

New Combustion Turbine/Combined-Cycle Plant Design and Technology Selection - Program 80

Program Overview

Program Description

At a time when the power industry needs to meet growing demand but the ability to build other generation resources is limited, informed decisions on gas turbine selections and plant designs are especially important. Technology selection impacts efficiency, emissions, availability, maintainability, and durability. Appropriate environmental control technologies are needed to meet regulatory requirements. The ability to fire fuels of variable composition and provision is critical for future refueling options. Flexible operational capabilities are needed for optimal plant dispatch, and planners need to understand coming trends and potential improvements for future growth.

The Electric Power Research Institute's (EPRI's) New Combustion Turbine/Combined-Cycle (CTCC) Plant Design and Technology Selection program (Program 80) provides the information and analysis needed to select combustion turbine technologies and specify combined-cycle plant designs for today's new generation requirements while planning for future technological advances.

Research Value

The research in this program helps give new plants flexibility to start quickly, operate efficiently at varying loads, and fire fuels of varying composition while meeting regulatory emission limits. Improved gas turbine plant profitability is achieved through an overall life-cycle approach, which includes a balanced understanding of capital and O&M costs, performance improvements, and technical risks associated with new high-efficiency turbine designs and the market contexts in which they operate.

- Optimal technology selections and designs increase plant profitability, reduce overall life-cycle costs, and improve operability.
- Managing technology risk helps control operation and maintenance expenditures.
- Objective, expert assessment of technology trends and worldwide experience results in better procurement decisions.

Approach

Up-to-date information and evaluations enable better procurement decisions and help minimize costs while optimizing plant performance, reliability, and operational flexibility for simple-cycle and combined-cycle combustion turbine plants.

- Experience-Intelligence reports and project risk reports provide concise analysis of subjects of topical interest, including current and emerging CTCC designs and cycles, reliability issues, maintenance strategies, industry trends, and related market conditions.
- CTCC technology durability, design and performance reports cover original equipment manufacturer (OEM) combustion turbine product lines, including design features, related risk concerns, and RAM-Durability experience. All 50-Hz and 60-Hz models over 20 MW are covered, including advanced and upgraded mature engines. For the steam bottoming cycle, procurement guidelines including lesson learned from recent plant experience support technical bid packages.
- Plant design, repowering and environmental siting reports cover design features, risks, and operating experience of heat recovery steam generators, steam turbines, and electrical generators, as well as integration in an operationally flexible plant design. Emissions control equipment is described, and regulatory trends are monitored. Software provides model-specific O&M cost estimates.

Accomplishments

EPRI's New Combustion Turbine/Combined Cycle Plant Design and Technology Selection program provides an objective, timely, life-cycle perspective on technology choice and improved plant design.

- Scope covers all 60-Hz and 50-Hz gas turbine models above 20 MW used in power generation.
- Knowledge base covers life-cycle O&M costs used in model selection.
- Component durability information is based on in-depth studies of fleet-leading issues.
- Design provisions are identified for plant operational flexibility and fuel variability.

Current Year Activities

The program R&D for 2010 will focus on advanced gas turbine-based plant designs offering higher efficiency, lower emissions, and improved cycling capability. Specific efforts will include:

- Following current subjects of interest in Combustion Turbine Experience and Intelligence reports
- Identifying new models, capabilities and features in Gas Turbine Product Line Design Evolution and RAM-D Issues reports
- Describing equipment and system design features for improved plant operability and fuel flexibility
- Enhancing maintenance life-cycle costing capability in Combustion Turbine Combined-Cycle O&M Cost Analyzer software
- Incorporating new equipment descriptions and emissions requirements in Environmental Control Technology and Regulatory Issues Handbook.

Estimated 2010 Program Funding

\$0.8M

Program Manager

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Summary of Projects

Project Number	Project Title	Description
P80.001	Experience-Intelligence Report and Project Risks	Project reports provide concise analysis of subjects of topical interest, including current and emerging CTCC designs and cycles, reliability/durability issues, maintenance strategies, industry trends and related market conditions.
P80.002	CT Technology: Durability, Design and Performance	Project reports cover CT product lines from major OEMs, including design features, related risk issues, and RAM-durability experience. All 50-Hz and 60-Hz models over 20 MW are covered, including advanced and upgraded mature engines.
P80.003	Plant Design, Repowering and Environmental Siting	Project reports cover design features and procurement specifications for commercially available combined-cycle plant equipment such as heat recovery steam generators, steam turbines, electrical generators and condensers, and include best practices for integration in an operationally flexible plant design. Emissions control equipment is described and regulatory trends are monitored. Software provides model-specific O&M cost estimates.

P80.001 Experience-Intelligence Report and Project Risks (067359)

Key Research Question

Technical advances and issues surrounding combustion turbine (CT) and combined-cycle (CC) plants are major factors in new generation decisions, and the impact of those decisions will be felt for years to come. To optimize use of new technologies, plant managers and technical staff need objective, concise knowledge of innovation drivers and industry experience.

CTCC plant owners and developers face multiple challenges, including reduced maintenance intervals, unexpected durability shortfalls of costly components, and unplanned maintenance events. A balanced approach to risk identification and cost allocation is essential in the technical development and financial strategy of any new plant project. Because CT maintenance can cost two to three times the price of the original equipment over the project life, CT owners need to consider major maintenance during project development and recognize the technical maturity of particular turbine models. In addition, owners and developers need to understand price volatility in fuel and electricity markets, and its impact on plant dispatch and profitability.

Approach

EPRI collects and analyzes information about current and emerging CTCC designs and cycle configurations, and publishes the results in a series of concise reports supplemented by technical presentations. Topics covered include hot-section design features, emerging alternative parts suppliers, compressor dependability, and lean, pre-mixed, low-NO_x combustion instabilities. Also addressed are the impacts of liquefied natural gas (LNG), syngas, high-hydrogen and biofuel firing, fuel market trends, air-cooled generator issues, and other topics as determined by members.

- The database for CT owners and operators, INTURB, provides a worldwide directory to facilitate contact with peers to discuss model- and configuration-specific concerns affecting procurement decisions.
- Project risk assessment reports help define and quantify risks associated with investment in new CT technologies and their maintenance.
- Guidance covers decisions about up-front maintenance strategies, such as self-managed maintenance or long-term contracts by the OEM or third parties.
- Special studies examine other aspects of project risk such as the electricity market, natural gas supply, and the timing and impact of LNG in the fuel marketplace.

Impact

EPRI reports provide the background and analysis to evaluate various technology and configuration options, allowing program members to:

- Take full advantage of new and existing CTCC plants through concise, current information on new technology developments and issues affecting efficiency, emissions, durability, reliability, and plant operating flexibility to meet dispatch demands
- Mitigate technology and market risk for new CTCC project development through evaluation of alternative maintenance approaches and insights on natural gas and electricity markets
- Gain insights on industry best practices and concerns via a peer-to-peer directory that facilitates experience sharing and lessons-learned reporting

How to Apply Results

Reports serve as a valuable resource for understanding major components of risk in project development and the use of insurance and maintenance contracts to mitigate a portion of the technical risk. Insights on model maturity and alternative parts suppliers support maintenance strategy planning. Other EPRI studies are employed to address project stakeholder concerns about equipment reliability risks and impacts from changing fuel and electricity market conditions. The INTURB CT owners' directory can help identify other

companies and contacts potentially able to provide valuable information and lessons learned from experience with equipment.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
CT Experience and Intelligence Reports: Concise reports in article format on select topics are issued electronically several times per year, supplemented by technical presentation at advisory meetings and webcasts. These products are compiled annually in a single report.	12/31/10	Technical Update
Combustion Turbine Owners INTURB Directory: Annual Update: This database contains information on more than 5,600 sites and 3,400 contacts worldwide to promote communications between owners and operators of gas turbines. Information on company sites and contacts is updated throughout the year.	12/31/10	Technical Resource
Project/Technical Risks Assessment: This report addresses and updates a topic of current interest from a risk perspective, such as fundamentals underlying trends in supply and demand of natural gas driving price volatility, approaches to minimizing technical risk in technology selection, life-cycle maintenance costing studies, or the impact of insurance in coordination with long-term maintenance agreements in minimizing costs associated with unscheduled maintenance events and business interruption.	12/31/10	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
CT Experience and Intelligence Reports	12/31/11	Technical Update
Combustion Turbine Owners INTURB Directory: Annual Update	12/31/11	Technical Resource
Project/Technical Risks Assessment	12/31/11	Technical Update

P80.002 CT Technology: Durability, Design and Performance (104059)

Key Research Question

Gas turbine manufacturers continue to add new and upgraded models to their combustion turbine (CT) product lines. For the highest-efficiency models, air-cooled components are displacing steam-cooled components in the G- and H-class. Understanding the design features of each model and their relationship to the overall design evolution and possible risks is a challenge. To meet this challenge, project developers and electricity generation owners and operators need an objective, in-depth perspective on technology risk and benefits, in addition to the operation and maintenance (O&M) implications of new and upgraded model offerings for all major original equipment manufacturer (OEM) suppliers.

Approach

This project periodically updates a multi-volume series of reports covering the heavy-duty and aero-derivative engines over 20 MW capacity most frequently used in power generation applications. These reports summarize design characteristics of the turbine product lines manufactured by General Electric, Siemens (including Siemens-Westinghouse), Mitsubishi, ALSTOM, Pratt & Whitney, and Rolls-Royce. Each report

includes a pedigree matrix detailing design attributes in a standard format. High-risk design features are identified, and relevant technical issues and experience are discussed. Reliability, availability, and maintainability (RAM) statistics are provided for selected models to further identify the overall model maturity and quantify RAM performance. Models of particular interest include more advanced F-, G-, and H/J-class machines, engines suited to highly cyclic duty, and those used for syngas/hydrogen firing. The project seeks information about advanced models as opportunities arise.

Impact

- Receive high-quality design assessments and in-service data for high-confidence technology selection and procurement decisions.
- Access independently obtained RAM statistics for use in plant economic modeling evaluations.

How to Apply Results

Members can use these detailed reports to account for site and market conditions and equipment capabilities, as well as identification of technical attributes and associated risks when planning generation additions. In procurement, the information is used to evaluate equipment and select appropriate technology.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Rolls-Royce CT Product Line - Design Evolution and RAM-D Issues - Update: This report describes the design evolution, features, and performance of the RB211, Trent, and Avon aeroderivative gas turbine models, including recent upgrades. Current reliability and availability data are included. Technical issues affecting maintenance, durability, and reliability are reported. Existing sites are listed.	12/31/10	Technical Update
General Electric Heavy-Duty CT Product Line – Design Evolution and RAM-D Issues - Update: This report describes the design evolution, features, and performance of the GE 7FA/9FA/6FA, 7FB/9FB, 7H/9H, 7EA/9E, and 6B/6C heavy-duty gas turbine models, including recent upgrades. Current reliability and availability data are included. Technical issues impacting life-cycle costs affecting maintenance, durability, and reliability are reported. Existing sites are listed.	12/31/10	Technical Update
Mitsubishi CT Product Line – Design Evolution and RAM-D Issues - Update: This report describes the design evolution, features and performance of the MHI M501F/M701F, M501G/M701G, M501D/M701D heavy-duty gas turbine models, including recent upgrades. The status of the newly announced air-cooled J machine also will be covered. Current reliability and availability data are included. Technical issues impacting life-cycle costs affecting maintenance, durability, and reliability are reported. Existing sites are listed.	12/31/10	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Pratt & Whitney CT Product Line – Design Evolution and RAM-D Issues - Update	12/31/11	Technical Update
ALSTOM CT Product Line - Design Evolution and RAM-D Issues - Update	12/31/11	Technical Update
Siemens (including Siemens-Westinghouse) CT Product Line - Design Evolution and RAM-D Issues - Update	12/31/11	Technical Update
General Electric Aero-Derivative CT Product Line - Design Evolution and RAM-D Issues - Update	12/31/12	Technical Update
Small CT Products for Power Generation and Cogeneration (i.e. Solar, Hitachi)	12/31/12	Technical Update

P80.003 Plant Design, Repowering and Environmental Siting (067360)

Key Research Question

A plant design must satisfy several requirements, including meeting increasingly stringent environmental regulations, minimal water use, high efficiency, capital cost recovery, and operational flexibility. Features such as rapid startup, rapid load change, and low-load operation are highly valued in many markets. These features are best considered during the procurement process, because retrofits are costly and might not be practical. Repowering an existing site or adapting a gas-fired plant for future coal syngas capability requires additional considerations.

Approach

Reports emphasize economical and flexible designs as well as consideration of project life-cycle costs for the selection of the heat recovery steam generator (HRSG), environmental controls, steam turbine, steam condenser, electrical generators, and other balance-of-plant equipment. New features and lessons learned from recent plant installations are integrated into equipment procurement guidelines. Equipment for the control of nitrogen oxides, carbon monoxide, particulate matter, volatile organic compounds, and other air pollutants is described. U.S. and worldwide regulatory trends are monitored. The CTCC O&M Cost Analyzer software estimates costs on a model-specific, component-level basis for different operating missions, quantifying the cost impacts of scheduled maintenance and the likelihood of unplanned events. O&M costs can be compared with other maintenance approaches based on long-term maintenance agreements or alternative parts replacement and repair.

Impact

- Develop more competitive designs and equipment procurement decisions by using detailed information on combined-cycle design features, performance, and reliability trade-offs.
- Enhance operational flexibility by identifying and evaluating new plant design features.
- Assess environmental control options on an objective and credible basis.
- Quantify and compare life-cycle maintenance costs based on user-defined scenarios.

How to Apply Results

Reports provide information for understanding equipment designs, making procurement decisions, and determining the most effective configurations to meet duty cycles and flexibility requirements. Equipment procurement guidelines can be used directly to support competitive bidding activities. Software quantifies the impact of operating scenarios on O&M costs.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
CTCC O&M Cost Analyzer, Version Update	12/31/10	Software
Equipment Selection and Procurement Guidelines	12/31/10	Technical Update
Gas Turbine/Combined-Cycle Environmental Control Technology and Regulatory Issues Handbook – Update	12/31/10	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Gas Turbine/Combined-Cycle Environmental Control Technology and Regulatory Issues Handbook - Update	12/31/11	Technical Update
Steam Turbine and Generator Designs for Combined-Cycle Plants - Update	12/31/11	Technical Update
Phased Refueling of Natural Gas-Fired Combined-Cycle Plants to Firing Hydrogen Syngas from Coal Gasification with CO ₂ Capture - Update	12/31/11	Technical Update
Lessons Learned in Startup and Commissioning of Simple-Cycle and Combined-Cycle Plants - Update	12/31/11	Technical Update
Heat Recovery Steam Generator Procurement Guideline - Update	12/31/11	Technical Update
Selective Catalytic Reduction of NOx: Reactor Designs and Procurement - Update	12/31/12	Technical Update
Cyclic Operation of Combined-Cycle Plants: Designs, Maintenance, Reliability and Cost Impacts - Update	12/31/12	Technical Update
Conversion to Dual Fuel Capability by Addition of Distillate Oil Firing Systems in CT Plants - Update	12/31/12	Technical Update
Repowering Studies and Assessments - Update	12/31/12	Technical Update
Steam Condenser Procurement Guideline - Update	12/31/12	Technical Update