OFFICE OF FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY • DOE/FE-0462 • ISSUE NO. 55, FALL/WINTER 2003

CLEAN COAL TODAY

A NEWSLETTER ABOUT INNOVATIVE TECHNOLOGIES FOR COAL UTILIZATION

NEWS BYTES

President Bush renewed his support for clean coal technologies in remarks delivered on September 15, 2003, at **Detroit Edison Co.'s Monroe Power Plant** in Michigan. The President toured the plant, which is undergoing a $650 million upgrading project to install selective catalytic reduction units. The full text of the President's remarks can be found on the U.S. Department of Energy, Fossil Energy web site www.fe.doe.gov, or at www.whitehouse.gov.

A dedication ceremony for the world's largest coal-powered fuel cell was

See "News Bytes" on page 4 ...

IN THIS ISSUE

DOE and U.S.-China Events 1
News Bytes 1
SECA Core Meeting 3
Regional Partnerships 4
DOE's Hydrogen Program 6
Guest Article – NFCRC 7
International Initiatives 9
Successful PDU Test Run 11
Upcoming Events 12
Simulation Modeling 13
CCPI Workshop 15
FE's Specialty Conferences 16
Status Report 18

DOE AND U.S.-CHINA CONFERENCES FOCUS ON COAL

Close to 250 attendees from government, industry, and the research community gathered in Washington, DC, November 17–19, 2003, for the Clean Coal and Power Conference, held this year in conjunction with the Second Joint U.S.-People's Republic of China Conference on Clean Energy. The conference was jointly sponsored by U.S. Department of Energy (DOE), Center for Energy and Economic Development (CEED), National Mining Association (NMA), Electric Power Research Institute, and the Council of Industrial Boiler Owners. China and the DOE Office of Fossil Energy (FE) have been working actively in the implementation of the U.S.-China Protocol for Cooperation in the Field of Fossil Energy Development and Utilization.

Secretary of Energy Spencer Abraham addressing the opening session of the Clean Coal and Power Conference

Department of Energy Secretary Spencer Abraham set the tone for the conference in his keynote remarks, noting the major strides in the development of clean coal technology he expects to see expanded by contributions from other major coal producing nations, particularly China and India. The United States, China, and India together account for 37 percent of the world's coal reserves and 46 percent of today's coal consumption. A number of speakers drew parallels in the experience of the United States and China — concerns about imports and energy security (China became a net oil importer in 1993), and their strong motivations to use coal more cleanly without economic disruptions. Secretary Abraham considers coal a crucial element of U.S. energy policy, and noted that hydrogen is a new opportunity for coal, the most recent in a long line of innovative uses. Carbon sequestration, he said, is one of the Administration's highest clean coal priorities, with FutureGen as the most exciting planned coproduction project with integrated sequestration. He noted that FutureGen plants (that include sequestration) and DOE's hydrogen program take "direct aim at as much as two-thirds of the carbon dioxide emitted in the U.S." China has joined both international forums spearheaded by DOE in these areas, the Carbon Sequestration Leadership Forum and the

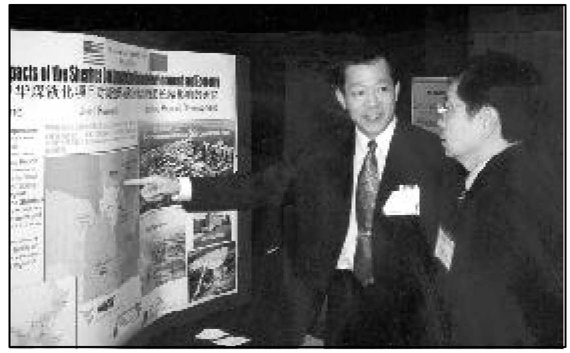
See "Clean Coal" on page 2 ...

"Clean Coal" continued...

International Partnership for a Hydrogen Economy. Under Secretary of State for Global Affairs, Paula Dobriansky, applauded the Chinese presence at the first Hydrogen Partners meeting that followed the Clean Coal-Joint Clean Energy Conference. She said the State Department is cooperating with China in a variety of activities including development of a hydrogen roadmap and climate change dialogs.

Energy security, both domestic and international, as well as the interrelationships among security, affordable electricity, and economic prosperity, were recurring themes throughout the conference. General Richard Lawson, Chairman of Energy, Environment and Security, Ltd., noted a National Academy of Sciences report (Making the Nation Safer: The Role of Science and Technology on Terrorism) that found coal infrastructure to be less vulnerable to terrorism than the supply systems of other energy sources. Jack Gerard, Chairman of the National Mining Association, made timely remarks about the value of incentives in energy policy legislation pending in Congress. The coal/prosperity theme was continued by Stephen Miller, President and CEO of CEED, who spoke of the societal benefits of coal and the importance of affordable energy to the economy.

Anne Korin, Director of Policy and Strategic Planning, the Institute for the Analysis of Global Security, predicted a large role for coal as a source of transportation fuel. She noted China's concern about oil imports and encouraged China to "leapfrog" oil entirely since "coal can replace every aspect of the transportation equation." She noted the success of the Sasol project in South Africa, and the DOE Liquid Phase Methanol project funded under the DOE CCT Program.



(L-R) Liu Yan of China Petrochemical Corporation (SINOPEC) and Francis Lau of the Gas Technology Institute discuss the Shenhua Coal Liquefaction project

Other speakers discussed DOE's programs in sequestration, FutureGen, and hydrogen, and provided updates on environmental regulatory issues. It was noted that China, too, is experiencing increasingly strict environmental regulations, particularly for SO_2. U.S. EPA representative Brian McLean stated that EPA is working with China to develop a cap and trade approach to emissions control. General Lawson indicated that one technology China plans to employ, supercritical pulverized coal, reduces CO_2 emissions by 10–15 percent.

FE Assistant Secretary Carl Michael Smith, the U.S. co-chair of the Permanent Coordinating Committee of the U.S./PRC Protocol Agreement, outlined features of the U.S.-China Protocol, which consists of five annexes (advanced power, clean fuels, oil and gas, environmental technologies, and climate science). Three years of activity have produced important results including conferences on clean coal and power and CO_2 emissions control, and workshops on SO_x/NO_x removal, IGCC and FGD technologies, electricity grid modeling, and coalbed methane development.

Shi Dinghuan, Secretary General of China's Ministry of Science and Technology (and the PRC co-chair of the Protocol Agreement), and members of his delegation provided an excellent overview of China's energy strategy and the role of clean coal technologies. China plans to continue with a coal-dominated but diversified and environmentally responsive energy mix. China's GDP is expected to quadruple by 2020, so increasing power production is crucial. Coal now provides 64 percent of the energy mix, and by 2020, coal production is expected to double, even though coal's share of the total mix will drop due to increased use of other sources such as nuclear energy. The energy scenario for the PRC in 2020 is expected to include 570 GW of coal power, 200 GW of hydroelectric power, 80 GW of natural gas combined-cycle, and 38 GW of nuclear. Secretary General Shi explained that significant emissions could result from coal burning, and recognizes that China needs technology to cope with the problem. This need creates significant opportunity for U.S. CCTs.

Throughout the conference, Chinese representatives spoke of huge energy demand, and the steps that already have been taken to supply some of the need through CCTs. For example, a 300- to 400-MW IGCC plant at Yantai in Shandong Province, constructed with U.S. technology, is expected to go on line in 2007. China expects IGCCs to become widespread after 2020. Supercritical and ultrasupercritical pulverized coal plants also will have an important role in the nearer term. Progress is being made, particularly in retrofitting CFBs to industrial boilers in Beijing as part of a "green" Olympics effort in which DOE is participating. Liquid fuels (to replace oil) for the increasing number of vehicles is a major concern, and two coal liquefaction projects are underway utilizing foreign investment and technology. Conference speakers also confirmed an interest in hydrogen and fuel cell powered cars. In terms of environmental control technologies, speakers focused on wet FGD, SNCR in the short term, and SCR in the longer term.

To assist in the PRC's transition to new technologies, China is in the process of a gradual restructuring and privatizing of its utility sector. This sector of the economy is moving from an integrated monopoly to competitive pricing. The China State Power Corporation, which historically has managed all aspects of power generation and distribution in China, is in the process of establishing competition in generation markets. Five "generation group corporations" as well as two "grid corporations" have been formed. Shares are sold on the open market. Madam Zhang Xiaolu, Vice President of one of these groups (the China Investment Power Corporation) spoke of the eventual PRC goal to unbundle generation, transmission, and distribution. In the next three years, six regional markets will be established to implement orderly competition. A pilot effort of this type is under way in Eastern China.

In all, the conference presented a significant opportunity to discuss the status of technology developments relating to global coal use, and the need for continued cooperation as the U.S. and China address concerns regarding air quality, global climate change, and energy security.

SECA Core Technology Program Review Meeting

NETL and the Pacific Northwest National Laboratory (PNNL) held a Solid State Energy Conversion Alliance (SECA) Core Technology Program Review Meeting September 30 – October 1, 2003, in Albany, New York. The event was hosted by the New York State Energy R&D Authority. SECA was formed to develop a $400/kW fuel cell — a tenfold cost reduction relative to current systems. The path chosen was to use solid oxide fuel cell (SOFC) technology, and to mass produce 3- to 10-kW SOFC modules that could be aggregated like batteries to meet a broad range of market needs. SOFCs are compatible with coal-derived synthesis gas and offer high-efficiency coal-based power options when linked to gasification. The SECA Core Technology Program (CTP) addresses research needs identified by Industry Teams carrying out the actual SOFC hardware development, system integration, and manufacturing of the modules. At the meeting, significant progress was reported toward addressing major research issues.

The CTP is moving closer to realizing a fully integrated fuel processor with multi-fuel capability that is small, and either removes sulfur before reforming, or uses sulfur-tolerant materials in reforming. A multi-fuel capability is important because transportation applications require use of either gasoline or diesel fuel. Diesel fuel is being targeted for fuel cell application because it typically contains high sulfur and carbon levels and is prone to produce carbon under reforming conditions. Progress is also being made in converting the relatively low, fluctuating voltage of SOFCs to higher, stabile end use AC or DC voltages.

Researchers have developed cathode compositions showing promise for providing satisfactory reactivity at temperatures (700–750 °C) compatible with using metallic interconnects and balance of plant components. These could replace more expensive and less conductive ceramics, and thus lower fuel cell stack costs. A major effort to reduce interconnect costs by developing alloys to displace ceramics is also paying dividends. An improved understanding of the chemical and thermomechanical stability of alloys at SOFC operating temperatures is emerging. Major progress has been made toward identifying the most promising bulk alloy materials and surface modifications to the bulk materials for survival under SOFC operating conditions.

Progress also has been made in characterizing the thermodynamics, kinetics, and mechanisms surrounding anode and fuel processing catalyst poisoning by sulfur and carbon and damaging oxidation experienced in SOFCs. Modifying the typical nickel/zirconia anode surface/interface properties and use of alternate materials are showing improved resistance to damage.

Another priority effort is directed at development of seals for planar SOFCs to prevent leakage of fuel and oxidant at cell component boundaries. The glass seals currently used are subject to fracturing under thermal stresses induced in

See "SECA" on page 4 ...

"SECA" continued...

operating cycles. Use of deformable glass-ceramic materials to relieve and heal cracks and mica-based compressive seals is showing promise for resolving this issue.

Models and simulation tools continue to emerge from CTP efforts that save Industry Teams time and money in investigating stack design, systems issues, and developings olutions. Training sessions have been held to transfer the technology to the Industry Teams.

The proceedings of the recent CTP Review Meeting are available through the NETL Web site at http://netl.doe.gov under Publications.

"News Bytes" continued...

held in August at **PSI Energy's Wabash River IGCC Plant** — a former, and highly successful, U.S. Department of Energy Clean Coal Technology project located in Terre Haute, Indiana. The 2-MW molten carbonate fuel cell system uses Direct Fuel Cell® technology developed by FuelCell Energy through a 25-year research partnership with DOE. The Wabash fuel cell represents the first and largest industrial-scale fuel cell power plant to be operated on coal-derived synthesis gas.

DOE Hosts First Meeting of Regional Sequestration Partnerships

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) held a kickoff meeting on November 3–4, 2003, in Pittsburgh, Pennsylvania, for seven regional teams that will help develop the framework and infrastructure needed for wide scale deployment of carbon sequestration technologies. In August, DOE selected teams from five geographic regions. The teams, representing the interests of some 140 organizations, 33 states, three Indian Nations, and two Canadian provinces, form the core of a nationwide network to determine the best regional approaches for capturing and permanently storing carbon dioxide (CO_2).

Carl Michael Smith, Assistant Secretary for Fossil Energy, welcomed participants to the first Sequestration Partnership team meeting

Carl Michael Smith, Assistant Secretary for Fossil Energy, provided welcoming remarks stressing the importance of the regional partnerships, and how they mark the third major sequestration effort taken by the Department in recent months to support President Bush's Global Climate Change Initiative — joining the Carbon Sequestration Leadership Forum and the FutureGen project. The Partnerships will promote collaboration within and among regions, and are expected to provide a platform for the U.S. to assist developing countries in their efforts to reduce greenhouse gas emissions. Smith said that DOE will be providing approximately $11.1 million to support the partnerships in the two-year Phase I effort. Each group will receive up to $1.6 million, with participating organizations contributing another $7 million, or an average of nearly 40 percent of the initial funding. A Phase II solicitation is envisioned for 2006, to build on Phase I efforts. It is expected that many of the partners would continue with small-scale field validation tests of promising sequestration technologies.

Scott Klara, NETL's Carbon Sequestration Technology Manager, introduced members of the DOE management team and outlined the Partnership's goals. The seven groups (see box on page 5) will develop baseline data for sources and sinks of CO_2; evaluate regulatory and permitting issues affecting sequestration; identify regional safety, permitting and public acceptance issues; establish monitoring and verification protocols; and evaluate potential sequestration technologies and CO_2 transportation methods. Klara emphasized the need for the partnerships to produce tangible results. The partnerships are to prepare regional action plans to address the technology options and pathways appropriate to their regions, and begin to build local coalitions to address regulatory permitting and public acceptance issues. Each team is to determine the benefits of sequestration for its particular region and focus on value-added land-based sequestration approaches. Engineering and scientific data would be developed by participants, allowing for later scale-up. Data might take the form of regional atlases to identify options for sequestration, sources of carbon dioxide, and existing infrastructure. These could be incorporated later into a national information repository, though that task is beyond the scope of the current Partnerships.

The second day of the meeting was devoted to structured breakout sessions with the objectives of developing approaches and identifying synergistic opportunities among the partnerships. Participants shared ideas about the role of the Partnerships in shaping future regulatory issues, and making best use of existing outreach frameworks. The groups agreed that streamlined regulations and permitting processes would speed siting of facilities for carbon conversion and capture, as well as pipeline transportation and eventual CO_2 sequestration. Long term ownership of CO_2 was considered an unresolved issue. The groups emphasized the importance of information sharing and discussed coordination methods. Technical topics explored included the need to acquire information from existing sequestration field tests; the desirability of uniform standards for databases and GIS tools; and methods for determining the purity of captured CO_2. The retrofitting of existing plants versus CO_2 capture in new plants was also considered.

Scott Klara, NETL's Carbon Sequestration program manager, outlined the Partnership's goals

SEVEN REGIONAL CARBON SEQUESTRATION PARTNERSHIPS

- *West Coast Regional Carbon Sequestration Partnership* is led by the California Energy Commission, Sacramento, California, and is made up of representative organizations from Alaska, Arizona, California, Nevada, Oregon, and Washington.
- *Southwest Regional Partnership for Carbon Sequestration* involves the efforts of 21 partners in eight states coordinated by the Western Governors' Association and New Mexico Institute of Mining and Technology, Socorro, New Mexico, and involves Arizona, Colorado, Kansas, New Mexico, Oklahoma, Texas, Utah, and Wyoming.
- *Northern Rockies and Great Plains Regional Carbon Sequestration Partnership* is headed by Montana State University, Bozeman, Montana, and covers Idaho, Montana, and South Dakota.
- *Plains CO_2 Reduction Partnership* extends across Minnesota, North Dakota, South Dakota, Montana, Wyoming, and two Canadian provinces. It is led by the Energy & Environmental Research Center at the University of North Dakota, Grand Forks, North Dakota.
- *Geologic Carbon Sequestration Options in the Illinois Basin* will evaluate sequestration options of the Illinois Basin of Illinois, western Indiana, and western Kentucky. It is led by the University of Illinois, Illinois State Geological Survey.
- *Southeast Regional Carbon Sequestration Partnership* is headed by the Southern States Energy Board, Norcross, Georgia, and involves Arkansas, Louisiana, Mississippi, Alabama, Tennessee, Georgia, Florida, North Carolina, and South Carolina.
- *Midwest Regional Carbon Sequestration Partnership* covers Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia and is coordinated by the Battelle Memorial Institute, Columbus, Ohio.

DOE HIGHLIGHTS GROWING HYDROGEN PROGRAM

At the industry-wide Pittsburgh Coal Conference, held in September 2003, Mr. Edward Schmetz of Fossil Energy's (FE) Office of Coal & Power Systems, took the opportunity to detail FE's new program to produce, deliver, and store hydrogen from coal. Coal can be an important mid- to long-term source for producing hydrogen for use in transportation and other energy sectors, particularly with carbon capture and sequestration. Coal and natural gas, along with renewable sources, could lead to the advent of a "hydrogen economy," which is expected to gradually evolve and take full form in the 2030–40 time frame. The widely attended annual Pittsburgh Conference has historically provided a forum for technical experts from industry, government, and the research community to exchange information on opportunities for coal to contribute to a secure, clean, and affordable energy future. FE's efforts are part of the $1.2 billion Hydrogen Fuel Initiative, announced by President Bush in January 2003 to develop technologies and infrastructure needed to produce, store, and distribute hydrogen for use in fuel cell vehicles and electricity generation. This effort is supportive of the FreedomCAR (Cooperative Automotive Research) program being conducted by DOE's Office of Energy Efficiency and Renewable Energy (EERE).

Some nine million tons per year of hydrogen are produced domestically, mostly by steam reforming of naphtha or natural gas. Hydrogen generally is used as a feedstock or intermediate chemical and not — as envisioned in a hydrogen economy — as an energy carrier for transportation or other market sectors. Hydrogen produced from fossil fuels (especially from our 250-year supply of coal) and used in advanced power technologies and fuel cell vehicles (FCVs) could contribute greatly to energy security. Powering 100 million FCVs (half the number of today's vehicles) with hydrogen would reduce oil imports by over 3 million barrels/day. Since hydrogen-powered vehicles emit only water vapor, criteria pollutant emissions also would decrease significantly, thus contributing to the Administration's Clear Skies goals. Finally, with integration of the CO_2 sequestration technology planned or under development in Fossil Energy's R&D program, the Hydrogen program would lead to near-zero emission hydrogen production and utilization technologies.

As outlined at the Pittsburgh conference, FE is pursuing targeted research in support of DOE's hydrogen program, while continuing a number of ongoing activities that would contribute to a hydrogen economy, e.g., programs for CO_2 sequestration, advanced gasification, and fuel cells. The basic process for producing hydrogen from coal involves gasification. In gasification and associated gas cleanup, coal, oxygen, and steam combine to produce a synthesis gas (syngas) largely free of sulfur and mercury contaminants. To produce hydrogen, this syngas, which is primarily hydrogen and carbon monoxide, undergoes a water-gas-shift reaction whereby water in the form of steam gives up oxygen to convert carbon monoxide to carbon dioxide and frees up additional hydrogen. Hydrogen then is separated from the carbon dioxide by using well established pressure swing adsorption (PSA) technology. PSA uses porous, high-surface-area adsorbent materials that, at high pressure, preferentially adsorb a selected gas on the surface area of the material and release the gas when subjected to a lowering of pressure.

Hydrogen can be produced from coal using current technology, but the process is costly. FE's program would develop efficient, higher temperature processes containing fewer steps. Improved processes also are required in all phases of gasification/hydrogen production and separation, as well as development of new capture and sequestration processes. Specifically, beginning this fiscal year, FE will use roughly $5 million to develop:

- advanced water-gas-shift reactors that improve efficiency of existing reactors by using more effective, sulfur-tolerant catalysts to enhance hydrogen production and reduce cost;
- novel membranes for advanced, lower cost separation of hydrogen from carbon dioxide and other contaminants;
- advanced technology concepts that combine hydrogen separation and water-gas-shift reaction; and
- technologies that utilize fewer steps to separate carbon dioxide, hydrogen sulfide, and other impurities from hydrogen.

The aim is to reduce hydrogen costs by 25 percent by 2015 through the development of a zero-emission, coal-based plant that coproduces hydrogen and electric power while sequestering CO_2. DOE's 2015 goals include plants that are 60 percent efficient.

In the transportation area, FE's program would strive to develop alternate hydrogen delivery systems using hydrogen-rich synthesis gas derived from liquid fuels. The hydrogen-rich fuels would be more compatible with conventional pipeline delivery than pure hydrogen, and would be formulated for efficient reforming at the application site. Today's hydrogen industry is small scale, with hydrogen produced at end use sites, and no large scale transportation, delivery, and storage system exists.

To support technology development, DOE's FutureGen initiative will serve as a platform to demonstrate and further develop hydrogen production and CO_2 sequestration technology suitable for use at commercial scale. FutureGen is a government/industry cost-shared project to build a 275-megawatt IGCC test facility for evaluating cutting-edge technologies. Project objectives include producing hydrogen at $4.00/million Btu, sequestering up to 100 percent of the CO_2 by-product, and producing electricity with zero emissions at less than a 10 percent increase in cost compared to non-sequestration systems.

International cooperation is also part of DOE's plan. "The International Partnership for a Hydrogen Economy," an effort spearheaded by DOE's Office of Energy Efficiency and Renewable Energy, sponsored an international ministerial meeting in November 2003. In addition, FE is participating in an International Energy Agency working group to address hydrogen issues, and is working closely with the European Union. Lastly, international partners will be actively sought to implement the FutureGen project.

The current FE Hydrogen Program Plan is available on the FE Web site http://www.fe.doe.gov/. Next steps in FE's Hydrogen From Coal program involve development of a detailed R&D multi-year program plan.

COAL-BASED HYDROGEN COPRODUCTION WITH CO_2 CAPTURE

This guest article was submitted by Professor Scott Samuelson, Director of the National Fuel Cell Research Center/Advanced Power and Energy Program, located at the University of California, Irvine.

A multi-disciplinary team led by the Advanced Power and Energy Program (APEP) at the University of California has identified an advanced coal-based system configuration that synergistically coproduces hydrogen (H_2) while recovering rather than emitting the carbon dioxide (CO_2). Advanced technologies that are currently under development, such as high-pressure fuel cells, ionic membranes and advanced gasifiers, are incorporated. This research is confirming that coal can, indeed, provide the transition to a hydrogen economy touted by the current administration and, when coupled with carbon sequestration, can be used to produce H_2 for decades without contributing to the buildup of CO_2 in the atmosphere. Additionally, affordable and environmentally safe sequestration of CO_2 offers a strategy to stabilize the contribution to greenhouse gases without requiring the United States and other coal-rich countries to make large-scale and potentially expensive changes to their energy infrastructures.

PLANT DESCRIPTION

The conceptualized plant design is depicted on page 8, and consists of an O_2-blown Advanced Transport Reactor (ATR) with hot gas cleanup followed by a shift/membrane unit that reacts the CO with H_2O contained in the syngas to generate H_2 in addition to that formed within the ATR. The H_2 is separated within this unit while the non-permeate gas from the unit, consisting primarily of CO, CO_2, H_2O, along with a fraction of the H_2 that is not separated, is fed to the anode side of a solid oxide fuel cell (SOFC). Air to the cathode side of the SOFC is supplied by the compressor of a gas turbine. The anode exhaust gas is fed, after heat recovery, to a second shift/membrane unit where additional H_2 is formed by shifting the remaining CO. Approximately 80 percent of this H_2 is separated and recycled to the SOFC. The non-permeate gas is fed to a catalytic combustor using O_2. The combustor and the ATR are supplied essentially 100 percent pure O_2 by an ion or oxygen transport membrane (ITM or OTM) air separation unit. The catalytic combustor oxidizes the small amounts of any remaining CO and H_2, leaving only CO_2, H_2O, and a small amount of O_2 in the stream. This stream is cooled while recovering the heat, and then further cooled to near ambient and treated in a sulfided activated carbon bed to capture the Hg. The stream is ultimately pressurized to 2,000 psi before being pipelined for sequestration of the CO_2.

On the cathode side of the SOFC, the compressed air, at approximately 20 bar, is heated in a regenerator (not shown in the diagram) prior to entering the SOFC. The hot depleted air exiting the cathode enters the hot side of the regenerator and is cooled to 1,650 °F, the temperature required by the ITM (or

See "Hydrogen" on page 8 ...

"Hydrogen" continued...

OTM) unit for air separation. In this membrane unit, O_2 is removed from the already vitiated air and exits the unit at sub-atmospheric pressure. The O_2 is cooled and compressed to gasifier pressure with a small side stream going to the catalytic "cleanup" burner. The non-permeate gas, now reduced in mass flow, pressure, and at the ITM/OTM exit temperature of 1,650 °F, is expanded in the turbine and exhausts to an HRSG.

The configuration includes a small circulating fluidized-bed (CFB) combustor that recovers energy from the unburned carbon while oxidizing the CaS formed within the ATR. A small fuel gas stream is also burned in the combustor to maintain its 1,600 °F temperature. Steam is raised in this system. The steam system uses heat from fuel gas cooling, and various heat exchangers.

SYSTEM PERFORMANCE

The estimates of system performance are being developed utilizing a bituminous coal (Illinois No. 6). The effective carbon capture is more than 90 percent of the carbon entering with the coal. The small emissions of the CO_2 are primarily from the CFB. Approximately 90 MMSCF/D of H_2 coproduct and 85 MW of electric power are exported by a nominal 2,000 ST/D coal plant. Overall thermal performance of this coproduction facility is much better than the minimum efficiency criteria set by DOE for advanced technology plants that either produce power only (60 percent on a HHV basis) or fuel only (75 percent on a LHV basis).

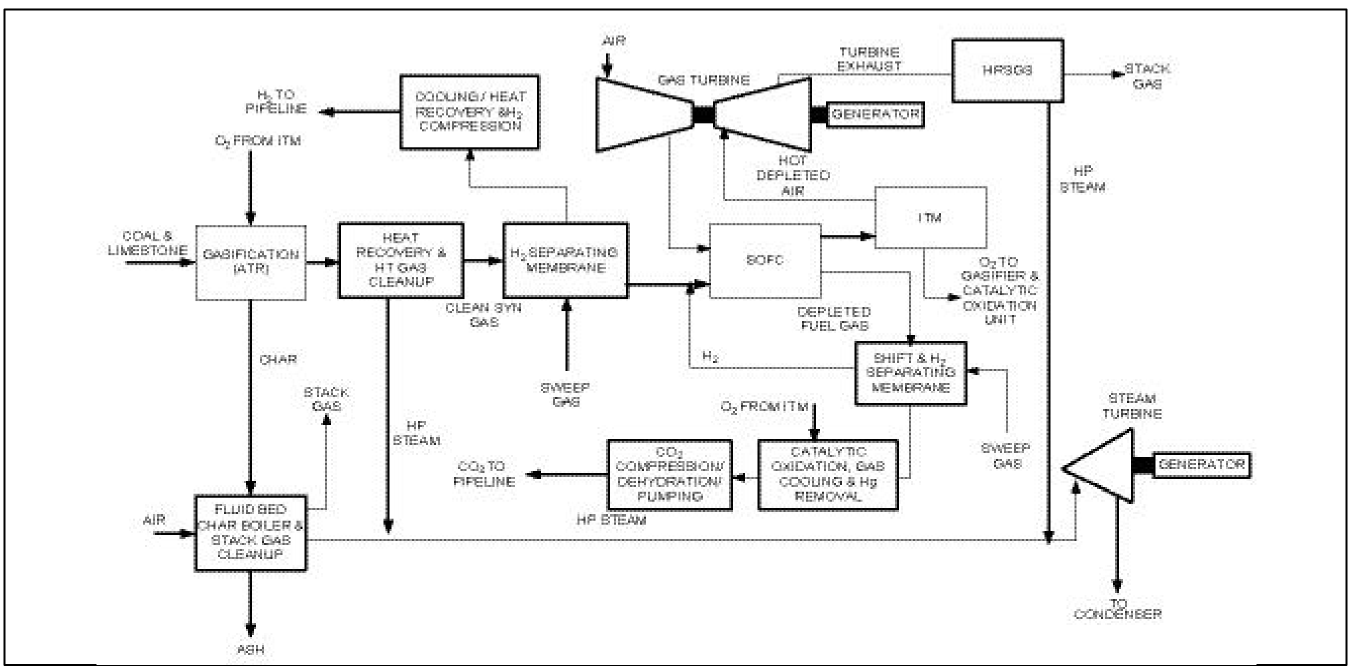
CONTINUING ACTIVITIES

Currently, the APEP lead team is projecting the plant cost estimates and economics. As part of this program, the development needs are being defined which will serve as a guide for the U.S. Department of Energy in identifying the research areas and technologies that warrant further support. A number of development needs already have been identified. The major development need for the gas turbine in this hybrid application is for a large unit (100 MW or larger) with the capability of operating in the "recuperative cycle" mode.

In addition, fuel cell system development needs include an operating pressure greater than 20 bar, and separate anode and cathode exhausts from the fuel cell. High current density materials (without use of exotic/expensive materials) are needed in order to limit the physical size of the fuel cell stack modules, as well as minimize the associated high temperature piping and manifolding. These materials would also reduce the overall cost of the system.

For the balance of plant systems, development needs include:

- stringent high-temperature cleanup requirements for sulfur species, alkalies, chlorides, and SiO_2 in the syngas to make it suitable for the fuel cell;
- ionic membrane separation of air with high oxygen flux rates;
- ATR operation at lower temperature while maintaining high carbon conversion; and
- high-temperature shift/membrane units for the separation of H_2 with high flux rates.



INTERNATIONAL INITIATIVES

INDIA AND UNITED STATES CONTINUE COLLABORATION

In September, Fossil Energy Assistant Secretary Carl Michael Smith and A.P.V.N. Sarma, Joint Secretary of India's Ministry of Coal, signed a Memorandum of Understanding for energy consultations and information exchange. The MOU provides for the establishment of a sub-ministerial working group to explore possible areas of mutual interest. In fossil energy and electric power, the group will consult on coal science, process modeling of advanced fossil technologies, effect of high-ash coal in boilers, cleanup of combustion wastes, and coal cleaning and preparation.

Dr. Lowell Miller (front right) and Secretary C.V. Arha (front left), Secretary of the India Ministry of Coal, and other members of the Indo-U.S. Coal Advisory Group meeting in Washington, DC in April 2003

The MOU follows bilateral negotiations at the 2nd meeting of the Indo-U.S. Coal Advisory Group, held in April 2003 in Washington, DC. At that time, a preliminary version of the MOU was signed by Dr. Lowell Miller, Director of FE's Office of Coal Fuels and Industrial Systems, and Special Secretary C.V. Arha of the Indian Ministry of Coal. Following the April meeting, a delegation of Indian engineers visited various energy sites in Pennsylvania, including a CFB plant burning waste coal, and two mine reclamation projects — one using biosolids and the other ash. The Indian delegation showed keen interest in surface mine reclamation policy, as well as technical and financial aspects of coal waste fuels. Fly ash is considered a good candidate as a soil additive for reclaiming abandoned surface mines in India. The US business delegation to the Coal Advisory Group has been helping to develop a model business plan for an Indian coal washery, or cleaning facility.

FGD TRAINING IN CHINA

In September 2003, a two-week training course on U.S. flue gas desulfurization (FGD) practices for coal-fired power plants was completed in China under the Fossil Energy Protocol that was signed by the U.S. Department of Energy (DOE) and China's Ministry of Science and Technology in 2001. The training activity was carried out by DOE's National Energy Technology Laboratory (NETL) and two teams of FGD experts. This training was conducted under Annex I on Advanced Power Systems.

James Eckmann of NETL opens the U.S.-China FGD Training Course in Beijing with Zhang Xialou of the China Power Investment Corporation (seated fourth and fifth from left)

Approximately 75 representatives from Chinese utilities and engineering firms participated in the first week of training, which was held in Beijing. The agenda dealt with U.S. practices for design, specification, and procurement of wet FGD systems. The audience was composed primarily of engineering staff from Chinese utilities that will be installing FGD systems to meet stricter sulfur dioxide standards for coal-fired power plants. The second week of training, held in Chongqing, focused on U.S. practices for operation and maintenance of wet FGD systems. Attendance exceeded 100, and was composed primarily of engineering staff from Chinese utilities that already have installed FGD systems.

See "International" on page 10 ...

"International" continued...

China has a set a target of 2005 to reduce sulfur dioxide emissions by 20 percent from 2000 levels, and has said that emissions reduction equipment must be installed in 137 key coal power plants to achieve this goal. Asian utilities, primarily those in China, are expected to order FGD systems costing just under $13 billion by the end of this decade. U.S. companies are world leaders in supplying FGD equipment and services, and while they have begun intensive marketing efforts in China, still face stiff competition from Japanese and European vendors. Several U.S.-based companies have established subsidiaries or licensing arrangements with local companies to sell FGD equipment and services in China. Educating Chinese utilities on U.S. FGD practices will increase their familiarity with U.S. capabilities to supply needed equipment and services.

U.S. DOE IS CARBON SEQUESTRATION LEADERSHIP FORUM SECRETARIAT

Fossil Energy's Office of Coal and Power Import/Export is acting as Secretariat for the multinational Carbon Sequestration Leadership Forum (CSLF). The CSLF is an international climate change initiative that is focusing on development of carbon capture and storage technologies as one possible means for stabilizing greenhouse gas levels in the atmosphere. The first meeting of the CSLF was held in June 2003 in Virginia, and was attended by more than 400 people from 17 countries plus the European Commission. To date, 15 countries plus the European Commission have signed the CSLF Charter, which establishes the framework for international cooperation in carbon sequestration activities.

Planning is underway for the next general meeting of the CSLF to be held January 19–23, 2004, in Rome, Italy. The event will include separate two-day meetings of the CSLF's Technical and Policy groups, and is expected to result in proposals for multinational projects related to carbon sequestration. Technical issues concerning costs and storage potential of various technology options will also be addressed, as will policy issues related to legal, regulatory and financial aspects of carbon sequestration. Stakeholder involvement in CSLF activities will be another important topic of discussion.

Additional information about the CSLF and its activities can be found at the CSLF web site, http://www.cslforum.org/.

CSLF Charter signing ceremony was held on June 25, 2003, in Washington,

NETL COMPLETES A SUCCESSFUL PDU TEST

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) recently completed a successful high-temperature desulfurization test in a facility designed to evaluate processes and sorbents for bulk removal of sulfurous compounds from coal gasification product gas streams. The proof-of-concept scale Gas Process Development Unit (GPDU) facility features four reactors, which can be integrated to allow sulfur absorption and simultaneous regeneration of sorbent in either a fluid-bed or a transport reactor.

Partial view of the PDU facility, located in Morgantown, West Virginia

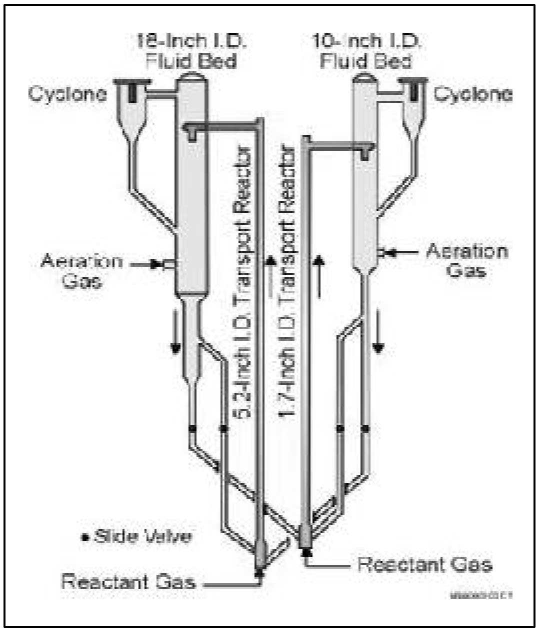
The GPDU transport absorber has an inside diameter of 5.2 inches with a vertical length of 50 feet, while the fluid-bed absorber has an inside diameter of 18 inches with a maximum bed height of 10 feet. The GPDU transport regenerator has an inside diameter of 1.7 inches with a vertical length of 50 feet, while the fluid-bed regenerator has an inside diameter of 10 inches with a maximum bed height of 12 feet. With a coupled absorber-regenerator reactor system that is capable of operating at pressures up to 385 psig and temperatures from 500 °F to 1,400 °F, the GPDU provides continuous sorbent circulation for integrated sulfidation-regeneration operation at a scale large enough to show potential for eventual industrial application.

While gas cleaning processes and sulfur sorbents suitable for coal gasification streams have been studied extensively in laboratory- and bench-scale systems at batch conditions, longer-term sorbent and reactor performance data at large-scale continuous conditions have, until now, been lacking. For acceptable economics, manufactured sorbents need to last thousands of sulfidation-regeneration cycles. With the continuous nature of operations, the GPDU provides a means to economically assess, in a relatively short time, the chemical and physical performance of candidate sorbents under cyclic conditions. Up to about 50 cycles per day can be achieved at the GPDU, depending on operating conditions. Additionally, with the choice of reactor types for absorption and regeneration, an optimum process can be determined. Successful demonstration of a continuous desulfurization process will lead to technology deployment that will reduce emissions, lower costs, and improve efficiency of power generation systems that integrate coal gasification with gas turbines and fuel cells.

An initial test was conducted at the GPDU in May 2003, including shakedown of individual subsystems. Principal activities included developing startup procedures, sorbent circulation/management techniques, and system operating protocols, as well as testing a syngas generator that is the source of sulfur-laden simulated gasifier fuel gas for GPDU operation.

RECENT PROGRESS

In September 2003, NETL conducted the first extended high-temperature transport desulfurization operations at the GPDU. A nominal 83,000 standard-cubic-feet-per-hour (about 5,200 lb/hr) of simulated air-blown coal gasification process gas, generated at the facility's syngas generator, was processed. The syngas, containing approximately 3,500 to 4,000 ppmv of hydrogen sulfide (5,000 to 6,000 ppmv dry basis), was desulfurized in the GPDU's transport absorber under process conditions of 300 psig pressure and a nominal 1,070 °F temperature. A nominal



3,300 pounds of zinc titanate sorbent, with a mean particle diameter of 70 microns, were circulated between the transport absorber and a regenerator reactor to provide uninterrupted syngas desulfurization. Designated as EXS03, this sorbent formulation was developed by RTI under DOE sponsorship and manu-

See "PDU Test" on page 12 ...

"PDU Test" continued...

factured by Intercat, Inc. During this first longer-term sorbent test, several continuous operational periods were achieved, with one uninterrupted period of over 11 hours. The sorbent exhibited around 99 percent sulfur capture, maintaining a relatively consistent 50 ppmv (dry basis) hydrogen sulfide in the absorber exit gas. Sorbent regeneration was accomplished using the facility's fluid-bed regenerator, which proved to be easily and reliably operated. This test showed that sorbent could be continuously circulated between the absorber containing fuel gas and the regenerator containing oxidizing gas in a safe and relatively easy fashion, and constituted a convincing demonstration of transport absorber technology at a significant scale. Attempts to demonstrate transport regeneration were unsuccessful in this first significant test campaign.

FUTURE PLANS

Near-term GPDU test plans include additional high-temperature gas desulfurization testing of the EXS03 sorbent in a transport absorber to expand on the recent promising results and to demonstrate that the continuous reactor system is controllable over even longer operational periods. Researchers also will explore methods to achieve higher temperatures at the GPDU so that transport regeneration can be successfully accomplished. A continuous transport absorber-regenerator system that can be controlled while meeting sulfur capture goals is the desired goal. The smaller size and lower projected capital cost of a transport reactor system make it economically attractive compared to other options. Because of the higher gas velocity and continuous circulation aspects of transport systems compared to other reactor types, sorbents will be more prone to unacceptable attrition. Therefore, a longer duration future test to further assess sorbent longevity is indicated.

Other near-term plans include warm gas desulfurization testing of a sorbent in the range of 500 °F to 800 °F. The sorbent to be tested, designated as RTI3 and manufactured by Süd-Chemie, has been formulated specifically for sulfur capture at these more moderate temperatures.

UPCOMING EVENTS

February 17–29, 2004
IEA Asia Pacific Conference on Zero Emissions Technologies
Sponsors: IEA Clean Coal Centre, U.S. DOE, among others
Location: Gold Coast, Queensland, Australia

May 2–6, 2004
Third Annual Conference on Carbon Capture and Sequestration
Sponsors: U.S. DOE, NETL, Monitor Exchange Publications and Forums, U.S. Climate Change Science Program, USDA, and U.S. EPA
Location: Alexandria, Virginia

May 18, 2004
Conference on Reburning for NO_x Control
Sponsor: NETL
Location: Morgantown, West Virginia

June 10–18, 2004
U.S.-China Industrial Boilers Workshop — "Increasing Energy Efficiency, Reducing Pollution & Greenhouse Gases"
(2-day workshop followed by study tour and plant visits)
Sponsors: EPA and China National Development and Reform Commission; organized by NETL and others
Location: Beijing, China

For information on these events, contact:
Kimberly Yavorsky
(412) 386-6044
kimberly.yavorsky@netl.doe.gov

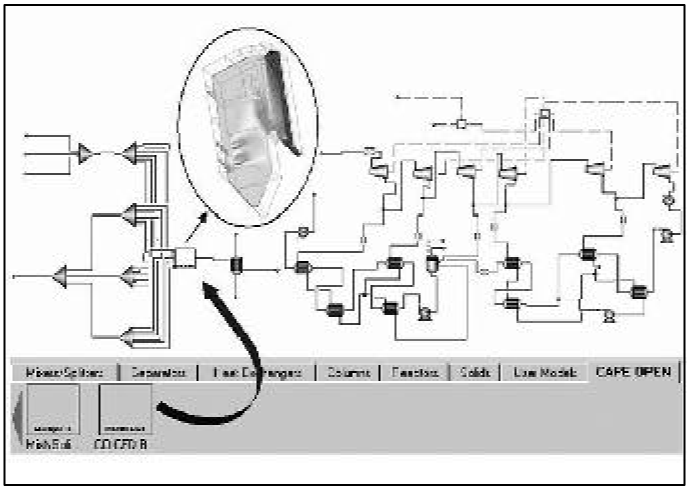
REVOLUTIONARY ADVANCED ENERGY SYSTEM MODELING

Under cost-shared cooperative agreements sponsored by the National Energy Technology Laboratory (NETL), Reaction Engineering International (REI) and Fluent Inc. (Fluent) are nearing the end of separate four-year efforts to develop new computational frameworks for simulating advanced energy systems. When completed later this year, the initial versions of the REI and Fluent tools will revolutionize the modeling of advanced energy systems by providing — for the first time ever — the powerful capability of automatically integrating detailed, stand-alone equipment models into process flowsheet simulation software. These new computational frameworks are expected to reduce the time, cost, and technical risk of developing the advanced energy systems envisioned by DOE's coal power program — systems capable of efficiently converting our vast domestic coal resource into electricity and multiple products, with near-zero emissions.

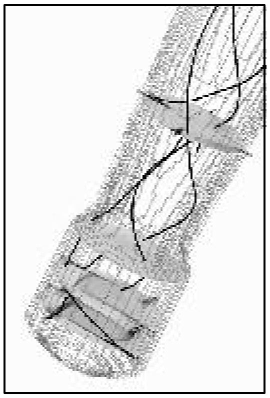
Currently, exchange of information between process flowsheet and equipment models — those most widely used in the energy and chemical industries — must be manually customized for each combination of models, a time consuming and costly endeavor. A process flowsheet model is used to study the integrated performance of multiple pieces of process equipment, while an equipment model is used for more detailed analysis of the individual performance of a single piece of equipment. Process flowsheet models are commonly constructed using commercial simulation software, such as Aspen Plus®, to perform global mass and energy balances. They rely on a combination of simple, but fast-running, component models that are either zero-dimensional (0D), e.g., specified conversion, or one-dimensional (1D), e.g., plug flow reactor. Equipment models typically are created using proprietary, "in-house" codes or with commercial, computational fluid dynamics (CFD) software. Often they are 2-dimensional or 3-dimensional (3D) models that are complex enough to optimize the design of a piece of equipment based on its physical geometry by calculating spatial distributions of various parameters (e.g., temperature, pressure, concentration, velocity, etc.).

When designing an advanced system, it often is desirable to share information iteratively between process flowsheet and equipment models, or better yet, run them simultaneously in an integrated fashion. This allows the overall system design to be based, as needed, on the more accurate and detailed information offered by equipment models. Likewise, an equipment model can make use of the extensive physical properties databases available in process simulation software. Such integration also ensures that using detailed equipment models to optimize individual components achieves a system-wide improvement, rather than just a local improvement at the expense of overall system performance. When plugged into a process flowsheet simulation, equipment models can take into account the effect of other equipment items on input parameters, for example, the effect of a recycle loop on the inlet composition. Detailed component models can feature "virtual sensors" that monitor critical equipment parameters (e.g., turbine blade temperatures) during process flowsheet simulation and issue warnings when they go out of range. Although these computational frameworks will not make demonstration plants unnecessary, they will reduce the number of demonstrations and improve the level of understanding gained from them.

See "Modeling" on page 14 ...



A proprietary Fluent® CFD model of a pulverized coal boiler is inserted into an AspenPlus® flow sheet of a municipal power plant



An REI equipment model shows gas temperature contours and coal particle trajectories within a two-stage gasifier

"PDU Test" continued...

FLUENT'S COMPUTATIONAL FRAMEWORK

The Fluent computational framework, developed under the four-year effort, uses the standard, CAPE-OPEN interfaces to link two widely-used commercial software products: Aspen Plus® for process flowsheet simulation and FLUENT® for CFD-based modeling, and will be marketed as an add-on to users of those systems. The CAPE-OPEN (Computer-Aided Process Engineering - Open Simulation Environment) interface used by the Fluent computational framework was developed for the process engineering community by a consortium of chemical companies, software vendors and universities. The use of this open interface standard allows any other model or software package with CAPE-OPEN interfaces to be easily plugged into the Fluent computational framework. User-friendly tools allow a CFD analyst to plug a FLUENT® model into an Aspen Plus® flowsheet in just a few hours. Software templates are also provided for easily creating and integrating CAPE-OPEN versions of proprietary models based on other programming languages.

To reduce model run times, the Fluent computational framework also provides the capability of creating fast-running, reduced-order models based on CFD solutions previously stored in the framework's database. These reduced-order models can be combined with rigorous FLUENT® CFD models and proprietary models to create flexible solution strategies for advanced energy systems.

The FLUENT® and Aspen Plus® user interfaces allow the results of process flowsheet simulation and CFD modeling to be viewed in tabular formats or as 3D graphical displays. The design engineer can also use Aspen Plus® analysis tools (e.g., optimization, sensitivity analysis, case studies) to optimize the CFD-based equipment model in terms of overall plant performance.

To demonstrate the utility of the Fluent computational framework, ALSTOM Power (a member of an industry-based advisory board for the project) used it to model a conventional power plant that supplies electricity to a municipality. The Aspen Plus® process flowsheet was comprised of models for a pulverized coal boiler, post-combustion cleanup equipment, fuel handling equipment, a steam turbine and generator, heat exchange equipment, and pumps. The computational framework enabled ALSTOM Power to improve the accuracy of the process flowsheet simulation by plugging in its detailed, proprietary, CFD models for the boiler: a 1D model of the tube bank heat exchanger fully coupled to a 3D, gas-side heat transfer model. The computational framework transfers steam-side parameters at the boiler inlet, such as steam flow rates, temperatures, pressures, and quality, from the process flowsheet model to the 1D tube bank model. Likewise, gas-side parameters at the boiler outlet are transferred from the 3D model to the process flowsheet.

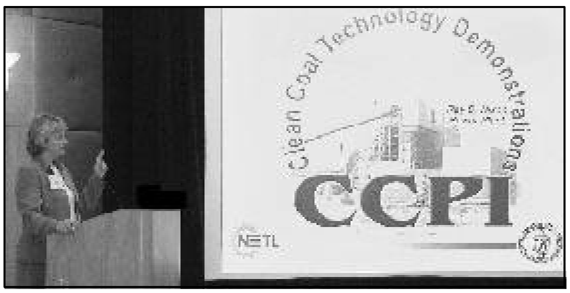
THE REI COMPUTATIONAL FRAMEWORK

In contrast to using commercially available software, the REI computational framework is based on software that is just emerging from the field of computational science. For process flowsheet simulation, the REI framework uses SCIRun, a software package developed at the University of Utah Scientific Computing and Imaging Institute (SCI) that is designed to support large scale, multidisciplinary simulations. The framework supports several model interfaces, ranging from simple interfaces for process engineering such as CAPE-OPEN to highly advanced interfaces designed for scientific computing such as the Common Component Architecture (CCA). This approach results in a seamless interface between all the equipment models within the framework, regardless of their level of complexity or the programming language used to create them. Altogether, the framework provides unique analysis capabilities to perform process flowsheet simulations, interrogate results and "drill down" on aspects of interest.

REI has populated its computational framework with a hierarchy of equipment models that can be interactively configured to simulate the performance a variety of advanced, coal-based energy systems. Component models are included for gasifiers (entrained flow and transport), heat exchangers, air separation units, gas turbine equipment (compressors, combustors, expanders), fuel cells (including exhaust oxidizers), and gas separation membranes. The models range from simple, 0D process models to detailed, 3D CFD models. Users can customize input parameters via standard dialog boxes or simply accept default values. The output of the REI computational workbench can be displayed using tabulated values, 1D plots, standard 3D CFD viewing techniques or advanced virtual reality visualization methods.

CLEAN COAL POWER INITIATIVE WORKSHOP

An open planning workshop for *Round 2* of the Clean Coal Power Initiative (CCPI) was held on August 26, 2003, in Pittsburgh, Pennsylvania, and provided valuable input to the draft solicitation issued for comment on November 26, 2003. A final solicitation is expected in mid-January 2004. The workshop was sponsored by the U.S. Department of Energy (DOE) Office of Fossil Energy and the National Energy Technology Laboratory (NETL). CCPI is a government/industry partnership designed to implement the President's National Energy Policy recommendation for increasing investment in clean coal technology to ensure reliability of electric supply, while simultaneously protecting the environment. The 10-year program could provide up to $2 billion for multiple competitions, with private partners contributing at least 50 percent of the funding. Seven projects have resulted from the initial CCPI solicitation, with selections made in January 2003. The projects, with a DOE share totaling $286 million and a total value of over $1.2 billion, are being negotiated, with awards expected in the near future. Two of the projects are directed at new ways to comply with the President's Clear Skies Initiative, which calls for dramatic reductions in air pollutants from power plants over the next decade and a half. Three other projects are expected to contribute to the President's Global Climate Change Initiative to reduce greenhouse gases. The remaining two projects would reduce air pollution through coal gasification and multi-pollutant control systems.



Janet Gellici, Executive Director, American Coal Council, provides perspective of coal's bright future

The planning workshop provided a forum for government, industry, academia, and other interested parties to offer their views on CCPI's *Round 2* and future program direction. *Round 2* would emphasize advanced, low-cost mercury and NO_x control technologies, as well technologies on the path toward zero emissions, such as coal gasification and other carbon sequestration-friendly technologies. Participant views were also sought on technical issues as they relate to DOE's Coal Power Program Roadmap.

Workshop attendance (over 170) represented the full spectrum of stakeholders (utilities, mining companies, suppliers, vendors, engineering and environmental firms, governments, academia, and research groups). The morning session featured keynote speaker Janet Gellici, Executive Director of the American Coal Council. The Council is an alliance of coal, utility, transportation, trading, port/terminal, and coal support service companies. Gellici reviewed the excellent strides made in coal mining and utilization in recent years that have resulted in a relatively low cost of electricity and cleaner power. She outlined a bright future based on this record, and the well established link between energy security and national security. Following the keynote speech, NETL Director Rita Bajura provided an overview of DOE's Coal and Power programs, consisting of core R&D, FutureGen, and demonstration programs. Bajura noted that CCPI is a key element of national energy policy, supporting such Presidential initiatives as Clear Skies, Global Climate Change, the Hydrogen Fuel Initiative, and DOE's Sequestration program. Bajura's talk was followed by targeted presentations on the Coal Power Program Roadmap; progress on CCPI *Round 1*, and lessons learned from *Round 1* in the business, management, and technical areas. In the course of the discussion, DOE noted that clarification and elaboration will be provided for *Round 2* technical proposals with respect to test plan expectations, project definition phase, and project-specific development activities.


U.S. DOE panelists respond during the opening Q&A session

The afternoon session featured a question and answer period moderated by Mike Eastman, NETL Technology Manager-Clean Coal Demonstrations, assisted by a panel from NETL and DOE headquarters. DOE representatives stressed the importance of "raising the bar" over existing technologies in terms of efficiency and environmental performance. They explained CCPI integration with central power R&D, as

See "CCPI" on page 16 ...

"CCPI" continued...
well as other leading edge initiatives such as FutureGen (zero-emission energy plants of the future) and Global Climate change. Speakers noted that repayment is mandated by Congress, and without such provisions, DOE funds to the applicant would be considered taxable income. Repayment provisions under the CCPI are actually more flexible than those under the Clean Coal Technology Demonstration Program; now room exists for creative approaches, since repayment does not always come from the technology vendor. The Q&A session also brought out that CCPI, as differentiated from research projects, is directed to readying technologies for commercial deployment. One area of discussion was the emphasis of *Round 2* on gasification technology, a DOE priority due to its environmental and carbon-management potential. Some participants saw DOE as emphasizing power generation at the expense of distributed generation, independent power producers, and industrial boilers that use coal. DOE remarked that, while the government recognizes the importance of smaller applications, for CCPI they are attempting the biggest "bang for the buck" in terms of long-term objectives of carbon management-friendly technologies. DOE panelists noted that the core R&D program demonstrates interest in the spectrum of technologies. The window of opportunity for mercury and NO_x control also were discussed in the context of a regulatory timetable that suggests these technologies will have to be developed in the near term.

For more information on the workshop and solicitation, see the CCPI Web page (http://www.netl.doe.gov/coalpower/ccpi/main.html).

FE Hosts Specialty Conferences

On October 28–30, 2003, the U.S. Department of Energy Office of Fossil Energy's National Energy Technology Laboratory (NETL) sponsored two Specialty Conferences focusing on reducing air pollution created by nitrogen oxides (NO_x) emitted by electric power plants. The conferences, held in Pittsburgh, Pennsylvania, devoted the first day to Unburned Carbon (UBC) on Utility Fly Ash; the following two days addressed Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR) for NO_x Control. This year marked the ninth year for the UBC Conference and the seventh year for the SCR/SNCR Conference. As in past years, these conferences were well received, bringing together a wide range of representatives of industry, academia, and government. Registration was 118 for the UBC Conference and 236 for the SCR/SNCR Conference; 59 people attended both Conferences. Combined, the Conferences drew 19 foreign registrants representing 10 countries.

Joe Cochran of Progress Materials, Inc. received from Tom Sarkus of NETL the first Award for Innovative Development in Reduction of Unburned Carbon on Utility Fly Ash

The UBC Conference focused on mitigation of UBC and utilization of fly ash. NO_x reduction, required to meet Title IV of the Clean Air Act Amendments (CAAA) of 1990, is being achieved through widespread use of low-NO_x burner (LNBs). However, use of these burners results in the production of excess UBC, which also is referred to as loss-on-ignition (LOI). This high level of UBC reduces boiler efficiency and can render fly ash unsaleable. Fifteen speeches and two poster presentations addressed such topics as control measures for reducing LOI, predictive performance tools, measurement techniques for UBC, and utilization, beneficiation, and characterization of high-LOI fly ash.

The keynote speaker for the UBC Conference was William A. Bruno, Vice-President, International Business & Development, CONSOL Energy, PA, who spoke on "Coal's Role in International Energy Development, Security, and Sustainability." Bruno emphasized the strategic international importance of coal, and noted that electrification is the most significant development of the 20th century. Coal's role can be expanded by encouraging electrification in developing countries, establishing sound environmental regulations, safeguarding energy supplies through diversification, and supporting advanced coal utilization technologies.

A highlight of the UBC Conference was a new award, to be presented at each subsequent conference, for Innovative Development in Reduction of Unburned Carbon on Fly Ash. The 2003 award went to Joe Cochran, Vice-President, Engineering and Development, Progress Materials Company, of St.

Tom Sarkus, NETL's Coal Power Projects Division Director, chaired both conferences

Petersburg, Florida, for invention and development of a patented Carbon Burn-Out process to beneficiate high-carbon fly ash while improving the overall efficiency of the combustion process.

Leading off the SCR/SNCR Conference was Robert W. McIlvaine, President, McIlvaine Co. McIlvaine, who

Audience participation kept both conferences lively

provided an "Overview of Recent NO_x Emission Levels and Aggregate Installation of U.S. and International SCR Units." Significant reductions in NO_x emissions are needed to meet increasingly stringent regulatory requirements. To this end, advanced controls are needed to meet EPA's "SIP Call" source NO_x emission rates of 0.15 lb/10^6 Btu for 22 states and the District of Columbia, and the revised National Ambient Air Quality Standards (NAAQS) for ozone and $PM_{2.5}$, both related to NO_x. To help bring about these reductions, McIlvaine noted that, through 2007, total projected SCR installations in the U.S. exceed 100 GW and represent an investment of several billion dollars including equipment and catalysts. McIlvaine urged a collaborative approach to NO_x control between the U.S. Environmental Protection Agency (EPA) and utilities, which would foster regulations that are both technically and economically achievable, and offer utilities greater regulatory certainty.

Thirty-one speeches and 15 poster presentations dealt with SCR/SCNR success stories, emissions control strategies, reagent preparation and mixing, and non-coal applications of SCR. Catalyst issues included deactivation, cleaning, regeneration, and management strategies that minimize total operating costs. Also described were alternative NO_x control technologies, including a selective auto-catalytic reduction process, a modified combination of LNBs and overfire air, and natural gas reburning.

Conference participants also discussed the possibility of multi-pollutant control legislation including not only NO_x and SO_2, but also mercury and carbon dioxide. It was noted that SCR can play a dual role, because catalysts can convert a major fraction of the mercury to oxidized species that can be captured in the downstream flue gas desulfurization process.

As a separate issue, several papers dealt with the problem of sulfur trioxide (SO_3), which can be formed by oxidation of SO_2 in the flue gas over the SCR catalyst, and can lead to visible plumes from the stack. One solution has been to react the SO_3 with magnesium oxide, forming magnesium sulfate which precipitates as a solid. Other approaches include modification of air preheater design and operating conditions, and development of models that predict the conditions leading to SO_3 formation. In addition, one supplier of SCR catalyst mentioned a proprietary regeneration technique that results in reduced oxidation of SO_2.

Conference proceedings, as well as a compact disk of UBC conference proceedings from 1995–2002, are available on the NETL Web site (http://www.netl.doe.gov) by clicking on "Publications." The conferences will be held again in mid-May 2005. NETL also is planning the second Reburning Specialty Conference for mid-May, 2004.

Speakers addressed a diverse audience in the morning session

STATUS OF ACTIVE CCT DEMONSTRATION AND PPII PROJECTS

ENVIRONMENTAL CONTROL DEVICES

Southern Company, Inc. – *Demonstration of Advanced Combustion Techniques for a Wall-Fired Boiler.* The purpose of the project was to evaluate the use of GNOCIS and other computerized process control software to further optimize operation of Plant Hammond Unit 4. The project ended on April 30, 2003. A Final Report and Post Project Assessment are being prepared. (Coosa, GA)

ADVANCED ELECTRIC POWER GENERATION

JEA – *ACFB Demonstration Project.* Construction of Unit 2 at the Northside Station was completed in December 2001. The DOE demonstration planned has been delayed while JEA made repairs/modifications to Unit 2. (Jacksonville, FL)

Kentucky Pioneer Energy, L.L.C. – *Kentucky Pioneer Energy Project.* The Environmental Record of Decision was published in the Federal Register on February 4, 2003, completing the NEPA process. Presentations to the PSC Siting Board were completed and a decision on issuing a Certificate is due. A groundbreaking ceremony for the fuel cell portion of the project (relocated to Wabash River) took place on August 13, 2003. (Trapp, KY and West Terre Haute, IN)

Tampa Electric Co. – *Tampa Electric Integrated Gasification Combined-Cycle Project.* Tampa's Polk Power Station completed its operational period at the end of October 2001 with over four and one-half years of successful commercial operation. The Post Project Assessment is in review. (Polk County, FL)

TIAX (formerly Arthur D. Little, Inc.) – *Clean Coal Diesel Project.* DOE and TIAX negotiated a modification to the Cooperative Agreement that will de-scope the original plan from 18-cylinder engine testing to 2-cylinder engine testing. The objective of the descoped project remains the same, *i.e.*, to demonstrate advanced Clean Coal Diesel technology based on the FME heavy-duty diesel engine using coal water slurry. The project includes 1,000 hours of testing on a two-cylinder engine at Fairbanks Morse in Beloit, Wisconsin using a Kentucky coal source for slurry fuel. The demonstration will include hardened parts on the 2-cylinder and the 18-cylinder engine, the ash tolerant lube oil system on the 2-cylinder engine, and emission cleanup system on the 18-cylinder engine. The team members are TIAX as the principal participant, along with FME, UAF, Usibelli Coal and CQ Inc. The period of performance is 7/12/94 through 9/30/05. (Beloit, WI)

COAL PROCESSING FOR CLEAN FUELS

Western SynCoal LLC (formerly Rosebud SynCoal® Partnership) – *Advanced Coal Conversion Process (ACCP) Demonstration Project.* In January 2003, Westmoreland Power, Inc. transferred ownership of Western SynCoal LLC to ENPRO, of Butte, Montana, to complete the Final Report for the ACCP Clean Coal Technology Demonstration Project. Western SynCoal LLC is working on the Final Report, expected to be completed in December 2003. (Butte, MT)

Air Products Liquid Phase Conversion Company, L.P. – *Liquid Phase Methanol Process Demonstration Project.* The Post-Project Assessment for the Liquid Phase Methanol (LPMEOH™) Process Demonstration Project was issued in October 2003, and is available on the Clean Coal Technology Compendium at http://www.lanl.gov/projects/cctc/. (Kingsport, TN)

INDUSTRIAL APPLICATIONS

CPICOR Management Company, L.L.C. – *Clean Power From Integrated Coal/Ore Reduction (CPICOR).* The CPICOR Cooperative Agreement expired on August 30, 2003, and Geneva Steel has been notified of the DOE's intent to deobligate the remaining funds. (Vineyard, UT)

ThermoChem, Inc. – *Pulse Combustor Design Qualification Test.* The Final Report has been submitted and accepted by DOE, and the Cooperative Agreement is in the close-out process. The Post Project Assessment has been accepted and is available on the Clean Coal Technology Compendium. (Baltimore, MD)

PPII STATUS

Tampa Electric Company, Big Bend Power Station Tampa – *Neural Network Sootblower Optimization Project.* Project came on line January 2003. Parametric testing and model development was completed in August 2003. In September 2003, the first stage neural network model was installed at the Big Bend Plant. After testing the model for three months with and without constant operator oversight, the model will be adjusted if necessary, after which the optimization and benefits demonstration phase of the project will begin. Preliminary indications are that implementation of the neural network sootblowing system will result in substantial improvements in NO_x

and particulate emissions and plant heat rate. (Apollo Beach, FL)

Universal Aggregates, LLC – *Commercial Demonstration of the Manufactured Aggregate Processing Technology Utilizing Spray Dryer Ash.* The NEPA process has been completed. The project has progressed through the design phase into construction. Ground was broken at the site on March 26, 2003, and construction has been proceeding smoothly. The site has been prepared, pilings have been driven, and foundations have been poured. Steel and vessel erection at the site began in late July 2003. All of the large equipment has been delivered and placed. The process building siding is being completed, and the curing vessel is being assembled at the site. Partial shakedown is expected to begin in December 2003, and construction should be completed in January 2004. The facility should be ready to operate in Spring 2004. (King George, VA)

Sunflower Electric Power Corp. – The combustion optimization sensors package consisting of the Burner Profiler, LOI/FEGT Sensors, and CO sensors is operational. Data are being archived on the MKE computer and by EtaPRO, which also collects plant performance data. Work on the Continuation Application is ongoing. The current outage schedule calls for a one-week outage in the spring and a two-to-three week outage in the fall. The OFA system will be implemented during the fall outage. The low-NO_x burner modifications and coal-balancing dampers have been installed. The coal-balancing dampers on Mill C are operating in automatic mode. System performance is being monitored and data are being archived in EtaPRO. The automated coal flow balancing system on Mill C is operational following resolution of a cable problem. (Garden City, KS)

Otter Tail Power Company – *Demonstration of a Full-Scale Retrofit of the Advanced Hybrid Particulate Collector (AHPC) Technology*. The project came on line in October 2002. Operations have shown very good particulate removal efficiency, but at the cost of higher system pressure drop. Performance testing has shown that the average collection efficiency of the AHPC is 99.997 percent. The outlet dust loading is almost two orders of magnitude lower than the guarantee limit of 0.002 gr/acf. However, AHPC system pressure drop also has exceeded guarantee limits and has resulted in premature bag replacement, excessive bag pulsing and premature bag failure. The power plant was shut down in December 2003, to replace bags and install test hardware. Pressure drop performance and bag wear will continue to be studied over the next several months. (Big Stone City, SD)

CLEAN COAL TODAY

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

Editor:
Phoebe Hamill

Phone: 202-586-6099

Fax: 202-586-1188

***E-mail*:**
phoebe.hamill@hq.doe.gov

Comments are welcome and may be submitted to the Editor.

U.S. DEPARTMENT OF ENERGY
FE-24
1000 INDEPENDENCE AVENUE
WASHINGTON, DC 20585-1290

Printed with soy ink
on recycled paper