CoalFleet for Tomorrow - Future Coal Generation Options - Program 66

Program Overview

Program Description

Around the world, electricity is produced largely from fossil fuels, and coal often is the predominant fuel choice. In North America, Australia, and parts of Europe, Asia, and Africa, coal-fired power plants supply more than half of the electricity consumed. However, as public concern over the environmental impacts of coal-based generation increases, new technologies and practices to improve plant efficiency and reduce emissions of air pollutants and greenhouse gases are of interest. If cost-effective, reliable, and highly efficient new coal plant designs with near-zero emissions and CO_2 capture were available to the industry, coal could be kept in the generation mix to constrain expected increases in electricity and natural gas prices.

The Electric Power Research Institute's (EPRI's) CoalFleet for Tomorrow® program (Program 66) targets the technical, economic, and institutional challenges to making highly efficient, near-zero-emission coal plants with CO_2 capture a prudent and practical investment option.

Research Value

The program focuses on deploying a portfolio of advanced coal technologies, including integrated gasification combined-cycle (IGCC), ultra-supercritical pulverized coal (USC PC), and oxygen (rather than air) combustion for PC and circulating-fluidized-bed combustion (CFBC) units. The program's R&D:

- Ensures that cost-effective, reliable, and highly efficient new coal plant designs with near-zero emissions and CO_2 capture are available to industry
- Provides timely and accurate engineering and economic information about advanced coal technologies to support generators' decision-making processes
- Serves as a source of accurate, unbiased information on the cost and status of advanced coal power generation technology for policymakers and regulators
- Facilitates implementation of the EPRI-Coal Utilization Research Council (CURC) roadmap for the development of the next generation of coal power, including USC PC that will achieve 47% HHV thermal efficiency (without CO_2 capture), and IGCCs based on H-class combustion turbines and advanced membranes for O_2 production and CO_2 capture
- Identifies optimal design strategies for integrating CO_2 capture and compression systems with coal power plants—either for greenfield projects or retrofits
- Shortens the development time for promising CO_2 capture technologies (post-, pre-, and oxy-combustion) through the cosponsoring support of the U.S. Department of Energy (DOE's) National Carbon Capture Center—a "plug and play" pilot- and sub-pilot-plant-scale testing facility

Approach

Working with advanced coal power project owners and developers, power industry equipment and service suppliers, and independent world-class experts, this program develops evaluation tools and technologies to help guide the design of innovative coal plant systems that manage cost and risk. EPRI works with DOE, the Coal Utilization Research Council (CURC), and numerous international organizations to include technology and information from public and private sources in coordinating advanced coal research, development, and demonstration.

- Engineering and economic evaluations and market assessments of advanced coal generation options help power generators screen technology options and conduct feasibility studies that assess the economics, operating performance, and technological risks of both gasification- and combustion-based advanced coal generation technologies.

- The CoalFleet roadmap for IGCCs sets out a plan for driving down capital cost by 30% by 2025 and, at the same time, improving thermal efficiency with CO_2 capture from today's level of about 30% to almost 40% by 2025.
- CoalFleet's UltraGen strategy lays out a plan for improving the thermal efficiency of PCs by increasing steam temperatures in prudent steps to 1400°F (760°C) while implementing improved CO_2 capture and compression. The endpoint is a design that will achieve almost 40% thermal efficiency by 2025, while having lower CO_2 emissions than a natural-gas-fired combined-cycle unit.

Accomplishments

Research program deliverables are targeted to support organizations considering the deployment of advanced coal power generation technology, either now or in the future. For example:

- Engineering and economic information is used by industry to support its coal technology evaluations and generation asset planning.
- Congressional testimony and other outreach activities have provided guidance on technical objectives and levels of research, development, and demonstration funding needed for coal-power CO_2 capture and storage technology to reach commercial readiness.
- Vital laboratory and in-service test data support qualification of high-temperature boiler and steam turbine materials for USC steam conditions of up to 760ºC (1400ºF).
- CoalFleet has invested more than $3.5 million in the development of its IGCC User Design Basis Specification, the most comprehensive compilation on IGCC state-of-the-art and lessons learned available anywhere. The 1,100-page document covers all aspects of IGCC design including feedstock choice, environmental and safety issues, and designing for reliable operation and maintenance.
- CoalFleet has invested more than $2.5 million in the development of its Guideline for Advanced Pulverized Coal Power Plants. Drawing on EPRI’s wide knowledge base about coal plants, the guideline compiles all the information that a new plant buyer must know before deciding what to build.
- A series of multimillion-dollar engineering studies have provided up-to-date cost and performance information on state-of-the-art IGCC and USC PC designs. Among other conclusions, the studies have shown that increasing PC thermal efficiency by using advanced steam conditions will provide cost-effective (<$25/tonne) reductions in CO_2 emissions and that judicious use of pre-investment will significantly moderate the cost and efficiency impact of retrofitting CO_2 capture in an IGCC.
- CoalFleet staff have helped several members define the scope of CO_2 capture and storage projects and assisted them in the preparation of proposals for government-sponsored demonstration projects.

Current Year Activities

The program R&D for 2011 will focus on informing stakeholders on the status of advanced coal power generation technologies and improving the economics of coal power plants with CO_2 capture and storage. Specific efforts will include:

- Updated engineering-economic evaluations and assessments of market trends and commercial technology offerings
- Optimized designs for integrating CO_2 capture and compression processes in both new power plants and retrofits
- Reference libraries (knowledge bases and design guidelines), including permitting information, available on www.epri.com for technology assessment and for IGCC and combustion-based plant design support
- Pilot-scale research and test results for pre-combustion and oxy-combustion capture of CO_2 and auxiliary components
- Vital laboratory and in-service test data to support qualification of USC boiler and steam turbine materials
- Implementation of projects identified in the CoalFleet IGCC and PC R&D Roadmaps

Estimated 2011 Program Funding

$6.0M

Program Manager

Jeffrey Phillips, 704-595-2738, jphillip@epri.com

Summary of Projects

PS66A Engineering and Economic Evaluations and Market Assessments of Advanced Coal Generation Options (062001)

Project Set Description

This project set helps power generators screen technology options and conduct feasibility studies that assess the economics, operating performance, life-cycle greenhouse gas emissions, and technological risks of both gasification- and combustion-based advanced coal generation technologies, and compares them to natural-gas-fired alternatives. Participants receive information about current government incentives for deploying advanced coal power generation technologies and potential regulatory constraints on CO_2 emissions and their impact on coal power economics. In addition, the project set examines concepts for improving the operational flexibility of advanced coal power plants equipped with CO_2 capture systems and evaluates the economic value of designing in that flexibility.

Project Number	Project Title	Description
P66.001	Advanced Coal Technologies Knowledge Base; Assessment of Economics, Experience, and Markets	This project helps power generators understand the technical and financial risks of advanced coal investments.
P66.002	Analysis of Advanced Coal Plant Deployment Options and Government Initiatives	This project provides concise summaries of legislative initiatives and background documents to inform the public, stakeholders, and decision makers about issues surrounding coal-fired power generation.
P66.003	Analysis of CO_2 Regulations on Fuel Markets and Operational Flexibility Requirements	This project examines issues related to fuel and power markets that affect decisions on what type of power plant should be built.

P66.001 Advanced Coal Technologies Knowledge Base; Assessment of Economics, Experience, and Markets (062002)

Key Research Question

Electricity suppliers face tremendous challenges to producing affordable electricity, including fluctuating natural gas prices, energy supply concerns, and the need to address climate change. Heightened demand for new coal power generation worldwide (along with high demand for mining equipment, ore-processing facilities, oil refineries and chemical/fertilizer plants, and other capital-intensive industrial facilities) already has caused huge increases in the price of advanced coal technologies. More recently, the economic downturn appears to have reversed some of the escalating trends; however, in some cases, financing may have become more problematic and costly. Generation planners need up-to-date information to make decisions.

Approach

This project helps power generators understand the technical and financial risks of advanced coal investments. Two annual reports address in-service advanced coal plants and new commercial designs, while an online library of information and links at www.epri.com provide situational (i.e., fuel, location, and timeframe-specific) comparisons of technologies in terms of cost, performance, emissions, and CO_2 capture convertibility. CoalFleet arranges site tours featuring advanced coal generation technology developments as a part of three technical workshops during the year and co-sponsors the DOE National Carbon Capture Center in Wilsonville, Alabama.

Impact

- Timely and accurate engineering and economic information on advanced coal technologies
- Impartial assessments of the capabilities of advanced coal technologies
- Up-to-date information on the development status of advanced coal technologies
- Site tours featuring advanced coal generation technology developments

How to Apply Results

The online knowledge base and the annual assessment reports serve as reference documents to support planning for new generation capacity, and as guides for selecting technologies to include in preliminary feasibility studies for new coal generation capacity. Attendance at two CoalFleet workshops provides members with an opportunity to visit sites of important advanced coal technology developments and receive previews and summaries of project deliverables. Members can use these workshop materials to fully understand the program results and integrate them in their own planning documents.

In addition, members have year-round access to CoalFleet's technical experts to answer questions about the status, cost, and performance of advanced coal power generation technologies. Through CoalFleet's sponsorship of the DOE National Carbon Capture Center (NCCC) in Wilsonville, Alabama, CO_2 capture test results will be made available and interpreted by EPRI's advanced coal technology experts (note that this information will be provided to funders of any of the three CoalFleet project sets).

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Engineering/Economic Evaluations of Advanced Coal Technologies with CCS: This annual update will estimate the capital cost, performance, and levelized cost of electricity for PC, IGCC, CFBC, and NGCC technologies, with and without CO_2 capture. Also included are assessments of how variables such as coal type, fuel prices, environmental criteria, tax incentives, and penalties affect technology and fuel selection. In addition, a special focus chapter will be written on a topic based on member feedback. In previous years these topics have included the impact of retrofitting CO_2 capture on a plant that was not previously designed for capture, best practices for controlling construction costs, and power plant capital cost inflation indices.	06/30/11	Technical Update
Operating Experience, Risk, and Market Assessment of Advanced Coal Technologies: This annual update will include analyses of the latest information from operating USC PC, advanced CFBC, and IGCC plants, and pilot oxy-combustion plants; evaluations of the latest designs, and assessments of risks and market opportunities for each technology, including their environmental performance and CO_2 capture conversion characteristics. Notable new coal power projects will be profiled.	12/31/11	Technical Update

Product Title & Description	Planned Completion Date	Product Type
Engineering/Economic Evaluations of Post-Combustion CO_2 Capture Retrofits: This report will provide members with a summary of the final results of a post-combustion CO_2 capture retrofit study that CoalFleet is conducting on five North American coal power plants. The study will examine the technical feasibility, capital cost, and operating impact of adding an advanced amine-based post-combustion capture system onto each of the five plants. Included will be a protocol for estimating the suitability of sites for retrofitting.	12/31/11	Technical Update
National Carbon Capture Center Test Report: This annual report will include evaluation of results from testing of CO_2 capture technologies for use with coal-derived syngas and oxy-combustion-derived flue gas as well as the first results from the post-combustion capture slipstream test facility. This report will also be available to funders of Project Sets 66B and 66C.	12/31/11	Technical Update
CO_2 Footprint Life-Cycle Analyses	12/31/11	Technical Update

P66.002 Analysis of Advanced Coal Plant Deployment Options and Government Initiatives (062003)

Key Research Question

Great uncertainty surrounds potential regulation of CO_2 emissions and how it might affect the electricity generation sector, particularly coal power generation. At the same time, government incentives encourage the use of advanced coal power generation and carbon sequestration technology, with the possibility of more to come. There is a clear need for better understanding of advanced coal technologies by policy decision-makers, and of carbon capture and storage (CCS) policies and incentives by power generators.

Approach

This project tracks the implementation of U.S. energy policies and related state policies, regulations, and incentives for advanced coal technology deployment. It also monitors climate change legislation at various government levels, and works with industry stakeholders via the Coal Utilization Research Council (CURC) technical committees to identify research, development, and demonstration priorities for advanced coal generation technologies, including CO_2 capture and storage. Information is conveyed via webcasts, topical reports and papers, and workshop presentations. In addition, through the CoalFleet Communications Outreach working group, background education materials on advanced coal power generation technologies, including CCS, are created and disseminated to electricity industry stakeholders, policymakers, and the general public.

Impact

- Concise summaries of pertinent legislative initiatives and policy implementation actions via technical updates, webcasts, and workshop presentations
- Surveillance by experienced energy policy observers
- Analysis of potential CO_2 policies on coal plant economics and operating strategies
- Expert on-call advice to guide power generation project planners through bureaucratic red tape
- EPRI advanced coal experts participate in developing industry consensus on RD&D priorities
- Fact-based background materials, which can be freely distributed and incorporated into company-specific communications materials, on advanced coal power generation technology

How to Apply Results

Presentations at three CoalFleet workshops in 2010 will provide up-to-the-minute information on advanced coal generation incentives and potential climate change legislation in the United States. Planners can use the concise summaries and intelligence from experienced energy policymakers to augment their own activities. This information will be supplemented in periodic technical updates on selected topics. In addition, members can contact EPRI experts with questions about government incentive programs and climate change legislation.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Compliance Strategies in Response to Potential/New U.S. CCS Legislation: The intent of this report is to examine the impact of potential or new US CO_2 emissions-related legislation on compliance strategies of power generation companies with coal-based generation assets.	12/31/11	Technical Update
CoalFleet Outreach Communications Initiative: The CoalFleet Outreach Communications Initiative was created in 2007 in response to members' requests for help in using EPRI materials for communications to policy makers and the public at large about the status and capabilities of advanced coal power generation technology. Its goal is to present balanced, fact-based information in a format that nontechnical audiences can understand. The materials are developed by EPRI staff and contractors based on feedback from a working group consisting of communications and technical experts from CoalFleet members. The materials could be factsheets, reports, presentations, and others depending on the target audiences. An example is the CoalFleet Vision report (1016877) prepared in 2008. Updates on the activities of the Outreach Communications working group will be given at CoalFleet technical meetings throughout the year.	12/31/11	Technical Resource

P66.003 Analysis of CO_2 Regulations on Fuel Markets and Operational Flexibility Requirements (065778)

Key Research Question

New advanced coal power plants represent investments of a billion dollars or more, with an expected service life of 50 years or longer. The rapidly changing prices of fossil fuels and the potential impact of CO_2 regulations, energy security initiatives, and other policies on fuel and power markets make the decision more difficult.

Approach

Building on other EPRI evaluations of fuel markets and capacity, the project examines global supply and demand-side drivers, including the potential impact of CO_2 emission restrictions on fuel choices. The research also investigates the value of a coal-fueled power plant that has the flexibility to cycle load in future market conditions including scenarios with CO_2 emissions costs.

Impact

- Support for minimizing risks through knowledge of fuel and power markets
- Understanding of the technical and regulatory drivers of fuel prices
- Insight into the potential impact of CO_2 emission restrictions on fuel demand and prices
- Identification of the economic value of including load-following and auxiliary load-shifting capabilities in coal power plant designs

How to Apply Results

Results will allow generation planners to make realistic assumptions in their “what if” scenarios of the market competitiveness of new coal power plants. Information on the value of including load-following and load-shifting capabilities will guide power plant designers on how much can be spent on additional plant equipment to facilitate those capabilities.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Analysis of Generation Capacity Turnover due to Policy Changes: Due to rapidly fluctuating fuel prices and uncertainty of potential CO_2 emissions regulations, the title and focus of this report are tentative. Changes will be made based on feedback from members at the beginning of the program year. Currently thinking is that the report will update of information developed in EPRI’s 2010 program year, based on modeling of the impact of proposed CO_2 emission and renewable energy requirements on the portfolio of generation assets for selected regions in the United States and globally.	12/31/11	Technical Update

PS66B Gasification-Based Power Plant Development and Deployment Support (IGCC) (062004)

Project Set Description

The low emissions and high potential efficiency of integrated gasification combined-cycle (IGCC) technology—together with the already proven ability to capture CO_2 from pressurized synthesis gas at scale of a million tons per year or more—make IGCC a technology that cannot be ignored in an era when CO_2 emissions are scrutinized. Gasification-based processes also offer options for co-production of power and clean transportation fuels or hydrogen, or even dedicated facilities for producing fuels or substitute natural gas.

In general, IGCC designs and market infrastructure are less well-established than for combustion-based advanced coal technologies, leading to an emphasis in this project set on frequent technical status reports, design specification guidelines, online information libraries, industry expert advisory groups, training tools, and support of the DOE's National Carbon Capture Center for hosting sub-pilot and pilot scale tests of pre-combustion CO_2 capture technologies.

Project Number	Project Title	Description
P66.004	Coal Gasification Technology Status - Annual Update	The annual update provides a concise summary of coal gasification technology written by EPRI's experts.
P66.005	Options for Improving Cycling Economics of Gasification-Based Power Plants	This project investigates options for improving load-following capabilities of an IGCC by shifting syngas production to nonpower products during periods of low power demand and by shifting large auxiliary loads such as oxygen-production and CO_2 compression from peak power to low power demand periods.
P66.006	Plant Design Guidelines for IGCC	Reduces the risk of deploying a new IGCC by supporting the use of standardized and optimized IGCC designs, which maximize plant reliability and shorten project development cycles.
P66.007	Permitting Support for IGCC Power Plants	A database of environmental permits for existing and proposed IGCCs is maintained and updated, and can be accessed via the CoalFleet Knowledge Base B at www.epri.com.

Project Number	Project Title	Description
P66.008	Advanced IGCC Improvements and Next-Generation Designs with CO_2 Capture	This project identifies optimum IGCC design configurations for near-term plants and fosters longer-term development of IGCC with improved CO_2 capture technology.

P66.004 Coal Gasification Technology Status - Annual Update (062005)

Key Research Question

IGCC technology is evolving rapidly in response to cost concerns, the desire to accommodate low-rank coal, and to provide a better transition from conventional operation to CO_2 separation. Several new gasifier technologies are being scaled up, and a number of new technologies for improving low-rank coal performance and syngas clean-up economics are under development. Generation planners need information about which technologies are ready for deployment and economically viable.

Approach

This project provides technical insight into the status, challenges, and opportunities associated with various gasification technologies and feedstock options, including coal, petroleum residuals, and biomass and wastes via an annual report covering technical developments and operating experience. The project also includes plant visits arranged through the Gasification User Association (GUA), a related supplemental project.

Impact

- Impartial technology assessments written by world-class gasification experts
- Up-to-date information on the status of coal gasification technology development
- Increased confidence in decisions about future plant design, project schedules, and implementation timing

How to Apply Results

Project planners and developers can use the information contained in the annual report, as well as insights gained during plant visits and CoalFleet technical meetings and webcasts, to understand opportunities and risks involved in deploying coal gasification technologies. Previous annual reports developed by this project are used as reference documents by EPRI members and are considered to be among the best available source of information on the existing fleet of coal-based IGCC units and other pertinent coal gasification facilities.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Coal Gasification Technology Status Annual Update: This project provides technical insight into the status, challenges, and opportunities associated with various gasification technologies via an annual report covering technical developments and operating experience. The annual report also includes a useful primer on gasification technology basics as well as an overview of IGCC capital and operating costs with and without CO_2 capture.	12/31/11	Technical Update

P66.005 Options for Improving Cycling Economics of Gasification-Based Power Plants (062006)

Key Research Question

As more renewable generation capacity is added, the need to operate coal power plants in a load-following mode will increase. This project examines ways enhance the cycling capabilities of an IGCC and to find economic uses of the syngas production capacity for nonpower products during periods of low power demand.

Approach

Options for poly-generation will be examined to determine whether they are amenable to cyclic operation and whether they would be economically attractive. In addition, the project will investigate design changes that would allow an IGCC to both quickly supply additional power during peak demand periods (e.g., supplemental firing of the HRSG) and enable deeper load reductions without negatively affecting heat rate.

Impact

- Because at least 60% of the investment in an IGCC is in equipment outside of the power generation block, it would be advantageous to IGCC economics to not have the syngas production equipment stand idle during periods of low power demand.
- By maintaining syngas production at full capacity, it may be easier to rapidly increase power output when called upon, and the thermal cycling of the syngas production equipment will be minimized

How to Apply Results

The results from this project, together with the economic modeling results from project P66.003, will help a plant designer make decisions that will maximize operating flexibility of an gasification-based power plant while also optimizing the investment of capital.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Options for Improving IGCC Cycling Capabilities: This report will document the findings in the first year of EPRI's investigation of options for improving load-following capabilities of an IGCC by shifting syngas production to nonpower products during periods of low power demand and by shifting large auxiliary loads such as oxygen-production and CO_2 compression from peak power to low power demand periods.	10/31/11	Technical Update

P66.006 Plant Design Guidelines for IGCC (062007)

Key Research Question

High capital costs, uncertain reliability, long project schedules, lack of standardization, and unique environmental permitting procedures are obstacles to deploying IGCC technology, which can offer superior environmental performance and could be the lowest-cost generating option for coal plants with CO_2 capture. Improved design guidance will enable program participants to move from using first-of-a-kind designs to designs based on lessons learned from early adopters of the technology.

Approach

This project supports the deployment of more reliable and economical IGCCs through the use of reference plant designs. It updates and expands an already world-class design guide for IGCC power plants with and without CO_2 capture. Through www.epri.com, the project also provides a continuously updated online reference library (Knowledge Base B) of design studies, operational and experience-based lessons-learned reports, and current project information. Lessons learned by both existing IGCC plants and CoalFleet members developing new

IGCC projects are incorporated into design guidelines, so that all members can benefit from the knowledge gained by early movers.

Impact

The objective of this project is to reduce the risk of deploying coal-fed IGCC plants by promoting the use of standard designs that meet the requirements of power generation companies. The project provides:

- Online IGCC reference information (Knowledge Base B)
- IGCC User Design Basis Specification (UDBS), which provides power plant developers with the most detailed design guidance for IGCC plants available
- Pre-Design and Generic Design Specification reports, which condense public filing documents and nonproprietary descriptions of new IGCC project designs into user-friendly reports
- Participation in the IGCC Design Guidelines Working Group, which can aid in developing in-house IGCC expertise

How to Apply Results

Participants may be able to save millions of dollars in engineering costs and shave several months off a project schedule by adopting existing designs and technologies for their projects, allowing for minor adjustments to meet site-specific requirements. Knowledge Base B provides around-the-clock access to technical reference information on gasification and IGCC power plants. The User Design Basis Specification can be used both as a primer on IGCC technology and design tradeoffs, as well as a template for creating an IGCC specification document to which suppliers can submit bids. The Pre-Design and Generic Design Specifications provide concise descriptions of IGCC early-deployment project designs and give members important technical information on the design and performance of a specific supplier's technology.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
IGCC User Design Basis Specification, Version 11: This project provides an update of EPRI's 2010 program year version of the UDBS, based on new technology developments and insights from new IGCC deployment projects. The UDBS will contain information on plant size, reliability-availability-maintainability goals, equipment train and sparing recommendations, backup fuel considerations, performance criteria, cost and time-to-build targets, operability requirements (e.g., turndown, ramp rate), emissions limits (steady state and startup/off-spec), plant safety and options for CO_2 capture. Areas of new focus in Version 11 will depend on feedback from members.	12/31/11	Technical Update

P66.007 Permitting Support for IGCC Power Plants (062008)

Key Research Question

The deployment of IGCC plants is complicated by uncertainty about regulations on greenhouse gas emissions. Obtaining environmental permits for a new IGCC coal plant is a critical-path item before construction can begin, and permitting a coal-based IGCC plant is highly complex, involving numerous tradeoffs. Given the limited regulatory experience base, permitting could cause significant delays in constructing a new plant.

Approach

This project provides a regularly updated online database of permit information covering the unique aspects of permitting IGCC units. A custom interface is programmed to facilitate common queries. For members of Project Set 66B, this project also provides consultation with EPRI staff on IGCC feasibility studies and project development efforts that will assist members working with regulators to enhance plant permitting.

Impact

- Significant reduction in the time required to permit an IGCC plant through ready access to a comprehensive set of IGCC permit data and consultation with EPRI staff.
- Information exchange among CoalFleet members, DOE, EPA, and other regulatory bodies, which could identify opportunities to streamline the IGCC permitting process.

How to Apply Results

The database of existing IGCC permit information will serve as a reference for any company trying to permit a new coal-based power plant. Consultation with EPRI staff can help members developing an IGCC project pinpoint potential areas of concern in preparing permit applications, with particular focus on aspects of an IGCC that differ from pulverized coal plants. In addition, members will have access to CoalFleet's IGCC permitting experts and can place their own staff in the CoalFleet IGCC Permitting Working Group, which will foster the development of in-house IGCC permitting expertise.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
CoalFleet IGCC Permitting Database: EPRI will monitor IGCC project developments worldwide, and update its IGCC permit database (on an ongoing basis) as new information becomes available from U.S. and international coal-based IGCC projects. The database is accessible via Advanced Coal Technologies Knowledge Base "B" on www.epri.com.	12/31/11	Technical Resource

P66.008 Advanced IGCC Improvements and Next-Generation Designs with CO_2 Capture (062009)

Key Research Question

Growing concern about the impact of CO_2 emissions on climate change is increasing the need to develop lower-cost methods for capturing CO_2 from coal-based power plants.

Approach

This project evaluates options for improving IGCC performance generally for all coal types, and for integration with water-gas shift reactors for CO_2 capture and hydrogen production. The project will examine various levels of CO_2 capture, from 20% up to practical maximums, to understand the incremental cost of capturing increasing amounts of CO_2. In addition, the project will evaluate optimum design options for plants with CO_2 capture as well as wise pre-investment strategies for IGCCs not initially designed to capture CO_2.

A primary focus of this project is a series of engineering-economic studies that examine near-term options for commercial-scale IGCCs. As a starting point, plant configurations defined in the UDBS (P66.006) have been evaluated. These case studies are now being expanded to look at the impacts of additional coal types and advanced turbine, gasification, and gas clean-up technologies.

A second focus of this project is to improve the economics of IGCCs with CO_2 capture by eliminating or mitigating sources of unavailability in plant operations. The CoalFleet IGCC RD&D Augmentation Plan (1013219) issued in 2007 provides a roadmap for improving IGCC reliability and availability. This project will foster efforts to bring improvements identified in the augmentation plan to reality.

Impact

- Independent engineering-economic evaluations of IGCC design options
- Identification of the potential advantages and risks of new technologies proposed for IGCCs with CO_2 capture
- Lower-cost methods of capturing CO_2 from coal-based power plants
- Higher IGCC operating availability, which will improve IGCC economics

How to Apply Results

Results from the engineering-economic case studies will give members realistic, up-to-date information on the cost and performance of near-term commercial IGCC technology. They also will provide guidance on the most economical design configurations for various operating scenarios. This project will monitor progress in implementing the CoalFleet RD&D Augmentation Plan and provide independent assessments of proposed advances, such as improved instrumentation, controls, and processes that could improve IGCC performance on low-rank coals. EPRI members can use this information to guide R&D investment decisions and anticipate when these enhancements will be commercially available. In addition to the deliverables listed here, Project Set 66B funders will also receive the Power Systems Development Facility (PSDF) annual report described in Project 66.001.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Engineering-Economic Evaluations of IGCC Plant Designs with CO_2 Capture: Phase 3: This report will summarize results from EPRI's third phase of IGCC "case studies," which will examine the cost and performance of different IGCC designs based on specific feedstocks at specific locations. Cases including various design optimization evaluations will also be included. The particular cases to be examined will be determined based on feedback from members.	09/30/11	Technical Update
CoalFleet IGCC RD&D Roadmap - 2011 Update: This report will update the CoalFleet IGCC RD&D Roadmap issued in 2007. Results from the ongoing IGCC case studies will serve as a baseline to assist in evaluating the potential cost savings and efficiency improvements of various advancements in IGCC technology. A particular focus will be given to technologies that can reduce the cost of capturing and compressing CO_2.	12/31/11	Technical Update

PS66C Combustion-Based Power Plant Development and Deployment Support (062010)

Project Set Description

Coal combustion-based power technologies face continuing environmental challenges to reduce pollutant emissions, including CO_2. However, because coal is an abundant fuel with a reliable supply network, it is important to keep it as an option for power generation in many parts of the world. This project set concentrates on the full range of solutions, including fundamental work such as qualification of stronger, more corrosion-resistant materials to allow boilers and steam turbines to operate at higher temperatures and raise generating efficiency. System-level activities include design guidelines and online information libraries to reduce the risk of building state-of-the-art plants, and combustion in an oxygen/CO_2 mixture instead of air (oxy-combustion). A central element of the project set includes identifying optimal designs for integrating CO_2 capture and compression systems with the power plant either for greenfield or retrofit applications.

Project Number	Project Title	Description
P66.009	Design and Materials Development for Post-Ferritic (1200ºF–1400ºF) Ultra-Supercritical PC Plants	This project is validating the advanced materials needed for boilers and steam turbines to operate with main steam conditions of up to 1400°F (760°C) and 5000 psi (345 bar).
P66.010	Evaluation of Oxy-Combustion for Advanced PC and CFBC Plants	This project will assess the development status and economics of oxy-combustion as applied to steam-electric power plants and the role that oxy-combustion is expected to play in reducing CO_2 capture costs.
P66.011	Analysis of Load-Following Strategies for PCs with CO_2 Capture Systems	This project will examine options for improving the load-following capabilities of coal-fired power plants equipped with CO_2 capture systems—either PCC or oxy-combustion.
P66.012	Plant Design Guidelines and Near-Zero Emission Designs for USC PC Plants	This project provides information on the design and performance of advanced PC steam generators, steam turbines, environmental controls, and CO_2 capture technologies integrated with the power plant.
P66.013	Integration of Post-Combustion CO_2 Capture Technologies with Advanced PC and CFBC Plants	Engineering-economic studies to identify cost saving improvements in commercial-scale applications of PCC technologies.

P66.009 Design and Materials Development for Post-Ferritic (1200ºF–1400ºF) Ultra-Supercritical PC Plants (062011)

Key Research Question

Part of the overall strategy for reducing the cost of CO_2 capture and storage (CCS) is to increase generating efficiency and lower the CO_2 per MWh released from the PC boiler. This approach benefits both post-combustion capture (PCC) and oxy-combustion and is also applicable to circulating fluidized-bed combustion (CFBC) technology. The maximum steam temperature achievable with ferritic steels is below 1160°F (630°C), limiting efficiency to below 40 percent (higher heating value, HHV) for a power plant burning bituminous coal and operating at conditions typical for the United States. It is projected that high-nickel alloys, materials with greater strength and corrosion resistance than ferritic steels, will allow steam temperatures up to 1400°F (760°C) and raise generating efficiency to above 45 percent (HHV). However, these alloys are more expensive and more difficult to weld than ferritic steels, and to date have not been used in coal-fired power plant applications. For use in these more efficient USC PC power plant designs, the materials need to be fully characterized and tested under commercially representative operating conditions.

Approach

This DOE-sponsored project (a collaborative of public agencies, research laboratories, and industry) is evaluating high-nickel alloys for use in steam turbines and air- and oxygen-fired boilers. Candidate materials are tested in the laboratory and on operating power plants simulating USC operating conditions of up to 1400°F (760°C) and 5000 psi (345 bar). The information developed includes creep strength, resistance to fireside and steamside corrosion (with and without coatings), welding procedures, and fabrication techniques. The initial five-year program for steam turbine materials is completed, and additional work is planned. A 10-year program to characterize boiler materials is approaching completion, and plans are being made to develop a component test facility to be installed in an operating boiler. This will be a circuit containing evaporative and superheat sections raising steam at 1400°F (760°C) and 5000 psi (345 bar), and includes turbine and pressure relief valves. The facility will demonstrate the suitability of the materials and fabrication procedures used for commercial application.

Annual progress reports—one on boiler materials and components, and one on steam turbine materials and components—summarize work plan accomplishments and results for tests of fabricated components placed in USC-simulated demonstration cells at existing pulverized coal units. These yearly progress reports, which include EPRI's perspective on the outcomes, will become available to members once DOE has reviewed the results.

Impact

- Results of this project could accelerate acceptance of new USC materials by codes and standards organizations, prospective buyers, financiers, and insurers, supporting their introduction into the commercial marketplace.
- By enabling efficiencies greater than 45% (HHV), these advanced materials could allow reductions in fuel consumption and overall emissions—including CO_2—by 15% to 22%, relative to the current U.S. fleet average for PC power plants. An efficiency of 45% in the United States corresponds to an efficiency of 50% (lower heating value) for European and Japanese plants, which also use slightly different efficiency calculation procedures.
- Demonstration of advanced materials in a power plant environment significantly reduces the risk of unavailability for initial applications of advanced USC PC plants.

How to Apply Results

Members will gain early access to information resulting from this project's research and will get priority in hosting demonstrations of new designs and materials. Once demonstrated, advanced materials will significantly reduce the capital cost and unavailability risk for new, highly efficient USC PC plants.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Technical Progress Report on Turbine Materials Development for USC Plants: The project provides an annual steam turbine material testing progress report, pending DOE's continued funding of the collaborative.	12/31/11	Technical Update
Technical Progress Report on Boiler Materials Development for USC Plants: The project provides an annual boiler material testing progress report, pending DOE's continued funding of the collaborative.	12/31/11	Technical Update

P66.010 Evaluation of Oxy-Combustion for Advanced PC and CFBC Plants (065779)

Key Research Question

Boilers designed to burn coal in a blend of oxygen and CO_2, instead of air, offer a third technology platform for separating and concentrating CO_2 and provide an alternative to post-combustion solvent or pre-combustion capture processes. Known as "oxy-combustion," this approach offers potentially lower costs and lower energy penalties for CO_2 capture at PC and CFBC plants, particularly if emerging low-cost oxygen production technologies reach commercial fruition.

Power plants that employ oxy-coal technology for CCS are likely to incorporate CO_2 purification technology, which will, as a fortuitous side-benefit, dramatically reduce the release of conventional pollutants to the ambient. There is the very real prospect that with development of technology supplements to the CO_2 purification unit, emissions of each criteria pollutant (CO, VOC, PM, SO_2, NOx, and HAPs), could be kept below 100 ton/year. These emissions levels would qualify the plant as a "minor source," greatly simplifying air emissions permitting. This would be a breakthrough for coal-fired power generation.

Approach

This project will advance the understanding of oxy-combustion technologies for PC and CFBC plants by evaluating design studies and pilot plant results, as well as their implications for scale-up to larger demonstrations and commercial units. In particular, EPRI will examine oxy-combustion burner performance, boiler heat transfer characteristics, materials compatibility with the different chemical environment within the boiler, the technologies that treat flue gas and purify the product CO_2 for geological storage, and the overall power plant process design/control. In addition, the project will assess the economics of oxy-combustion and the role that it is expected to play in reducing CO_2 capture costs.

Impact

- Accurate information on the status of oxy-combustion technologies, pilot plant results, technical challenges faced, and prospects for their resolution
- Information about the relative costs and likely commercialization timeframe for oxy-combustion as a CO_2 capture measure for coal-combustion-based power plants

How to Apply Results

Members will have early access to objective information about oxy-combustion technology, pilot test results, and early unit design decisions, allowing them to better evaluate the oxy-fuel combustion option for their specific requirements. In addition to the products listed here, Project Set 66C funders will also receive the National Carbon Capture Center (NCCC) annual report described in Project 66.001. An examination of the economic and technical feasibility of pressurized oxy-combustion systems is part of the NCCC research plan.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Engineering-Economic Analysis of a Commercial-Scale Oxy-Combustion Coal Power Plant: This report will document the results of an engineering-economic analysis of a commercial-scale supercritical pulverized coal power plant designed to operate in oxy-combustion mode.	06/30/11	Technical Report

P66.011 Analysis of Load-Following Strategies for PCs with CO_2 Capture Systems (062013)

Key Research Question

Increased renewable energy generation capacity on power systems will require coal-fired power plants to operate more frequently in a load-following mode. However, the addition of CO_2 capture systems could hinder a plant's ability to load-follow unless that capability is designed in from the beginning.

Approach

This project will examine options for improving the load-following capabilities of coal-fired power plants equipped with CO_2 capture systems—either post-combustion capture (PCC) or oxy-combustion. Both explicit turndown strategies, as well as auxiliary load-shifting options such as delayed regeneration of capture solvents and off-peak storage of oxygen for later use, will be investigated. In later years, a dynamic simulator may be developed to allow more detailed analysis of load-following issues.

Impact

- Load-following strategies could make new coal plants a low-cost option for peak power.
- As more renewable generation options are added, having the ability to rapidly change power output of a coal power plant will be essential in maintaining power system reliability.

How to Apply Results

The results from this project, together with the results from the economic modeling in roject P66.003, will help coal plant designers make cost-effective decisions on investments needed to accommodate expected load-following scenarios.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Analysis of Load-Following Strategies for PCs with CO_2 Capture Systems: This report will document the results obtained during the first year of EPRI's evaluation of options for improving the load-following capabilities of coal-fired power plants equipped with CO_2 capture systems—either PCC or oxy-combustion.	12/31/11	Technical Update

P66.012 Plant Design Guidelines and Near-Zero Emission Designs for USC PC Plants (062014)

Key Research Question

Analyses carried out by EPRI (Prism and MERGE) and the International Energy Agency among others concluded that coal-fired power plants integrated with CCS will be an essential tool for reducing CO_2 emissions while keeping electricity prices affordable. It is widely accepted that this approach consists of two major technology components: developing more cost-effective, less energyintensive CO_2 capture technologies (PCC and oxy-combustion); and raising the generating efficiency of the power plant to lower the CO_2 per MWh released from the boiler, thereby lowering the amount to be captured, transported, and stored. The technologies involved in both these components are in the early stages of demonstration prior to their full deployment.

The guidelines will collect information from the demonstration projects being implemented worldwide and from the ensuing commercial applications to guide generation planning activities. The information collected will include advanced boiler and steam turbine design and operational experience, environmental control technologies, advanced material performance, CO_2 capture technologies, and CO_2 transportation and storage.

Approach

This project provides an update of EPRI's design guideline for advanced PC plants. The guideline is supported by an online reference library (Knowledge Base C) at www.epri.com, containing technical papers, design data for existing units and those under construction, operating parameters such as availability and emissions data, materials selections, and selected links screened for relevance by EPRI staff and the CoalFleet advanced combustion experts.

An important aspect of this work is identifying ways to reduce the penalties associated with incorporating CCS with the power plant. Included are design and integration approaches that improve heat economy and lower the reduction in power output associated with CCS, reduce cooling requirements and water consumption, and minimize potential reductions in availability and capacity factor. This project also includes a reference plant design study for a PC plant with final steam temperatures of 1260°F (680°C), which would entail the use of nickel-based alloys in high-temperature components (see P66.010). Finally, the project could include a generic pre-design specification for an advanced PC plant, based on the permit application package developed by a CoalFleet project. Compiling reference documents and databases and keeping them current provide vital industry data and allow information to be shared.

Impact

- Faster and better-informed internal evaluations of advanced coal technologies by CoalFleet members, including initial technology screenings in advance of feasibility studies
- Information to reduce outage rates, constraints on ramping and turndown, and O&M costs for initial applications of advanced PC and CFBC units
- Information about the likely future performance and economic impacts of incorporating PCC and oxy-combustion processes in new PC and CFBC plants and retrofitting these technologies to existing plants.
- Exchange of nonproprietary information that can speed the process of deployment, bringing advanced coal technologies with CCS to maturity more quickly and reducing costs for the entire industry

How to Apply Results

CoalFleet members can access the guideline and online reference library via www.epri.com and incorporate the data and lessons learned into siting studies, permit applications, preliminary designs, and CCS studies. Through participation in a project-related industry working group, members can discuss information needs with their peers and ask questions of EPRI experts.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Guidelines for Advanced Pulverized Coal Power Plants Integrated with CO_2 Capture and Storage, v8: This guideline is an update of EPRI's 2010 program year Version 7 of the advanced PC guideline, based on new technology developments and insights from recent and ongoing USC PC projects.	09/30/11	Technical Update

P66.013 Integration of Post-Combustion CO_2 Capture Technologies with Advanced PC and CFBC Plants (062015)

Key Research Question

Regulations limiting CO_2 emissions from coal-fired power plants are expected in the near future in the United States and many other countries. Although technologies for post-combustion capture of CO_2 from flue gases have been applied commercially in the chemical and industrial gas industries at a small scale, none has been applied at the scale needed for a large coal-fired power plant. PCC design studies using the latest amine solvents suggest the energy requirements for solvent regeneration (expected to be provided by steam extracted from the turbine circuit) will be large, reducing plant output by 20% or more. However, considerable research into solvents with lower heats of regeneration, including improved amines and alternatives to amines, is taking place around the world. Energy penalties will be further reduced by effective thermal integration, the nature of which will depend upon the properties of the solvent selected as well as the characteristics of the power plant. Comprehensive and objective analyses of this rapidly changing field are needed to guide power producers planning to integrate PCC technology with new PC or CFBC units or to retrofit capture technology to existing units.

Approach

This project evaluates various PCC technologies for application with new advanced PC and CFBC units. The project will address both designs for retrofit after initial operation without CO_2 capture as well as optimal integration of PCC processes in new units that will capture CO_2 upon initial commissioning. Two design integration approaches will be investigated. The most operationally flexible design with the highest capital cost will incorporate the ability to turn off the PCC system, allowing for increased power production during periods of peak demand. The least flexible design with the lowest capital cost also allows the capture system to be turned

off, but the power production remains the same. Initial analyses are based on advanced amines, but alternative solvents and capture technologies will be evaluated as data become available.

Impact

- Estimates of how incorporating PCC processes into PC and CFBC plants affects power plant costs, performance, and operation, helping improve plans for coal-fired capacity additions and CO_2 management
- Information on the modifications necessary to existing power plant components such as steam turbines and feedwater heaters, to achieve optimal heat integration of the power and capture plants
- Information to reduce outage rates, constraints on ramping and turndown, and operational and maintenance costs for initial applications of CO_2 capture technologies in new PC and CFBC units

How to Apply Results

CoalFleet members can incorporate insights from this project into their generation planning studies, plant feasibility and CO_2 capture readiness studies, and corporate carbon management strategies.

2011 Products

Product Title & Description	Planned Completion Date	Product Type
Engineering and Economic Analysis of 1300F Series USC Plant with Post-Combustion Capture: This report will estimate the cost and performance of a 1300ºF (700ºC) ultra-supercritical pulverized coal power plant built from the beginning with an advanced post-combustion CO_2 capture system. It will be a companion to the study report issued in 2010, which looked at an SCPC with 1100ºF (593ºC) steam conditions with two different options for post-combustion capture, and will help identify the economic savings that could be obtained from designing plants that capture CO_2 with more efficient steam cycle conditions.	03/31/11	Technical Update
Integrating CO_2 Capture Technologies into New PC and CFBC Plants - Alternate Process II: This report will assess cost and performance impacts of integrating emerging post-combustion CO_2 capture technologies. It will be completed in conjunction with Program 165 as a companion to the report developed in the 2009 program year.	12/31/11	Technical Update