Office of Fossil Energy, U.S. Department of Energy • DOE/FE-0215P-35 Issue No. 35, Summer 1999

CLEAN COAL TODAY

A Newsletter about Innovative Technologies for Coal Utilization

Project News Bytes

The Department of Energy's Clean Coal Technology project with **Clean Energy Partners, L.P.** has lost its site at AMEREN Corporation's Grand Tower Station near Carbondale, Illinois. The project is a Round V selection to demonstrate a 477-MWe Integrated Gasification Combined Cycle (IGCC) system and a 1.25-MWe Molten Carbonate Fuel Cell system. The gasification technology is the British Gas/Lurgi (BG/L) slagging, fixed-bed, oxygen blown gasifier. Project participants are currently seeking another site for the project.

On April 13, representatives from DOE held a Public Environmental Scoping Meeting in Lakeland, Florida, for the proposed **McIntosh Unit 4 Pressurized Circulating Fluidized Bed Combustion**

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LPMEOH™ Project Performs Well During Second Year Of Operation

The Liquid Phase Methanol (LPMEOH™) Process Demonstration Plant, located at Eastman Chemical Company's chemicals-from-coal complex in Kingsport, Tennessee, has completed its second year of operation and has made significant progress toward accomplishing demonstration objectives. The four year demonstration program will show how the LPMEOH™ Process can be effective for converting a portion of the coal-derived synthesis gas to methanol. During this past year, major record-setting milestones were achieved in overall plant availability, continuous operation, catalyst life, and catalyst slurry concentration.

The LPMEOH™ plant applies new technology to produce methanol from coal-derived synthesis gas.

Catalyst performance for 1998 was excellent, achieving an average deactivation rate as low as 0.2 percent per day. Methanol production exceeded nameplate capacity of 80,000 gallons per day (260 tons per day), and the plant availability exceeded 99.7 percent for the 1998 calendar year. A record-setting 94 days of continuous operation was completed in late October 1998. Another important milestone was achieved in the LPMEOH™ reactor this past year, when a catalyst concentration of greater than 45 weight percent was demonstrated with no negative effects on plant performance. These operating improvements are expected to result in significant benefits for future designs, including significant capital cost savings, increased operating flexibility, and lower maintenance costs.

This commercial-scale demonstration of the LPMEOH™ Process is managed by Fossil Energy under a cooperative agreement with the Air Products Liquid Phase Conversion Company, L.P., a partnership between Air Products and Chemicals, Inc. and Eastman Chemical Company. The demonstration technology's novel reactor combines the reaction and heat-removal systems, distinguishing LPMEOH™ from other commercial methanol-production

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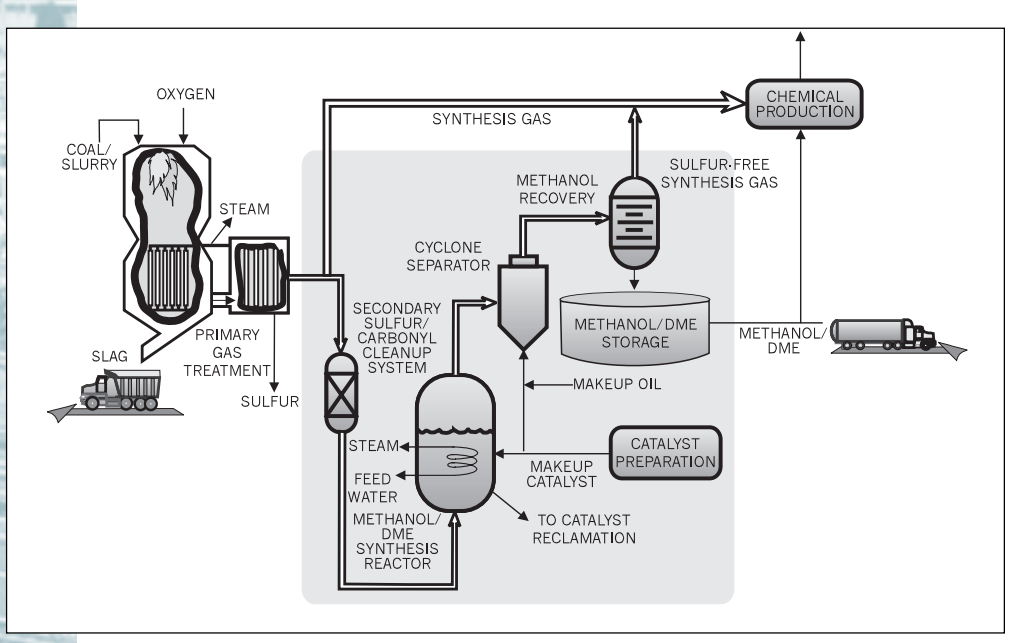
...LPMEOH continued

processes that send synthesis gas through a fixed bed of dry catalyst pellets. In contrast to these fixed bed technologies, the liquid phase is comprised of micron-size, temperature-sensitive methanol catalyst particles suspended in an inert mineral oil. The mineral oil acts as a temperature moderator and a heat removal medium, transferring the heat of reaction from the catalyst surface via the liquid slurry to boiling water in an internal tubular heat exchanger.

The LPMEOH™ Process Demonstration Plant is truly a commercial-scale methanol plant. Since initial operations began in April 1997, the LPMEOH™ Process Demonstration Plant has produced over 35 million gallons of methanol, all of which has been accepted by Eastman for use in its commercial chemical synthesis of acetic anhydride. Most of the product methanol is refined to chemical-grade quality (99.85 weight percent purity) via distillation and used by Eastman as chemical feedstock elsewhere in their commercial facility. A portion of the product methanol has been withdrawn prior to purification (about 98 weight percent purity) for use in off-site, product-use tests. Methanol has many commercial uses as a fuel, chemical feedstock, and as an integral part of exciting new technologies such as fuel cells.

Now entering the third year of its four-year operating program, the LPMEOH™ Process Demonstration Plant continues to perform as a state-of-the-art technology. The operational flexibility and robustness of LPMEOH™ technology has been shown and is expected to be increasingly put to the test during latter portions of the demonstration program. Future demonstration testing will include wide variations in synthesis gas feed composition simulating various commercial gasifiers. Testing will also evaluate quick start, stop, and ramping capabilities which are important parameters in load-following power applications. Economic advantages will continue to be tested, particularly in the context of IGCC applications. The net result will be a fully commercialized methanol technology that can be utilized and integrated in the power and chemical industries.



LPMEOH PROJECT SCHEMATIC

FOSSIL ENERGY'S TRANSPORTATION FUELS AND CHEMICALS R&D PROGRAM

The Office of Fossil Energy is directing an R&D program whose goal is to develop technology options for production of ultra-clean transportation fuels from our nation's fossil resources that could supplement petroleum-derived fuels. This program supports the development of technologies that convert coal, natural gas, and other indigenous carbonaceous feedstocks to ultra-clean transportation fuels that are environmentally superior to current petroleum. These ultra-clean fuels will be able to comply with the expected stringent fuel emission specifications of 2004 and beyond. Technologies include both indirect and direct methods to convert the feedstocks. Indirect conversion gasifies the carbonaceous feedstock to produce a clean synthesis gas (a mixture of hydrogen and carbon monoxide) that is used to synthesize a variety of fuels and chemicals. Synthesis options include production of hydrocarbons (Fischer-Tropsch synthesis) and production of oxygenates (alcohol synthesis). The most advanced technology arising from the Fossil Energy indirect liquefaction R&D program has been the highly successful commercial-scale demonstration of the Liquid Phase Methanol Process developed jointly by DOE, Air Products and Chemicals, Inc. and Eastman Chemicals Company under the Clean Coal Technology Program.

In the other method — direct conversion — hydrogen is combined with coal under high pressure and moderate temperature to produce a high quality refinery feedstock and high value carbon products. Direct liquefaction is very amenable to co-processing the coal with refinery resid (heavy ends) and waste streams as well as municipal wastes such as tires and plastics.

The U.S. demand for cleaner burning transportation fuels continues to intensify. Vehicle and engine manufacturers strongly support the development of technologies that produce very low, preferably zero-sulfur fuels that will dramatically reduce engine exhaust emissions. For example, Fischer-Tropsch synthesis can produce zero-sulfur diesel fuel very efficiently through conversion of synthesis gas. Synthesis gas can be produced from natural gas or by the gasification of our Nation's domestic resources of coal, petroleum refinery waste by-products, and other carbonaceous feedstocks. Engine tests conducted with such fuels have shown significant decreases in particulates and other emissions, even when used in conventional, unmodified diesel engines. Much attention is also being given to fuel cell-powered vehicles in which the hydrogen for the fuel cell would be derived from sulfur- and contaminant-free liquid hydrocarbons.

Clean fuels and chemicals being developed have the potential to allow our fossil resources to be used in an environmentally benign manner and thus act as transition fuels as we progress toward sustainable energy use. Use of these fuels and chemicals would expand the market for domestic coal and other carbonaceous feedstocks. Continued advancements in, and pre-commercial scale testing of indirect and other conversion technologies will enable the program to achieve its goal of establishing an alternative fuels and chemicals industry in the U.S. by 2015.

The historic drivers the Fossil Energy Fuel Programs of the 1970s and 1980s were to enhance U.S. energy security and strengthen the economy by facilitating the establishment of a new industry. These motivations remain very important, but it has become evident over the past several years that coal-derived fuels and chemicals will not make a significant market penetration unless the environmental aspects related to their production and utilization are fully addressed. Therefore, the focus of the program has changed to one that is primarily market driven by both regional and global environmental concerns. Transportation vehicles in the United States currently account for a large portion of urban air pollution including 81 percent of carbon monoxide, 50 percent of nitrogen oxides, 37 percent of VOC's as well as some particulates. The transportation sector also contributes over one-third of the United States carbon dioxide greenhouse gas emissions which, absent new reduction initiatives, are projected by the Energy Information Administration to increase more than 40 percent by 2020. Energy security may well come back as a driver in the longer-term if a major supply/demand problem arises from diminished world oil resources. Some knowledgeable petroleum geologists, although in the minority, are suggesting this may occur early in the 21st century.

One environmental initiative is being proposed by the Office of Science and Technology Policy in the White House. This effort brings together engine manufacturers, petroleum refiners and the Department of Energy in a cooperative program to coordinate activities to identify and develop performance characteristics for fuels that: 1) can be used in fuel cells and advanced direct injection engines; and (2) ensure that advances in fuel use efficiency do not come at the expense of environmental quality.

See "Fuels" on page 4...

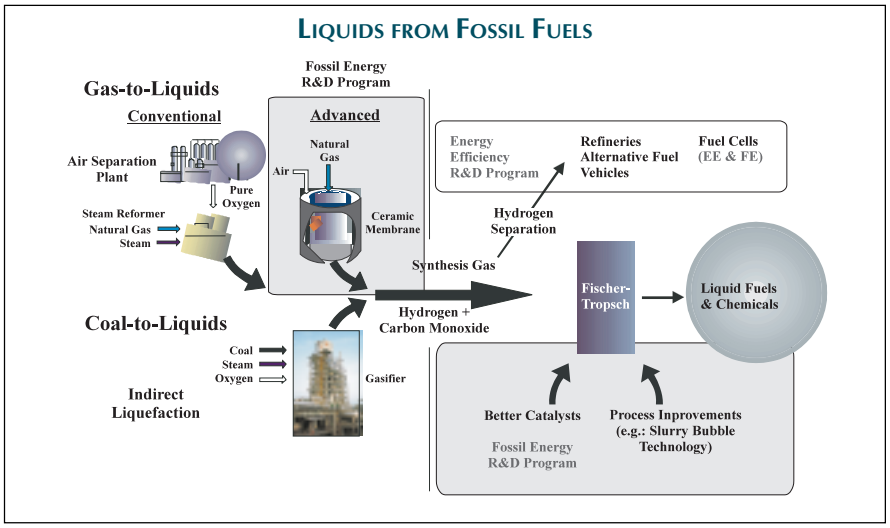
...Fuels continued

The objectives of the Office of Fossil Energy are similar to those of the Presidential initiative. One of the program goals is to utilize the ultra-clean fuels produced by converting coal and other carbonaceous feedstocks into fuels for high efficiency automobiles, sports/utility vehicles, and light trucks. These fuels are ideally suited to the new generation of vehicles being developed in the Office of Renewable Energy and Energy Efficiency and the Partnership for a New Generation of Vehicles programs. Within Fossil Energy, programs are being coordinated with the gas-to-liquids program in order to provide a unified structure, and are co-funded with industry and universities.

Specific R&D to develop Fischer-Tropsch and other fuel technologies include: 1) development of new catalysts for producing Fischer-Tropsch diesel and oxygenates such as dimethyl ether; 2) development of state-of-art high productivity, low cost three phase bubble column reactors; 3) fuels characterization and determination of environmental emissions; and 4) feasibility activities for early plants to demonstrate these concepts.

One such promising concept would gasify coal, possibly in combination with petroleum bottoms, wastes or biomass to produce a clean synthesis gas which would be used to co-produce ultra-clean transportation fuels, chemicals and electric power. This integrated configuration is highly efficient, thereby emitting fewer greenhouse gases. It also produces a concentrated carbon dioxide stream that would be amenable to sequestration. Configurations such as this, that can use a combination of feedstocks to produce multiple high value products in an efficient and environmentally benign manner, are examples of possible Early Entrance Co-Production Plants as well as the Vision 21 complex. Additionally, these ultra-clean fuels can be used to reduce carbon monoxide by 41 percent, NO_x by 30 percent, and particulates by 26 percent.

At present, FE is evaluating co-funded proposals submitted by industrial teams for the first three pre-detailed design phases of Early Entrance Co-Production Plants. These studies include: 1) feasibility and market studies to address the technical, economic and environmental issues associated with the proposed plant concept; 2) supporting research; and 3) a site-specific preliminary design. The Department has not committed to funding the remaining phases that would encompass the detailed engineering design, construction and operation of the plant. With the information obtained in the first three phases, it is anticipated that the industrial teams will be able to obtain private sector funding for the detailed design and construction phase of the program. During the initial phases, the teams may also identify innovative financing strategies.



NEW FOSSIL ENERGY PUBLICATIONS

Carbon Sequestration — State of the Science (a working report for road mapping future research and development), February 1999, available through the Fossil Energy web site (www.fe.doe.gov/sequestration).

Clean Coal Technology Annual Program Update, April 1999, available from Gene Kight (FE-20), U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874.

Commercial-Scale Demonstration of the Liquid Phase Methanol (LPMEOH™) Process, Topical Report Number 11, April 1999, available through FETC Library, 3610 Collins Ferry Road, Morgantown, WV 26507-0880, or on the web at www.fetc.doe.gov (click on "Other Publications" and then "Topical Reports").

Office of Coal & Power Systems Multi-Year Program Plan, May 1999, available from FE Office of Communications, U.S. DOE, 1000 Independence Ave., S.W., Washington, DC 20585, phone: (202) 586-6503.

MILLIKEN CCT DEMONSTRATION PROJECT NEARS COMPLETION

Milliken CCT project, with S-H-U scrubber in foreground.

The Milliken Clean Coal project, located in Lansing, New York, selected during Round IV of DOE's CCT Program to demonstrate an advanced SO_2 scrubbing technology, is approaching completion and has achieved all of its ambitious performance objectives for SO_2 and waste utilization. In October 1992, the New York State Electric & Gas Corporation (NYSEG) entered into an agreement with DOE to conduct the demonstration at Milliken Units 1 and 2. The project has been in operation since 1995 and performance testing was completed last year. Units 1 and 2 are 150-MWe pulverized coal-fired units built in the 1950s. Total cost of the CCT project was $159 million, of which DOE provided $45 million (28 percent).

The Clean Coal Project involved installing a Saarberg-Holter-Umweltechnik formic acid-enhanced (S-H-U) wet limestone scrubber at both units, the PEOA™ artificial intelligence system, and a heat-pipe combustion air preheater in one unit. Also installed, but not a part of the Clean Coal Project, were low-NO_x burners for NO_x emissions reductions and an ESP upgrade. The project goals were to demonstrate SO_2 emissions reduction of 98 percent firing 3.2 percent sulfur coal, improved boiler efficiency, low energy consumption (approximately 1 percent of station net output) and minimum solid waste production through by-product utilization. Commercial quality gypsum was successfully produced, but the goal of producing a marketable calcium chloride solution from the FGD stream was not achieved. The PEOA™ system has been sold commercially and replicated in the communications industry.

In the S-H-U process, flue gas is scrubbed with a limestone slurry in the absorber vessel. A single, two-compartment reinforced concrete co-current/counter-current absorber was employed, which provides separate absorber sections for each unit within a single vessel. The absorber vessel was lined with a ceramic tile, manufactured by Stebbins, for corrosion resistance. The S-H-U process is designed specifically to take advantage of the benefits of organic acid enhanced absorption, utilizing a low concentration of formic acid additive in the scrubbing liquid. Formic acid acts as a buffer in the absorber and improves both the rate of limestone dissolution and the solubility of calcium in the scrubbing liquid, thereby enhancing SO_2 absorption efficiency. Operation at low pH provides the benefit of producing soluble calcium bisulfite as a reaction product, rather than the less soluble calcium sulfite. This greatly increases the ease of oxidation to gypsum and essentially eliminates the potential for sulfite scaling within the absorber, thus reducing maintenance costs. Gypsum from the project is trucked to a wallboard manufacturer located in Mississauga, Ontario, Canada.

The significantly lower energy consumption rate of the S-H-U process compared to conventional wet limestone FGD systems derives from its lower pressure drop and liquid-to-gas ratio. Because the S-H-U process is based on formic acid buffering of the recycle slurry, it is stable under all operating conditions. Formic acid buffering also results in a lower FGD blowdown rate than that of a conventional scrubber. The S-H-U process can maintain high SO_2 removal and high calcium utilization with greater than 50,000 ppm chloride in recycle slurry.

The project features unique equipment design and construction. The single absorber handles flue gas from two boilers in a single, split unit, which allows construction in confined spaces and reduces retrofit costs. This versatile method of construction in conjunction with tile lining allows for continuous operation in a pH range of 3-12, and tolerates chloride levels in excess of 100,000 ppm, as well as high temperatures.

The testing program was conducted over a period of 36 months. Typical parameters tested include SO_2 reduction efficiency, power consumption, process economics, load following capability, reagent utilization, by-product quality, and additive effects. Unit 1 acted as a baseline and was operated continuously at design conditions while parametric tests were performed on Unit 2 to define performance limits of the S-H-U FGD system. Coal tested varied from 1.6 percent to 4.0 percent sulfur using at least three coal types. The formic acid process design was based on using 800 ppm formic acid in the scrubber slurry. The design limestone grind was 90 percent (170 mesh) when using formic acid and 90 percent (325 mesh) without formic acid.

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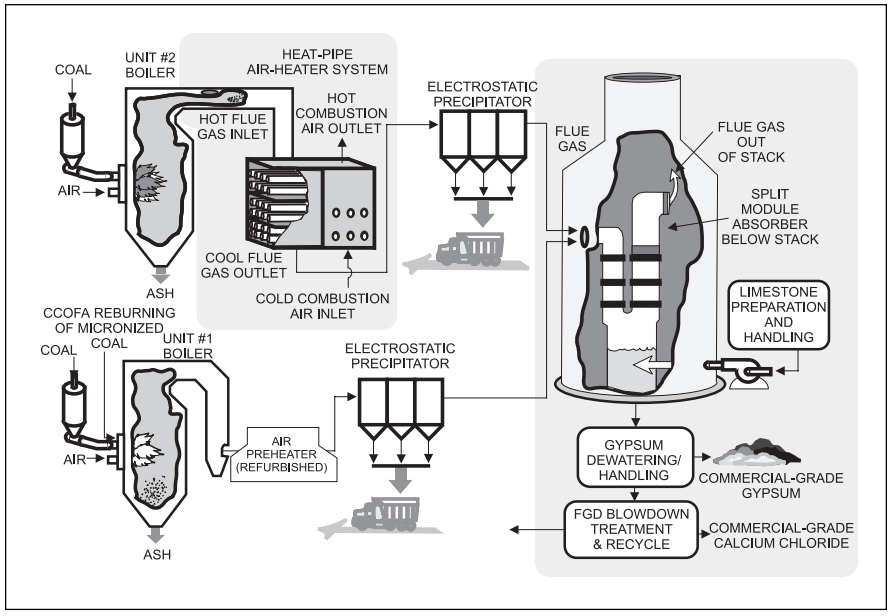
...Milliken continued

Each S-H-U module contains four co-current spray headers and three counter-current spray headers. The design gas velocity in the co-current scrubber section is 18 ft/sec. Tests at higher velocities were performed on the Unit 2 scrubber by shunting some of the gas flow from Unit 1 to the Unit 2 scrubber. Operating variables studied include formic acid concentration, coal sulfur content, limestone grind size, and flue gas velocity within the absorber vessel. In addition, FGD efficiency was examined as the number and location of operating spray headers were varied.

Overall, for SO_2 removal using a variety of coals:

- The maximum and sustained SO_2 removal demonstrated was 98-plus percent with all seven recycle pumps operating and using formic acid. The maximum and sustained removal without formic acid was 95 percent.
- The difference in SO_2 removal between the two grind sizes tested during the low sulfur testing (90 percent - 325 mesh and 170 mesh) was quite small — 2.6 percent absolute, indicating the more costly, finer mesh is not necessary.
- SO_2 removal during the high velocity test was greater than the design velocity test, meaning design requirements will not cause units with booster fans to achieve less sulfur removal.
- The co-current pumps had no measurable effect on pressure drop, whereas counter-current pumps significantly increased the scrubber pressure drop, indicating energy savings and lower operating costs.

The project met or exceeded its goals and objectives in almost every case, and also was accomplished within budget and on schedule. It will stay in operation as part of the plant's compliance strategy.



MILLIKEN PROJECT SCHEMATIC

FUEL CELLS — A KEY TO VISION 21

–PART OF A SERIES ON VISION 21–

Fuel cell technology is an essential element in the Office of Fossil Energy (FE) "Vision 21" program—a program to realize, by the year 2015, a new class of fuel and product-flexible energy facilities that can:

- Use a wide range of fuels;
- Competitively produce a combination of electricity, clean fuels, chemicals, and steam;
- Achieve efficiencies greater than 60 percent; and
- Emit near zero pollutant emissions, and, with sequestration, no net CO_2 emissions.

Unlike conventional power generation technologies, fuel cells generate power electrochemically, rather than mechanically. As a result, fuel cells offer high efficiency independent of size or load, converting a significant portion of the chemical energy in the fuel to electricity. Existing commercial fuel cells have capacities up to 200 kW and efficiencies of 40–45 percent, and use reformed natural gas for the hydrogen needed to fuel the systems. Under Vision 21, stand-alone fuel cells will have capacities up to 100 MW, efficiencies greater than 60 percent, and the capability to use coal-derived synthesis gas, as well as methanol, light oil, and landfill gas. Fuel cells, when integrated with gas turbines in hybrid cycles, have the potential for greater than 70 percent efficiency.

Similar to a continuously fueled battery, fuel cells produce direct current (DC) through an electrochemical process. In a fuel cell power plant, hydrogen bearing fuels, such as natural gas and coal, are converted to a clean, hydrogen-rich gas. Fuel is then fed, along with air, to a fuel cell power section - over two cell electrodes - converting the fuel to DC electricity. A power conditioner converts the electricity to high-quality AC power. Numerous fuel cells are combined in stacks to obtain a specific voltage and power output. The only emissions are water, carbon dioxide (CO_2), and heat.

The versatility of fuel cells make them ideal candidates for a variety of applications, including distributed generation applications. Market estimates indicate that a significant early-entry market exists to sustain the initial high cost of some distributed generation fuel cell technologies. Market penetration of the phosphoric acid fuel cell (PAFC) technology (by ONSI Corporation) has demonstrated the reliability and suitability of fuel cells for premium power (e.g., computer centers and hospitals), as well as other opportunity fuel niche applications, such as landfill gas, anaerobic digester gas, and waste gas. Ozone non-attainment areas represent significant market potential for fuel cells. Conservative estimates of the premium power market are about $1 billion annually in the U.S., while globally the U.S. EPA estimates some 40-50 GW of market for opportunity fuels.

The primary technical challenges to gaining widespread commercial acceptance of fuel cells are in reducing costs and enhancing efficiencies. Demonstrations at commercial-scale also are needed to ensure and reliability. The goal is to reduce fuel cell cost by a factor of ten through improved manufacturing techniques and systems integration. Efficiency improvement is being addressed by focusing on fuel cells with inherently high process temperatures to enable internal reforming of fuels and operation in a combined cycle mode—using waste heat to generate steam for a steam turbine. Also, hybrid cycle concepts, seeking synergistic integration of fuel cells and gas turbines, leverage operating characteristics of each to significantly advance efficiencies.

Current R&D efforts target commercialization of high temperature molten carbonate and solid oxide fuel cells in the 2002-2005 time period. This early entry to the marketplace will provide experience in the installation and operation of fuel cells for on-site power generation applications, as well as supply valuable feedback to guide design improvements and performance benchmarks. For fuel cell/gas turbine hybrids, FE has initiated five parallel design efforts to provide a springboard for the hybrid program to begin in 2000. Plans include incorporating micro-turbines on two of the high temperature fuel cell configurations, which already operate at higher than atmospheric pressure.

Moreover, a "21st Century" fuel cell development effort will be undertaken, identifying and building upon novel fuel cell concepts. These concepts are expected to push efficiencies up to 70-80 percent by 2015, to have cell stack costs less than $100/kW, and have fuel cell system costs between $400-600/kW. FE is considering conceptual studies to identify the R&D necessary to develop promising new concepts. This should result in generic manufacturing R&D that would crosscut several 21st Century fuel cell concepts. In this effort, FE plans to partner with various National Laboratories to focus on gas processing, materials R&D, dynamic modeling, virtual design and simulation, and fuel reforming improvements for meeting program goals.

INTERNATIONAL INITIATIVES

DOE PLAYS MAJOR ROLE IN REDUCING EMISSIONS IN KRAKOW, POLAND

Air quality in many Central European cities has degraded during the past several decades with heavy use of solid fuels for heating. Since 1990 the U.S. Department of Energy has been involved in a program aimed at reducing air pollution caused by small coal-fired sources in Krakow, Poland. Although the activity is focused on the city of Krakow, it is expected that the results will be applicable to the entire region. Formal basis for the U.S. assistance to Poland in this area was provided by the Support for Eastern European Democracy (SEED) Act of 1989. Part of this legislation directed that DOE cooperate with U.S. and Polish experts to undertake an assessment and implementation program in Poland to use fossil fuels cleanly in small-scale combustion equipment. Funding for this program has been provided to DOE by the U.S. Agency for International Development.

The program was specifically directed toward the emissions problems of low (altitude) emissions sources in Krakow. A city of 750,000 and Poland's capital from the 11th to 17th centuries, Krakow is a major university and industrial center, and contains numerous historic buildings. The city has been included in the UNESCO list of world cultural heritages.

The assistance program was designed to assess the total problem of low-level emission sources within the center of 'Old Krakow' and progress to the outskirts; identify specific large emission sources; determine cost effective approaches for long-term remediation; and use a multi-faceted technical approach to implement new technologies. Air quality has improved dramatically since the program began. A number of major emitters have already had numerous thermal/burner/particulate control systems installed. The program is currently in its last phase, in which many particulate sources are being closed via connection to an expanded district heating system, home stoves will have electric heating elements installed, and electrical upgrading is being implemented. United States funding provides new equipment, preferably through joint US-Polish suppliers, to a variety of city, regional and private energy offices and partners. A significant upgrade to the large Polish American Children's Hospital is also underway; the only dedicated pediatric medical research facility in Poland.

Core Separators will be installed to reduce emissions in Poland and neighboring countries.

A number of projects have evolved from the Krakow effort and have been implemented in other parts of Poland and Central Europe. Due to lower initial and operating costs, mechanical particulate collectors have traditionally been installed in industrial applications in Poland rather than the more complex devices. One such device is the Core Separator developed by LSR Technologies, of Acton, Massachusetts. Original development work on the Core Separator was done under the DOE Small Business Innovative Research Program. Manufacture/assembly plants have been built in Poland. Dust emissions from this device are typically 3-6 times lower than from the best cyclone collectors and its performance approaches that of fabric filters and electrostatic precipitators, but at a much lower cost. Within Krakow, Core Separators were installed at a 6-MW stoker fired boiler in a motor manufacturing plant and at a 1.5-MW boiler located at the central bus service center. Particulate removal at these sites averaged 94 percent. Another 52 Core Separators are either in operation or being installed within Poland and neighboring countries.

The total Krakow program continues to show marked improvement in air quality due to the many emission sources which are either being controlled or eliminated. Core Separators alone are removing >575,000 metric tons per year of particulate in the region. Through 1998, it is estimated that >126,000 metric tons of CO_2 emissions per year have been eliminated; with new ongoing remediation projects, another 25,000 metric tons/year will be eliminated. Upgrading the large Children's Hospital complex alone will eliminate approximately 15,000 tons/year of CO_2, as well as complete closure of a large coal-fired closure of a large coal fired dedicated (17.5 MW) boiler. Clearly, the joint U.S./Poland effort is having a positive environmental impact in the region.

FIRST ANNUAL MEETING OF U.S.-CHINA ENERGY AND ENVIRONMENTAL TECHNOLOGY CENTER

EETC, officially inaugurated in November 1997, held its first annual Board of Directors meeting in Washington, D.C. this April and reviewed accomplishments over the past year, as well as new directions. EETC is funded jointly by DOE, EPA and the Chinese State Science and Technology Commission. The U.S./China Institute has a cooperative agreement with DOE to manage and operate the EETC. Tulane and Tsinghua Universities, in turn, are subcontracted to run the day-to-day operations. EETC's mission is to enhance the competitiveness and adoption of U.S. clean and environmentally superior technologies in China by focusing on education and training, promoting the use and profitability of U.S. technology, and supporting policy development in China to encourage the responsible use of coal.

Over the past year, the HTI (Hydrocarbon Technologies, Inc.) direct liquefaction project, proposed to be located near Shaanxi Province, has advanced from pre-feasibility to the feasibility study phase. EETC has acted to promote the project to the Chinese Government. Other liquefaction projects, sponsored by German and Japanese companies with financial support from their respective governments, are also contending for the ultimate award. A commercial plant using HTI technology could produce 50,000 barrels/day of gasoline and diesel fuel while feeding 10-12,000 tons/day of bituminous coal. The pre-feasibility study established that the project can use a variety of Chinese coals. The feasibility study will include further testing as well as evaluation of economics and project financing. DOE has supported test runs on Chinese coals at a continuous bench test unit.

The Chinese government appears ready to make a decision on another project, a 300-MW commercial/ demonstration IGCC project to be located in Yantai in the Shandong Province. Foreign investment is being sought. Construction is expected to start in 2000-2001. Since 1993, DOE and U.S. industry have been working closely with the Chinese Government, industry, and R&D organizations to help China develop this first IGCC project.

EETC is also supporting the efforts of Babcock & Wilcox to secure an FGD joint venture from China's State Power Corporation, a government agency which has decided to increase the engineering and fabrication capacity of FGD systems throughout China. B&W was a co-sponsor with the EETC of the February 1998 "U.S.-China Workshop on SO_x Control Technology."

In other areas, EETC has been sponsoring studies of upgrading coal-based fertilizer plants to become more energy efficient. EETC has helped the city of Chongqing convert its fertilizer plant to natural gas, but in most cases natural gas sources are not available. Finally, EETC will broaden its activities in climate change and CO_2 reduction, establishing a special task force and continuing work in coal gasification, coal washing, biomass gasification for distributed power, and ash utilization.

Rita Bajura, FETC Director, addressed 13th Annual U.S./Japan Joint Technical Workshop on Coal Technology.

U.S./JAPAN WORKSHOP HIGHLIGHTS R&D COOPERATION

A successful 13th Annual U.S./Japan Joint Technical Workshop on Coal Technology was held in early March at the Rocky Gap Lodge near Cumberland, Maryland. Sixty-six workshop participants, including a strong Japanese delegation of 24 scientists and engineers, exchanged R&D project information relating to advanced clean coal technologies, coal liquefaction, liquefaction materials, and surface gasification. Technical exchange meetings in CO_2 sequestration and fuel cells took place last fall. Japan has recently been pursuing coal utilization R&D quite aggressively, and has been involved in direct liquefaction research.

Rita Bajura, Director of the Federal Energy Technology Center and new Co-Chair of the U.S.-Japan Coordinating Committee on Coal Energy R&D, spoke on the globalization and deregulation forces behind energy supply decisions, and summarized FE's current R&D focus. She led a strong U.S. team of government representatives, members of research organizations, and the private sector. Akira Sugawara, Japanese Co-Chair, of the Ministry of International Trade and Industry (MITI) led a Japanese delegation of utilities, research organizations, industry associations, and energy companies.

See "Japan" on page 10...

...Japan continued

The technical exchange was open and frank. Hiroshi Enomoto, of MITI's Agency of Natural Resources and Energy, spoke on Japanese coal utilization policy, noting that Japan imports 80 percent of its total energy feedstock and 99.7 percent of its oil (with oil accounting for 54 percent of Japan's total energy consumption). Japan is the second largest foreign consumer of U.S. coal. Only five percent of coal used is domestic. Other industrialized nations (Germany, France, and Italy) import over 95 percent of their oil. The U.S. depends on imports for 20 percent of its total energy and 50.7 percent of its oil, with oil comprising 38 percent of total U.S. energy consumption.

Workshop participants noted that ample, low cost, stable coal supplies worldwide bode a measure of diversification and economic safety for both industrialized and developing countries, making the development of clean, efficient, coal utilization technologies an imperative for the future. DOE presentations introduced the Vision 21 research program the Department has proposed for coal-based power and fuel systems in the next century. McDermott International, Inc. summarized low-NO_x burners, as well as emissions control studies for particulate matter and trace elements. The Energy & Environmental Research Center described an advanced hybrid particulate collector, American Electric Power gave a presentation on the 600-MWe demonstration of selective non-catalytic reduction to be conducted at its Cardinal Unit 1, and Air Products & Chemicals presented an overview of advanced integration concepts for oxygen plants and gas turbines in gasification/IGCC facilities using ion transport membranes.

Japan's New Energy Development Organization described the EAGLE (Energy Application for Gas, Liquids, and Electricity) integrated coal gasification, molten carbonate fuel cell combined cycle plant that is moving toward pilot-scale demonstration in the 2000-2002 time frame. About 90 percent of the project is funded by the Japanese government. Japan's Electric Power Development Company presented recent results from the 71-MWe Wakamatsu PFBC plant, as well as from recent PDU testing of an advanced PFBC process. Representatives from Tokyo Electric discussed results obtained from a 200 tons/day IGCC pilot plant at Nakoso, using a process design by Mitsubishi Heavy Industries.

Following the workshop, representatives from the Japanese delegation toured FETC in-house laboratory facilities and the Tampa Electric IGCC project.

July 28-29, 1999 —
Appalachian Rivers II Conference
Location: Morgantown, WV
Co-Sponsors: U.S. DOE, FETC
Contact: Conference Services
Phone: (304) 285-4108
E-mail: confserv@fetc.doe.gov

September 13-17, 1999 —
13th U.S.-Korea Joint Workshop on Energy and Environment
Location: Reno, NV
Co-Sponsors: U.S. DOE, Office of Fossil Energy, FETC, Korea Institute of Energy Research
Contact: Kim Yavorsky
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E-mail: yavorsky@fetc.doe.gov

September 22-23, 1999 —
Energy Products for the 21st Century
Location: Cincinnati, OH
Sponsor: FETC
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October 11-15, 1999 —
16th Annual Pittsburgh Coal Conference
Location: Pittsburgh, PA
Co-Sponsors: Univ. of Pittsburgh, Conference Advisory Board, FETC, Participating Organizations
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Phone: (412) 624-7440
Fax: (412) 624-1480
E-mail: zarnich@engrng.pitts.edu

November 1-5, 1999 —
Clean and Efficient Coal Technology in Power Generation
Location: Jakarta, Indonesia
Co-Sponsors: LSDE BPP Teknologi, FETC
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CCT PROGRAM SUCCESSES

The following are highlights of important successes of the Clean Coal Technology Demonstration Program.

Taking on Smog

The CCT Program enabled the utility industry to respond cost-effectively to the first wave of NO_x control requirements and positioned industry to respond to more stringent standards in the 21st century. To date, over one-third of coal-fired generating capacity in the U.S. has installed low-NO_x burners, with sales exceeding $1.5 billion.

Eliminating Acid Rain

The CCT Program directly contributed to meeting initial SO_2 reduction requirements under the Clean Air Act Amendments of 1990 (CAAA) by installing advanced technology at affected plants. The resultant portfolio of technologies redefined the state-of-the-art in scrubber technology, enabling utilities to respond to more stringent standards imposed by the CAAA in 2000.

Powering the 21st Century

The CCT Program was instrumental in commercializing atmospheric circulating fluidized-bed (ACFB) technology at utility-scale. Today, there is an estimated 9.5 gigawatts of ACFB installed worldwide.

Pressurized fluidized-bed combustion (PFBC) technology also is beginning to make significant market penetration. Over 1,000 MWe of PFBC capacity now exists, all with the specific technology demonstrated under the Program.

Four integrated gasification combined-cycle (IGCC) projects, representing a diversity of gasifiers and cleanup systems, are pioneering the introduction of this power generation technology. By 2000, nearly 5,000 MWe of IGCC capacity will be installed worldwide.

Preventing Pollution

The CCT Program is making available a number of technologies capable of removing impurities from and enhancing the energy density of a broad range of coals. The resultant clean solid and liquid products serve as a means of pollution prevention.

- New processes are being demonstrated that either supplement or eliminate coke in steelmaking, thereby reducing or precluding toxic emissions associated with coke production.
- A novel process demonstrated use of cement kiln dust (CKD), a solid waste, as a means to scrub SO_2 from stack gas, while converting the CKD to cement kiln feedstock and producing no pollutant emissions.

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...News Bytes continued

Demonstration Project — City of Lakeland, Department of Water & Electric Utilities. A Notice of Intent to Prepare an Environmental Impact Statement, announcing the meeting, was published in the *Federal Register* on March 26, 1999. In the afternoon, an informal session was held for the public to meet with DOE staff, and representatives from Lakeland Electric, the municipal power company sponsoring the project. Written comments were due by May 21, 1999.

In April 1999, **ThermoChem, Inc.** received authorization from the U.S. Department of Energy to continue their Pulse Combustor Design Qualification Test project beyond design. Construction of the commercial-scale pulse combustor unit at the Manufacturing and Technology Conversion International, Inc. test facility in Baltimore, Maryland, is scheduled to be complete in October 1999. Operation of the pulse combustor test facility will begin in November 1999.

STATUS OF ACTIVE CCT DEMONSTRATION PROJECTS

ENVIRONMENTAL CONTROL DEVICES

Southern Company Services, Inc. – *Demonstration of Advanced Combustion Techniques for a Wall-Fired Boiler.* Long-term testing of the advanced overfire air (AOFA), low-NO_x burners (LNB), and combined LNB+AOFA systems are complete. Final testing of GNOCIS is complete. A Draft Final Report for Phase 4 has been issued. An extension of the project is being negotiated. (Coosa, GA)

New York State Electric & Gas – *Milliken Clean Coal Technology Demonstration Project.* All testing has been completed. The Draft Final Report has been reviewed, and the Final Report is being prepared for publication. The project was a complete success. All demonstration goals were met or exceeded. The unit is currently in operation and is scheduled to stay in operation as part of the plant's compliance strategy. (Lansing, NY)

New York State Electric & Gas – *Micronized Coal Reburning Demonstration for NO_x Control.* All testing has been completed at the Kodak site in Rochester, New York. The goals and objectives for the Kodak site have been met or exceeded. The system is in operation and will remain in operation, allowing Kodak to effectively reduce NO_x in accordance with their agreement with the State of New York. Testing at the Milliken site is still ongoing, and final testing is in progress. The final report should be published by late summer 1999. (Ithaca, NY) (Lansing, NY and Rochester, NY)

NOXSO Corporation – *Commercial demonstration of the NOXSO SO_2/NO_x Removal Flue Gas Cleanup System.* Project is on hold pending results of bankruptcy proceedings.

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.* The City of Lakeland continues to negotiate with Foster Wheeler on the turnkey contract. On April 13, 1999, DOE and the City of Lakeland held an information open house and public environmental scoping meeting. DOE will prepare the Environmental Impact Statement (EIS) as part of the National Environmental Policy Act process. Groundbreaking for Unit 4 is projected for mid-2001, pending successful completion of the NEPA process. (Lakeland, FL)

Jacksonville Electric Authority (JEA) (formerly York County Energy Partners) – *ACFB Demonstration Project.* In September 1997, DOE signed an agreement with Jacksonville Electric Authority to cost-share refurbishment of the first (Unit 2) of two units at North Side Generating Station. Construction is planned to begin in October 1999, with operation in early 2002, followed by two years of operations. Activities are underway to draft an Environmental Impact Statement. (Jacksonville, FL)

Clean Energy Partners, LP – *Clean Energy Demonstration Project.* The project, which was to be located at Grand Tower Power Plant near Carbondale, Illinois, has lost its site. Project participants are seeking a new location. (site pending)

Sierra Pacific Power Co. – *Piñon Pine IGCC Power Project.* This project continues to make progress achieving integrated operation of all systems. However, recent problems with the gasifier forced Sierra to shut down the gasifier. Inspection showed damage to the combustion air tube, coal feed tube and refractory on the interior of the gasifier. The damaged sections of the air- and coal-feed tubes were cut out and are being analyzed to determine the most probable cause of the failure. After repairs are made, Sierra will continue to try to bring the gasifier on-line. Sierra hopes to achieve full system operation and deliver syngas to the combined cycle power plant this summer. Sierra continues to operate the plant normally in the gas combined cycle mode. (Reno, NV)

Tampa Electric Co. – *Tampa Electric Integrated Gasification Combined-Cycle Project.* Tampa's Polk Power Station has completed two years of successful commercial operation. As of the end of the fourth quarter of 1998, the unit has achieved an over 70 percent gasifier on-stream factor, the gasifier has operated 11,000 hours, and the combustion turbine has operated 12,000 hours producing over 3,500,000 MWh. In addition, power production availability set a new record of 100 percent for three continuous months — Dec 1998, Jan 1999, and Feb 1999. (Mulberry, FL)

Wabash River Joint Venture – *Wabash River Coal Gasification Repowering Project.* The combustion turbine at the power generation facility experienced a compressor failure on March 13 and remains in an extended shutdown. A root cause investigation is under way to determine the cause of the compressor damage. The current projection is that the plant will return to operation in mid-June 1999. Although the project is experiencing delays, it operated very successfully in 1998. (West Terre Haute, IN)

Alaska Industrial Development and Export Authority – *Healy Clean Coal Project.* The Healy Clean Coal Project began its second year of demonstration operations in January 1999 following a maintenance and modification outage. Demonstration operations were suspended for a 20-day period in February 1999, as the result of limestone supply problems. The extreme cold weather (~-40°F) in Central Alaska, has made it difficult for the local supplier to mine and deliver a stable, quality supply of limestone to the plant. Without this, emission levels may exceed compliance. Once demonstration operations resumed, combustor characterization and particulate compliance testing were successfully completed. Emissions from the plant when operating at full load or 62 MWe (gross) continued to be within permit levels. (Healy, AK)

Arthur D. Little, Inc. – *Coal-Fueled Diesel Engine Demonstration Project.* The 18-cylinder diesel arrived on January 30, 1999. Off-loading the engine from the railcar was delayed nearly three weeks due to the extremely cold weather (-50 °F) temperatures. The engine was successfully moved into the facility's building by the end of February. DOE conducted a design/construction review in early May. (Fairbanks, AK)

COAL PROCESSING FOR CLEAN FUELS

Custom Coals International - *Self Scrubbing Coal™: An Integrated Approach to Clean Air*. In September, the Federal Bankruptcy Court held a hearing on conditions necessary to close the sale between Custom Coals Laurel and Tanoma Energy. Tanoma and the Pennsylvania Department of Environmental Protection were unable to reach agreement on important issues, and Custom Coals' plan for reorganization was determined to now be void. In December, C.J. Betters Enterprises of Monaca, Pennsylvania purchased the facility at auction for $3 million and has reached an agreement with DOE to supply a detailed proposal for continuation of the project. The proposal is expected in September 1999. (Central City, PA; Martin Creek, PA; Richmond, IN; Ashtabula, OH)

Rosebud SynCoal® Partnership – *Advanced Coal Conversion Process (ACCP) Demonstration.* The Rosebud SynCoal® Project in Colstrip, Montana has processed over 2.0 million tons of raw subbituminous coal. Over 1.3 million tons of SynCoal® has been supplied to customers, including industries (primarily cement and lime plants) and utilities. Rosebud SynCoal® Partnership has constructed a Pneumatic SynCoal® Fuel Project at Montana Power's Colstrip power plant. The system will enable the ACCP facility to operate full time. Rosebud was recently granted a 24-month no-cost time extension. Operations have now been extended to January 2001. (Colstrip, MT)

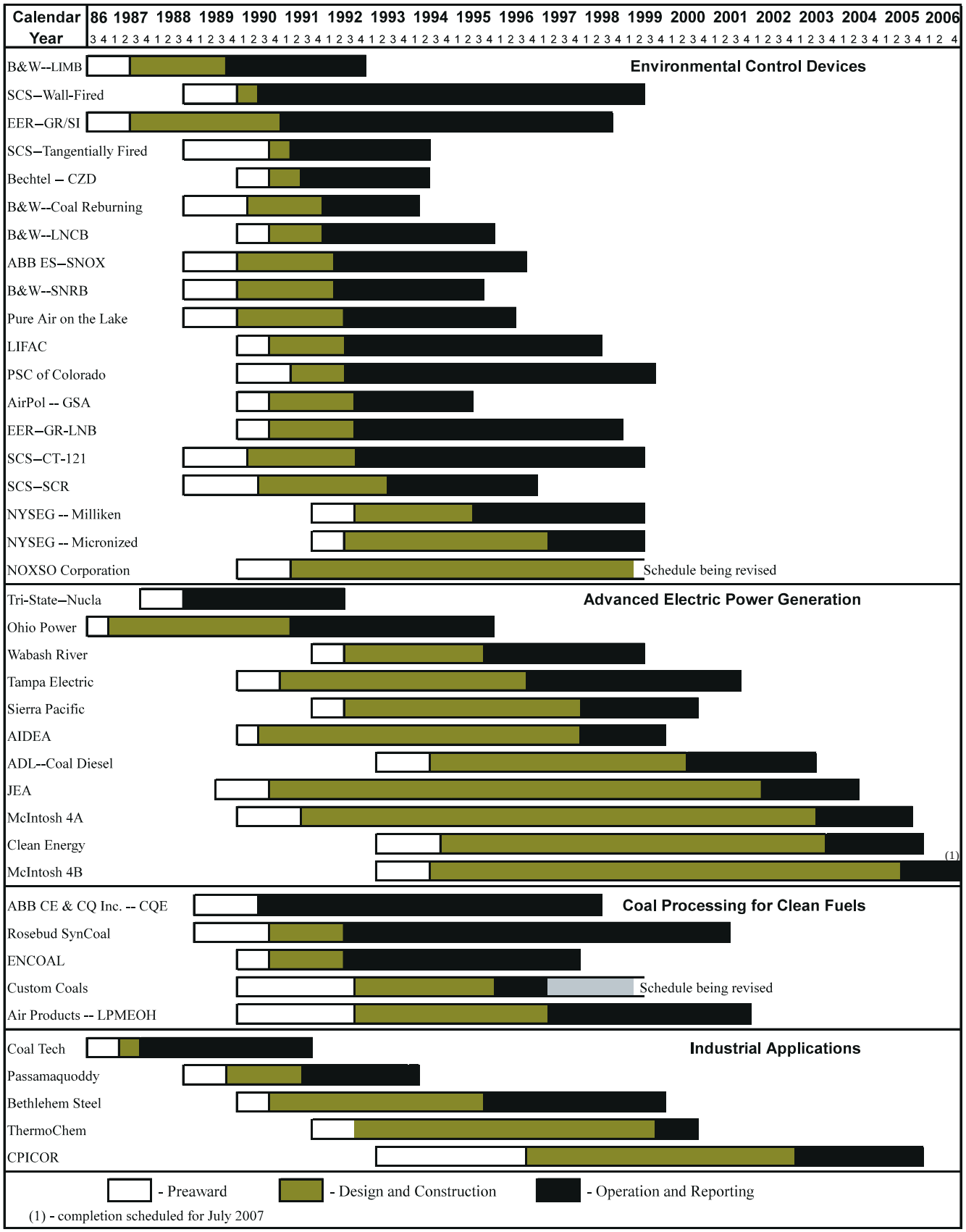
Air Products Liquid Phase Conversion Company, L.P. *Liquid Phase Methanol Process Demonstration Project.* The Liquid Phase Methanol (LPMEOH™) Process Demonstration Facility continues to experience stable operation on coal-derived synthesis gas. The reactor continues to be operated at a temperature of 235°C, somewhat lower than the design temperature 250°C. Fresh catalyst additions made to the reactor since early 1999 have increased the catalyst loading to over 151 percent of design without indications of mass transfer limitations. During stable test periods, the rate of decline in catalyst activity has met the design target of 0.4 percent per day. Since being restarted with fresh catalyst in December 1997, the demonstration facility has operated at greater than 99 percent availability. Since April 1997, over 35 million gallons of methanol have been produced, all of which was accepted by Eastman Chemical Company for use in downstream chemical processes. During a scheduled maintenance outage in March 1999, a code inspection of all pressure vessels was completed. All vessels inspected showed no evidence of erosion, pitting, or fouling. (Kingsport, TN)

INDUSTRIAL APPLICATIONS

Bethlehem Steel Corporation - *Blast Furnace Granulated Coal Injection System Project.* All testing is completed and the Final Report is in preparation. Tests have clearly demonstrated that granular coal can be used on a large blast furnace with good results. In addition, the furnace operation shows that low volatile coal replaces more coke than does lower-carbon-content, high volatile coal. The high volatile coal required 31.4kWh/ton to pulverize during this trial and only 19.6kWh/ton to granulate. Providing granulated coal reduces the cost of power for size reduction by 40 percent. (Burns Harbor, Indiana)

CPICOR™ Management Company, L.L.C. *Clean Power From Integrated Coal / Ore Reduction.* CPICOR™ has completed the design activities for a nominal 3,000 metric ton-per-day liquid metal direct iron reduction project using the HIsmelt® Process. The CPICOR Management Company (CMC) has identified a preferred location for the direct iron reduction portion of the demonstration project within the Geneva Steel Company's plant in Vineyard, Utah. The NEPA process has been initiated and a Notice of Intent for the EIS is expected to be issued in the near future. CMC team members are also designing the power production end of the project, which will be physically separated from the iron production section. (Vineyard,UT)

CCT PROJECT STATUS BAR CHART



SEVENTH CLEAN COAL TECHNOLOGY CONFERENCE PREVIEW

The Seventh Clean Coal Technology Conference will be held June 21-24, 1999, in Knoxville, Tennessee. This year the program will focus on the ability of clean coal technologies (CCTs) to ensure the continued use of coal as an essential component of the nation's energy supply. These technologies will ensure the viability of coal to satisfy the growing national energy demand while continuing to meet increasing environmental requirements and maintaining competitiveness in both international and domestic markets.

The near-term commercial potential of CCTs has progressed significantly through a focused industry/government partnership, cemented over the past 12 years of a joint technology development program. At the same time, U.S. DOE's Clean Coal R&D Program continues to develop innovative advanced technologies that hold the promise of providing energy from fossil fuels in the long-term. Imaginative concepts such as the "Vision 21" complex now focus the investigative effort on the development of those technologies that will address the future environmental, economic, social and market conditions that impact coal as a source of energy.

This conference provides a forum to discuss benchmark issues and the role, as well as the need, for these technologies in the next millennium. The program is designed to address three key issues, and provide in-depth technical discussions on major technology areas. A reception will be held Monday evening, June 21.

—Tuesday, June 22— The conference will open with an Opening Plenary Session, with a Keynote Address: Without Clean Coal, Can the International Community Achieve its Societal and Economic Goals?" To answer this, three panelists will address the following: The Essential Balance Between Energy, Environment, and Economics in a Sustainable Economy; An Industry's Pledge for the 21st Century; and A New Power Industry to Meet the Changing Demands of the Markets of the Future. Three Conference Issues will then be introduced: Deploying CCTs; Global Community Responsibility — Role of Technology and Project Developers, Financiers, Consumers, and Governments; and Coal in Tomorrow's Energy Fleet: Pressures and Possibilities. Following the Plenary Session, Panel Sessions will present two of the three issues (with the third presented on Wednesday).

Issue 1– Deploying CCTs, will provide an overview of the economics of CCTs compared to alternatives for power generation, followed by a developer's perspective on factors that influence technology choice in competitive power markets and how CCTs fit. The last two presentations will be on environmental and other regulatory issues affecting decisions to choose CCTs, and incentives that can be introduced to remove the barriers to deployment of CCTs.

Issue 2– Global Community Responsibility: Role of Technology and Project Developers, Financiers, Consumers, and Governments, will provide insight from a range of financial and development sectors. Presentations will be from: a developing country representative, a World Bank speaker, a commercial banker/financier, and a U.S. project/technology developer.

—Wednesday, June 23— The third Panel Session will be followed by a Panel Sessions Summary. ***Issue 3— Coal in Tomorrow's Energy Fleet: Pressures and Possibilities*** will look at four issues: Electric Power Research Institute's Energy Roadmap; Vision 21: Clean Energy Generation Technologies for the Millennium; CO_2 Sequestration: Opportunities and Challenges; and The Future of Clean Fossil Technologies in a Deregulated Environment.

A Panel Session Summary will follow, with summaries of all three Issues, and discussion of options, followed by a Luncheon Address. Upon conclusion of the Luncheon, conference attendees are invited on a site tour of Air Products Liquid Phase Conversion Company, LP's Liquid Phase Methanol Project (LPMEOH™), in Kingsport, Tennessee. Energy Secretary Richardson will participate in the site tour and will speak at the evening dinner.

—Thursday, June 24— Three Technical Sessions will address how CCTs can meet the needs of combustion systems as well as longer term needs and technology opportunities of post-2010. A luncheon speaker will address CCTs: A Rational Roadmap to Reliability.

Other Conference events will be: Riverboat Theme Reception, reception hosted by Air Products, Poster Session, and Exhibits.

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