT INNOVATIVE TECHNOLOGIES FOR COAL UTILIZATION

PROJECT NEWS BYTES

October 2000 proved to be a record-setting month at **Air Products Liquid Phase Conversion Company's Liquid Phase Methanol (LPMEOH™) Demonstration Project** in Kingsport, Tennessee. Significant milestones in the production of methanol were achieved. A new monthly production record of 2.5 million gallons was set as production rates at or exceeding nameplate capacity of 80,000 gallons per day were maintained for 23 continuous days. The previous monthly record for methanol production was 2.1 million gallons set in September 1998. In addition, methanol production rates as high as 93,850 gallons per day were also achieved for shorter periods of time during this record-setting month. These rates surpassed the 93,000 gallons per day record

See "News Bytes" on page 3...

IN THIS ISSUE

New Power Plant Initiative	1
Project News Bytes	1
Early Entrance Coproduction	2
Carbon Products Consortium	4
FE's Sequestration Program	6
Upcoming Events	8
CO ₂ Sequestration Conference ...	8
CO ₂ Capture Test Network	9
International Initiatives	10
R&D Milestones	13
Status of CCT Projects	14

CONGRESS ENACTS NEW POWER PLANT IMPROVEMENT INITIATIVE

On October 11, 2000, Congress enacted Public Law 106-291, Appropriations for the Department of Interior and Department of Energy (DOE). The law included the Power Plant Improvement Initiative — a new DOE Office of Fossil Energy effort to demonstrate advanced coal-based technologies for both existing and new power plants. The conference report accompanying the law recognizes that coal currently supplies more than half the nation's electric power, is plentiful, low-cost, reliable, and important to our economic and energy security.



Robert Kripowicz, Acting Assistant Secretary for Fossil Energy, described the new Power Plant Improvement Initiative to the National Coal Council.

Under the initiative, the government would provide \$95 million for advanced coal projects, with industry putting up a cost-share of at least 50 percent. The solicitation will follow the governing provisions of the Clean Coal Technology Program and the associated principles, such as real and intellectual property rights and technical project management residing with industry. There also is a repayment provision for licensing, sales, or leasing of the technology for both domestic and international markets. The advanced coal technologies must represent near-term commercialization possibilities and can include coproduction of heat, fuels and/or chemicals, as well as technologies that utilize coal waste products such as coal fines. The conference report further states that the technologies funded must offer advancements in efficiency, environmental controls, and cost competitiveness well beyond today's power plants or those that have been demonstrated.

In a speech before the National Coal Council in November 2000, Robert S. Kripowicz, the DOE Acting Assistant Secretary for Fossil Energy (FE), elaborated on FE's goals under the initiative and future plans. He noted that the Initiative enjoyed bi-partisan support and "...signals [that] our national decision makers are looking for ways to strengthen the reliability of our infrastructure. It recognizes that coal is part of the equation." Most recent appropriations supporting FE's Vision 21 and carbon sequestration programs seem indicative of their receptivity to a "broader range of options," Kripowicz noted.

See "Initiative" on page 2...

...Initiative continued

According to Kripowicz, higher gasoline and heating oil prices have rekindled awareness of the importance of energy in our lives. Many energy analysts had felt gas turbines were sufficient to meet the relatively low annual growth in demand. More recent data shows that energy demand has increased in the past two years from 2 to 3 percent per year, causing analysts to rethink their position. According to Kripowicz, the Initiative will help achieve the two vital goals of extending the life of existing plants and "squeezing more efficiency out of them," as well as accelerating introduction of new plants.

Congress directed DOE to establish clear technical and financial criteria for selection of projects. Kripowicz noted that time frame, as well as capacity factors, will be important. "[Congress] did not underscore the words 'next few years,' but I will. That is what we will be looking for — technologies that can extend the life of existing power plants, squeeze out higher generating efficiencies several or more percentage points, be applicable to new plants, and ensure that we extract the full benefits of coal in meeting *near term* reliability concerns.... We also want to look at technologies that provide a higher capacity factor from existing plants, although Congress didn't explicitly cite this in its report."

DOE issued a Draft Request For Proposals on December 6, 2000. Comments are due by January 5, 2001. A public Comment and Response session was held in Pittsburgh, Pennsylvania on December 15, 2000. Final selections will be made shortly after September 30, 2001. The full text of Kripowicz's remarks can be found at <http://www.fe.doe.gov>, then click on Events and Remarks, and finally, click on FE speeches.

EARLY ENTRANCE COPRODUCTION PLANT ADVANCES WITH FINAL AWARD

The U.S. Department of Energy (DOE) Office of Fossil Energy (FE) has announced the final project to be awarded under an Early Entrance Coproduction Plant solicitation issued in February 1999. Several interesting concepts for a precursor to a multi-product 21st century energy facility now are taking shape.

This award to Waste Management & Processors Inc. (WMPI) of Gilberton, Pennsylvania is a \$7.8 million grant for feasibility studies, research and development, and an engineering design for one of the Early Entrance Coproduction Plants. These advanced multi-product plants are envisioned to be able to produce electricity, along with such energy products as liquid transportation fuels, chemicals, and hydrogen. They optimize the economics of coal utilization, while producing clean fuels capable of complying with stricter environmental regulations. The facility proposed by WMPI would gasify anthracite waste with the resulting syngas subsequently converted into a high-quality, zero-sulfur transportation fuel. Diesel-powered cars and trucks operating on this fuel will produce much lower levels of exhaust pollutants such as soot and ozone-forming nitrogen oxides. Nexant Inc., an affiliate of Bechtel National Inc., Texaco Global Gas and Power, and SASOL Technology Ltd., are partnering with WMPI.

WMPI was one of three projects selected under the 1999 solicitation. Global Energy and Texaco Inc., earlier awardees, have begun their projects, with each planning to use different gasification and gas-conversion processes to coproduce a clean fuel and power from fossil feedstocks such as coal and petroleum coke. DOE will cost-share the projects through the preliminary engineering phase. The WMPI project will be built on a 20-acre site in the heart of the anthracite mining region of northeast Pennsylvania. Currently, two circulating fluidized-bed boilers at the site, also fired by anthracite waste, provide steam to produce 80 MW net power. The steam is sold to local institutions.

In WMPI's new coproduction project, anthracite waste will be fed as a slurry to a Texaco gasifier. The synthesis gas, composed of carbon monoxide and hydrogen, would then be cleaned to remove sulfur and other impurities. A concentrated carbon dioxide stream would be produced, and potentially could be sequestered, significantly reducing greenhouse gas emissions from the plant. The portion of the synthesis gas not used for power would be fed to a Fischer-Tropsch (F-T) reactor for liquid fuel production, and would be supplemented with hydrogen from either a methane steam reformer or a water-gas-shift reactor. The reactor uses proprietary SASOL technology with a slurry-phase reactor that produces F-T products. These products are sent to a liquids recovery unit for conversion to fuel gas while the wax is sent to a hydrocracker to produce a combined 5,000 barrels per day of naphtha and diesel. The heat derived from the gasification and fuel-making processes will be used to generate steam. Net electricity output is about 50 MW.

In the Global Energy Inc. project, the company will apply its gasification process to the Air Products and Chemicals Inc. Liquid Phase Methanol technology, which produces methanol from coal-based feedstocks. Both technologies are associated with successful Clean Coal Technology (CCT)

Program projects — the **Wabash River Coal Gasification Repowering Project**, and the **Commercial-Scale Demonstration of the Liquid Phase Methanol Process**. Siemens Westinghouse will lend its expertise in advanced turbines, while Methanex will help produce and market the chemical-grade methanol, to be used by Dow Corning and Dow Chemicals.

The Texaco project, partnered with Brown & Root Services, GE Power Systems, and Praxair Inc., involves feeding a coal slurry into Texaco's gasifier to produce clean fuel, steam, and electricity. The synthesis gas is desulfurized before being channeled into a gas turbine combined-cycle unit and fed to an F-T reactor. Liquids produced in the reactor will be upgraded into diesel and naphtha. Sulfur removed from the synthesis gas is converted to and exported as sulfuric acid. The complex also exports medium pressure steam to an adjacent facility. Gas turbines are driven by fuel gases produced by the

gasification and F-T sections. The products are electricity and hot exhaust gases.

Opportunities for coproduction facilities are plentiful. In addition to power generation and transportation fuel production for new facilities, the system could repower existing inefficient power plants or be inte-

grated into refineries and chemical plants to clean up waste by converting it into marketable products. The process can improve a coal plant's efficiency by 25 percent and offer a fuel that, in engine tests, has been shown to substantially reduce hydrocarbon, carbon monoxide, and particulate (soot) exhaust emissions when compared to today's diesel fuels.

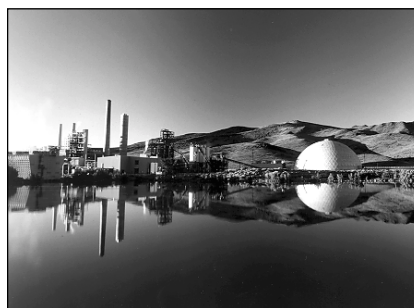


Wabash River Generating Station, site of the Global Energy Inc. Early Entrance Coproduction Plant project, will integrate the Liquid Phase Methanol technology being demonstrated in the Kingsport, Tennessee CCT project.

...News Bytes continued

established shortly after start-up in April 1997. The LPMEOH™ Process Demonstration Facility has produced over 70 million gallons of methanol, all of which has been accepted by Eastman Chemical Company for use in downstream chemical processes.

In October 2000, Sierra Pacific Power Company announced that it has agreed to sell its Tracy/**Piñon Pine** Station to WPS Power Development, Inc., a wholly-owned subsidiary of WPS Resources Corporation of Green Bay, Wisconsin. The sale price of the asset bundle, which includes the Tracy Plant, Piñon Pine, and other smaller generation facilities, was \$249.8 million. Sierra anticipates the sale to close in May



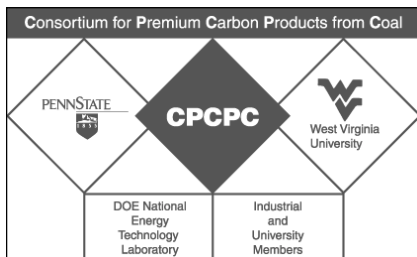
2001. Currently, the Piñon Pine Plant is not operating due to damage to the hot gas filter vessel and the filters. The Piñon Pine Clean Coal Technology project is scheduled to end January 1, 2001. The plant continues to operate normally in the gas-fired combined-cycle mode.

An announcement was made in September 2000 that Westmoreland Coal Company agreed to acquire

Montana Power Company's coal business unit for \$138 million in cash. The transaction includes the purchase of three of Montana Power's coal businesses, including Western SynCoal LLC. SynCoal owns and operates the patented coal-enhancement facility known as the **Advanced Coal Conversion Process Demonstration** facility, a DOE Clean Coal Technology project located at the Rosebud Mine in Colstrip, Montana. In 1999, Western SynCoal LLC sold 269,000 tons of enhanced coal. The two other coal businesses purchased by Westmoreland include coal mining operations in Texas and Montana. The transaction is expected to be completed by year's end and is subject to various contingencies, including regulatory approvals.

CARBON PRODUCTS CONSORTIUM REVIEWS ACCOMPLISHMENTS AND FUTURE RESEARCH

In October 2000, the industry-led Consortium for Premium Carbon Products from Coal held its semi-annual meeting to review significant accomplishments achieved since the organization's inception in June 1998 and to select new research projects for 2001. This industry-driven group supports and conducts research and technology transfer focused on the development, commercialization, and promotion of technologies needed to produce competitively priced premium carbon products from coal or coal-derived feedstocks. The Consortium is providing a focal point for industry, academia and the government to join together in investigating non-fuel technologies for coal.



Led by The Pennsylvania State University (Penn State), West Virginia University (WVU), and DOE's National Energy Technology Laboratory (NETL), the Consortium is composed of more than 50 members from industry and academia who identify, select and co-fund projects with the most potential. Members include: anthra-

cite and bituminous coal producers, manufacturers of speciality carbon and graphite products, activated carbon producers, municipally owned water treatment facilities, carbon fiber and composite producers, aluminum producers, carbon black and coal tar pitch producers, battery manufacturers, coal-fired electric utilities, and academia. Each member appoints a representative to an Advisory Committee, which serves as a steering committee for the Consortium. A Council, which includes seven elected industrial members as well as representatives from Penn State, WVU, and NETL, evaluates and selects research projects solicited from the Consortium membership. These are funded on a 50 percent cost-share.

The Consortium is currently supporting projects for utilizing coal to make products such as activated carbons, low-cost carbon fibers, carbon foams, carbon anodes, and specialty carbons. New and emerging markets for these carbon products include activated carbon filters and beds for water pollution control; carbon-based materials for batteries, fuel cells, and for other energy storage devices; surface transportation applications such as lightweight chassis components for highly efficient vehicles; and civil infrastructure applications for repair and retrofit of buildings and bridges.



Activated carbon treatment tanks, in Redlands, California, being tailored for the removal of perchlorate from water.

As improved manufacturing processes open new markets for carbon products and their derivatives, demand for carbon materials is expected to increase in both traditional and new markets. As costs for carbon products come down, more such products are expected to enter into commodity markets. The declining quality of petroleum-based feedstocks and their uncertain supply in a competitive market, will contribute to the trend toward use of alternative feedstocks. Coal is the most likely feedstock because of its high initial carbon content, low cost, and abundant domestic supply.

For 1999 and 2000, the Consortium selected and funded 19 projects, many of which have shown significant promise. As a result of their October 2000 meeting, the Consortium selected 8 new research projects for funding. In one of these, researchers from Penn State, in collaboration with U.S. Filter, will continue their demonstration of the versatility and efficacy of coal-based activated carbons in purifying drinking water. Recent tests at Penn State have shown that when coal-based



Graduate student Brian Bland, with the pilot plant he constructed in the carbon products program of West Virginia University's Department of Chemical Engineering. The plant generates up to 20 pounds of coal-derived pitch per day, the starting point for carbon foams, speciality coke, mesophase pitches, and carbon fibers.

activated carbon is properly tailored to carry some positive charge, its capacity for adsorbing perchlorate and other negatively charged ions from water can be enhanced. Perchlorate is of concern to the water industry since it may be contaminating some drinking water sources, and there are few other economically viable and health-appropriate methods for removing it to sufficiently low levels (i.e., <18 parts per million). Penn State tests have also shown that perchlorate can be desorbed from the activated carbon with chemical regeneration, allowing the activated carbon to be reused. This approach may also prove to be effective in removing other contaminants from water.

Lower cost has also been demonstrated in producing carbon fibers for use in future transportation vehicles. Consortium-sponsored research by MER Corporation is entering

its third year. Thus far, MER has demonstrated that coal tar pitch can be processed for producing graphite fibers equivalent to or superior to commercial graphite fibers produced from polyacrylo-nitrile (PAN) and petroleum. Low cost is achieved through the elimination of a time-consuming and costly thermal treatment step used in producing graphite fibers from coal tar pitch. This process simplification has led to the potential of coal tar pitch fibers being produced at less than \$5 per pound, as opposed to the \$10–18 per pound cost of fibers produced from PAN and petroleum. Lowered costs make it possible for the vehicle industry to commercially utilize lightweight graphite

fibers in making auto body parts. In the new project just awarded, MER will more fully evaluate the use of coal tar pitch in a continuous fiber production line to verify commercial potential of the process. If commercially successful, MER estimates that a potential 25–60 million tons of coal per year could be utilized to produce high-quality fibers for transportation industry applications.

At the October meeting, West Virginia University presented a progress report on its efforts with Alcoa to develop an all-coal carbon anode for the aluminum industry, and was selected by the Consortium to build on this research. Previous work has shown that pre-hydrogenation and solvent extraction of coal under carefully controlled conditions is an effective technique for producing low-ash, coal-derived binder pitch and coke suitable for making anodes for the aluminum industry. Petcoke,

normally used for this purpose, are declining in quality. They contain vanadium and nickel metals that catalyze detrimental oxidation processes within the anode in the aluminum electrolysis cell and result in shorter service life and higher emissions of carbon dioxide. In the new project, coal-derived pitches and cokes will be made at West Virginia University and supplied to Alcoa and Koppers Industries, where test anodes will be produced and evaluated. Low levels of trace metals such as vanadium and nickel, and lower sulfur content in an all-coal anode, should extend the service life and also decrease emissions coming from smelting operations.

Penn State is also working on coal-based anodes for aluminum electrolysis. In a new project, Penn State is teaming with Alcoa and PrepTech, Inc. to investigate a co-coking process that involves the simultaneous co-carbonization of coal and petroleum-derived decant oil in a delayed coker.

In other projects, the Consortium is supporting research to: study production of carbon-based electrodes with select electrical, thermal, and mechanical properties to improve performance of lithium-ion batteries and fuel cells; study the use of anthracite coals as feedstocks for producing binder pitches and carbon fibers; and evaluate cleanability of fly ash carbons from coal-fired power plants, to be used as feedstocks for premium carbon products. For information on the Consortium and associated research, check the web site (<http://www.energy.psu.edu/cpcpc>) or e-mail cpcpc@ems.psu.edu.

FOSSIL ENERGY'S CO₂ SEQUESTRATION PROGRAM GAINS MOMENTUM

Low-cost, reliable energy services are a foundation of the nation's economic prosperity. A major challenge is to reduce greenhouse gas emissions from electricity generators, and one method receiving increased attention is carbon sequestration. In November 2000, world leaders were unable to reach consensus on the Kyoto Protocol while meeting in The Hague for the Sixth Conference of Parties (COP-6). Meanwhile, the U.S. Department of Energy (DOE), Office of Fossil Energy (FE) has taken a proactive approach in developing a long-term response to climate change, more than tripling its sequestration budget — from \$6 million in FY 2000 to almost \$19 million in FY 2001.

In 1998, DOE significantly expanded the Carbon Sequestration Program with the vision of bringing certain sequestration concepts to the point of deployment. U.S. industry has expressed strong interest in the program through overwhelming responses to solicitations accompanied by offers of significant cost-sharing. Advances in technology have been achieved and several companies have identified carbon sequestration applications that offer significant collateral benefits.

The scope of the FE Carbon Sequestration Program is broad. It includes separation and capture of CO₂; storage of captured CO₂ in geologic formations or in the oceans; conversion of CO₂ to benign solids, fuels, and useful products; and enhancement of carbon storage in natural sinks, such as forests and farms. Carbon sequestration includes options where CO₂ is captured *directly* from a large point source of CO₂ emissions as well as concepts where CO₂ is captured *indirectly* from the atmosphere to offset dispersed emissions.

All program activities strive toward reducing the cost of capturing and sequestering carbon. The long-term goal is to achieve \$10/ton of avoided net costs for sequestration, while ensuring that large-scale carbon storage does not produce any negative environmental impacts.

CO₂ CAPTURE AND SEPARATION

The Carbon Sequestration Program is focused on creating cost-effective CO₂ capture options for the sizeable fleet of existing coal and natural gas-fired generation assets in the United States. CO₂ capture options available today are expensive to build and consume a significant amount of energy (see *CO₂ Capture RD&D Test Network Created*, on page 9).

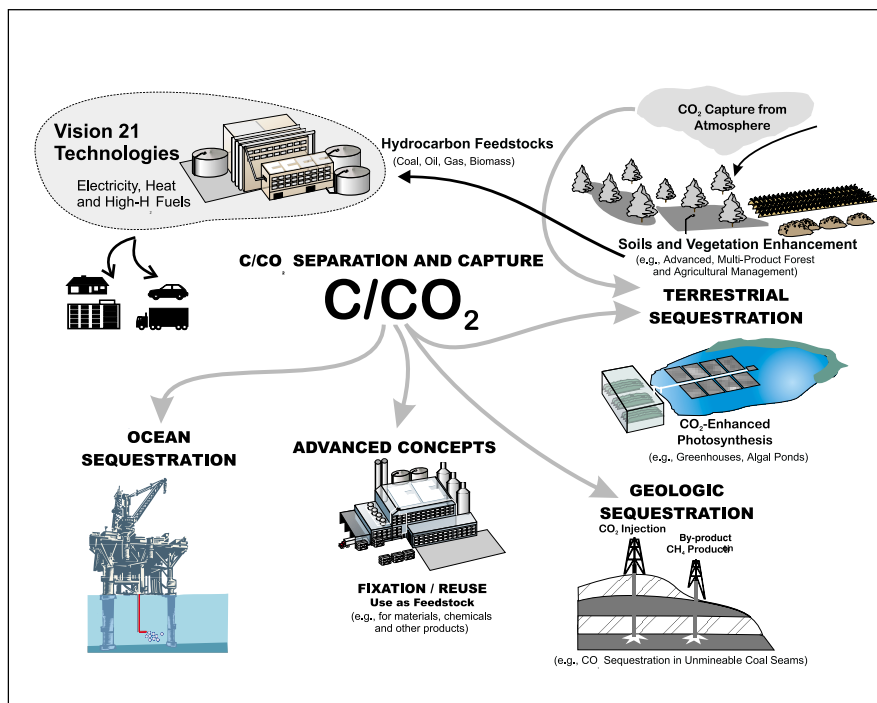
The program is funding several promising research efforts to develop new technologies. In one project, researchers at Nextant Inc., the Los

Alamos National Laboratory, and Simeteche are developing a process that removes CO₂ from flue gas by bringing it into contact with water at low temperature and high pressure. The process forms hydrates, ice-like complexes of water and CO₂ molecules. Other interesting CO₂ capture technologies being explored include a vortex tube gas/liquid conductor, sodium-based CO₂ sorbents, and palladium membranes.

CO₂ STORAGE IN GEOLOGIC FORMATIONS

The primary objective of research on geologic sequestration is to verify that storage in underground formations is secure and environmentally acceptable. Depleted oil and gas reservoirs have contained fluids over geologic time frames. Still, it is necessary to verify the efficacy and acceptability of underground CO₂ storage through rigorous scientific experimentation.

In one project, Sandia National Laboratory and Strata Production Company are preparing to field test the concept of storing CO₂ in de-



pleted oil and gas reservoirs. As part of a three-year test, up to 10,000 tons of carbon dioxide will be injected into non-producing oil wells in the West Pearl Queen oil field in Southeast New Mexico. Scientists will closely monitor the field to determine how the injected CO₂ travels through the reservoir and to verify that it will remain sequestered.

Injection of CO₂ into certain geologic repositories can enhance the recovery of valuable hydrocarbon resources, as in enhanced oil recovery (EOR) and enhanced coal bed methane recovery (EGR). However, traditional CO₂ injection techniques for EOR and EGR are designed to *minimize* the amount of CO₂ that remains trapped in the ground. An opportunity exists to alter injection techniques to *maximize* the amount of CO₂ sequestered — thus meeting the program objectives for cost-effective sequestration and providing an economic incentive for industry participation. Working with industry, the program is exploring value-added geologic sequestration options in the San Juan basin in New Mexico, the Black Warrior Production Fairway in Alabama, and the Shradler Bluff on Alaska’s North Slope.

CARBON SEQUESTRATION IN TERRESTRIAL ECOSYSTEMS

Terrestrial ecosystems are widely recognized as major biological scrubbers for CO₂. Terrestrial sequestration is defined as either the net removal of CO₂ from the atmosphere, or the prevention of CO₂ emissions from leaving terrestrial ecosystems. One approach is revitalizing land degraded by mining, highway construction, or poor management so that trees and other vegetation can flourish — thus sequestering carbon in the form of both plant matter and soil carbon. Focus is being given to the use of coal combustion by-products and other solid waste materials in restoring damaged soils. In one project, the Tennessee Valley Authority (TVA) and EPRI have teamed to investigate the use of solid by-products from the flue gas desulfurization unit at TVA’s Paradise Station plant to amend nearby coal mine spoil land. In another effort, researchers at the University of Texas at Austin’s Bureau of Economic Geology and others are studying ways to reclaim mine land in Appalachia. These activities could produce three-way wins where carbon is sequestered, landfill space is conserved, and a habitat for plants and animals is reestablished.

OCEAN SEQUESTRATION

In the area of ocean sequestration, the program is conducting two field tests. One, being conducted in the Monterey Bay will provide information on the stability of CO₂ hydrates in the deep ocean. The other, being conducted off the coast of Hawaii, will provide information on the fate, transport, and potential environmental impacts of injecting liquid CO₂ into the mid ocean (see *International CO₂ Ocean Sequestration Field Experiment*, on page 10).

LONGER-TERM R&D

Applied research is being conducted into advanced concepts for CO₂ conversion and storage in the oceans. Research projects include conversion of CO₂ to biomass via algae, conversion of CO₂ to hydrocarbons via cyanobacteria, and catalyzing the natural reaction of CO₂ with rocks to form solid compounds called mineral carbonates.

Carbon sequestration is a new and exciting field of research with possible strategic implications for major users of coal, oil, and natural gas. As such, the First National Conference on Carbon Sequestration is certain to be a groundbreaking event (see page 8).

Range of Estimates for CO₂ Sequestration in U.S. Geologic Formations

Geologic Formation	Capacity Estimate (GtC)
Deep saline reservoirs	1-130
Natural gas reservoirs in the United States	25 ^a 10 ^b
Active gas fields in the United States	0.3/year ^c
Enhanced coal-bed methane production in the United States	10

a Assuming all gas capacity in the United States is used for sequestration

b Assuming cumulative production of natural gas is replaced by CO₂

c Assuming that produced natural gas is replaced by CO₂ at the original reservoir pressure



UPCOMING EVENTS

– March 5–8, 2001 –

26th International Conference on Coal Utilization & Fuel Systems

Location: Clearwater, Florida
Sponsor: ASME-FACT, CTA, DOE/NETL

Contact: Barbara A. Sakkestad
Phone: (301) 294-6080
Fax: (301) 294-7480
E-mail: BarbaraSak@aol.com

– March 29–30, 2001 –

Solid State Energy Conversion Alliance (SECA) Workshop

Location: Arlington, Virginia
Sponsor: DOE/NETL

Contact: Kim Yavorsky
Phone: (412) 386-6044
Fax: (412) 386-6486
E-mail: yavorsky@netl.doe.gov

– May 15-16, 2001 –

2001 Conference on Unburned Carbon (UBC) on Utility Fly Ash

Location: Pittsburgh, Pennsylvania
Sponsor: DOE/NETL

Contact: Kim Yavorsky
Phone: (412) 386-6044
Fax: (412) 386-6486
E-mail: yavorsky@netl.doe.gov

– May 16-18, 2001 –

2001 Conference on Selective Catalytic Reduction (SCR) & Selective Non-Catalytic Reduction (SNCR) for NO_x Control

Location: Pittsburgh, Pennsylvania
Sponsor: DOE/NETL

Contact: Kim Yavorsky
Phone: (412) 386-6044
Fax: (412) 386-6486
E-mail: yavorsky@netl.doe.gov

FIRST NATIONAL CONFERENCE ON CARBON SEQUESTRATION



Recognizing the growing momentum behind the concept of carbon sequestration and seeking to foster new industry/government R&D partnerships, the U.S. Department of Energy and the National Energy Technology Laboratory are sponsoring the *First National Conference on Carbon Sequestration* in May 2001 at the Renaissance Hotel in Washington, DC. It will be the first conference of its kind in the United States.

The conference will consist of a combination of plenary sessions, technology track breakout groups, and poster presentations designed to accommodate persons with different levels of familiarity with carbon sequestration technology. This format will provide an opportunity for researchers and scientists to hear about new ideas and experimental results, for industry professionals to assess the strategic role that carbon sequestration could play in their business operations, and for policy makers to learn about this promising new field of study.

Conference topics will include:

- Technology advances in the area of CO₂ capture and separation;
- Domestic field tests where CO₂ will be injected into underground geologic formations;
- Projects being undertaken by power generators to revitalize damaged lands so that trees can be grown on them; and
- Advanced concepts for converting CO₂ to fuels, benign solids, or useful products.

Information can be obtained from the NETL web site (<http://www.netl.doe.gov>). Go to the bottom of the page and click on Events, or contact Kim Yavorsky via e-mail (yavorsky@netl.doe.gov) or phone (412-386-6044).

CO₂ CAPTURE RD&D TEST NETWORK CREATED

On October 11 and 12, 2000, a workshop on establishing an International Test Network for CO₂ Capture, was held at the Hilton Hotel in Gaithersburg, Maryland. The workshop was organized by the International Energy Agency Greenhouse Gas Research and Development Programme (IEA GHG RD), US DOE, and ABB Lummus Global of Switzerland to identify areas for collaborative R&D. In attendance were 42 researchers from 10 countries, representing industry, government, and academia. The workshop focused on CO₂ capture techniques that employ regenerable chemical scrubbing at atmospheric pressure, considered the most mature capture technology.

Acting Assistant Secretary for Fossil Energy, Robert S. Kripowicz, opened the conference by describing progress to develop carbon sequestration technology in the U.S. Kripowicz described the efforts of the Office of Fossil Energy and of DOE's Office of Science to chart a roadmap for research on various carbon sequestration options. He described carbon sequestration as the third leg of the DOE climate change strategy, joining energy efficiency and the use of low- or no-carbon fuels.

Capture of CO₂ represents approximately 75–80 percent of the cost of CO₂ sequestration. Transportation costs are highly dependent on the locations of the capture facility and the storage site. Three capture methods exist: regenerable chemical scrubbing at atmospheric pressure, regenerable physical scrubbing at elevated pressures coupled with hydrogen production, and fossil fuel combustion in a CO₂/O₂ atmosphere. Chemical scrubbing, using monoethanol amine (MEA), is commercially available. The largest industrial application for CO₂ is in the oil and gas industry, for enhanced oil recovery (EOR). The natural CO₂ sources used in EOR are cheaper than exhaust stream CO₂, but their use does not help the carbon disposal problem faced by power plants. Although plants that capture CO₂ from fossil energy sources are currently operating for customers in the food and fertilizer industries, drastic cuts in both energy consumption and plant costs must take place for CO₂ capture to be successfully introduced into the electric utility industry.

Four major areas of collaboration constituting the International Test Network were identified at the meeting: (1) evaluation of the capabilities of current CO₂ scrubbing performance models, (2) development of an analytical framework to perform transparent and consistent analyses of CO₂ scrubbing, (3) improvement of existing scrubbing methods through fundamental research, process development, and systems integration, and (4) initiation of a feasibility study to define the characteristics of a future demonstration plant for investigating advanced CO₂ capture concepts.

Test facilities of differing characteristics currently exist in Australia, Canada, Japan, the Netherlands, Norway, and the United States. The proposed new demonstration plant would make it possible to evaluate all CO₂ scrubbing technologies in an integrated manner and at one site.

The proposed future demonstration plant would likely be a new coal-fired unit in which CO₂ capture is fully integrated into the power generation process. Such a demonstration plant would be built by the year 2007 and

would serve as an international test bed for studying the best available CO₂ scrubbing technology in tandem with other environmental control systems, at a near-commercial scale.

In conjunction with the workshop, attendees made a field trip to the Warrior Run Power Plant, a coal-fired electric generating facility owned by American Electric Services Corporation. The facility is located on a brownfield plant site in the Allegheny County Industrial Park, south of Cumberland, Maryland. The CO₂ scrubbing facility at Warrior Run, built by ABB Lummus Global, represents the current state-of-the-art of gas cleaning technology. The CO₂ produced, which is equivalent to the exhaust from a 3-MWe power plant, is sold to soft drink companies.



State-of-the-art CO₂ scrubbing facility is located at coal-fired Warrior Run Power Plant in Cumberland, Maryland.

The next step for the International Test Network is to obtain expressions of interest from Workshop participants, and secure agreement on the broad principles of a collaboration agreement on CO₂ scrubbing at atmospheric pressure. The network would be established under the auspices of the IEA GHG RD, and the collaboration agreement would be an annex to the IEA agreement.

INTERNATIONAL INITIATIVES

INTERNATIONAL CO₂ OCEAN SEQUESTRATION FIELD EXPERIMENT: 2000 OCEANOGRAPHIC RESEARCH CRUISE

The U.S. Department of Energy and the U.S. Naval Research Laboratory were the primary sponsors of a 7-day oceanographic research cruise that was conducted at the end of October 2000 by the scientific research team of the International CO₂ Ocean Sequestration Field Experiment. This is the second research cruise in preparation for the Ocean Sequestration Field Experiment to take place in the summer of 2001. The Field Experiment is sponsored by government agencies of the United States, Norway, Canada, Australia, and Japan, as well as Japan's Central Research Institute of the Electric Power Industry (CRIEPI). ABB Corporation of Switzerland is the private sponsor. The experiment will inject some 40–60 metric tons of pure liquid CO₂ into the deep ocean about two kilometers offshore of Keahole Point on the west coast of the island of Hawaii in order to improve understanding of underlying physical phenomena and improve the accuracy of predictive computer models needed to evaluate environmental impacts. The previous effort in ocean sequestration in U.S. waters was a small experiment by the Monterey Bay Aquarium Research Institute in deep waters off of California. Public comment has been received and an Environmental Assessment on the Field Experiment should be issued in the near future.



The CTS assembly is used to collect water samples and measure profiles of temperature, salinity, density, and pH versus depth.



The submarine Pisces IV was used on five dives during the October 2000 excursion.

The first research cruise was conducted in August 1999. Ocean current records, temperature, sea water chemistry profiles, and bacterial production data were collected to characterize the site during that cruise. This year's cruise undertook a preliminary sampling of the bottom sediments at a depth of 800 meters, and performed a detailed mapping of the sea floor to pinpoint a best candidate site to conduct the 2001 experiment.

Both the 1999 and 2000 oceanographic cruises employed the 222-foot long University of Hawaii research vessel Ka'imikāio-Kanaloa ("heavenly searcher of the sea"). The manned submersible Pisces IV supported the research effort, which included 20 scientists and engineers from the United States, Japan, Norway, and Canada.

In addition to the technical tasks, the research team took time during the 2000 cruise to host on-board students and teachers from three local high schools and a group of undergraduate students from the University of Hawaii at Hilo. Based on feedback received, this science education effort was a resounding success.

IGCC PROTOCOL WITH INDIA SIGNED



On September 13, 2000, the U.S. Department of Energy (DOE), U.S. Agency for International Development (USAID), India Ministry of Power, and National Thermal Power Corporation (NTPC) signed a Protocol of Intent to conduct a detailed technical and economic feasibility study for setting up a commercial-scale integrated gasification combined-cycle (IGCC) demonstration plant in India. The study will seek to establish the most

suitable IGCC technology for India's coal and environmental conditions; explore possible financing structures competitive in India; and develop an implementation plan for IGCC technology demonstration in India. The agreement was signed for by DOE Deputy Secretary T.J. Glauthier, USAID Deputy Administrator Harriet Babbit, India's Secretary of Power A.K. Basu, and NTPC Director A. Palit. This follows the signing of a Joint Statement on Cooperation in Energy and Environment in New Delhi on March 22, 2000, which articulated both countries' desire to increase their energy and environment cooperation. USAID and NETL are discussing possible IGCC activities to be conducted under the ongoing Greenhouse Gas Pollution Prevention Project.

VIETNAM EMERGING AS A GLOBAL COAL PARTNER

An important milestone was reached with "The 3rd Asia Pacific Economic Cooperation (APEC) Coal Trade and Investment Liberalization Facilitation (TILF) Workshop," which was held in Hanoi, Vietnam on November 8–9, 2000. This event, coupled with a visit by President Bill Clinton to Vietnam in conjunction with the APEC Ministers' summit, marked a growing recognition of Vietnam as an emerging market in the global economy, as well as a market for U.S. technology and clean coal technologies in particular.

The recent Coal TILF Workshop addressed six key issues for Vietnam's existing coal mining industry, facilitating: development of the surface coal mining sector, environmental mine management, the existing coal industry, profitable energy development, development of Vietnam's coal resources, and electricity for economic development.



President and Mrs. Clinton being briefed while visiting an excavation site near Tien Chah, Vietnam during a trip that included President Clinton's attendance at the APEC summit. (Photo by Sharon Farmer/The White House)

Vietnam is the newest member of APEC, joining the organization in 1998. The first time Vietnam participated in this forum was in Tokyo, Japan in February 1999. At an earlier meeting of the Japanese Committee for Pacific Coal Flow International Symposium in 1998, Tran Mien, Mining Master for the Vietnam National Coal Corporation had reported on the coal potential in Vietnam, which has anthracite, semi-anthracite, coking coal, long-flame (brown) coal, lignite, and peat coal. Mien had cited the high calorific value (8,000 kcal/kg on average), low sulfur content (under 0.5 percent), and low volatile matter (under 10 percent) of Vietnamese anthracite coal, which is primarily supplied to heavy industry and power generation facilities. Vietnam's long-flame brown coal is of mean calorific value (4,000–6,000 kcal/kg), with high volatile matter (over 45 percent), and high sulfur content (over 6 percent), and has been used primarily for cement

production. Mien further cited coal import/export facilities, noting in particular two such facilities located at Cua Ong and Hong Gai towns in the Quang Ninh area. Most anthracite deposits are located near Quang Ninh providing a convenient export port. However, facilities there are quite old (using cranes built in 1925) and in need of modernization.

At the time of this presentation, Mien also discussed the environmental aspects of coal operations throughout Vietnam, including the effects on arable lands, as well as forestry lands, impacts on water resources, and the overall impacts on the environment of mining operations and wastes. Noting that environmental protection was a very new field for Vietnam in general, Mien described the country's environmental policy, and efforts to investigate environmental impacts caused by coal utilization in accordance with international standards. Mien also expressed interest in acquiring knowledge and technology to put Vietnam in line with environmental protection efforts in progress throughout the Asia-Pacific region.

INFORMATION EXCHANGE THROUGH ICCR

The 12th International Conference on Coal Research, including a one-day workshop to identify potential collaborative research projects between member countries, was held in Sandton, South Africa in September 2000. The conference was sponsored by the International Committee for Coal Research (ICCR) in association with the South African Institute of Mining and Metallurgy. Several representatives from the U.S. Department of Energy, Office of Fossil Energy (FE) played active roles in the conference and workshop — speaking on environmental issues affecting coal-fired power plants and the role of coal in transportation fuels and chemicals, chairing a session relating to coal characterization, and participating in the research and development (R&D) workshop. The U.S. Geological Survey and the National Institute of Occupational Safety & Health were also important U.S. contributors to the conference.

The ICCR was created in 1973 (in response to that year's oil crisis) for the purpose of promoting coal research. Membership, now at 14 countries (Australia, Belgium, Canada, China, France, Germany, Japan, New Zealand, Poland, Russia, South Africa, Spain, United States, and the United Kingdom), is open to all coal-producing countries with substantial production or consumption, along with environmental control R&D. General Richard Lawson, recently retired President and CEO of the NMA, chaired the ICCR for the last 10 years. The conference is held every three years, and attendance at Sandton included 170 delegates from 13 countries. Robert S. Kripowicz, Acting Assistant Secretary for Fossil Energy, led the FE delegation.

The highlight of the conference was the one-day R&D workshop where the conference organizers sought to promote R&D collaboration among the ICCR countries. A number of breakout sessions were organized around various R&D themes. Of particular interest to FE's R&D Program were breakout sessions on coal classification, characterization, conversion, and combustion; coal processing and fines recovery; and carbon management. A total of 229 candidate projects were submitted by various ICCR countries prior to the conference for consideration by the group. In most areas, opportunities were identified where R&D information could be exchanged, with the goal of developing future collaborative projects. In combustion, gasification, and power generation, the U.S. expressed interest in joining other countries' efforts to match coals with gasifiers; share computer models; study ionic liquids for coal desolution as a precursor to conversion technology; and study low-smoke fuels. In coal processing and fines recovery, the U.S. expressed interest in information exchange on dense media-based fine coal beneficiation, dewatering and agglomeration, and coal preparation simulators.

The carbon management session focused on fugitive emissions and gas extracted from mining, emissions control, and CO₂ sequestration. The U.S. expressed interest in collaborating with other countries in sharing information on coal bed methane production associated with CO₂ sequestration in coal seams, and developing a means to capture and use coal mine methane emissions.

Each ICCR country, having now prioritized its R&D interests, will begin a dialogue with other interested countries on how to begin cooperating. Interested organizations in ICCR countries are invited to talk to their official representative about how they can get involved.

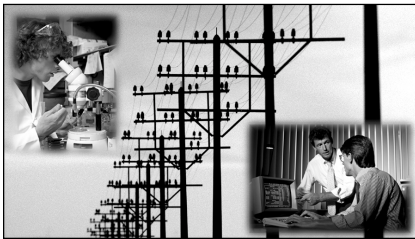


CLEAN COAL TODAY

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

Editor: Phoebe Hamill
Fax: 202-586-1188
Voice: Call through GSA Deaf Relay
1-800-877-8339
and ask for 202-586-6099 (TTY)
Internet: phoebe.hamill@hq.doe.gov
Comments are welcome and may be submitted to the Editor.

R&D MILESTONES



Corn Belt Energy Corporation commits to Low-Emission Boiler System (LEBS) project in Logan County, Illinois. Corn Belt Energy, a member-owned energy cooperative headquartered in Bloomington, Illinois, plans to begin construction in early 2002 of a 91-MWe LEBS proof-of-concept plant near Elkhart, Illinois. The plant includes Babcock Borgig Power's low-NO_x, U-fired boiler equipped with D.B. Riley's low-NO_x slagging combustor, which was developed under a contract with the U.S. Department of Energy (DOE). Total costs are expected to reach \$137 million, with DOE, the Illinois

Department of Commerce and Community Affairs, and the Illinois Clean Coal Board providing a total of \$51 million. The plant, which will be built on land owned by the Turriss Coal Company, is one of several coal-fired power plants currently planned in the United States during this decade. The plant will use approximately 370,000 tons of coal per year. The basic boiler design has been used for 30 years in Europe, but the advanced design features of the combustors, with air and fuel staging, substantially reduce NO_x emissions. The plant will use scrubbers to reduce sulfur dioxide emissions, and air-cooling condensers to reduce water use by as much as 68 percent. This plant is the first application at near-commercial scale of the coal-fired burner technology developed under the LEBS project.

Memorandum of Understanding (MOU) between DOE and DOI to reforest abandoned mine lands. In September 2000, DOE's Office of Fossil Energy signed an MOU with the Department of Interior's Office of Surface Mining (OSM) for cooperation to promote a market-based approach to reclaiming abandoned mine lands through reforestation. OSM has over 600,000 acres of abandoned mined lands. OSM has an ongoing reforestation initiative, while DOE administers a program of voluntary reporting of greenhouse gas reduction under the Energy Policy Act of 1992. The MOU envisions DOE and OSM working together to encourage more privately funded tree plantings, which could in turn result in the reporting of increased greenhouse gas emission reductions under DOE's program. OSM and DOE will share technical information and improve outreach to promote reforestation. A market-based approach is considered to increase the quantity and quality of reclaimed abandoned lands at a reduced cost to taxpayers. Reclaimed land helps to offset effects of climate change by sequestering carbon. Other benefits include restoration of water resources and wildlife habitat, decreased erosion, and establishment of recreational opportunities.

National Energy Technology Laboratory researchers investigate a dry, regenerable sorbent for CO₂ capture. NETL researchers have evaluated the potential of using alkali metals to capture CO₂ from gas streams. These sorbents could be used in various process schemes as an alternative to the more conventional wet scrubbing technique with aqueous amine solutions. Based on analyses that identified the range of temperatures where absorption and regeneration would be thermodynamically feasible, the researchers determined that potassium carbonate would be a viable candidate. This sorbent could be applied downstream of the economizer in a coal-fired power plant at a low absorption temperature (less than 145 °C). Experiments were conducted in both a thermogravimetric analyzer (TGA) reactor and a packed-bed reactor with potassium carbonate sorbent supported on a high-surface area, activated alumina. The results have indicated that CO₂ capture is favored at the low absorption temperature (50–60 °C), with thermal regeneration easily occurring at 150 °C. Researchers are using the data obtained to determine the feasibility of the cyclic process with potassium carbonate at a larger scale. In addition, other sorbents that can withstand the harsh environment of integrated gasification combined-cycle are being investigated.

Researchers investigate using a photoreactor to remove mercury from power plant flue gas. Earlier difficulties with an atomic fluorescence analyzer at NETL suggested that photochemical oxidation of mercury with 253.7 nm radiation is a potential means of removing mercury from flue gases. As a result of this finding, photochemical reactions of mercury with various constituents in flue gas could be an attractive alternative to sorbent or scrubber-based processes for mercury capture. NETL researchers are investigating the photochemistry of elemental mercury in simulated flue gases and the resulting deposition of mercurial compounds. When examined using a quartz flow reactor at temperatures between 80–350 °F and irradiated with 253.7 nm ultraviolet light, mercuric compounds were found to form favorably at lower temperatures. The presence of sulfur dioxide and nitric oxide (additional pollutants in flue gas) was found to enhance the formation of mercuric compounds.

STATUS OF ACTIVE CCT DEMONSTRATION PROJECTS

ENVIRONMENTAL CONTROL DEVICES

Southern Company Services, Inc. – *Demonstration of Advanced Combustion Techniques for a Wall-Fired Boiler.* All testing on the original project has been completed and reported. Phase 4 has been extended 19 months to evaluate use of GNOCIS and other computer programs to decrease NO_x and LOI and increase efficiency by optimizing the use of additional plant equipment, including ESPs and sootblowers. (Coosa, GA)

ADVANCED ELECTRIC POWER GENERATION

City of Lakeland, Department of Water & Electric Utilities – *McIntosh Unit 4A PCFB Demonstration Project and McIntosh Unit 4B Topped PCFB Demonstration Project.* Lakeland Electric continues to evaluate its options to meet future power demand. During this internal review, Lakeland, Foster Wheeler, DOE, and others have been reviewing the system concept, siting, and financial issues in order to improve the project. (Lakeland, FL)

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

Kentucky Pioneer Energy, L.L.C. – *Kentucky Pioneer Energy Project.* Kentucky Pioneer Energy, L.L.C., has replaced the Clean Energy Partners, LP, as the project participant and has moved the site to a new location in Trapp, Kentucky. A Draft EIS will be issued in early 2001. (Trapp, KY)

Sierra Pacific Power Co. – *Piñon Pine IGCC Power Project.* On October 27, Sierra Pacific Power Company announced that it has agreed to sell its Tracy/Piñon Power Station to WPS Power Development, Inc., a wholly-owned subsidiary of WPS Resources Corporation of Green Bay, Wisconsin. The sale price of the asset bundle, which includes the Tracy Plant, Piñon Pine, and other smaller generation facilities, was \$249.8 million.

Sierra anticipates the sale to close in May 2001. Currently the Piñon Plant is not operating because of the hot gas filter vessel and the filters. The project is scheduled to end January 1, 2001. The plant continues to operate normally in the gas-fired combined-cycle mode. (Reno, NV)

Tampa Electric Co. – *Tampa Electric Integrated Gasification Combined-Cycle Project.* Tampa's Polk Power Station has completed four years of successful commercial operation. As of the end of the third quarter 2000, the gasifier has provided syngas to the combustion turbine to produce 6,056,541 MWh of electricity. Also, during the third quarter the gasifier set a continuous run record of 1,153 hours and 53 minutes and a record 1,718 hours and 14 minutes when using hot restarts to correct minor problems. (Mulberry, FL)

Wabash River Joint Venture – *Wabash River Coal Gasification Repowering Project.* The Wabash River Cooperative Agreement expired on January 1, 2000. The participant has submitted the revised Final Report, which has been accepted by DOE and will be available from the FE website's Clean Coal Technology Compendium. The Cooperative Agreement is currently in the close-out process. (West Terre Haute, IN)

Alaska Industrial Development and Export Authority (AIDEA) – *Healy Clean Coal Project.* Demonstration operation under the Cooperative Agreement was completed in December 1999, and final reporting is nearly complete. Copies of topical reports describing the key technical activities carried out during the project's two years of demonstration operations are available on the Clean Coal Technology Compendium at <http://www.lanl.gov/projects/cctc/>. As the result of a settlement, AIDEA turned the plant over to Golden Valley Electric Association, Inc. for custodial care in April 2000. Golden Valley has engaged a consultant to determine the technical, regulatory, and economic feasibility of a full retrofit to a conventional low-NO_x burner and lime spray dryer emission control system, and of a limited retrofit that retains the TRW entrained (slagging) combustors, but re-designs the coal handling system. The plant will not operate until this determination is complete and the appropriate modifications are made. (Healy, AK)

Arthur D. Little, Inc. – *Clean Coal Diesel Project.* Pilot testing of the hardened elements for the diesel engine and the CWF is under way. Testing is scheduled to continue until spring 2001. Testing is taking place at the Fairbanks Morse test facility on a small 2-cylinder diesel engine. Shakedown of the demonstration diesel on fuel oil is still under way. Only minor problems have been encountered. Shakedown testing was scheduled to be completed in December 2000. (Fairbanks, AK)

COAL PROCESSING FOR CLEAN FUELS

Western SynCoal LLC (formerly Rosebud SynCoal® Partnership) – *Advanced Coal Conversion Process (ACCP) Demonstration.* The ACCP Demonstration Project in Colstrip, Montana, has processed nearly 2.7 million tons of raw subbituminous coal. Over 1.8 million tons has been supplied to customers, including industries (primarily cement and lime plants) and utilities. A new customer is now using SynCoal as a fuel supplement in its gold ore roaster process. The supplemental fuel system at Colstrip Unit 2 has been in operation for over a year and has been performing well. Unit 2 has consistently experienced significant benefits

in improved heat rate, reduced auxiliary load, and reduced slag-related limitations. (Colstrip, MT)

Air Products Liquid Phase Conversion Company, L.P. – *Commercial-Scale Demonstration of the Liquid Phase Methanol Process.* The Liquid Phase Methanol (LPMEOH™) Process Demonstration Facility continues to experience stable operation on coal-derived synthesis gas. During October 2000, a new monthly production record was set (see Project News Bytes). Since being restarted with fresh catalyst in December 1997, the demonstration facility has operated at greater than 99 percent availability. Since April 1997, the facility has produced over 70 million gallons of methanol, all of which was accepted by Eastman Chemical Company for use in downstream chemical processes. The monitoring of all potential catalyst poisons, and methods for their removal and control, continue to be an important part of the on-going plant operation. (Kingsport, TN)

INDUSTRIAL APPLICATIONS

CPICOR Management Company, L.L.C. – *Clean Power From Integrated Coal/Ore Reduction.* DOE has continued its work toward an Environmental Impact Statement for this project, a draft of which is expected

to be issued in early 2001. The CPICOR Management Company (CMC) continues to perform baseline environmental monitoring and preliminary engineering and design. CMC also continues to work closely with the Australian developers of the Hismelt Process and iron/steel engineering firms to establish a process and mechanical design database for this project. This project will be designed to produce 3,300 tons per day of liquid iron and approximately 160 MWe from the by-product gases. CMC is discussing teaming arrangements with several engineering and IPP firms. (Vineyard, UT)

ThermoChem, Inc. – *Pulse Combustor Design Qualification Test.* The Test Plan and Environmental Monitoring Plan were submitted to DOE for final review in December 2000. Construction of the 253-tube heater bundle is complete. The refractory was dried in December, and sand was added to the reactor. After a short shakedown period, testing is underway and is scheduled to be completed by the end of January 2001. ThermoChem, Inc. is planning to establish design parameters of the scaled-up heater to meet the requirements of the overall system performance for a commercial-scale steam reformer system for coal gasification and other significant commercial applications. (Baltimore, MD)



**U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874**

FE-24
