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CLEAN COAL TODAY

A Newsletter About Innovative Technologies for Coal Utilization

News Bytes

A U.S. Department of Energy (DOE) project has successfully demonstrated the commercial readiness of a multi-pollutant control system designed to meet the needs of smaller (50–400 MW) coal-fired electric generating units. The Greenidge Multi-Pollutant Control system, tested as part of DOE's Power Plant Improvement Initiative, offers deep emission reductions, low capital costs, small space requirements, applicability to high-sulfur coals, mechanical simplicity, and operational flexibility. The system was tested at a 100-MW coal-fired power plant at AES Greenidge's facilities in Dresden, New York. For further information, see the Techline at www.fe.doe.gov/news/techlines/2008/ ◆

DOE announced the selection of Dr. Victor K. Der as the new

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Inside This Issue

International Greenhouse Gas Conference Focuses on CCS

The 9th International Conference on Greenhouse Gas Control Technologies (GHGT9) held November 16–20, 2008, in Washington, D.C., drew record attendance – almost 1,500 participants from 42 countries, including a large European contingent. Over 150 students participated, as well as many young professionals. The International Energy Agency's (IEA) Greenhouse Gas R&D Programme is custodian of the biennial conference series. The U.S. Department of Energy (DOE) served as the main sponsor for GHGT9, while the Massachusetts Institute of Technology was conference organizer. Over the years, the conference has increasingly focused on carbon capture and storage (CCS). Six technical conference tracks, the largest number ever, brought participants up to date on scientific knowledge and technology advances, as well as policy, regulatory, and public acceptance issues.

Dr. Kelly Thambimuthu, Chairman of the IEA Greenhouse Gas R&D Programme, addresses opening session

The GHGT9 conference came at a time of many pending developments on the international front: the United Nations climate change meeting in Poznan (Poland) in December, and the International Scientific Congress in Copenhagen in March 2009, tasked with preparing a summary of existing scientific knowledge for the UN Climate Change Conference (COP-15). Specifics on an Obama Administration greenhouse gas policy were unknown, but attendees doubted any U.S. cap and trade (or other) program would be ready in time for the March conference. Dr. Kelly Thambimuthu provided keynote remarks on opening day, and set the stage for the four-day proceedings with an overview of CCS readiness and challenges to its wide-scale implementation. Overall, there are more than 25 planned or proposed integrated CCS demonstration projects worldwide. Total anthropogenic CO_2 captured and injected could increase to 24 million tons/year by 2012. According to an established modeling team led by Jae Edmonds of Pacific Northwest National

See "Greenhouse Gas" on page 2...

... "Greenhouse Gas" continued

Laboratory and the Joint Climate Change Research Institute, up to 2,200 billion tons of CO_2 (600 GtC) would have to be captured and stored with CCS in the 21st century in order to achieve emission stabilization scenarios in the 450–550 ppm range.

Thambimuthu described five of the largest CCS projects operating today, most involving capture and storage of one million tons or more of CO_2/year in on-shore geological formations or subsea beds. Capture today is mostly from natural gas processing facilities while capture technology for power plants is still at pilot scale. The Sleipner project, located in Norway's North Sea, has since 1996 been capturing and injecting CO_2 in subsea beds. Weyburn, in Saskatchewan, has captured CO_2 from the Great Plains (North Dakota) coal gasification plant and injected it into Canadian enhanced oil recovery (EOR) fields. In Salah in Algeria has, since 2004, been capturing and injecting CO_2 into a gas field. The Rangeley project in Colorado has been operating since the mid 1980's injecting 3 million tons/year of CO_2 from a natural gas processing facility. Snohvit, in Norway, began in 2008 to capture and inject 0.7 million tons/year into a saline formation. DOE is involved in MVA (monitoring, verification, and accounting) and basin assessments for many of these promising international storage projects, as shown in the table below.

According to Thambimuthu, large-scale deployment (going from tens to the necessary thousands of plants) must go hand in hand with increased efficiencies to make up for extra energy required to both capture and store CO_2. While long-distance transport of CO_2 by pipeline is an established technology, development of a large open access pipeline infrastructure would be needed quickly in many regions. Thambimuthu echoed the concerns of many in stating the importance of a predictable market price for avoided carbon emissions, and an accompanying regulatory structure. While some emerging economies, such as China and Brazil, are showing interest in CCS, other countries are being left behind. The Clean Development Mechanism (CDM) under the Kyoto treaty, has yet to accept CCS as a mitigation technology for emission reduction credit.

Technical panels reported considerable progress from the various research and demonstration projects. Storage security has been found to increase over time due to trapping mechanisms such as capillary trapping in pore spaces, dissolution in the formation, or mineralization. In all, a successful storage project must include: fundamental storage knowledge, careful site selection and detailed characterization, safe operations with extensive MVA, potential remediation plans, regulatory oversight, and long-term financial responsibility. In terms of CO_2 capture, participants agreed there has been a huge increase in interest, equally spread among pre-, post- and oxyfuel-related approaches. Several international pilot tests specific to capture in power plants are under way or planned. The 30 MW Vattenfall oxyfuel project (Germany) came on line in December 2008. Three of the U.S. Regional Partnerships plan to capture and inject power plant CO_2 in geological formations. The

Selected DOE Participation in International CO_2 Storage Projects

Location	Period (U.S.)	Operations	Reservoir	Operator/Lead Org.	Int'l Recognition
North America, Canada Saskatchewan Weyburn-Midale	2000–2012	1.8 Mt CO_2/yr commercial 2000	oil field carbonate EOR	Encana, Apache	IEA GHG R&D Programme, CSLF
North America, Canada, Alberta Zama oil field	2005–2009	230,000 tons CO_2, 80,000 tons H_2S demo	oil field EOR	Apache (Reg. Part.)	CSLF
Europe, North Sea Sleipner	2002–2011	1 Mt CO_2/yr commercial 1996	marine sandstone	StatoilHydro	IEA GHG R&D Programme, European Commission
Europe, Germany CO2SINK, Ketzin	2007–2010	60,000–90,000 tonnes CO_2 demo 2008	gas field sandstone	GeoForsch-ungsZentrum, Potsdam	CSLF, European Commission
Australia, Victoria Otway Basin	2005–2010	100,000 tonnes CO_2 demo 2008	gas field sandstone	CO2CRC	CSLF
Africa, Algeria In Salah gas	2005–2010	1 Mt CO_2/yr commercial 2004	gas field sandstone	BP, Sonatrach, StatoilHydro	CSLF, European Commission
Asia, China, Ordos Basin	2008–TBD	assessment phase CCS	Ordos Basin	Shenhua Coal	

conference reported interesting new breakthroughs in alternative and new sorbents, including one developed at the University of Regina in Canada, which holds promise in reducing capture costs by as much as 50 percent. However, capture costs — the largest cost component of CCS — have risen 10–20 percent in the past two years due to rising equipment and other costs.

A number of presentations featured European concerns and efforts to reduce greenhouse gases, regulate CO_2, and promote CCS. Europe established the first formal Emissions Trading Scheme in 2005 as part of compliance with the Kyoto Protocol. Early in 2008, the European Union distributed a draft CCS directive to member nations (approved in December 2008). Ambitious proposals have been put forward for demonstration projects. Speakers discussed the Zero Emission Platform, which argues for a CCS role in the European Commission's Strategic Energy Technology Plan and recommends an EU Flagship Program of up to 12 industrial-scale CCS demonstration projects across Europe. This level of effort would be adequate to test a mix of emissions sources, capture technologies, transport modes, and storage settings. In another proposal, the IEA recommended to the G8 nations a need for 20 demonstration plants by 2020, and this goal was endorsed by the G8 leaders at the Hokkaido Summit in the Summer of 2008. In December 2008, the European Commission approved a goal of a 20 percent reduction in CO_2 emissions (from 1990 levels) by the year 2020. Included is a provision to make emission allowances available for funding CCS projects across Europe.

Attendees noted U.S. progress in CCS-specific regulation. EPA, in summer 2008, circulated a draft rule for a new special class of injection wells under the Safe Water Drinking Act. The United States was also commended for its Regional Partnership effort. DOE took the opportunity at the conference to announce the seventh and final Phase III award for large-scale demonstration to the Big Sky Regional Partnership.

Students and young professionals were drawn to conference panels on training programs. Above is Pamela Tomski of EnTech Strategies, LLC, program director of the DOE-funded Research Experiment in Carbon Sequestration (RECS)

The conference also reported considerable CCS progress in Australia and China. Australia, in a government-funded program, is moving forward with a cap and trade scheme, and has adapted petroleum regulation to allow CCS offshore. The CO2CRC Otway Project is injecting CO_2 from a nearby natural gas well. Small capture plants have been established at the Munmorah and Loy Yang power plants, while a larger capture plant will start operation at Hazelwood in February 2009. The Callide 30 MW oxyfuel retrofit is in progress with operation scheduled for 2011. Developments in China include the Huaneng group planning China's first post-combustion capture CO_2 pilot plant. Huaneng also plans to build a 250 MW IGCC demonstration under the GreenGen Programme. DOE is working with the Shenhua Group to evaluate CO_2 storage options for its coal-to-liquids plant in Inner Mongolia.

While various countries are making technological progress, participants agreed that economic, regulatory, and institutional issues (public acceptance, long-term liability, subsurface ownership) remain. David Hawkins of the Natural Resources Defense Council stated that CCS is ready to be used today in large-scale projects, as long as well-crafted public policy addressing economic and regulatory barriers gives it a jump start. He argued for a cap and trade system, with added incentives, and performance standards for new power plants. Other participants favored a more free market approach. As brought out in the conference, there has been a large increase in understanding of CCS benefits across the economy (cement, steel, refinery applications) in addition to coal-fired applications. Additionally, there can be significant benefits from cost-effective CCS projects involving biomass (including a coal-biomass mix). Such projects can have negative net CO_2 emissions, thus "scrubbing" existing CO_2 from the atmosphere.

Despite policy and regulatory uncertainties, there was widespread agreement at GHGT9 that CCS has an essential role to play in any future international plans for greenhouse gas reductions. ■

DEMONSTRATION OF INTEGRATED OPTIMIZATION SOFTWARE

NeuCo, Inc., of Boston, Massachusetts, has completed its post-project assessment, marking a successful finish of the project "Demonstration of Integrated Optimization Software at the Baldwin Energy Complex." The 45-month project began in February 2004, as part of the Department of Energy's (DOE) Clean Coal Power Initiative. DOE contributed $8.5 million to the approximately $19 million project cost.

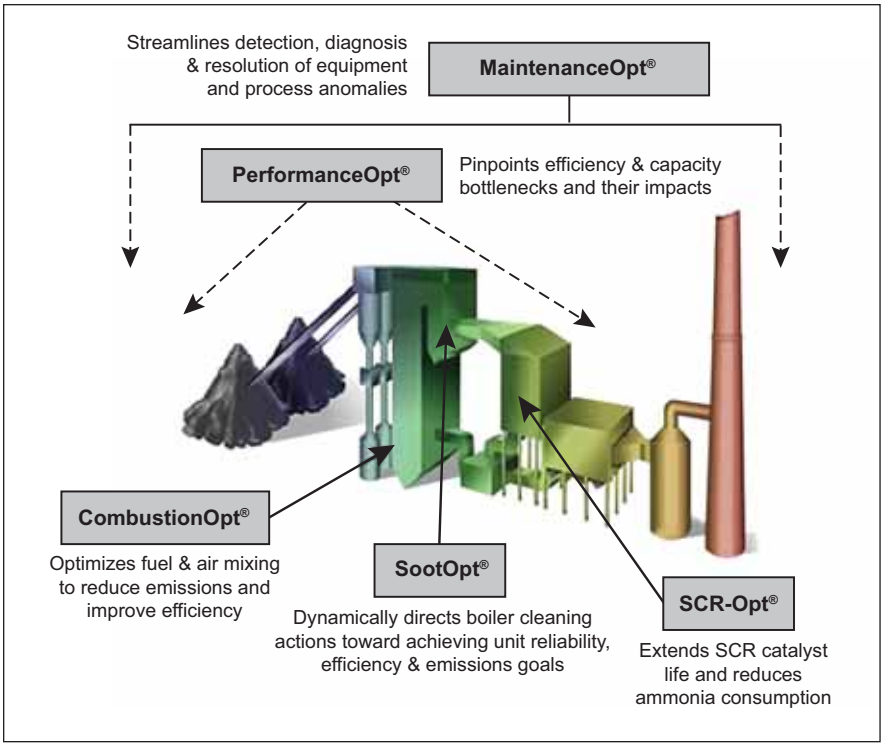
NeuCo has designed and demonstrated the integration of five system control modules using its proprietary ProcessLink® technology of neural networks, advanced algorithms and "fuzzy" logic to maximize performance of coal-fired plants. The separate modules control cyclone combustion (CombustionOpt®), sootblowing (SootOpt®), SCR operations (SCR-Opt®), performance (PerformanceOpt®), and equipment maintenance (MaintenanceOpt®). ProcessLink® provides overall plant-level integration of controls responsive to plant operator and corporate criteria. Benefits of an integrated approach include NO_x reduction; improvements in heat rate, availability, efficiency and reliability; extension of SCR catalyst life; and reduced consumption of ammonia. All translate into cost savings. As plant complexity increases through retrofit, repowering or other plant modifications, this integrated process optimization approach will be an important tool for plant operators.

Dynegy Midwest Generation's Baldwin Energy Complex

CombustionOpt® and SCR-Opt® are tightly integrated, closed-loop optimization systems. They use neural networks to better understand input variables to achieve varying performance objectives as determined by plant operators. Relationships among input variables are based on both real-time and recent, data. The historical data helps to determine how variables interact, while at the same time the system is monitoring a variety of sensors in real time. Important relationships for CombustionOpt® and SCR-Opt® include ammonia (NH_3) consumption, heat rate, and NO_x formation. CombustionOpt® calculates in real-time the control settings that improve the mixing of the fuel and air in the furnace, leading to reduced furnace NO_x production. When a unit is equipped with an SCR, CombustionOpt® and SCR-Opt® are integrated to improve the mixing of the fuel and air in the furnace to reduce furnace NO_x production and maintain critical combustion parameters, such as combustion efficiency, while increasing SCR efficiency. The integrated goals of these models are to maintain flame quality and reduce SCR inlet NO_x, which results in lower NH_3 flow to the SCR system.

SootOpt® is a closed-loop optimization system that aligns soot blowing actions with unit goals. It factors in heat rate, reliability, emissions, and operational constraints. SootOpt® models the effect of soot blowing on heat transfer throughout the furnace and back-pass and determines which cleaning actions to best achieve improved boiler operation. If the sootblowing operation is triggered when not needed, the steam (or other media) is wasted, efficiency suffers and excessive sootblowing increases wear on the boiler parts being cleaned. Delays in sootblowing can result in lower furnace efficiency and increased NO_x production.

PerformanceOpt® is a predictive performance management system that identifies efficiency and capacity losses. PerformanceOpt® performs mass and energy balances on a minute-by-minute basis. MaintenanceOpt® continuously monitors process and equipment data to identify anomalies evidencing equipment health problems. It identifies the most likely causes, and estimates the impacts on efficiency, reliability, and capacity. It then prioritizes the order in which problems should be addressed. MaintenanceOpt® displays all the information required to determine whether the detected anomaly points to a real problem or is the result of imprecise sensors. Engineers then use MaintenanceOpt's® diagnostics database to determine severity of a problem.



NeuCo's integration concept (courtesy of NeuCo, Inc.)

PROJECT GOALS MET

One goal of the project was to reduce boiler NO_x emissions by five percent. Average reductions were, in fact, between 12 and 14 percent, due to combined beneficial impacts of CombustionOpt®, SootOpt®, and SCR-Opt®. Operational data also showed a drop in NH_3 consumption.

Other goals were to reduce heat rate by 1.5 percent, and increase annual available MWh by 1.5 percent. Heat rate improvement was 0.7 percent, less than anticipated. Optimization allows for considerable plant operator discretion, and during the tests the operator set a higher priority on NO_x reduction.

The increase in MWh was achieved by prioritized alerts and knowledge-based diagnostics for a wide array of plant equipment and process anomalies. Thus, derates often associated with moving from high-sulfur, high Btu Illinois coal to Powder River Basin coal were avoided. Management of cyclone flame quality also improved. Cyclone conditions were closely watched, thus avoiding temporary derates due to slag buildup.

Greenhouse gases, mercury, SO_2, and particulate emissions decreased with lowered coal consumption and decreased heat rate.

While the benefits of integrated optimization must be determined on a plant-by-plant basis, the benefits derived from NeuCo's optimization suite were compared to the technology's costs using several different scenarios. In all cases, the cost of the technology was recovered in well under one year. ■

... "News Bytes" continued

Principal Deputy Assistant Secretary for Fossil Energy. Most recently, Dr. Der was the Deputy Assistant Secretary for Clean Coal. He has worked at DOE for 35 years in various programs. ◆

Dr. Samuel J. Biondo was named Acting Deputy Assistant Secretary for Clean Coal within the DOE Office of Fossil Energy. Dr. Biondo has worked for over 25 years in the Fossil Energy Program. In addition to serving as the DAS for Clean Coal, Dr. Biondo will continue to serve as the Director of the Office of Clean Energy Systems. ◆

On December 2, 2008, the Washington Coal Club presented the 2008 *Senator Jennings Randolph Lifetime Achievement Award* to Dr. Lowell Miller, Director of DOE's Office of Sequestration, Hydrogen & Clean Coal Fuels within the Office of Fossil Energy, and to Donald L. Bauer, Corporate Vice President, DL Bauer Consulting, LLC. Mr. Bauer served from 1982–1988 as Principal Deputy Assistant Secretary for Fossil Energy, and was Acting Assistant Secretary from 1985–1986. ◆

The Secretary of Energy's Achievement Award was presented January 7, 2009, to the National Energy Technology Laboratory's Incentive Tax Credit Team. Section 1307 of the Energy Policy Act of 2005 authorizes tax credits for certain clean coal projects. The NETL team was recognized for its work with the Department of Treasury in developing proposal guidelines and reviewing proposals. ■

THE EERC'S NATIONAL CENTER FOR HYDROGEN TECHNOLOGY: A BRIDGE TO THE U.S. HYDROGEN ECONOMY

By Gerald Groenewold, EERC Director

The University of North Dakota Energy & Environmental Research Center (EERC) dedicated its new National Center for Hydrogen Technology (NCHT) facility on September 5, 2008. After more than two years in the planning and construction stages, the NCHT facility is now complete, and is already in need of expansion.

The facility provides a cornerstone to address the nation's enormous challenge of developing new technologies to guarantee the country's energy security for the long term. Hydrogen is not only an important bridge to energy security, but also a key solution in managing our carbon footprint.

The EERC was designated as the National Center for Hydrogen Technology in November 2004 in recognition of over 50 years of expertise in the development of hydrogen technologies. U.S. Senator Byron Dorgan has consistently been a strong proponent for this program in Congress.

Shortly after this designation, the EERC secured funding for a facility to house the enormous amount of research anticipated in hydrogen. The facility was designed to significantly enhance the strategic research, development, demonstration, and commercialization of hydrogen and fuel cell technologies. The building includes specialized state-of-the-art equipment to provide solutions for the world's growing energy needs. The work being done here is a major link to building a hydrogen economy in the United States.

The effort represents a significant partnership among numerous corporate partners, the U.S. Department of Energy (DOE) National Energy Technology Laboratory, the state of North Dakota, the city of Grand Forks, and the EERC. Partial funding for the facility was provided by the North Dakota Centers of Excellence Commission, which awarded the EERC $2.5 million, and the city of Grand Forks, which provided $500,000 in matching funds. The EERC contributed the remaining $500,000.

EERC's National Center for Hydrogen Technology

Currently, the EERC's hydrogen program has about $50 million in funded projects with more than 80 partners worldwide. Building construction and expansion of the hydrogen program generated 50 new jobs at EERC, and an additional 50–100 indirect jobs as a result of increased economic activity in the Greater Grand Forks region.

FEATURED PROJECTS IN THE FACILITY

Beyond the spectacular main entrance is an intricate network of state-of-the-art laboratories and technology demonstration areas focused on bringing hydrogen into the mainstream.

The first floor of the facility includes the Gas Processing and Fuel Cell Laboratory, which houses highly specialized equipment for hydrogen purification, trace metal removal and cleanup, and a solid oxide fuel cell test stand. Commercial partners involved in these activities include DOE, Corning Incorporated, and Air Products and Chemicals, Inc.

To the south of the main lobby, through a 12-inch-thick blast-proof wall, is the facility's high-bay demonstration/testing area. It houses a variety of hydrogen technology demonstration projects, along with a staging area for vehicle testing.

Several large projects involve hydrogen production from natural

gas or industrial flare gas, on-demand hydrogen production from liquid fuels, and coal and biomass gasification to produce hydrogen and liquid fuels.

One project in particular is demonstrating a method for producing on-demand hydrogen at high pressure. The project, involving a variety of private sector partners, is producing extremely pure hydrogen from a variety of feedstocks, including alcohols, petroleum liquid fuels, synthetic fuels, and military fuels such as JP-8. The hydrogen is produced on-site, when needed, at pressures up to 12,000 psi, which significantly reduces costs by removing the need for hydrogen compression and large-scale storage.

This on-demand system is moving toward commercial deployment and it could be deployed using the current fueling station infrastructure in the United States. It represents an enormous breakthrough with respect to the infrastructure challenges and costs associated with production and distribution of hydrogen.

Another project is demonstrating the production of hydrogen from natural gas or industrial by-product gases. This process is unique in that it also produces a concentrated product stream of carbon dioxide, resulting in tremendous potential for carbon sequestration.

Producing hydrogen from a variety of feedstocks available to an industrial site is a key to revolutionizing the market economics of hydrogen production. Hydrogen is a key ingredient to many industrial processes, including the manufacturing of gasoline, jet fuel, diesel, plastics, agricultural fertilizer, pharmaceuticals, and food oil products.

Another important activity is the Materials Laboratory, housed in the second floor of the new building. The laboratory is engaged in multiple projects with DOE and Siemens Power Generation involving the creation of advanced alloy metals and bonding materials for use in high-temperature hydrogen-utilizing turbines. Several high-pressure hydrogen gas purification technologies and other spin-off applications are also being tested.

Vehicle testing is another key focus of the EERC's hydrogen program, and is taking place in Minot, ND, in cooperation with Basin Electric Power Cooperative and DOE. Several vehicles have been successfully tested, including a fuel cell battery–electric hybrid ice resurfacer (the eP-Ice Bear); a Hyster fuel cell forklift; a Bobcat Fuel Cell Tool-Cat; and three trifuel Chevrolet 4 x 4 internal combustion vehicles, which run on standard gasoline, ethanol, and hydrogen. The 4 x 4s are running on hydrogen produced from electrolysis, using the electrical current generated from wind turbines, to separate hydrogen from water.

EERC is demonstrating, at pilot-scale, technology to produce hydrogen from natural gas

THE ROAD AHEAD

The research and technology demonstration capabilities in the EERC's NCHT facility have only just begun. Several technologies are under construction inside the high-bay demonstration area, including a reactor for hydrogen gas cleanup and a gasifier for the production of hydrogen from both coal and biomass. These technologies will be operational within the next six months.

Because of the overwhelming corporate response to the EERC's hydrogen program and capabilities, plans to expand the facility to the south are already under way. The EERC is working to secure funding for an additional demonstration facility attached to the current building. It is anticipated that expansion will be completed within the next two years. ■

UPCOMING EVENTS

February 10 – 12, 2009
International Colloquium on Environmentally Preferred Advanced Power Generation (ICEPAG) 2009
Sponsor: DOE
Location: Newport Beach, CA
Contact: Lorin Humphries
Phone: 949-824-7302, Ext. 212
E-mail: lah@apep.uci.edu
Web site: http://www.apep.uci.edu/ICEPAG2009/

IGCC DYNAMIC SIMULATOR RESEARCH AND TRAINING CENTER

In October 2008, the National Energy Technology Laboratory (NETL) began cooperating with university and private sector partners in an 18-month effort to develop a simulator of Integrated Gasification Combined Cycle (IGCC) with carbon capture to be used at a research and training center in Morgantown, West Virginia. IGCC with carbon capture is considered key to high-efficiency, near-zero emissions power plants of the future. Dynamic simulation provides a continuous view of a plant in action by calculating its transient behavior over time. While dynamic simulation of IGCC has been used on a limited basis, the Morgantown facility will offer the first full-scope, real-time dynamic simulator for research and training on the operation and control of IGCC with carbon capture.

Simulator research and training will be carried out at the IGCC Dynamic Research and Training Center, with a flagship facility at the NETL campus and a satellite facility at West Virginia University's National Research Center for Coal and Energy. NETL and its partners will use the simulator as an advanced research platform for IGCC operability and control studies, including modeling predictive control; high-fidelity dynamic model analysis of gasification and carbon capture technologies, and demonstration of real-time virtual power plant simulation capabilities. The training effort will feature hands-on training in plant operations and control demonstrations. The NETL flagship facility will be used primarily for research, while the satellite at West Virginia University will train graduate students and others interested in IGCC technology.

THE TRAINING CENTER

The simulator architecture is designed to provide maximum flexibility and allows training or demonstration for up to 16 users on the plant-wide IGCC system or independent combined cycle and gasification systems. The training system consists of 12 computer workstations: eight for the operator trainee stations, two to serve as the simulation masters, and two for the instructor station. Due to the distributed nature of the dynamic simulator software, the process and control models will be running in the background on all the workstations to maximize efficiency.

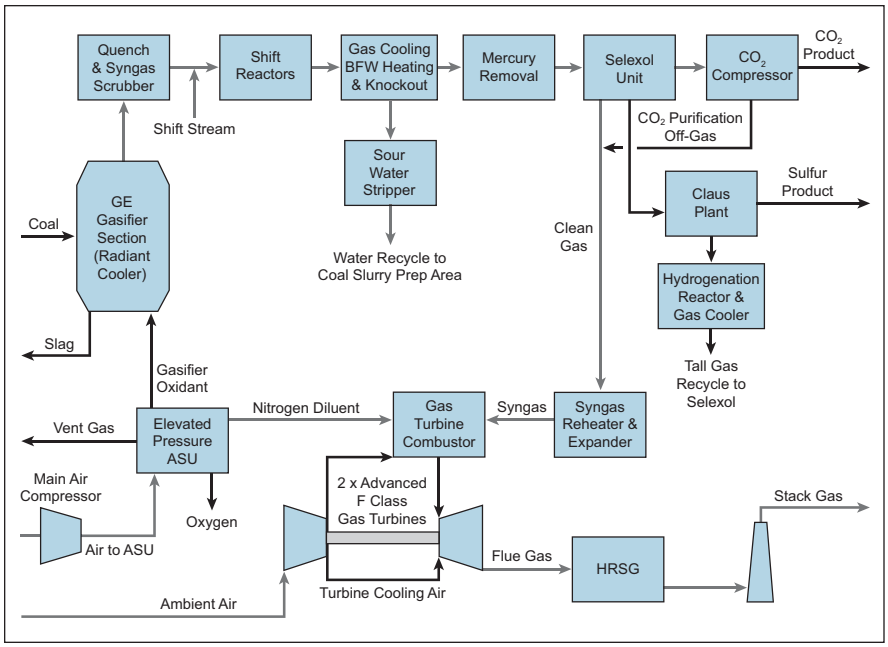
The client instructor station provides the interface for the instructor to control the operational and educational features of the simulation software. It will offer the user the following features: Run, Freeze, Snapshot (storage of existing conditions), Backtrack (restoration to previous conditions), Time Scaling (slower/faster than real-time), Trending (view real-time plant simulation data), Record/Replay Scenarios, Remote Functions (operator functions that would normally be performed from outside the unit control room such as the operation of manual valves), Trainee Performance Reporting, I/O Override, and Alarms.

SIMULATION FEATURES

The simulator is based on an IGCC reference plant which served as engineering model in a peer-reviewed system study – Case 2 in the DOE/NETL report "Cost and Performance Comparison of Fossil Energy Power Plants Volume 1, Bituminous Coal and Natural Gas to Electricity Final Report (DOE/NETL-2007/1281), Rev. 1 August 2007." Process descriptions and Process & Instrumentation Diagram drawings for these plant sections, along with a discussion of modeling expectations, control strategies, operating procedures, and representative malfunctions, are presented in the detailed planning report for the IGCC simulator (DOE/NETL-2008/1324).

The IGCC reference plant for the generic dynamic simulator

Example of a Dynamic Simulator Training Center (courtesy Invesys Process Systems)



Schematic of IGCC reference plant used for the generic dynamic simulator

will be a 746 MW gross (556 MW net) plant consisting of dual train entrained-flow gasifiers producing clean syngas for combustion in two F-class advanced combustion turbines with a combined net output of 464 MW. The exhaust of the combustion turbine is sent through a Heat Recovery Steam Generator (HRSG) and produces steam that is supplied to a steam turbine having a net output of 275 MW. A sweet gas expander will supply 6.3 MW of net output. A dual-stage Selexol™ unit will be used to sequentially remove hydrogen sulfide and carbon dioxide. The plant is designed to consume approximately 3,300 tons per day of coal and/or petroleum coke.

The simulator will be designed and operated both as a single, integrated model of an IGCC plant and as multiple, independent models of gasification and combined-cycle plant sections. Users can thus train in the separate components or in the entire integrated system. The IGCC simulator will be capable of simulating a number of operating conditions including normal operation, complete cold, warm, and hot plant startups, plant shutdowns, load following and shedding, fuel switching, and response to ambient condition variations. The simulator will also be able to handle abnormal and emergency events in real-time, including malfunctions and equipment failures.

SIMULATOR SOFTWARE

The NETL IGCC dynamic simulator will be based on interoperable, flexible, and extensible software components that provide the ability to build, run, modify, and control the IGCC simulation through an integrated model-building and run-time environment. The best-in-class dynamic simulation software, DYNSIM®, from IPS' Simsci-Esscor will be used.

The Human-Machine Interface (HMI) for the IGCC simulator will be designed to have the "look and feel" of a power plant Distributed Control System operator interface. IPS' Wonderware® award-winning InTouch® HMI software will be used for the IGCC operator HMI. InTouch® is the most widely used HMI software in the world, found in over one-third of the world's process and energy plants.

The dynamic simulator is scheduled to be deployed at the research and training center in mid-2010. It will serve as a focal point for collaborative IGCC research and development among NETL, universities, and the power and energy industries. It will also satisfy industry's growing need for training and experience in operation and control of commercial-scale IGCC with carbon capture. The generic IGCC simulator being developed could serve as the basis for future plant-specific simulators. ■

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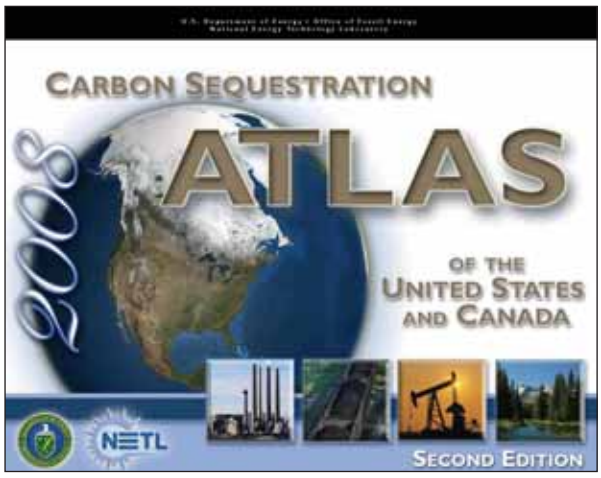
Comments are welcome and may be submitted to the Editor.

DOE RELEASES CARBON SEQUESTRATION ATLAS

In November 2008, the Department of Energy (DOE) released a second edition of its *Carbon Sequestration Atlas of the United States and Canada* (Atlas II) containing updated information on the location of stationary carbon dioxide (CO_2) emission sources, as well as the locations and storage potential of various geologic sequestration sites. The atlas, which was created by the National Energy Technology Laboratory (NETL), provides a national view of carbon capture and storage (CCS) data provided by DOE's seven Regional Carbon Sequestration Partnerships (RCSPs).

Atlas II contains a number of updates and enhancements, including a coordinated update of CCS potential across the majority of the United States and portions of Canada. Additionally, Atlas II is accompanied by an online version featuring interactive maps. Other additions include:

- New basins and formations added to the CO_2 storage portfolio
- Updated information on DOE's Carbon Sequestration Program and Regional Carbon Sequestration Partnerships (RCSPs)
- Definitions of CO_2 resource versus CO_2 capacity that reflect the uncertainty of geologic storage estimates for CO_2 across the RCSPs
- Updated information on the location of stationary CO_2 emission sources and the locations and storage potential of various geologic sequestration sites
- Information about the commercialization opportunities for CCS technologies from across each RCSP.



The atlas is divided into two main segments. National Perspectives provides a broader view of CO_2 sources in the U.S. and Canada, with a series of maps displaying storage potential across three major geologic formations: saline formations, coal seams, and oil and gas reservoirs. Total cumulative resource estimates included 138 billion metric tons across all RCSPs for oil and gas reservoirs, 157–178 (low/high range) billion metric tons for unmineable coal seams, and 3,300 to more than 12,000 billion metric tons for saline formations.

Regional Perspectives goes on to profile individual RCSPs in detail, with information about their respective purposes, projects, development, and output. Each RCSP self-reported its information, including the resource estimates used to compute the cumulative national resource estimates.

An interactive companion to Atlas II — the National Carbon Sequestration Database and Geographical Information System (NATCARB) — explores geological sequestration of carbon through linking geological and emission databases from several regional centers into a single interactive mapping system. NATCARB is run by the Kansas Geological Survey.

NATCARB online access has been modified in Atlas II to address the broad needs of a spectrum of users. It includes not only GIS and database query tools for the high-end technical user, but also simplified displays for the general public employing readily available web tools such as Google Earth™ and Google Maps™. The online companion to Atlas II is located at: http://www.natcarb.org/index.html.

Atlas II also includes an appendix discussing the methodology used in collecting the updated information for the 2008 edition. All data in Atlas II were collected before June 2008. While these data sets are not comprehensive, it is anticipated that CO_2 resource estimates as well as geologic formation maps will be updated every two years as new data are acquired and methodologies for CO_2 storage estimates improve.

More information about DOE's Carbon Sequestration Research Program can be found at http://www.fossil.energy.gov/programs/sequestration/index.html. ■

INTERNATIONAL INITIATIVES

INDIAN PLANTS DEMONSTRATE BEST PRACTICES

A project being implemented by the Department of Energy's (DOE) National Energy Technology Laboratory (NETL) has been quietly making progress in reducing carbon dioxide (CO_2) emissions from Indian coal-fired power plants. The project is aimed at demonstrating low-cost U.S. best practices to improve and maintain the efficiency of existing Indian power plants. Many of these plants operate at efficiencies several percentage points below their design basis owing to the poor quality (high-ash) of most Indian coals, poor plant maintenance, and lack of diagnostic tools and instrumentation. The current effort is part of the flagship Power Generation Best Practices program taking place under the Power Generation and Transmission Task Force of the Asia Pacific Partnership (APP) on Clean Development and Climate. The foundation of this project can be found in the technical assistance that NETL has provided to the U.S. Agency for International Development (USAID) in India since 1982 on several cooperative projects to improve power plant efficiency. As a direct result of this earlier work, millions of tons of coal have been saved and more than 68 million metric tonnes of CO_2 emissions avoided.

In the current effort, NETL has been working with USAID and the U.S. Department of State to provide tools and training on efficiency and operations and maintenance issues. India's Ministry of Power requested assistance at the Kolaghat plant of the West Bengal Power Development Corporation Limited and the Ropar plant of the Punjab State Electricity Board.

Ropar power plant in Punjab, India

NETL contracted with Storm Technologies, Inc. (STI) of Albemarle, North Carolina, a utility combustion performance improvement consultant, to conduct an initial walk-through of the two plants in March 2008. During the visit, a number of operational deficiencies were uncovered (e.g., air leakage into the furnace, inadequate insulation, improper location of sensors, coal leakage from pulverizers, fugitive emissions around the boiler, and steam leaks). However, because neither plant has gravimetric coal feeders, it was difficult to quantify the impact of these problems on plant efficiency. Nevertheless, during a planned plant outage, the staff acted on many of STI's critical recommendations, leading to a reduction of about 75 kcal/kWh in the plant's heat rate.

Subsequently, NETL provided the critical diagnostic instrumentation needed to measure the plants' performance. STI, working with engineers from the NTPC's Centre for Power Efficiency and Environmental Protection (CenPEEP), benchmarked the two plants, made recommendations for efficiency improvement, and conducted a 2-day workshop on coal-fired power plant combustion optimization and efficiency improvement. In September 2008, NETL coordinated 2 weeks of training on efficiency improvement for engineers from NTPC, the two power plants, and India's Central Electricity Authority. The training was conducted at three U.S. power plants: the Reid Gardner Station, in Moapa Valley, Nevada; the Orlando Utility Commissions Stanton Energy Center, in Orlando, Florida; and the EON US – Louisville Gas & Electric Company's Trimble County Station, in Bedford, Kentucky.

After the U.S. training, the Ropar and Kolaghat plants began turbine and steam testing in the designated units. Steam turbine tests carried out by CenPEEP on one 210-MW unit at the Ropar and Kolaghat plants identified up to 137 kcal/kWh as recoverable from gross turbine cycle heat rate losses. After successful boiler optimization tests at Ropar, a measurable boiler efficiency improvement of at least three percent (approximately 100 kcal/kWh heat rate improvement) was identified. By tuning the pulverizers at the initial Ropar unit, using the provided test equipment, the unit's heat rate was immediately improved by 25 kcal/kWh. Both turbine and boiler tests have been completed at Ropar, and preliminary data show a total heat rate improvement potential of 237 kcal/kWh. This is in addition to the heat rate recovered during the plant outage – for a total improvement of 312 kcal/kWh. If similar improvements are achieved in the remaining five units at Ropar, the total improvement could be as much as 1,872 kcal/kWh.

In a typical 210-MW Indian coal-fired unit, an improvement of 25 kcal/kWh will save about 1.2 metric tonnes of coal per day, which is equivalent to about 525 metric tonnes of CO_2 emissions reduction annually. Extrapolating these figures to the other units at Ropar, the estimated total annual CO_2 emissions reduction is about 40,000 metric tonnes/year. Similarly positive results are expected when testing is completed at Kolaghat in February 2009. In total, once the recommended actions are implemented in both plants, almost 80,000 metric tonnes of CO_2 emissions can be avoided annually. Recently, it was agreed to conduct similar work at a third Indian power plant –Tamil Nadu State Electricity Board's Tuticorin plant.

This project demonstrates that maintaining the operating parameters of existing Indian coal-fired power plants at close to optimum can result in significant efficiency gains and improved environmental performance at little or no capital cost. It is hoped that these early results from Ropar, along with other planned activities, will be widely replicated in the many under-performing Indian coal-fired power plants. Not only could millions of tons of CO_2 emissions be avoided, but the financial performance of these plants would be significantly improved. NETL and its partners are planning an outreach program, including workshops and technology transfer, to encourage other Indian state utilities to adopt the best practices being demonstrated at these plants.

ACTIVITIES OF FE-LED APEC EXPERT GROUP

The Expert Group on Clean Fossil Energy (EGCFE) is one of five expert groups under the umbrella of Asia Pacific Economic Cooperation's (APEC) Energy Working Group. APEC was established in 1989 and is made up of 21 member economies on both sides of the Pacific Ocean. These economies account for nearly 70 percent of global economic growth over the past 10 years. The U.S. Department of Energy's Office of Fossil Energy has chaired the EGCFE since its inception in the early 1990s, and Scott Smouse of the National Energy Technology Laboratory is the current chair. The EGCFE aims to commercialize clean coal technologies for new and existing plants in developing APEC economies where coal use is growing rapidly. Part of this effort requires evaluating and reporting on the APEC experience in various aspects of clean coal technology: new plants, upgrade of older plants, or environmental monitoring. To this end, EGCFE recently issued three reports available at the EGCFE website: http://www.egcfe.ewg.apec.org/studies.htm

- *Technology Status and Project Development Risks of Advanced Coal Power Generation Technologies in APEC Developing Economies (EWG 06/2007A)* An October 2008 report by Worley Parsons reviews the current status of IGCC and supercritical/ultrasupercritical pulverized-coal (PC) power plants and summarizes risks associated with project development, construction, and operation. The report includes an economic analysis using three case studies of Chinese projects: a supercritical PC, an ultrasupercritical PC, and an IGCC plant. The analysis discusses barriers to CCTs and ways to encourage CCT adoption for new power plants.

- *Lessons Learned in Upgrading and Refurbishing Older Coal-Fired Power Plants – A Best Practice Guide for Developing APEC Economies (EWG 05/2007)* Another October 2008 Worley Parsons report reviewed upgrading and refurbishment projects recently implemented by coal-fired power plants in developing APEC economies, and produced a Best Practice Guide for 15 classes of upgrade and refurbishment items (e.g., coal pulverizer upgrades, sootblowers, superheaters, and turbines) to aid in decision-making. There is an urgent need to optimize the performance of older coal-fired power plants in the Asia Pacific region. Refurbished power plants are more efficient and emit less CO_2. Plants can also be upgraded with new pollution control equipment to emit less SO_2, NO_x, particulates, and other emissions, including mercury.

Conference delegates touring the 300-MW steam turbine at the Cam Pha, Vietnam power plant during the joint APEC-ECO Asia conference. The plant, which is scheduled to be operational in 2009, uses two 150-MW subcritical circulating fluidized bed (CFB) boilers supplied by Foster Wheeler.

- *Environmental Monitoring for Coal-Fired Power Plants in Developing Asian APEC Economies (EWG 06/2007)* This November 2008 report by Science Applications International Corporation assesses environmental monitoring and reporting by individual coal-fired power plants, makes recommendations regarding how monitoring should be applied, and evaluates the interrelationship of monitoring and regulation in promoting CCTs. Effective monitoring is needed to ensure that power plants are performing as expected, and to confirm that they are complying with applicable environmental regulations. Older coal-fired power plants in APEC economies often have limited monitoring capabilities, making their environmental performance difficult to measure.

Aside from producing useful reports, the EGCFE holds one or more major international seminars every year. In August 2008, in partnership with USAID's ECO-Asia Clean Development and Climate Program, EGCFE held the "Cleaner Coal Workshop on Solutions to Asia's Growing Energy and Environmental Challenges" in Ha Long City, Vietnam. As part of the workshop program, participants arrived at policy recommendations such as: adoption of supercritical technology in India and Vietnam; increased coal-biomass co-firing; use of Continuous Emissions Monitoring, and more research in upgrading low-rank sub-bituminous coal. In November 2008, the EGCFE joined with the Indonesian Coal Society to jointly organize the annual APEC Clean Fossil Energy Technical and Policy Seminar and CoalTech 2008 Conference and Exhibition in Jakarta under the theme of "Find the Way: Securing a Clean Future for Coal." The event was attended by over 200 experts from government and industry from throughout the region. The next EGCFE seminar is being planned for Korea around October 2009.

ACTIVE PPII AND CCPI PROJECT STATUS

PPII STATUS

CONSOL Energy Inc. – *Greenidge Multi-Pollutant Control Project*. This highly successful project concluded on October 18, 2008, having achieved all of its emissions reduction goals. The demonstration project was conducted at the 104 MWe coal-fired AES Greenidge Unit 4 near Dresden, NY. The multi-pollutant control system includes a hybrid selective non-catalytic reduction (SNCR) / in-duct selective catalytic reduction (SCR) system to reduce NO_x emissions, followed by a circulating fluidized bed dry scrubber system to reduce emissions of sulfur dioxide (SO_2), sulfur trioxide (SO_3), hydrochloric acid (HCl), and hydrofluoric acid (HF). Mercury (Hg) removal was also achieved via the co-benefits afforded by the in-duct SCR, dry scrubber, and baghouse. Performance targets included NO_x reduction to ≤0.10 lb/mmBtu, ≥95 percent removal of SO_2, SO_3, HCl, and HF, and Mercury removal ≥90 percent. Actual measured results were a NO_x emission rate of 0.10 lb/mmBtu, SO_2 removal of 96 percent, Hg removal of 94–98 percent, SO_3 removal in the range of 95 to 97 percent, and HCl removal of 97 percent. HF concentrations were typically at or below the detection limit, precluding the determination of removal efficiency. (Dresden, NY)

CCPI STATUS

Great River Energy (GRE) – *Lignite Fuel Enhancement*. GRE is installing four dryers on Unit 2 as part of the Clean Coal Power Initiative (CCPI) project. Due to success obtained in the prototype phase of this CCPI project, GRE is installing four more dryers on Unit 1 with its own funds. Thus, the entire Coal Creek Station is being retrofitted with lignite coal dryers. To date, GRE has completed the construction of three floors in the dryer building and installed the major pieces of equipment, i.e., four dryers on the bottom floor, four baghouses on the middle floor, and four fans on the top floor, for each of the two 546-MW units at the Coal Creek Station in North Dakota. For the Unit 2 dryers, the major dryer internals, such as water coils, air sparger, fire protection system, and explosion protection system, have been installed. The dryer building is mostly enclosed. Electrical cables, lights, and heating systems are being installed in the dryer building to facilitate complete enclosure of the building and installation of other auxiliary equipment. Steel erection is taking place in the fan room area for the installation of heat exchangers. The construction of the coal crusher building is in progress. (Underwood, ND)

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

NeuCo Inc. (formerly Pegasus Technologies) – *Mercury Specie and Multi-Pollutant Control*. The third and final budget period (BP3), which represents the actual demonstration phase, began on January 1, 2009. Approval to continue to the demonstration phase was determined by software development and integration to plant wide data acquisition and control systems, as well as gathering of sufficient preliminary data to demonstrate potential to achieve project performance goals. During BP3, long term plant-wide optimized operation will be demonstrated by comparison of optimized test results (with emphasis on mercury reduction optimization) with baseline data and with the targets established for the project. The project will result in the host site (NRG Texas Limestone Plant) having the most advanced network of integrated optimization systems ever applied in the industry and the only one with integrated mercury optimization. (Jewett, Texas)

We Energies – *TOXECON™ Retrofit for Mercury and Multi-Pollutant Control*. Average mercury removal for the calendar year 2008 was greater than 90 percent. This level of removal was obtained by using both neat and halogenated powdered activated carbon (PAC) at injection rates nominally between 1.0 and 1.5 lb/mmacf. The continuous emission monitoring system for mercury is continuing to perform well, routinely

passing daily calibration checks with very few maintenance issues. The primary subcontractor on the project, ADA-ES is investigating techniques to utilize TOXECON™ baghouse ash. Conductive concrete applications and advanced concrete additives are being investigated. A conductive concrete pad is being installed at the Presque Isle Plant to evaluate structural integrity. Several polymer-based air entrainment additives have been recently tested that show promise to allow high carbon containing ash concrete to be used in transportation-based applications. Much of work will be addressed at the EUEC conference in Phoenix in February 2009. Dedicated papers addressing baghouse bag performance, high carbon ash containing concrete performance as well as overall project status will be provided. (Marquette, MI)

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

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