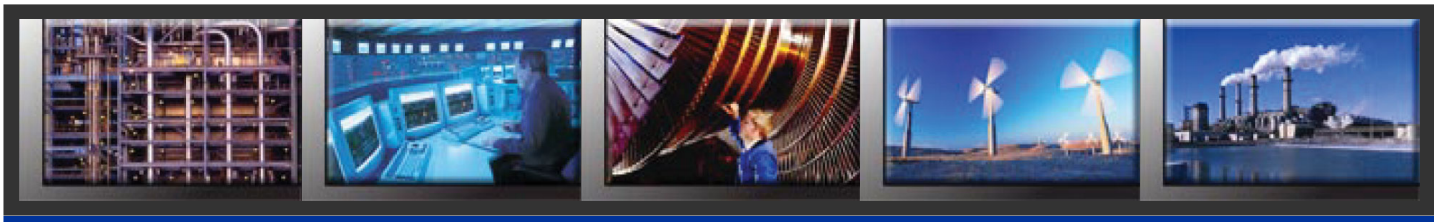
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Generation Sector Update



A Report from EPRI's Generation Sector — December 2008/January 2009

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DEAR EPRI GENERATION MEMBERS

The end of the year 2008 found EPRI Generation staff making significant technical progress in all Sector program areas. Of particular note are the numerous updates in the broad area of environmental controls – from feasibility studies of emerging carbon capture and biofixation concepts, to ongoing in-plant demonstration of carbon capture technologies, to addressing the calibration issues of new mercury control technologies that have already been implemented.

Environmental control programs and related activities represent nearly 40% of our Sector's funding, consistent with the high level of priority that Generation members have assigned to the specific knowledge gaps and research needs in this area. Reducing costs associated with compliance with environmental regulations has made this area strategically important for both existing and new fossil generation.

As we enter 2009 and face the challenges of emerging environmental policies and regulations both at home and abroad, we look forward to working collaboratively with you to continually sharpen our research and development portfolio, and to keeping you abreast of our technical progress. We'll also touch on other, equally important work that helps maintain the viability of the existing generation fleet, and provides diverse options for new generation in an increasingly challenging market for cleaner electricity.

Bryan Hannegan
Vice President, Environment and Generation
bhannegan@epri.com
650-855-2858

Stu Dalton
Director, Generation
sdalton@epri.com
650-855-2467

Norris Hirota
Director, Generation
nhirota@epri.com
650-855-2084

CoalFleet for Tomorrow-Future Coal Generation Options (Program 66)

CoalFleet conducts survey of Japanese and Chinese ultra-supercritical coal plants.

Report offers data on experiences with advanced designs.

A new EPRI report, *Survey of Ultra-Supercritical Pulverized Coal Power Plants in Japan and China (EPRI document # 1018444),* is now available. The report details the characteristics of USC plants, including design data on efficiency, emissions, and suppliers of key equipment. It also features information on the materials deployed in both the steam turbines and steam generators and, where available, the operational experience from the plant owners.

The information contained in the report was collected from a variety of sources, including a questionnaire mailed to Japanese power plants operators; trip reports from site visits to key Japanese USC plants; data collected from industry experts in China and Japan; and a literature survey, including technical papers and presentations from recent conferences.

This phase I report is primarily intended to share the experience of Japanese and Chinese power companies operating supercritical and ultra-supercritical plants with EPRI's CoalFleet members. Based on the response received from the utilities that participated in this survey, a second phase is planned to provide additional insights into design and operational problems and how they were resolved, as well as further identification of the major causes of forced outages. For more information, contact Des Dillon (ddillon@epri.com, 503-908-0151).

CO_2 Capture & Storage (Program 165)

GHGT9 Conference offers details on new CO_2 capture processes.

EPRI-supported meeting attracts 700 papers.

The announcement by Siemens of a new capture process and growing interest in CO_2 storage were just two of the highlights of the Ninth International Conference on Greenhouse Gas Control Technologies (GHGT9), held Nov. 16-20 in Washington, DC. The Siemens' system, in development with E.ON, uses an amino-acid salt in a regenerative absorption capture process. A 150 Nm3/hr pilot is projected to come online in August 2009 near Frankfurt, Germany, with an expected parasitic load of about 20% (including compression) after further process and solvent improvements, while avoiding corrosion, solvent degradation, and environmental concerns over solvent releases or disposal. Siemens stated the heat of regeneration in its process is 3.5 GJ/tonne CO_2, and that it plans to lower it to 2.3 GJ/tonne through further, unnamed improvements.

Other major announcements and observations included:

- Nearly 1,500 attendees were on hand, including many early-career participants, up from 1,000 in 2006.
- More than 700 papers were submitted, including 350 on capture.
- MHI stated it will be ready for commercial orders by the end of 2011.
- There is an increased interest in biomass co-firing with CCS for its potential to reduce atmospheric concentrations of CO_2.
- There is growing interest among the geology community in pressure buildup in storage reservoirs (the potential that a number of saline reservoirs intended for CO_2 geo-storage might be confined and experience excessive pressure increases during the injection period). Such a buildup could restrict the capacity of the reservoir and/or force saline water and/or CO_2/saline water mixtures to flow through fractures or fissures into drinking water aquifers. Several researchers discussed methods of moving saline water from the injection formation to other reservoirs or the ocean (in the case of sub-surface ocean storage) to avoid such pressure buildups.
- Similarly, several papers on storage emphasized that the heterogeneous nature of target injection formations means that the industry will need to prepare bottoms-up characterizations of intended formations (i.e., many wells and other measurements) to sufficiently understand the potential capacity and injectivity of the reservoir. This will require significant investment in time (3-5 years) and money, but will be less risky than quicker, lower-cost characterizations that may lead to injection in formations found to be unsuitable after a short time into the project.

- Accurate, low-cost surface leak detection monitoring, mitigation, and verification (MMV) is still not available and is a significant challenge.
- Several presenters argued that CO_2 transport is not a critical issue; the potential safety issues are understood and managed today (e.g., a CO_2/H_2S mixture is transported today); the CO_2 pipeline industry has a better safety record than the natural gas pipeline industry (maybe because CO_2 is not flammable or explosive); the required build-out of the pipelines will be at a pace that is no quicker than previous pipeline additions and probably slower; and the required infrastructure is not directly scalable to the amount of CO_2 that will be captured and stored, since much of that will happen close to the source power plant.

The Program 165 staff attended and covered most of the technical sessions. For more information, contact Brice Freeman (bfreeman@epri.com, 650-855-1050).

EPRI looking at potential of microalgae cultivation for production of biofuel and biofixation of CO_2.

White paper primer in development.

EPRI is supporting several research initiatives to explore the potential of the cultivation of microalgae for the joint production of biodiesel fuels and reduction of power plant carbon dioxide (CO_2) emissions. The initiatives are an extension of earlier investigations on biofixation conducted under a broad, two-year EPRI Technology Innovation showcase project to investigate emerging technologies for post-combustion CO_2 controls. The findings of EPRI's studies will help utilities better understand the potential costs and benefits of a commercial-scale microalgae operation for biofuel production and biofixation of CO_2.

Microalgae are microscopic aquatic plants which convert a significant fraction of photosynthetic energy into lipids which can be used to produce biodiesel. They have several distinct advantages over other crops for biofuels production – they are a non-food source, they can use otherwise nonproductive land, and they can be used in conjunction with wastewater treatment facilities. Some species also are salt-tolerant, allowing the use of brine as the hosting medium. And they have much greater productivity than terrestrial plants; for example, soy, palm, and canola produce between 40 and 400 gallons of biofuel per acre per year, while algae have the potential to produce 1,000 to 5,000 gallons per acre.

In nature, algae scavenge dilute CO_2 from their surroundings. Fossil-fueled power plants can be sources of free or low-cost CO_2 but the potential is limited by the available land area. The greatest potential benefit is in partial CO_2 mitigation and polishing of primary pollutants with an option, if profitable, for revenue sharing from biofuel production.

EPRI is partnering with Independence Bioproducts and FirstEnergy for a one-year demonstration of an open pond system to be hosted at the utility's 413-MW R. E. Burger Plant near Shadyside, Ohio. EPRI and Southern Company are jointly sponsoring a study by Burns and McDonnell to look at the costs and process design of a photo-bioreactor. A report will be published in early 2009. EPRI also is developing a white paper that will provide a technical primer on microalgae production and include an explanation of the technology, its potential, and costs. For more information, contact Brice Freeman (bfreeman@epri.com, 650-855-1050).

EPRI study evaluates utility business case for CCS.

Analyses will include case studies from similar technologies in other industries.

An EPRI-sponsored study is evaluating the potential roles for U.S. electric utilities in the development and operation of the expected future infrastructure for carbon capture and storage (CCS).

The first elements of this multi-year project are being conducted for Program 165 by Stanford University's Program on Energy and Sustainable Development (PESD). The aim of the project is to identify the possible opportunities and risks for electric utilities in a variety of different business scenarios involving a CCS infrastructure.

The project examines a future scenario where the CCS infrastructure is mature—where CO_2 is being captured from plant flue gas, injected into wells, and continuously monitored. Between that future scenario and the present is a gap. A gap analysis might be employed to assist utilities in understanding the different possible options available to them for building out and owning different elements of that infrastructure, including CO_2

capture, pipeline transport, and injection/storage. In other words, in which cases would it make sense for utilities to take on all the benefits and liabilities of implementing and owning one or more of these elements of the infrastructure?

The PESD analysis will consider different business models, including a utility model, a merchant model, and a state-owned model. In each case, the analysis will explore where the value is in the chain from capture to storage. How will real companies manage exposure to risks and seize rewards across the CCS value chain? What policy incentives are needed to kick-start a commercial-scale CSS industry?

The PESD also is developing a number of in-depth case studies of a sample of the first semi-commercial CCS projects. And it is analyzing the paths taken by several already mature industry "analogs"—including nuclear power, liquefied natural gas (LNG), and sulfur dioxide (SO_2) controls. In each case, the team is looking at possible lessons learned from these examples. Who created the niche? What were the relative roles of regulation and private enterprise? What was the transition from niche services to commercialization? How did advocates organize for effective political action? What was the structure of "path-breaking" deals?

The first results of the project will be published in early 2009 in a report available to P165 funders. For more information, contact Brice Freeman (bfreeman@epri.com, 650-855-1050).

Testing and data analysis underway at We Energies Pleasant Prairie pilot project for CO_2 capture.

Data collection progresses after commissioning hurdles overcome.

EPRI's year-long program is collecting and analyzing data from a pilot-scale version of a process that uses chilled ammonia to capture carbon dioxide (CO_2) from the flue gas of a pulverized-coal generating plant. In earlier laboratory experiments, the chilled ammonia process demonstrated the potential to capture more than 90% of CO_2 at a cost projected to be far lower than other technologies currently available. For the pilot project, which represents a milestone in CO_2 capture efforts, the process has been scaled up to a 1.7 MWe system.

We Energies provided the host site and utilities for the scaled-up system at its Pleasant Prairie Power Plant in southeastern Wisconsin. Alstom, which holds the exclusive license to the chilled ammonia process, constructed and is operating the pilot project and also is providing funding. With the support of a consortium of 37 national and international utilities, EPRI is managing data collection in a series of engineering and environmental performance tests and will use these data to prepare a technical and economic evaluation of the process. The tests are designed to demonstrate proof-of-concept, establish the integrity of the process, measure energy consumption, and lay the foundation for applying the chilled ammonia process on a commercial scale.

After resolving several commissioning challenges, the liquid sample collection/analysis routines are in place and working well, and the continuous data logging routines are in place. Additional instrumentation has been installed to quantify CO_2 product and makeup/blowdown flows. The monitoring regime is documenting parameters in system operations and maintenance and collecting data on ammonia loss and makeup, process water loss and makeup, the purity of the CO_2 product, and the fate of various emissions (including sulfur dioxide, sulfur trioxide, nitrogen oxides, particulate matter, mercury, and hazardous air pollutants).

With detail from this pilot data collection, researchers will be able to estimate key factors affecting commercial-scale operation, including process thermal requirements and the impact on the plant's power cycle, material operating costs, equipment capital costs, and levelized costs for CO_2 removal and the cost of electricity. Tests designed to optimize performance are looking at how changing parameters can affect the process. These tests are investigating how varying independent parameters (such as flue gas flow rate, strength of the ammonia solution, and process temperatures and pressure) can affect dependent parameters (such as CO_2 removal and quality, use of heat and chilled water, and materials usage and disposal).

In a series of gas sampling campaigns, researchers are setting the independent parameters at optimum levels and then taking profiles of the flue gas composition and measuring the usage parameters. Gas sampling was conducted in March, July, September, October, and November, and is planned for January 2009. Preliminary data indicate the potential for high CO_2 capture.

The pilot project at Pleasant Prairie treats about 1% of the plant's flue gas and could capture up to 15,000 tons per year of CO_2. Because of the nature of this pilot plant, the gas captured is being released to the atmosphere, but eventually the pressurized CO_2 from such facilities will be transported for storage in appropriate geologic formations.

The chilled ammonia process holds promise for electric utilities because its parasitic load could be as low as 15-20% of the power plant's energy output, or about half to two-thirds the energy demand of today's most commonly used industrial carbon capture technology, an absorption process that employs a solvent called monoethanolamine (MEA). This lower energy demand would translate into correspondingly lower cost increases in future applications of CO_2 controls. For more information, contact Dick Rhudy (rrhudy@epri.com, 650-855-2421).

OPERATIONS AND MAINTENANCE

I&C and Automation for Improved Plant Operations (Program 68)

New research assists utilities using advanced pattern recognition tools for monitoring assets.

A new report, *On-Line Monitoring: Data Classification for Improved Modeling Effectiveness: Functional Requirements Specification* (1016189) provides data classification methods which enable better diagnostics and more reliable online monitoring by allowing the selection of the most suitable modeling methods for plant operating data. This work was sponsored by EPRI's Program on Technology Innovation. For more information, contact Aaron Hussey (ahussey@epri.com, 704-595-2009).

ENVIRONMENTAL CONTROLS

Combustion Performance and NO_X Control (Program 71)

New tests will quantify impacts on boiler tubes.

As part of an ongoing multi-participant project to assess first-order causes of circumferential cracking in boiler tubes, a parametric test program has been initiated at PPL's Brunner Island #3 760 MW power plant. The parametric tests will isolate key parameters so that specific impacts on boiler tube temperature and temperature variations can be quantified. Key parameters include the impact of wall blowing, slag shedding, utilization of overfire air, fuel and air balancing, etc. The ultimate goal will be to provide a listing of best practices consistent with minimization of boiler tube cracking. For more information, contact Tony Facchiano (affachiano@epri.com, 650-855-2494).

Production Cost Optimization (PCO) project releases initial results.

Report includes details on costs/benefits of 25 potential power plant efficiency applications.

Initial results are available from EPRI's Production Cost Optimization (PCO) Project, which assists coal-fired power plants in reducing heat rate and optimizing production costs.

The benefits of heat rate reduction are substantial – lower fuel costs directly benefit the power producer's bottom line (for example, a 1% heat rate reduction at a typical 500-MW plant operating at 90% capacity factor and firing bituminous coal can achieve as much as $700,000 in annual fuel savings); it is the most cost-effective control for lowering carbon dioxide (CO_2) on the margin (in the example above, a 1% heat rate reduction corresponds to an equivalent 1% reduction in CO_2 emissions, or about 40,000 tons/year); it will also result in decreases in other emissions such as nitrogen oxides (NO_X), sulfur dioxide (SO_2), and mercury; and under deregulation, as utilities dispatch plants within a fleet, heat rate improvement can earn plants a better position in the dispatch order.

Heat rate can be improved by reducing energy losses, and in most utility fleets today, initial improvement in heat rates can be achieved not with deployment of new technology but rather with a re-commitment to best operating practices. But several disincentives have acted to steer power companies away from supporting heat rate reduction activities, including an increasing emphasis on plant availability, implementation of post-combustion environmental controls which reduce the plant efficiency, New Source Review considerations, and fuel adjustment clauses in utility rates.

Phase 1 of the PCO project, which began in 2006, is designed to assist plants in re-implementing and/or enhancing their heat rate programs to reduce production costs. The goal is to achieve a minimum of a 1% heat rate reduction at each unit involved. To date, nine plants have completed on-site assessments, and seven of those plants have received their completed analysis and reports. Additional sites have been lined up for assessment. A new EPRI report entitled *Production Cost Optimization Assessments* (1015734) describes the assessments and the results thus far.

Phase 2 of the PCO project, which began in 2008, aims to identify capital projects with the potential to improve power plant cost optimization. A new EPRI report, entitled *Capital Projects for Efficiency Improvements (*1015735), was released in December. It describes a methodology to assess different potential capital improvements and provides a reference document on a wide range of possible capital projects that appear to be cost-effective and have the potential to result in efficiency improvements. The list of potential power plant capital improvements assessed in this report is not exhaustive, nor do all result in a positive annualized benefit. This report is a first effort: future editions will assess additional projects and may possibly include maintenance projects. For more information, contact Jeff Stallings (jstallin@epri.com, 650-855-2427) or Sam Korellis (skorellis@epri.com, 704-595-2209).

Integrated Environmental Control (Program 75)

Several sorbents marketed as ash-compatible show high mercury removals.

Short-term tests on PRB-fired boiler show mercury removals ≥ 90%; impact on ash usability being determined.

Portland General Electric (PGE) and EPRI are conducting full-scale field tests to determine if newly developed ash-compatible activated carbons (ACAC) can achieve mercury removals of >70-90% while preserving ash sales for the host site, PGE's Boardman 615 MW station. The unit is equipped with an ESP for particulate control. Several manufacturers (Calgon, Norit, and Sorbtech) have developed ash compatible versions of their standard brominated carbons (Calgon Ultra, Sorbtech C-PAC, Norit Darco Hg-LH EXP 1, Norit Darco Hg-LH EXP 224). EPRI tested several of these sorbents for three days each to assess mercury removal and ESP/ash impact as a function of sorbent injection rate. Norit EXP 1 was selected for a four-day test to evaluate longer-term operation and mercury control effectiveness and enable a more in-depth study of ash use as a partial cement replacement in concrete manufacture.

The preliminary test results showed that at least two of the ACACs achieved similar mercury removals as the standard brominated Norit Darco Hg LH (greater than 90% removal at ~4 lb/MMacf injection rate). Various concrete tests are ongoing on ash/carbon mixes collected from the ESP hopper during sorbent injection testing to evaluate the sorbent's impact, if any, on concrete mixes. PM emissions data also are being analyzed. These results show significant promise for retaining potential ash sales while achieving high mercury removals across the ESP if the ACAC supplied can be demonstrated to have low impact on concrete mixes. For more information, contact Ramsay Chang (rchang@epri.com, 650-855-2535).

EPRI laboratory device shows value in screening novel sorbents.

Device may be adapted for QA/QC of delivered sorbents at plant site during commercial ACI operation.

The main technical objective of EPRI's screening device is to compare the mercury adsorption effectiveness of various new materials against a standard activated carbon (such as Darco Hg LH) with known performance. This laboratory device uses simulated flue gas, but has been shown to provide a reliable prediction of performance range (better, comparable to, or less good than the standard) and is low cost. Screening tests of several novel, non-carbon based sorbents that had been proposed to EPRI as improvements showed lower mercury removals than standard activated carbon, providing early feedback to the developers and saving the cost of field tests.

In its latest use, several novel sorbents, claimed to be very effective for mercury control, were screened. The novel sorbents included Thiol SAMMS, Enviroscrub, and a University of Florida sorbent, all non-carbon based. None of the sorbents showed comparable mercury removal to the standard under the conditions tested. The Enviroscrub sample, however, provided 100% SO_2 and 25% NO_X capture, while the University of Florida sample oxidized 40% of the elemental mercury.

The screening approach also is being developed as a tool to be used in actual flue gas at a power plant site; e.g., to test batches of sorbent when received from a supplier during commercial operation. For more information, contact Ramsay Chang (rchang@epri.com, 650-855-2535).

Long-term tests of fate of mercury captured by an FGD have been completed at one site.

Low re-emissions suggest the captured mercury is bound up in gypsum fines.

For many years, EPRI (formerly in collaboration with DOE) has been trying to understand which discharge stream received the preponderance of the mercury captured by the FGD – flue gas via re-emissions, liquid blowdown, gypsum fines, or coarse gypsum. The technical community believes this partitioning of the mercury and re-emissions are controlled by the same chemical processes. Because field tests conducted to date – all snapshot batch tests – did not yield definitive answers, EPRI decided to conduct long-term tests in case the process is driven by transients. The recently completed test is the first. For this site, most of the mercury enters the FGD with the flue gas (i.e., not the limestone). Approximately two-thirds of the coal mercury is captured by the ESP due to the high loss on ignition (LOI) content of the fly ash. Mercury captured in the FGD stays mainly with the gypsum fines as they are processed through the hydrocyclones. While this site is a good example of a system with minimum re-emissions, EPRI still is looking for a site where re-emissions are significant. For more information, contact Richard Rhudy (rrhudy@epri.com, 650-855-2421).

Large-scale mercury oxidation catalyst continues to operate at steady pressure drop.

Recently-obtained Ontario Hydro mercury samples are being analyzed.

This large-scale, two-year demonstration of a mercury oxidation catalyst at the Lower Colorado River Authority (LCRA) Fayette Station 100-MW unit has now operated six months, with pressure drop now steady at 2 in. H_2O. It is intended to demonstrate an option for increasing mercury removal at PRB-fired plants with ESP/FGD; the goal is to oxidize a substantial fraction of the elemental mercury produced in a PRB-fired boiler so that the FGD can capture it. The second of three rounds of Ontario Hydro mercury measurements were conducted during the last week of November, and the results are expected to be ready by late December. These results will be correlated to the installed mercury continuous emissions monitors (CEMs) to validate their measurements of total mercury, elemental mercury conversion efficiency, re-emissions and mercury speciation. The pressure drop across the catalyst beds is holding steady at 2 in. H_2O after four months of a steady increase from 1.5 in. H_2O. Some cell plugging has been observed. For more information, contact Brice Freeman (bfreeman@epri.com, 650-855-1050).

In slipstream SCR, mercury oxidation remained high in aged catalyst and after regeneration.

The second set of catalyst testing has been completed at the Plant Gorgas pilot SCR units. Preliminary results indicated only a slight degradation of mercury oxidation with the aged catalyst, and slight improvement for the regenerated catalyst compared to the original condition. For more information, contact Chuck Dene (cdene@epri.com, 650-855-2425).

Particulate & Opacity Control (Program 76)

Two compatible ESP power supplies could make performance largely independent of ash properties.

Tests underway on EPRIswitch's polarity reversal feature and ROPE's pulsing technology.

Testing of EPRIswitch, the high-frequency power supply that combines voltage wave shaping to optimize the collection of high resistivity dusts with polarity reversal for improved plate cleaning during rapping, began in October. The polarity reversal switch failed shortly after power supply start-up but the reason for the failure was easily identified by the manufacturer. The power supply is being repaired and will be returned to the test site for further testing in the near future.

At the same time a program to evaluate ROPE (rapid onset pulse energization), an advanced voltage pulsing power supply, is getting underway. ROPE has the potential to produce efficient collection of even the most difficult, high-resistivity dusts. Assuming successful tests of the individual systems, EPRI plans to combine the ROPE pulsing technology with the EPRIswitch polarity reversal technology to produce an extremely effective and flexible power supply. This would enable ESP performance to be largely independent of ash properties, greatly reducing the ESP factor in the fuel flexibility equation and providing an opportunity for reduced fuel costs at many plants. EPRI is seeking tailored collaboration participants for the ROPE field test. For more information, contact Ralph Altman (raltman@epri.com, 423-899-0072).

Continuous Emissions Monitors (Program 77)

Resolving calibration issues in Mercury CEMs caused by fluctuating nitrogen flow.

Tests show using back pressure regulator maintained constant oxygen levels in the nitrogen gas generators.

Experiments were conducted to verify the effectiveness of the two approaches – orifices and needle valves – to regulating back pressure to the nitrogen generator in order to achieve stable nitrogen flow. Both approaches worked well; however, some modification was required to accommodate the use of both the reference and the installed calibrators at the same time. ThermoFisher and EPRI have found that the calibrator needs to use both a back pressure regulator and a needle valve on the nitrogen generator. ThermoFisher has changed its "firmware" to vary the chamber flow only when changing concentrations. This minimizes the impact of the load on the nitrogen generator and helps to alleviate the problem. For more information, contact Chuck Dene (cdene@epri.com, 650-855-2425).

Results of mercury calibrator field study published.

EPRI has published the results of a study to develop field procedures for certifying mercury (Hg) calibrators as traceable to a National Institute of Standards and Technology (NIST) standard and to establish periodic quality assurance and quality control (QA/QC) procedures for the calibrators. The results are published in an EPRI report entitled *EPRI Hg Calibrator Traceability and QA/QC Procedures Project* (1015772), which will assist operators of coal-fired plants in understanding one of the key regulatory requirements associated with Hg continuous emission monitors (CEMs)—how to ensure that the monitors' Hg calibrators are traceable to a NIST standard.

Hg CEMs purchased to date by utilities have been shipped without NIST traceable calibrators, so NIST traceability must be resolved in the field. In August 2007, EPA released a draft interim traceability protocol for Hg calibration generators. As drafted, however, this protocol would have been difficult to implement and would have created an undue cost and logistical burden on the end users and calibrator vendors. As a result, EPA subsequently proposed to conduct a cooperative "Field Calibrator Study" in order to provide a basis for drafting a revised traceability protocol for Hg elemental gas calibrators.

The study's primary focus was to develop procedures for transferring NIST certification from the NIST prime calibrator to calibrators installed at source facilities. The procedures involved a series of monthly bracketing comparisons, which required bracketing the response of the candidate calibrator with a before-and-after response from a NIST traceable reference calibrator. Ten utilities participated in the study, and the number of calibrators was sufficient to provide feedback on the overall stability and performance of the calibrators. The project team was able to draft detailed bracket comparison checks for Thermo and Tekran calibrators. Results of the study have shown that the calibrators were relatively stable over the course of the study, and that the bracket comparison can be used to assess the calibrator performance.

The study also provided potential periodic QA checks that can be used in the field to verify the operation of the Hg elemental calibrators. One method that provides a useful ongoing QA check involves the use of permeation tubes in the Tekran systems. A refinement of the comparison procedures and further testing are needed to enable the use of compressed Hg gas cylinders as a tool for conducting ongoing QA assessments.

Following the field portion of this study, the next step is to begin the process of evaluating the data and working with EPA in the development of a workable NIST traceability protocol which should contain procedures that can be performed in a field environment and provide both the end user and regulatory bodies assurance that the calibrators are performing as intended. It also should provide performance requirements that are reasonably attainable and based on what the calibrators have demonstrated can be achieved in the field study. For more information, contact Chuck Dene (cdene@epri.com, 650-855-2425).

Coal Combustion Product (CCP) Use (Program 78)

Laboratory tests better at defining differences between FGD and natural gypsum.

Crop chemical analyses did not show any significant differences between treated and untreated plots.

The EPRI-Ohio State University network of sites assessing the agronomic benefits ad environmental acceptability of using FGD gypsum as a soil amendment currently consists of 10 sites in six states and seven crops. Analyses conducted to date show little difference between the FGD gypsum and the commercial gypsum products. The commercial gypsum had higher carbon and nitrogen, probably due to incorporation of additives during the formation of the commercial prills. The commercial gypsum also had higher solubility and lower purity.

The most significant difference with respect to trace constituents was higher mercury concentration in the FGD gypsum; however all samples were less than 0.7 mg/kg. Pre-and post-treatment soil analyses were available for two of the North Dakota sites. The most notable differences were the higher calcium and sulfur content of the soils in the treatment plots, as would be expected. There were no significant differences noted for the soil trace metal contents. Initial crop yield data for three sites indicated a tendency for higher yields on the gypsum application plots, but the limited data were not statistically significant. Crop chemistry did not suggest any significant differences between treated and untreated plots. For more information, contact Ken Ladwig (keladwig@epri.com, 262-754-2744).

Agricultural Research Service (ARS) urged to give high priority to research on FGD gypsum use in agriculture.

EPRI assists members in helping USDA/ARS understand need for R&D.

EPRI participated in the U.S. Department of Agriculture's Stakeholder Workshop on Agricultural Waste & Byproduct Utilization, held Nov. 4 and 5 in St. Louis. The purpose of the meeting was to gather stakeholder recommendations on priority areas for ARS research over the next five years in developing cost-effective management practices, technologies, and decision aids for producers of agricultural waste and by-products. One primary ARS focus area will be the use of industrial byproducts in a variety of agricultural applications. EPRI and three member power companies which were considered stakeholders at the meeting highlighted the importance of ARS research on use of FGD gypsum and other FGD products. EPRI and the three companies provided substantial input into planning for that research. EPRI's staff considers collaboration with ARS important to the value and environmental acceptability of FGD gypsum use in agriculture. For more information, contact Ken Ladwig (keladwig@epri.com, 262-754-2744).

COMBUSTION TURBINES

Combustion Turbine and Combined Cycle O&M (Program 79)

Bio-diesel for gas turbines focus of EPRI research.

Recent legislation such as state-level renewable portfolio standards (RPS) is driving a surge in interest in using these biodiesel fuels in gas turbines. To date, EPRI has conduct two full-scale biodiesel field tests on utility-sized gas turbine engines as part of an on-going supplemental project entitled "Bio-Diesel for Gas Turbines."

The research includes comparing gas turbine emissions and performance characteristics operating on distillate and biodiesel, and assessing the impact on fuel handling and storage stability. The project also proposes to study technical feasibility and economic viability of using biodiesel blends and generate data that could be useful for supporting air permit decisions and switching to biodiesel based on RPS. For more information, contact Leonard Angello (langllo@epri.com, 650-855-7939).

New CT/CC Design, Repowering and Risk Mitigation (Program 80)

New GE 7E first-stage turbine wheel analysis completed.

Next up is examination of last-stage compressor wheel; Alstom 11N rotor.

Gas turbine rotor life becomes an issue after 100,000 to 200,000 hours of operation, or 2500 or more starts, depending on the specific model. GT rotor materials for D/E class machines are similar to steam turbine rotor

materials. EPRI has completed the initial analysis for a GE 7E first-stage turbine wheel, with particular emphasis on the rim, bolt holes, and bore regions. This analysis combined with degraded material property data provides a basis for establishing the critical inspection flaw size. Additional work is planned for analyzing the last stage compressor wheel which sees similar conditions to the first stage turbine wheel. A parallel effort on the Alstom 11N rotor addressing the L-bore cooling slot and fourth stage wheel is being launched. For more information, contact John Scheibel (jscheibe@epri.com, 650-855-2850).

SOAPP-CT Workstation Version 8.1 now available.

New version including updates to CT performance for a majority of the 100+ models included in the database.

Electric utilities increasingly are finding it difficult to allocate sufficient resources to study the latest developments, evaluate alternatives, and optimize solutions for new plants. The impact of different configurations and scenarios on plant cost and performance, and consequently on the most cost-efficient plant design, often is neglected. Competitive pressures have driven engineering towards more standardized designs, which may have good performance and cost for "average" applications, but often are sub-optimal for any specific application.

SOAPP (State-of-the-Art Power Plant) is a fully integrated, easy-to-use tool for detailed conceptual design and economic analysis of gas turbine-based projects. SOAPP incorporates site-specific performance, equipment sizing, piping and GA drawings, O&M and capital costs, cash flow and return on investment to support plant design decisions based on life-cycle cost economics. The software generates site-specific heat balances, emissions estimates, equipment lists and sizing, process flow and piping diagrams, general arrangement drawings, project schedules, capital and O&M cost estimates, and annual cash flow estimates. This fully integrated framework supports a life-cycle cost approach to decisions.

EPRI recently released Version 8.1 of the SOAPP Combustion Turbines (SOAPP-CT) Workstation software with significant enhancements. It helps to optimize the numerous decisions tied to a typical $200 – $500 million combined-cycle project. Productivity savings to the domestic power industry in the support of planning studies alone could reach $10 million per year. The SOAPP Workstation reduces a task that otherwise could take several man-months of effort to less than several hours, resulting in productivity savings. More importantly, it enables users to evaluate many more alternatives than they could afford to evaluate without SOAPP, and thus achieve an optimal design.

New features in Version 8.1 include:

- **New and Updated Combustion Turbine Performance Estimates.** Combustion turbine performance for a majority of the 100+ models has been updated in this latest release. Eleven new models are included in this latest release: Alstom GT11N2-50 Hz, General Electric LM6000PD-Sprint (50 & 60 Hz), General Electric LM6000PF (50 & 60 Hz), General Electric LM6000PF-Sprint (50 & 60 Hz), General Electric LMS100PA (50 & 60 Hz), Pratt & Whitney FT8+ PowerPac (50 & 60 Hz).
- **Updated Capital Cost Estimates.** The capital cost estimates have been updated to reflect 2007-2008 pricing for both major equipment and balance-of-plant equipment items. The SOAPP software calculates the total capital cost of the project in base-year dollars and presents the total plant investment and total capital requirement on a $ per kW basis.
- **Revised Maintenance Costs for Aero-Derivative Engines.** Maintenance intervals for aero-derivative engines typically have very little sensitivity to the number of starts incurred each year. SOAPP-CT Workstation maintenance cost algorithms were modified to better represent this characteristic.
- **Updated Project Schedule Algorithms.** The project schedule algorithms were updated such that the project schedule incorporates a duration for the placement of the selective catalytic reduction (SCR) and carbon monoxide (CO) catalyst equipment when a simple cycle plant is selected.

For more information about SOAPP software, visit the SOAPP Web Site (www.soapp.com), or contact the EPRI Customer Assistance Center at 1-800-313-3374. To request a demonstration of SOAPP-CT via a personalized webcast, or to find out how you can obtain SOAPP-CT through the SOAPP Supplemental Project, contact Dale Grace (dgrace@epri.com, 650-855-2527).

Dispersed Generation and Hydropower (Program 84)

New report details wind power economics.

Includes data on major components.

EPRI released a new Technical Update report on wind turbine and related technology status in December: *Wind Power Technology Status and Performance and Cost Estimates – 2008* (1015806). As of December 2007, the installed wind capacity was 16.8 GW in the U.S. and 94 GW worldwide and is forecast to triple by 2012. Major wind turbine components include the rotor, blades, gearbox, generator, yaw drives, sensors and controls, towers and foundations, and SCADA system. As gearbox reliability continues to be an issue, several new technologies are being developed and applied to improve the reliability of the gearbox or eliminate the gearbox entirely. The estimated cost of new wind projects is now greater than $2200/kW for wind plant rated capacities between 50 and 500 MW, mainly due to the increasing cost of steel, copper, concrete and other raw materials and the high demand for wind project components. EPRI is continuing to monitor wind turbine technology status and plans to issue periodic updates in the future. For more information, contact Chuck McGowin (cmcgowin@epri.com, 650-855-2445).

Technical and economic studies look at 100% biomass repowering at Southern Company plants.

R&D in 2009 to include study of carbon footprint of biomass generation.

EPRI is conducting technical and economic studies for Southern Company on the conversion of several of its coal-and gas-fired units to 100% repowering with renewable wood biomass. Results of the studies, together with Southern's own financial analyses, are providing the analytical basis for the company to proceed with plant conversions.

The studies are compiling and analyzing data for plants at Georgia Power, Gulf Power, Alabama Power, and Mississippi Power, and include pulverized coal-fired boilers and gas-fired units. The studies are investigating the full range of issues involved in power conversion, including unit operational changes, expected operational costs, new environmental controls, emissions, new fuel storage and handling equipment, required fuel supply, and local and regional fuel suppliers. A state public service commission is expected to rule on the proposal to convert Plant Mitchell to biomass by March 17, 2009. Retrofit construction would begin by spring of 2011, and the biomass plant would likely begin operations in June 2012.

Other EPRI studies are looking at Gulf Power's Plant Scholz, which has two 40-MW pulverized coal-fired boilers, and Mississippi Power's Plant Sweatt, which has two 40-MW gas-fired boilers. For Alabama Power, the EPRI team is taking a high-level view of regional biomass supply in the state, which will then help focus on the most cost-effective plants for conversion.

Other EPRI biomass R&D includes:

- **Biomass Cofiring Handbook –** will capture information from various U.S. demonstrations and international experiences, and provide a "one-stop shop" for information on co-firing biomass with coal.
- **Role of Biomass Gasification in Power Generation –** project is analyzing some of the key variables and issues that may still restrain deployment of biomass gasification-based energy projects. The results will provide EPRI members with guidance in deciding on project development efforts.
- **Biomass Carbon Life-Cycle Perspectives –** will summarize current research on the carbon footprint of biomass-based power generation.
- **Fluid-Bed Boilers for Biomass –** will summarize world experience in using fluid-bed boilers for biomass combustion and identify key issues in handling, materials, and environmental performance.

For more information on these projects or the Biomass Interest Group (BIG), contact Dave O'Connor (doconnor@epri.com, 650-855-8970).

Alaska river in-stream power plants report looks at systems in three sites.

Includes overview of state of RISEC technology.

A recent EPRI report, *System Level Design, Performance, and Economic Assessment: Alaska River In-Stream Power Plants* (RP-006-AK, available at http://oceanenergy.epri.com/attachments/risec/reports/Alaska_RISEC_Final_Feasibility_Study_Report_10-31-08.pdf) describes the results of a study of the feasibility of deploying River In-Stream Energy Conversion (RISEC) systems in Alaska river electricity generation applications. The report describes the results of assessments of system-level design, plant performance, and costs and economics for RISEC plants installed at three Alaska river sites.

RISEC technology converts the kinetic energy of water in free-flowing rivers into electricity by placing water turbines (similar to wind turbines) directly into the flowing water. Currently, RISEC devices are at a very early stage of development. In order to be able to carry out performance, cost, and economic assessments, EPRI established a baseline device design consisting of open-rotor, horizontal-axis turbines mounted on a pontoon structure.

Although significant uncertainties with respect to commercial deployment of RISEC devices remain to be addressed, the results of the study indicate that this technology could be used to offset some of the diesel generation in remote villages and could be attractive from an economic point of view. Residents of remote Alaska villages are suffering from the high price of electricity, often 65 cents/kWh and higher for diesel fuel generated electricity.

This report offers utilities a summary of the specific issues relevant to determining the feasibility of installing RISEC devices at three Alaska river sites. The report also provides an overview of the current state of development of RISEC technology and the challenges of planning for its deployment.

The results of this study include data on power density, rotor size, power density peaks, small deployment scales, local flow variations, operational issues and simple payback periods (SPP). For more information, contact Roger Bedard (rbedard@epri.com, 650-855-2131).

GENERATION PLANNING

Understanding Power and Fuel Markets and Generation Response (Program 67)

Information from annual seminar leads to new economic forecasts.

Record prices in oil, coal and natural gas, and very sharp downward adjustments were common in markets in 2008. As a result, the presentations made at the EPRI-EEI Annual Power & Fuel Supply Seminar, held Nov. 18 and 19 in Washington, DC were especially informative for electric utilities. Those presentations now are available online for funders of Program 67, including:

- Recasting generation choices: global perspectives on fuel and currency effects
- The incredible uncertainty in U.S. generation, including coal vs. gas
- Deutsche Bank on oil fundamentals
- Citigroup on financing
- Oil market linkage to natural gas prices
- Aftermath of coal cancellations: reserve margins, wind boom (Texas lessons)
- U.S. gas market transformations (shale gas, pipelines, etc)
- International coal developments, impacts on U.S. markets

An example of the information presented was the talk by Adam Sieminski, chief energy economist for Deutsche Bank, on “Oil Market Dynamics – Lessons in Fundamentals and Geopolitics.” He noted that Deutsche Bank’s revisions to its estimates for global GDP highlighted the extraordinary fluidity of events. Going into October, the company was projecting GDP growth at 3.5% for 2009 but eventually revised that down to 1.2%. That was much lower than other agencies’ estimates, reflecting Deutsche Bank’s conclusions that “we think it is worse than people believe” on the observation that global economies are not sheltered from

U.S. contagion. After the seminar, DB's economics team revised its estimates of 2009 global GDP lower still, to "barely above zero" in 2009 (i.e. to 0.2%). For more information, contact Jeremy Platt (jplatt@epri.com, 650-855-2628).

New report looks at fundamentals of natural gas trading and exchanges.

Provides comprehensive analysis of trends in gas trading, emergence of new markets/exchanges.

A new EPRI report describes the latest trends and changes taking place in the principal natural gas trading venues and the implications of these changes for electric utilities. *Characteristics of Natural Gas Trading and Exchanges* (1016790) tracks trends in trading levels, the degree to which different types of traders are long or short in the market, the use of trading activity information in hedging market risks, and a variety of problems with the data that impede interpretation.

Natural gas is an extremely important fuel in the electric industry, accounting for 54% of annual fuel expenses and frequently driving power prices. The boom in trading activity and the controversies surrounding energy trading (and natural gas trading in particular due to its great importance to the power industry) call for detailed, dispassionate analysis of natural gas trading. For individuals involved in day-to-day trading, the report provides an integrated perspective. For others, the report helps to demystify the variety and usefulness of data reported by the various exchanges.

The new EPRI report addresses seven topics:

- **Commodities as an Asset Class –** provides an overview of the size of the exploding derivative markets and the participants with focus on the speculative traders and investors.
- **Fundamentals and Beyond –** briefly reviews international crude oil and domestic natural gas fundamentals, and discusses the nature and impact of market psychology.
- **Natural Gas Markets –** reviews trading volumes and participants in the three principal markets: the Exchange Traded Markets, the Bilateral Over-the-Counter (OTC) Markets, and the Exempt Commercial Markets.
- **Volume and Open Interest –** discusses traditional concepts of interpreting changes in volume and open interest against price movements.
- **CFTC Commitment of Traders Report –** introduces CFTC information about the levels of trading, types of trading, and participants (e.g., commercial versus non-commercial).
- **Market Oversight –** reviews the actions taken to date by the U.S. Congress and the CFTC to strengthen market oversight and curb excessive speculation. Also includes a critique of the recent CFTC analyses of speculators' roles in the energy markets.
- **European Gas Markets –** offers a high-level overview of the National Balancing Point and continental gas markets.

For more information, contact Jeremy Platt (jplatt@epri.com, 650-855-2628).

Summary of new power plant announcements released.

Details trends in capacity additions.

Accurate data on the status of new generation capacity is vital for near-term industry asset valuations and market projections. It also is a key component of assessments of reserve margins, retirements, capacity utilization, gas use, capacity premiums, and movement from baseload to cycling operations. EPRI's *Energy Markets and Generation Response* newsletter on new power plant announcements, "Tracking Capacity: Coal Decline, Evolving Gas Boom and Wind Exuberance," monitors capacity additions in coal, natural gas, wind, and nuclear, and is the program's first update on the subject since mid-2007. Energy companies can use the information in this newsletter to better understand the trends and directions of capacity additions and the factors affecting those trends.

Substantial changes in the outlook for power plant capacity additions are captured in this newsletter article. The most significant developments are a net decline in coal-fired capacity additions, an evolving construction boom in gas-fired capacity, and an exuberance of wind-capacity additions. At present, EPRI's evaluation of the development status of announcements yields likely additions of 29.5 GW of coal plants during the 2008 to 2016 period, 57.3 GW of natural gas combined cycles, 12.8 GW of combustion turbines, 3.7 GW of nuclear, and 41.5 GW of wind, with announced retirements of 13 GW also noted.

For more information on the newsletter, contact Jeremy Platt (jplatt@epri.com, 650-855-2628).

Technology-Based Business Planning Information and Services (Program 9)

Executive summary provides cost and performance data on central station options.

A new EPRI report offers strategic planners and senior company management a concise snapshot of current cost and performance and technology trends for eight central station (>50 MW) technology options most likely to be considered for near-term (2008-2015) implementation.

The report, *Power Generation (Central Station) Technology Options: Executive Summary* (1017443) is available to the public. It is based on research in progress for the latest edition of EPRI's longtime industry standard Technical Assessment Guide (TAG®), which is available only to funders of the TAG Program. The 2008 edition of the TAG will be available in January 2009. This Executive Summary is being made available to meet the demand for credible information created by an unprecedented level of activity world-wide in planning for power generation. Its publication responds to requests from several interested parties to disseminate the TAG® information more widely on a limited level.

For each of the eight technologies – pulverized coal, integrated coal gasification combined cycle, fluidized bed combustion, combustion turbine combined cycle, nuclear, wind turbine, solar thermal, and biomass – the report presents a one-to three-page overview that includes:

- Brief technology description
- Survey of the technology development status (key developers and pilot/demo activities)
- Current and projected technology performance and costs
- Major technical issues and future development direction/trends
- Development and commercialization timeline
- Relevant business issues

This 2008 *Executive Summary* provides users a single reference source for generic cost estimates for eight electricity generation technologies that takes into account the impact of the challenges they face: escalating material and labor costs, competition for engineering and construction services, uncertainty in fuel prices (especially natural gas), uncertainty with respect to fossil power plants CO_2 emissions capture and sequestration, and uncertainty on long lead times and costs for new nuclear capacity. For more information, contact Ram Ramachandran (gramacha@epri.com, 650-855-2722).

OUTREACH ACTIVITIES

International Electricity Partnership – On Nov. 13, EPRI's Barbara Tyran and John Novak participated in a meeting with representatives from international associations and companies to begin organizing the International Electricity Partnership (IEP). Electric industry leaders, representing companies that provide the majority of the world's electricity, met in Atlanta, Georgia in October and agreed to form a partnership to deliver advanced electric technologies needed for a global low-carbon future. The purpose of the partnership is to expand an exchange on climate change, hold discussions among staffs currently involved in the international climate negotiations, and develop ways to better articulate the importance of technology development and timing.

National Coal Council (NCC) – The NCC is a public advisory group that provides advice and guidance as requested by the Secretary of Energy on policy matters related to coal. At the fall NCC meeting on Nov. 14, EPRI's Stu Dalton gave a presentation on the status of advanced coal with CO_2 capture technologies.

Federal Energy Regulatory Commission (FERC) Natural Gas Workshop – On Nov. 21, EPRI's Revis James testified at a FERC workshop on natural gas, providing information on the potential impact of global climate change and other factors on natural gas demand in the electric power sector.

For more information, contact John Novak (jnovak@epri.com, 202-293-6180).

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EPRI | 3420 HILLVIEW AVENUE | PALO ALTO, CA 94304 | WWW.EPRI.COM