Program Overview

Electric utilities face very large investment decisions with very long-term consequences. However, tremendous uncertainties exist in many dimensions, including technology development, regulations, loads, fuel markets, and electricity markets. These uncertainties are extensively interrelated and potentially very disruptive to planning for an optimum asset mix. Analysis and integration of the vast amount of available information, opinion, and uncertainty related to the above areas are critical to a successful technology strategy. Furthermore, increased public scrutiny and media coverage of the electric sector require objective, credible technical information, and analysis to inform regulators, policymakers, and the media.

Aging infrastructures, long-term growth in electricity demand, a competitive and increasingly complex marketplace, and changing regulatory environment require that optimal technology development and investment strategies incorporate tools and data that enable an integrated understanding of technology options, costs, and market drivers. This diverse set of resources should include:

- Comprehensive, credible, and up-to-date data and analyses of:
  - Technology costs and performance
  - Forthcoming changes in the generation fleet
  - Fuel markets and infrastructures
- Consistent analysis methodologies and tools for:
  - Incorporating technology costs and performance in asset planning
  - Evaluating portfolio strategies (e.g., retire/retrofit/replace) under unprecedented change
  - Anticipating new regimes in price/cost volatilities and their inter-relationships
  - Optimizing transactions (e.g., fuel, power) to better manage risk

Research Value

EPRI's Power Technology, Market Analysis and Risk program (Program 178) integrates three vital areas of research: technology assessments, power/fuel market analyses, and methods for managing market/enterprise risk. Key examples include the annual Technical Assessment Guide TAG®, an ongoing series of reports assessing coal and gas markets, and integrated analysis of generation asset portfolio strategies under diverse scenarios. Together, they provide:

- Comprehensive data, methodologies, and tools, resulting in a sound technical basis for technology planning, investments, and market strategies;
- Complementary research to the other areas (e.g., fuel markets and volatility analysis can enhance quality of technology cost estimates); and
- Collaborative research and development, which allows participants to get the maximum value from EPRI's industrywide data and analysis when making key technology and business decisions.

Approach

- Technical reports capture industrywide cost and market data, establish reference values, offer new and improved analysis methods, and provide insights into key trends. An example is the Technical Assessment Guide TAG®. Another example is gauging the impact of gas shales.
- Algorithm development and software tools provide customizable and flexible application of accepted methodologies to analysis of technology costs, asset portfolio planning, market risk, and price/cost volatility. Flagship products include TAGWeb® and the Energy Book System (EBS).
• Meetings and webinars, such as the annual EPRI/EEI conference on Power Technology, Fuel Supply and Market Risk.
• Critical technology cost and market data inform EPRI’s public domain research conducted under the Energy Technology Assessment Center (ETAC).

Accomplishments
• EPRI’s Technical Assessment Guide (TAG®) is recognized as an authoritative source for up-to-date technology information. It is well-accepted by regulators, and is sought after as a critical resource by both U.S. and international agencies and researchers.
• EPRI’s fuel and industry markets research continues to expand understanding of the link between power plant project developments and domestic and global fuel markets; changing assessments of fuel supply and availability; and impacts of changes in infrastructures critical to the fuel supply chain. The most recent accomplishment is an extensive analysis of “generation shifts,” e.g., displacement of coal by natural gas, and the prognosis for its continuation.
• EPRI’s power markets and risk research provides updates on existing forecasting and risk mitigation approaches, as well as methods for addressing emerging risks. This research area includes the "Energy Book System" (EBS) for asset valuation and risk management.
• Innovative, scenario-based analysis of generation asset portfolio planning, integrating portfolio financial risk analysis tools.

Current Year Activities
The Power Technology and Market Risk program in 2012 will focus on key issues and strategies that inform participants' management of asset portfolios.

• Existing data sets, tools, and services to participants will be maintained and enhanced, particularly in the TAG® and power markets and risk areas.
• Annual deliverables such as the TAG® technology report and the Annual EPRI-EEI Power & Fuel Supply Seminar will be provided.
• EPRI will continue to feature TAG® prominently as a basis for many of its public-domain research activities.
• Emerging issues with high uncertainty and complexity will be investigated.
• Generation asset portfolio management strategies focus on retire/retrofit decisions and critical uncertainties. Related impacts on cycling/provision of load-following services also will first be examined in a supplemental study this year.
• Fuel, electricity, and emissions market effects on asset valuation and risk will be explored.
• Key forecasting and analysis methods will be matched to appropriate problems.

In 2012, Program 178 will consist of two project sets:

• Project Set 178-A continues its focus on conventional and advanced technology cost and performance for new generation capacity screening, with supporting information on technology risks, life-cycle management, regulatory impacts of emissions and portfolio standards, and cost escalation analysis featuring the Technical Assessment Guide (TAG®), generation capacity additions topics, and advanced technology topics.
• A new Project Set 178-B "Power & Fuel Markets: Risk and Response" is being formed by merging two previous and highly complementary project sets on market analysis and market-value/risk methodologies. In addition to ongoing activities, a high priority is research on how to make major generation asset decisions in the face of potentially disruptive uncertainties (e.g., regulations, technologies, and markets) with long-term consequences.
The first project set addresses the power technology theme; the second addresses market analysis and value/risk methodologies. Substantial synergies exist between the two; for example, generation asset planning draws heavily on technology characterizations, but also requires fuel market information as an important input and sensitivity in integrated resource planning (IRP) assessments. Likewise, corporate performance under various technology strategies often is best examined using sophisticated simulations of power markets, revenue-cost spreads, and risks. This program develops information, methods, and case studies across this spectrum to support industry generation and environmental planning and risk management.

**Estimated 2012 Program Funding**

$2.0M

**Program Manager**

Revis James, 202-293-6348, re james@epri.com
Summary of Projects

178A Technology-Based Business Planning Information and Services (TAG) (069229)

Project Set Description
The electric industry faces declining demand for power, increasing environmental regulations, and an aging infrastructure. However, these challenges are part of a typical industry cycle, and an upward swing in power demand is anticipated in the next few years, which will require new generation facilities to make up for retirements and to meet new demand. The current planning process for new generation facilities requires credible technology information and data that can be customized to individual company needs to meet changing regulatory environments. The Electric Power Research Institute’s (EPRI’s) Technical Assessment Guide (TAG®) project set delivers time-critical, technology-based business planning information, tools, and services that help planners, technologists, engineers, marketers, and financiers optimize capital investments in generation, storage, and transmission and distribution infrastructure. Research priorities in 2012 will include:

- Production of the annual “Power Generation and Storage Technology Options” report, capturing the latest industry data on technologies and cost and performance
- A report on generation capacity impact topics, including technology risks, regulatory impacts, life-cycle management, and cost escalation
- Complementary research completed via supplemental projects, addressing customization of technology evaluation via the TAGWEB™ software, and systemwide planning via the Electric Generation Expansion Analysis System (EGEAS) software.

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<tr>
<th>Project Number</th>
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<tr>
<td>P178.001</td>
<td>Technical Assessment Guide (TAG®)</td>
<td>The TAG® focuses on power industry and fuel market developments and asset management questions, drawing on previous studies, premiere analysts, databases, and market simulation techniques to provide critical planning information. In addition to the TAG technical report, project participants can obtain a one-year subscription, from 1/1/11 to 12/31/11 or from 1/1/2012 to 12/31/2012, depending on the project participant funding year for up to five users of the TAG®-Web software package. A development effort is being initiated in 2011 to enhance analytical capabilities and user-friendliness of the Electric Generation Expansion Analysis System (EGEAS) software. It is a web-based integrated resource planning tool that would be seamlessly linked to the TAGWEB™ software for sharing the technology screening results. The funding solicitation for this effort will be initiated on June 1, 2011, with software delivery scheduled for fourth quarter 2012. The supplemental project notice (SPN) for each of these software packages provides additional details.</td>
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P178.001 Technical Assessment Guide (TAG®) (065783)

Key Research Question
It is anticipated that the demand for power in the United States will pick up in the next few years, and the costs for building new power generation facilities will increase. As the planning process for new capacity additions is fairly long and a diversified set of technologies has to be considered, energy companies need credible and consistent information on the performance and cost of both conventional and emerging power system technologies. Implementation of environmentally friendly and effective, capital-intensive, and long-asset-life technologies is more important than ever before. Developing and implementing strategic technology solutions
require linking technology plans to business plans, which in turn requires critical information on the technologies. This information includes consistent, up-to-date data on the performance and cost of conventional and emerging electricity technologies and facilitates analysis of plant retirements, major asset replacement/refurbishment, and new capacity additions.

Approach

The program offers a range of tools — from cost and performance (including emissions) reports to customizable software and technology-planning case studies — that target specific, current issues while staying focused on technology trends. Research covers issues such as cost escalation and credit squeeze for new plants, in addition to the annual cost and performance update for as many as 19 power generation and storage technologies. Examples include understanding and clarifying escalation or decline in project costs; the impact of significant amounts of renewable technologies in the system on baseload technologies; the impact of new EPA emission rules on existing fossil assets; and the role of combustion turbines/combined-cycle systems in planning for new capacity in the near term.

Impact

Benefits of collaborative research in this area include:

- Up-to-date market and technology-relevant databases, methods, and tools.
- Quick response to members on current issues.
- Cost and performance data and evaluation tools help participants make decisions on technology choices and facilitate integrated resource planning and interaction with regulatory agencies.
- TAG® is an authoritative source of cost and performance information on advanced and conventional generation, storage, transmission and distribution, and environmental control technologies. The TAG® program format and content are updated annually to meet changing industry conditions.
- Technology planning case studies provide information “upstream” of technology information.
- Project participation includes membership in the Electric Utility Planning User Group (EUPUG), which serves as a forum for planning managers and directors to share ideas and concepts in a peer group.

How to Apply Results

Project technical reports help participants with preliminary technology screening, preliminary project planning, negotiating with vendors, and communicating options for new generation capacity to upper management and to regulatory agencies, where applicable. EPRI's program staff performs industry issue-specific analyses to enhance the application of results. The web-based programs provide consistent cost and performance information and methodologies that allow users to customize information to company-specific situations in advanced and conventional generation, storage, and environmental control technologies.

2012 Products

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<tr>
<td>Technical Assessment Guide (TAG®): The TAG® contains technology descriptions, trends, design basis, cost estimate bases, and key technology data, including capital costs, operating and maintenance costs, heat rate, and availability. The technology descriptions include an overview of process conditions, emissions and any required controls for effluents, market data including vendor offerings, resource (fuel) requirements and data, current R&amp;D activity, and future potential for enhancements.</td>
<td>12/31/12</td>
<td>Technical Report</td>
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### Generation Capacity Addition Topics - Technology Risks, Life-Cycle Management, Regulatory Impacts, Material, Equipment, and Labor Cost Escalation

In addition to the cost and performance information on power generation technologies in the Technical Assessment Guide (TAG®), the new generation capacity additions warrant explicit information on complex topics that may affect the capital investment and operating life. In the past, these topics have been addressed to a lesser degree in the TAG® report. In the current environment, the scope of these topics has expanded. This special report would complement the TAG® and would address the implications of technology risks, life-cycle management considerations, regulatory impacts due to emission control requirements, portfolio standards, and cost-escalation impacts on materials (concrete, structural steel, and piping).

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<td>Technical Report</td>
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### Technical Assessment Guide (TAG®) - Advanced Technologies

The power generation industry is attracting new capital investments in R&D for the development and implementation of new technologies for new generation and storage capacity additions. Many of the developments are taking place outside the current industry infrastructure and are driven by environmental regulations and expectation of high return on investments. Some of the advanced concepts include integration of currently available commercial technologies such as wind and storage, and solar and storage. A breakthrough in technologies that have been in long development cycles such as fuel cells also is possible. This report would cover the potential for various technologies and provide a feasibility analysis by looking at the various components of the technology and their break-through time frame. In general, the time frame for this would be 2015-2030.

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<td><strong>Technical Assessment Guide (TAG®) - Advanced Technologies:</strong> The power generation industry is attracting new capital investments in R&amp;D for the development and implementation of new technologies for new generation and storage capacity additions. Many of the developments are taking place outside the current industry infrastructure and are driven by environmental regulations and expectation of high return on investments. Some of the advanced concepts include integration of currently available commercial technologies such as wind and storage, and solar and storage. A breakthrough in technologies that have been in long development cycles such as fuel cells also is possible. This report would cover the potential for various technologies and provide a feasibility analysis by looking at the various components of the technology and their break-through time frame. In general, the time frame for this would be 2015-2030.</td>
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### TAGWEB Software (Supplemental / SDF)

The TAGWEB™ (Technical Assessment Guide Web) software is an integrated, web-based software that provides current cost and performance data and technology trends for:

- Fossil technologies: pulverized coal, coal gasification/combined cycle, fluidized-bed combustion and combustion turbine/combined cycle
- Nuclear technologies
- Renewable energy in the form of wind, solar thermal, photovoltaic, geothermal, and biomass technologies
- Small-scale generation such as fuel cells, internal combustion engines (diesel), small CTS less than 25 MW, and microturbines
- Storage technologies represented by compressed air energy, batteries, pumped hydro, flywheels, and superconducting magnetic energy technologies

The TAGWEB™ data facilitates input to simulation models for integrated resource plans, which lead to selection of least-cost technology and fuel choice for the benefit of the public. Ratepayers can benefit from more-informed decisions by utilities and by their PUCs with regard to increased capacity planning and implementation. The Technical Assessment Guide (TAG®) provides data used for analysis by EPRI’s Energy Technology Assessment Center, which develops public-domain technical analyses and assessments of energy technologies, energy-economic analyses, and potential for emissions reductions, including CO₂.
Electric Generation Expansion Analysis System - (EGEAS) Software (Supplemental / SDF) Version 10.0: EGEAS (Electric Generation Expansion Analysis System) is a state-of-the-art modular production costing and generation expansion software package, developed under EPRI sponsorship, for use by utility planners to develop and to evaluate integrated resource plans, avoided costs, and plant life management plans. It also has modules that accommodate demand-side management options and facilitate development of environmental compliance plans. EGEAS contains three capacity analysis options that range from preliminary analysis tools based on screening curves to sophisticated non-linear optimization using generalized Benders decomposition and dynamic programming algorithms. A stand-alone, detailed probabilistic production-costing algorithm also is available for production cost and reliability analyses.

- The key features of EGEAS are:
  - Dynamic programming logic to form candidate portfolios from identified alternatives, meeting a capacity planning constraint (e.g., maintain x% reserve margin).
  - Conducts Present Value Revenue Requirement or lowest-electric-rate economic ranking of candidate portfolios dispatched with an existing and future set of assets.
  - Ability to quickly run a number of scenarios to test different generation plans.
  - Simple economics — easy to understand and explain results.
  - Well-accepted by regulators.

Current applications:
- Front-end screening tool.
- Asset retirement evaluations
- Emission evaluations from power plants

EGEAS has particular capabilities that are highly valued by utilities. It can be used to determine a reduced number of portfolios requiring a more detailed analysis (hourly dispatch, stochastic analysis) of fuel and transmission-related costs. It also provides the option to limit run time for specific portfolios.

PS178B Power & Fuel Markets: Risk and Response (072104)

Project Set Description

This project set integrates the research formerly carried out in separate projects sets on market analysis and value/risk/planning methodologies. The research is now organized into three projects having complementary analysis and methodological components as outlined below. Specific scope will be updated to reflect member priorities in response to ongoing research findings and critical issues.

The areas of focus of the projects are:
- Market developments in fuel and power pricing, with implications for market forecasting and modeling. Examples include continuing shifts in generation (e.g., coal displacement by natural gas), shifts in peak and off-peak price spreads, and gas/power price volatility.
- Information and methods for optimizing value and risk of an energy portfolio, with focus on market forces and operational uncertainties. In addition to enhancing the range of EPRI’s Energy Book System, examples include the use of heat rates as a commodity of trade and forecasting and managing increasing instability of coal burn.
• Making major portfolio decisions that have long-term consequences, given the likelihood of highly disruptive changes in regulations, technology, market, and consumer demand. Examples include how regional fleet transition, uncertain in timing and extent, affects portfolio performance; and drawing lessons from international asset shifts.

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<tr>
<td>P178.002</td>
<td>Power &amp; Fuels: Industry Development and Market Evolution</td>
<td>The power industry is facing an unprecedented magnitude of uncertainty in technologies, regulations, fuel/power market behaviors, and consumer demand. Decision making, whether it be transactions for near-term risk mitigation or major commitments on the longer-term asset mix, requires up-to-date information on fuel market behaviors and implications for asset utilization. This project will assess energy market developments to provide in-depth understanding of the changing generation infrastructure; related markets in coal, natural gas (NG), and emission allowances; and impacts on generation assets. Moreover, this project will assess implications for methodologies of forecasting and modeling market behavior, which are essential inputs to decisions regarding asset mix and financial risk management.</td>
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| P178.003       | Energy Markets & Assets: Optimizing Value and Risk | The energy business is prone to substantial and complex financial risk. This project continues EPRI's research on algorithms and methods to help members assess and hedge portfolio risk exposures to key industry uncertainties and will now reflect updated assessments on the nature of these risks as well. These uncertainties include:  
  • Price volatility and correlations of fuel, power, transmission, and emissions markets;  
  • Counterparty credit uncertainty and collateral estimation;  
  • Intermittent generation (wind, solar) impacts on supply and operational uncertainties;  
  • Regulatory uncertainty, such as carbon restrictions or renewable requirements  
  • Load uncertainty, including disruptive developments such as energy efficiency, large-scale price-demand response, and plug-in hybrid vehicles |
| P178.004       | Portfolio Migration: Asset Deployment in an Era of Disruptive Uncertainty | This project provides information and methods to assist in assessing long-term implications of generation asset-planning strategies in the face of substantial long-term uncertainty. Initial focus is on coal generation retire/retrofit decisions, because these are in the forefront of utility planning today, pushed by local regulations and EPA regulations (e.g., SO\textsubscript{2}/NO\textsubscript{x} under the Transport Rule, mercury/other toxics under HAPS MACT, water intake structure parameters, and ash disposal requirements). |


Key Research Question

This project examines the interface between the power industry and its use of fuels. Coal and gas markets will be shaped by events in the power sector. Fleetwide SO\textsubscript{2} controls, for example, will alter coal selection and coal flows. Both coal and gas markets will be affected by large-scale retirements throughout the decade. Following on the program's 2011 analysis of coal markets, the prominent issue slated for 2012 is instability in the gas market — currently in oversupply at unsustainably low prices but facing a potential surge in demand.
The tensions of this dynamic combine the leading economic and environmental forces of the day and are central to generation planning and risk assessment. Moreover, natural gas prices and gas-linked power prices are moving into a new regime created by gas shales, calling for new characterizations of volatility and correlation. Significant shifts in coal selection are also triggered, and these dynamics are occurring at a global scale. EPRI is well-positioned to bring new insights into these assessments due to its position in the sector incurring the greatest changes in fuel use.

Approach

This project will assess energy market developments to provide in-depth understanding of the changing generation infrastructure; related markets in coal, natural gas (NG), and emission allowances; and impacts on generation assets. Moreover, this project will assess implications for methodologies of forecasting and modeling market behavior, which are essential inputs to decisions regarding asset mix and financial risk management.

Delivery will be via reports, webinars, advisory presentations, newsletters, and the following major annual seminar held late in the year:

- **EPRI-EEI Annual Seminar on Power Technology, Fuel Supply and Market Risk.** This flagship event delivers and expands upon EPRI’s research findings and introduces topics of growing urgency for consideration by planners and as topics for future research.
- **Newsletters.** The project issues a series of newsletters (articles) on new power plants, retirements, research findings, and timely research topics not addressed in the primary deliverables.

Scope and focus of research, subject to changes per member input as markets evolve, will be as follows:

- **Generation Shifts.** Gas oversupply, recession, and renewables have greatly affected power generation since late 2008. Vulnerabilities of segments of coal generation have been magnified, and natural gas use has gained greatly. EPRI will apply its experience in monitoring and interpreting these forces.

- **Gas Supply and Pricing Scenarios/Adjustments to Oversupply.** Gas market evolution in the United States has both national and global importance. Production has become decoupled from price, raising questions about the timing of adjustments and eventual equilibrium prices. At the same time, the industry is retiring greater amounts of coal-fired generation, with implications for escalating demand. Analysis will examine the fundamentals and knowledge gaps behind price scenario development.

- **Energy Market Modeling.** A key question in energy market modeling is how peak and off-peak power price spreads and their volatilities may change with continuing shifts in the generation mix, penetration of renewables, and expansion of efficiency programs. Another key question is how the diversification of gas supply sources with gas shale development is changing natural gas pricing volatility and correlations, entering a regime that departs from historical relationships. EPRI will assess these changes, which will become inputs to power and natural gas transactions-centered work in the next project.

- **International Markets topics: Coal Trade and LNG Pricing.** The United States has shifted from being a potential top-tier LNG importer, which triggered vast investments in liquefaction and regasification, to being an exporter of price depression. Oil-linked pricing is under pressure both in Europe and Asia, countered to some extent by a step-up in Japan’s LNG reliance. The international coal trade has reached new heights, with no impetus at all from shipping rate escalation that accompanied the 2008 run-up. Its development and adjustment will impact U.S. domestic coal prices and possibly call for rethinking coal equilibrium pricing. Sound analysis and case studies will help planners gauge these developments.

In addition to the studies outlined above, this project is closely linked to one of the proposed supplemental studies, “Displacement of Coal Generation by Natural Gas: Limits and Implications of Alternative Dispatch of Fossil Units”. Touted as a low-cost measure to reduce CO2 emissions, a detailed and comprehensive understanding of dispatch economics and transmission is needed to quantify the impacts of coal displacement policies including gas demand levels.
Impact
Fuel is an enormous expense for energy firms, and relative pricing among fuels dictates generation asset utilization. Moreover, fuel prices are volatile in the short run and exhibit very large swings over time. Improvements in understanding the trends in fuel pricing and linkages to power pricing will enhance decision-making and provide extremely valuable leverage to the enterprise.

How to Apply Results
Information delivered via reports, webcasts, seminars, and newsletters will improve staff decision-making. There are opportunities for custom or collaborative projects to help ensure effective application of knowledge and extend the research yet further.

2012 Products

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<tr>
<td>EPRI-EEI Annual Seminar on Power Technology, Fuel Supply and Market Risk, and Series of Newsletters: This flagship annual event draws together practitioners and researchers to address the principal issues affecting energy planning and market development, with implications for planners, risk managers, traders, and forecasters. A primary focus of this event and the series of newsletters is presentation and elaboration upon EPRI’s recent research findings, introducing topics of growing urgency as well as future research.</td>
<td>12/31/12</td>
<td>Technical Resource</td>
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<tr>
<td>Gas Supply, Generation Shifts and Pricing Scenarios: Gas market evolution of recent years has both national and global importance. Gas oversupply, recession, and renewables have greatly affected power generation since late 2008. Vulnerabilities of segments of coal generation have been magnified, and natural gas use has gained greatly. In some cases, production has become decoupled from price, raising questions of the timing of adjustments and eventual equilibrium prices. At the same time, the industry is retiring greater amounts of coal-fired generation, with implications for escalating gas demand. Analysis will examine the fundamentals and knowledge gaps behind price and supply scenario development. This information is essential to evaluating risks associated with different retire/retrofit/replace strategies.</td>
<td>12/31/12</td>
<td>Technical Update</td>
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<tr>
<td>Energy Market Modeling: Regime Change under Shales, Coal Retirements, and Shifting Demands: Energy planners and financial risk managers need models that reflect current and anticipated price behaviors. Major changes in fuel supply, power demand, and regulations are causing unprecedented and little understood changes in market behaviors. Two principal thrusts of this line of research proposed for this year include: a) potential changes in peak/off-peak power price spreads and their volatilities, as there are shifts in generation mix, and b) natural gas pricing volatility and correlations, entering a regime altered by gas shale supplies. These issues affect both transactions and technology choice (e.g., value of storage).</td>
<td>12/31/12</td>
<td>Technical Update</td>
</tr>
<tr>
<td>International Markets: Coal Trade and LNG Pricing: This report presents top issues in international generation and fuel markets, both influencing and influenced by U.S. power sector evolution and fuel markets. Global forces continue to affect local coal prices, for example, and the United States is currently exporting price depression in natural gas prices. This analysis will also help frame longer term equilibrium levels in both traded coal and LNG. The latter is particularly important to the period of reintegration of U.S. and global gas markets. These developments affect longer term performance of assets.</td>
<td>12/31/12</td>
<td>Technical Update</td>
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P178.003 Energy Markets & Assets: Optimizing Value and Risk (072102)

Key Research Question

The energy business is prone to substantial and complex financial risk. This project continues EPRI’s research on algorithms and methods to help members assess and hedge portfolio risk exposures to key industry uncertainties and will now reflect updated assessments on the nature of these risks as well, such as:

- Price volatility and correlations of fuel, power, transmission, and emissions markets;
- Counterparty credit uncertainty and collateral estimation;
- Intermittent generation (wind, solar) impacts on supply and operational uncertainties;
- Regulatory uncertainty, such as carbon restrictions or renewable requirements;
- Load uncertainty, including disruptive developments such as energy efficiency, large-scale price-demand response, and plug-in hybrid vehicles

The emphasis of this project is on how to best respond to the many changing and uncertain fundamentals affecting portfolio opportunities and risk. Thus, the emphasis is on transactions, spanning sales and purchases of power, fuel, capacity, and emissions allowances. The research draws on mature capabilities developed in the pre-existing research programs combined here, including the Energy Book System (EBS) software.

Approach

This project performs a mix of market studies, custom case studies, and algorithm development. Delivery will be via reports, webcasts, advisory presentations, application of program software, and updated software:

- **Energy Book System (EBS).** EPRI’s Energy Book System has continued to develop capabilities through base and supplemental research. Developed as a research tool for market-based value and risk analysis of energy assets and portfolios, it has proven useful to many power companies for risk analysis and asset planning. EBS can be used in custom projects and often serves as the testbed for new algorithm development.

Additional topics of focus for 2012 are as follows, subject to changes per member input:

- **Estimation and Use of Implied Heat Rates in Transaction Planning.** Heat rates have become a widely used marker in energy (power) trading and market forecasting. An advantage is that they project the balance of required production units and loads upon which to layer-in natural gas price volatility. This research will examine the practices of projecting heat rates, their comparative volatility, and their use alongside price measures in regions with different generation mixes.

- **Survey of Regulation and Practices Regarding Hedging.** Hedges, such as forward contracts for power or fuel, reduce future cash flow uncertainty but at the risk of locking prices that may appear unfavorable with hindsight. Furthermore, application of even the most carefully considered opinions on hedging decisions may be seen by regulators as speculation entailing unfavorable rulings in rate cases. This research will examine actual hedging practices and contrast with views and rulings by regulators.

- **Fuel and Transportation Procurement.** Uncertainty of fuel burn is growing in parts of the country subject to the greatest swings in relative fuel prices or wind penetration. This work will examine the adaptations in fuel and transportation procurement that are being triggered by greater instability in coal burn and by greater use of natural gas, documenting impacts on both the power and fuel industries.

In addition to the studies outlined above, this project is closely linked to one of the proposed supplemental studies, “How to Optimize Timing and Nature of Forward Generation Commitments.” A common but challenging task for owners of generation, particularly IOUs and unregulated producers, is how much and how far in advance to lock in output quantities and prices. The balancing of risks and opportunities under uncertainty, and clarifying the nature of tradeoffs, requires quantitative modeling.
Impact

Failure to properly assess and manage risk exposures can result in suboptimal or even catastrophic performance. Improvements in assessments of market-based value and financial risk management have very high leverage in terms of cash flow and business stability.

How to Apply Results

Information delivered via reports, webcasts, and software will improve staff decision-making capability. There are opportunities for custom or collaborative projects to help ensure effective application of knowledge and extend the research yet further.

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<td>Energy Risk: Methods and Measures under Disruptive Uncertainty: EPRI has been developing and refining influential algorithms for assessment of market-based value and risk in energy portfolios since the beginning of power markets in the mid-1990s. Many such methods have been embedded into EPRI’s Energy Book System software, as a test bed as well as operational use. Current attention is focused on potential changes in market modeling (&quot;regime change&quot;) due to gas price volatility and the power-gas price relationship, as well as &quot;course correction&quot; analysis as the future includes potentially highly disruptive uncertainties in regulations and technology. By keeping current, planners will continue to be able to address today’s most pressing issues and decisions requiring risk quantification. Algorithms are published in reports. Inclusion in software depends on membership needs.</td>
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<td>Technical Update</td>
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<td>Implied Heat Rates: Estimation and Use in Risk Analysis and Transaction Planning: Heat rates have become a widely used marker in energy (power) trading and market forecasting. This report will examine the practice and roles of using heat rates as a supplement to more traditional price measures. This research has the potential to offer planners and risk managers additional insight into market behavior, and to bridge experience across energy trading and fundamental assessments.</td>
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<td>Technical Update</td>
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<td>Hedging and Power/Fuel Procurement: Regulations, Trends and Practices: This report examines practices of hedging power and fuel management with a principal thrust to survey and draw lessons from the treatment of hedges across the regulatory community. Among the topics, there is growing interest in the term of gas supply agreements. Moreover, there is continuing tension between reducing future cash flow uncertainty and locking prices that may become unfavorable with hindsight. A further challenge is increasing instability in coal burn. Benefits include cross fertilization and improved public understanding of risk management value, regardless of market direction.</td>
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P178.004 Portfolio Migration: Asset Deployment in an Era of Disruptive Uncertainty (072103)

Key Research Question

This project provides information and methods to assist in assessing long-term implications of generation asset-planning strategies in the face of substantial long-term uncertainty. For example, potential coal generation retire/retrofit decisions are in the forefront of utility planning today, pushed by local regulations and EPA regulations (e.g., SO2/NOx under the Transport Rule, mercury/other toxics under HAPS MACT, water intake structure parameters, and ash disposal requirements). Timetables and approaches to restricting CO2 emissions may change, but the direction is clear.
This project conducts studies and simulations to complement other research addressing key drivers and trends in transformation of the generation fleet. It builds on the program's first study of a hypothetical fleet and its performance under rapid and deferred retirements. The aim is to provide insights into both: 1) the scale and nature of market/revenue impacts, and 2) methods of assessing increasingly dramatic changes in the generation mix. After integrating knowledge gained in the accompanying supplemental research, this work will provide guidance on retirement planning that links capacity and operational components.

**Approach**

Power companies have to make major asset decisions now, with long-term consequences, yet the future holds potentially major disruptions in regulations, technology, markets, and consumer behavior. This project selects one or more timely topics in major asset decision-making and provides research via analysis, surveys, and algorithm development.

- **Case Studies of Portfolio Migration.** Several topics for case studies are currently proposed here, whose precise definition will be modified on completion of ongoing related research and committee priorities. One topic, "Impact of Regional Fleet Transition Uncertainty on Company Portfolio Planning," addresses large but uncertain changes in the pace of retirements/replacements at a regional/interconnection level. An undertaking of enormous scope and complexity, the goal is to determine how industry responses are themselves a collective variable and source of risk in individual company planning. A second topic for consideration is quantifying tradeoffs between high capital cost/low fuel cost (nuclear, coal with carbon capture and storage) and low capital cost/(potentially) high fuel cost (natural gas combined cycle) generation options. This topic would be aimed at longer-term planning by which time natural gas price escalation is a more tangible risk.

- **Critical Infrastructure Characterization.** Coincident development of, or access to, electric transmission, renewables, water supplies, and natural gas are critical stages in portfolio development. A first emphasis in this series is characterization of pipeline and gas storage costs to serve power company requirements. Particularly in regions with less well-developed gas delivery infrastructures, the power sector may require substantial capital investments by the natural gas industry to build or expand pipeline capacity and gas storage to provide reliable natural gas supplies. To complement the preceding power sector-focused studies, this assessment will review costs associated with gas delivery, reasons for their variation, and their means of payment. Drawing in part on national-scale studies, this work will translate cost consequences to the smaller scale of individual company commitments and transactions.

- **Lessons from International Generation Shifts.** Recent and near-to-intermediate term changes in generation offer lessons in coal retirements, natural gas capacity additions, renewables penetration, and operational considerations. In addition to updating EPRI's examination of the Spanish experience, this study will examine additional regions undergoing substantive change — e.g., Ireland and the United Kingdom — and identify important planning considerations that should not be overlooked.

In addition to the studies outlined above, this project is closely linked to several proposed supplemental studies:

- "Timelines for Capacity Turnover: Gauging Impacts of Multiple Factors and Stakeholders on the Pace of Retire/Replacement Decisions," an effort to convene and tap regional working groups to incorporate practical insight into how fast things can get done;
- "Accommodating Swing: Frontiers in Resource and Operational Planning for Flexibility," a hard look at impacts of coal retirements on how to provide load-following capabilities; and
- "Adding Course Correction Flexibility to Medium/Long Term Generation Planning," an effort to weigh and contrast generation choices that offer different tradeoffs of capital commitment, fuel cost risks, payback periods, and "off ramps."
Impact

Given the substantial future uncertainties in technology, markets, regulations, and consumer behavior, there is potential for large investments today to become uneconomic prior to providing sufficient cash flow to cover their cost. Improved analysis and planning can help craft portfolio strategies that minimize this risk.

How to Apply Results

Information delivered via reports, webcasts, and algorithms will improve staff decision-making capability. There are opportunities for custom or collaborative projects to help ensure effective application of knowledge and extend the research yet further. Results will be designed to complement existing member planning efforts and facilitate evaluating the viability of different asset planning strategies under alternative possible future scenarios.

2012 Products

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<th>Product Title &amp; Description</th>
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<tr>
<td>Generation Fleet Transition: Case Studies of Major Build/Retire/Repower Decisions under Regulatory and Technological Uncertainty: Power companies have to make major decisions regarding generation projects now, with long-term consequences under regulatory and technological uncertainty. With guidance from utilities having alternative experiences and perspectives, case studies will quantify critical decision factors. Topics are anticipated to include uncertainties derived from the unpredictability of simultaneous responses across regions beyond the scale of typical corporate planning, and traditional tradeoffs between capital and risk.</td>
<td>12/31/12</td>
<td>Technical Report</td>
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<td>Generation Fleet Transition: Critical Infrastructure Characterization: The first topic in this line of supporting research on non-generation infrastructure is a characterization of economic considerations in costing the gas supply chain needed to support gas projects, the growing default option for dispatchable new capacity. These insights will help firms understand the costs and risks of their gas supply options, and alternative financing.</td>
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<td>International Generation Shifts: Trends and Implications: The international experience offers a rich literature in coal retirements, natural gas capacity additions, renewables penetration, and operational considerations. In addition to updating EPRI’s examination of the Spanish experience, this study will examine additional regions undergoing substantive change — e.g., Ireland and the United Kingdom — and identify important planning considerations that should not be overlooked.</td>
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Supplemental Projects

Electric Generation Expansion Analysis System (EGEASWEB) (072152)

Background, Objectives, and New Learnings

EGEAS (Electric Generation Expansion Analysis System) is a state-of-the-art modular production costing and generation expansion software package developed under EPRI sponsorship for use by utility planners to develop and to evaluate integrated resource plans, avoided costs, and plant life management plans. It also has modules that accommodate demand-side management options and facilitate development of environmental compliance plans. EGEAS contains three capacity analysis options that range from preliminary analysis tools based on screening curves to sophisticated nonlinear optimization using generalized Benders decomposition and dynamic programming algorithms. A stand-alone, detailed, probabilistic production-costing algorithm is also available for production cost and reliability analysis.

- The key features of EGEAS are:
  - Dynamic programming logic to form candidate portfolios from identified alternatives meeting a capacity-planning constraint (e.g., maintain x% reserve margin).
  - Conducts Present Value Revenue Requirement or lowest electric rate economic ranking of candidate portfolios dispatched with an existing and future set of assets.
  - Ability to quickly run a number of scenarios to test different generation plans.
  - Simple economics - easy to understand and explain results.
  - Current applications:
    - Front-end screening tool
    - Asset Retirement evaluations
    - Emission Evaluations from power plants

EGEAS has particular capabilities that are highly valued by utilities. It can be used to determine a reduced number of portfolios requiring a more detailed analysis (hourly dispatch, stochastic analysis) of fuel and transmission-related costs. It also provides the option to limit run time for specific portfolios.

Project Approach and Summary

This project will develop an enhanced Version 10 with a substantially improved user interface.

A nonworking prototype has been developed in 2010 as a platform for developing a new version of the EGEAS software capable of operating in the web environment with remote access and will focus on the following activities: 1) development of a new web-based Graphical User Interface (GUI) to enhance the useability and user-friendliness of the EGEAS software, 2) implement new enhancements for variations in data input and results, and 3) implement program structure to keep up with the operating system platform changes in the software industry. EPRI’s staff software programmers proficient in Fortran coding and in the latest GUI development technology will be involved in the new version development.

The proposed EGEAS Software Version 10 development will set up a baseline for the EGEAS software to operate in a web-based environment and to evaluate the impact of new technologies in system planning — e.g. renewable technologies on a large scale as well as on a distributed small scale, incorporation of storage technologies, fuel cells, and plug-in hybrid electric vehicles.

Benefits

EGEAS has the following applications:
- Generation expansion plans
- Environmental dispatch and optimization
- Integrated resource planning studies (IRPs)
• Analysis of independent power producers (IPPs)
• Power pooling and economic dispatch studies
• Impacts of cogenerators and small power producers
• Marginal cost, contract, and other rate evaluations
• Plant life management and repowering evaluations
• Avoided energy and capacity costs
• Reserve and system reliability analyses
• Generating unit evaluation with bid-based pricing
• Evaluating demand-side management options
TAGWEB™ (055977)

Background, Objectives, and New Learnings

The TAGWEB™ (Technical Assessment Guide Web) software is an integrated, web-based software that provides current cost and performance data and technology trends for:

- fossil technologies: pulverized coal, coal gasification/combined cycle, fluidized-bed combustion, and combustion turbine/combined cycle
- nuclear technologies
- renewable energy in the form of wind, solar thermal, photovoltaic, geothermal, and biomass technologies
- small-scale generation such as fuel cell, internal combustion engines (diesel), small CTs less than 25 MW, and microturbines
- storage technologies represented by compressed air energy, batteries, pumped hydro, flywheels, and superconducting magnetic energy technologies

The TAGWEB™ data facilitates input to simulation models for integrated resource plans, which lead to selection of least-cost technology and fuel choice for the benefit of the public. Rate payers will benefit from more informed decisions by utilities and by their PUCs with regard to increased capacity planning and implementation. The Technical Assessment Guide (TAG) provides data used for analysis by EPRI’s Energy Technology Assessment Center, which provides public-domain technical analyses and assessments of energy technologies, energy-economic analyses, and potential for emissions reductions, including CO₂.

Project Approach and Summary

Several new capabilities have been added based on 2010 research. Database updates were based on the research in the following areas:

- 2008 fluctuation in the financial markets and its impact on new power plant project execution
- Impact of 2008/2010 recession on prices of bulk materials (piping, structural steel, and electrical cables), labor, and equipment used in power plant construction
- Continuing impact of global warming concerns, particularly CO₂ emissions, on continued operation of existing and planning for new fossil-fuel-based power plants
- New trends in technology designs that enhance performance

In addition to the annual technology cost and performance evaluations, the TAGWEB database has been significantly enhanced to reflect current market conditions and technology trends in the following areas: cost and performance updates for Pulverized Coal, large Combustion Turbine/Combined Cycle, Nuclear, Solar Thermal (ST), Photovoltaic (PV), Biomass, Wind, and Storage technologies.

The following topics have also been addressed and included in the 2010 TAGWEB database: CT/CTCC demand and market impact, transmission impacts due to generation capacity addition/retirement, cycling duty impact on PC and CTCC plants, environmental emissions and control, impact of worldwide construction activity, and analysis of cost escalation impacts on future power plants.

The TAGWEB software was also enhanced with modeling capability for evaluation of renewable/storage technologies, analysis of data, and improved user friendliness. The TAGWEB software platform has also been upgraded to the .NET environment to enhance its graphical user interface (GUI), and upgrades to the analytical and reporting functions have been added to evaluate options for current industry uncertainties.

Benefits

An overview of the TAGWEB™ software and its benefits are provided below:

- “One-Stop” information source and analytical tool for capital investment planning
- Consistent, credible, current information
• Extensive research on specific technologies and competing options
• Cost and performance information on advanced and conventional generation, storage, and environmental control technologies
• Analyze key uncertainties, such as:
  • What if natural gas prices increase by 20% in one year, in five years
  • What if combustion turbine heat rates increase by 10% after 2 years in operation
  • What if initial market price for electricity is only 1¢/kWh How does it affect return on investment (ROI)
  • How do I analyze market uncertainties with respect to technical parameters
  • Which electricity technologies should be considered
  • How do renewable and storage technologies fit into future planning
Timelines for Capacity Turnover: Gauging Impacts of Multiple Factors and Stakeholders on the Pace of Retire/Replacement Decisions (072106)

Background, Objectives, and New Learnings

Accelerated replacement of coal-fired units, first anticipated in response to possible CO₂ regulation, is now being driven by air quality regulation and consent decrees. The market and policy modeling community is being caught short by this phenomenon, because industry-scale assessment tools cannot portray the effects of numerous local considerations that affect capacity retirement and replacement. The objectives of this study are to identify pacing factors and their variation and to offer “rate factors” for capacity turnover in different time blocks. This new dimension of analysis will inform planners’ interpretation of forecasts, anticipation of bottlenecks, estimation of costs and rates, and planning for risks and contingencies.

Project Approach and Summary

This project will integrate knowledge and data from regionally-informed agencies and stakeholders to identify the procedures and quantify the range of factors that will shape how rapidly regulated and unregulated entities in the power industry can retire plants, add new capacity, trigger investments as needed in the fuel supply chain, and maintain reliability throughout this process. A core regional working group will be convened, to be comprised of utilities, architect engineers (A/E), regional reliability organizations, EPRI, and others. The principal objective is to identify the scope and interrelationships of critical steps and to estimate “rate factors” (plus the uncertainty around them), which companies and others can incorporate in investment, market, and policy assessments as they see fit.

Segments to be represented will include generation, engineering and design, procurement, labor management and construction, transmission, gas transportation and storage, regulators, land acquisition, land use management and agency oversight, financial entities, and other stakeholders/influencers. As a first cut, EPRI will coordinate development of a research network that can piggyback on regional reliability organizations and A/E experience, expanding to address the additional issues that must be considered.

Benefits

Although models permit specification of large-scale retirements of capacity in relatively short periods of time (e.g., 33 GW of coal in five years), several challenges would be involved in implementing such a scenario. The many factors involved in plant retirement, retrofitting controls, and installing new capacity are known within individual companies, but the elements are numerous and complex, and some are outside recent experience (e.g., building into a low or declining load environment, and incurring massive changes simultaneously across the industry). This study will bring a new and practical dimension to energy analysis, modeling, and both private and public impact assessments by translating these factors into parameters representing realistic limitations to the capability to turn over capacity.
Displacement of Coal Generation by Natural Gas: Limits and Implications of Alternative Dispatch of Fossil Units (072107)

Background, Objectives, and New Learnings

Coal generation is vulnerable to many forces and policies, and gas supply faces many uncertainties. Into this mix, coal displacement by natural gas — pushed by proactive policies — remains poorly understood in detail, and therefore in aggregate, in spite of being highly amenable to analysis. Respected organizations, such as the Congressional Research Service and MIT in its Future of Natural Gas initiative, have offered indicative findings based on simplifications and assumptions. Extending this earlier research, additional analysis will add the rigor necessary to assess potential impacts with confidence.

By conducting comprehensive simulations, EPRI’s series of analyses will assess power flows and feasibility, operational considerations, increased gas requirements, and the important dimension of economic tradeoffs. Among the complexities, the Mid Atlantic and Northeast regions do not have sufficient head room in gas power plant capacity to meet demand in the medium term — a consideration that requires careful attention to seasonal and daily load variation. Further considerations are ongoing coal plant retirements, their impacts on peak/off-peak prices central to coal and gas plant economic evaluations, and transmission system modifications. The many aspects have to be carefully analyzed, using a detailed regional model. In addition to these quantifications, which are important to gas market risk assessment as well as utility asset planning, this work will also advance understanding of how to assess this topic.

Project Approach and Summary

Coal displacement by natural gas is already happening, to an extent far greater than ever seen before. This project draws on EPRI’s recent detailed analysis of those generation shifts and EPRI’s ongoing generation/technology case studies employing state-of-the art simulation. A staged approach is planned, expanding in geographic scope with growing company participation.

Steps include:

Study design and geographic scoping. This step will align participant priorities and resources, evidence of coal unit vulnerability (e.g., EPRI’s generation shifts analysis), and simulation data and capabilities. Time periods for the analysis will also be selected. Due to the scale of a wave of coal plant retirements in response to EPA regulations, selection of time periods/regulatory stringency is a critical step to defining the population of coal units most likely to be displaced.

Scenarios/rules to achieve coal displacement. Defined in terms of economic forces increasing coal generation costs (e.g., due to CO2 measures) or enhancing natural gas generation competitiveness (e.g., due to very low costs of supply). Alternative mechanisms will also be considered.

Methodological guidance/workshop. EPRI will convene a workshop among top practitioners familiar with utility operations and gas/coal competitiveness, project participants, and other stakeholders. Preliminary simulations will be introduced. Following this up, results will be conveyed to a broader audience via webinar.

Generation/transmission/market simulation. Conducted using mature simulation capabilities. The principal simulation engine anticipated for this project is LCG Consulting’s UPLAN modeling suite. Complementary methods of analysis will be applied, contingent on sufficient project resources.

Benefits

Policy considerations are ever-present in economic, technology, and market forecasting. Coal displacement by “unused” gas, achieved by yet-to-be articulated policies, is seen by many as a low-capital-cost means to reduce CO2 emissions and as a means to boost demand for “unused” gas supplies. Simple in concept, how the idea will work in the power industry cannot be easily generalized due to the industry’s great complexity and diversity.
Benefits include better assessment of levels and risks and increased public awareness of potential trade-offs. These benefits derive from quantifying gas market and other impacts arising from this policy dimension. Depending on perspective, these impacts might be considered risks by some and opportunities by others.
Accommodating Swing: Frontiers in Resource and Operational Planning for Flexibility (072108)

Background, Objectives, and New Learnings

Resource planning requirements have been changing. Environmental response planning (retire/retrofit/replacement) is a rapidly growing element of generation planning, but there is an increasing need to accompany this area with planning to accommodate load-following ("swing") requirements. Whether driven by wind penetration or measures that will advance retirements of coal-fired capacity, this shift requires closely integrating operational considerations and constraints into resource planning.

Load-following requirements are incorporated in the ancillary service requirement by most of the independent system operators (ISO). These services are required in the day-ahead market or during the reliability unit commitment (RUC) and supplemental reserve process. Due to increasingly higher requirements to match renewable portfolio standards (RPS), units with flexible output and fast response are in premium demand. Coal retirements are anticipated to produce a similar impact.

The need for flexible units to provide load following will be a growing factor in generation planning. Through a series of case studies aimed principally at the implications of coal plant retirement, this project will advance understanding of the impact and the practice of integrating operational considerations. It is expected that results will indicate that capacity has very different values, depending on the ability of a portfolio of generating and demand-side assets to operate flexibly. Moreover, flexibility may drive the need to add new, flexible capacity ahead of schedules based on resource adequacy (reserve margins) alone.

Project Approach and Summary

Regional case studies will examine how progressive retirement of coal-fired generation in a mixed-generation system causes changes in operating practices (coal cycling, ramping and turndown strategies) and eventually leads to an emphasis on flexibility in replacement capacity (e.g., gas-fired, load-following generation).

Peak and off-peak electricity price spreads and operational flexibility of assets will be key considerations. The loss of traditional load-following resources and increasing reliance on gas-fired capacity may also change the economics of potential energy storage options. It may also reduce the frequency of the use of scarcity pricing for real-time energy.

Case studies will first test and employ models coupling traditional (hourly) and more granular modeling. Alternative research platforms, problems with joint capacity and operational aspects, and geographic areas will be examined with additional case studies, subject to the level of industry participation and priorities. The research plan will be coordinated with EPRI’s wind integration and storage research, where advances in measurement of portfolio flexibility are taking place.

Benefits

EPRI’s case studies, based on real assets in operating markets, will be crafted to illustrate methods to integrate resource and operational planning and the value of doing so. The studies will also show how operational considerations affect decisions on timing and type of replacement capacity, capacity value, the role played by transmission system configurations in different parts of the planning area, and changes in sources of revenue (e.g., energy and ancillary services) across the generation fleet.
How to Optimize Timing and Nature of Forward Generation Commitments (064256)

Background, Objectives, and New Learnings

In the United States, Canada, and many other countries, there are both forward and spot markets for electric power. Owners of power generation resources (and holders of rights to generation capacity) thus face a fundamental question: How far forward in time—that is, how far in advance of production—should they sell the output of their generators?

Due to the volatility of wholesale energy prices, and the corresponding uncertainty about future forward and spot prices, decisions about when to sell power and when to purchase fuel can have a dramatic impact on the revenues and profits that owners realize. These decisions can also have a major impact on the amount of risk generation owners bear.

Although forward transactions can reduce market risks, they can introduce credit risk—the possibility of loss in the event that a contract counterparty fails to pay or deliver. Forward transactions can also introduce risks due to requirements to post collateral or other credit support.

Forward transactions can influence decisions about the type, quantity, and timing of physical capacity expansion, as well as the costs and risks associated with generation resources in place.

Yet, despite the importance of decisions about the timing of power transactions, there is no generally accepted framework for making them.

The purpose and new learning of this research are to construct a framework and methods for making such timing decisions. The results of this research will also serve as a foundation for future phases of this work regarding optimizing the form of generation sales (e.g., energy, capacity, and ancillary services.).

Project Approach and Summary

This project received seed funding from an early participant to identify the motives and factors that influence decisions about how far forward in time—that is, how far in advance of production and delivery—to commit the output of electric power generation resources. The seed phase concluded that decisions about how far forward to commit are tradeoffs between the benefits of risk reduction, on the one hand, and the costs associated with establishing and maintaining forward contract commitments, on the other hand. The seed phase also concluded that decisions about how far forward to sell power may reflect management perceptions of the market—in particular, perceptions that current forward prices are out of line with their expectations for future spot and forward prices, and thus provide opportunities for profitable trade.

Three lines of investigation are planned as next steps. First, because many of the benefits and costs of forward contracting are intangible and difficult to quantify, EPRI plans to create the means to quantify the associated benefits and costs. Second, forecasting (unobservable) future spot and forward prices and translating those forecasts into present-value equivalents to compare with current (observable) forward prices are largely subjective processes. EPRI plans to investigate new ways to perform these tasks.

Finally, EPRI plans to combine the results of these two lines of investigation into an integrated process for decision making.

The approach to this research will include consultation with participating member companies to understand more about the full costs associated with negotiating, executing, and maintaining power and energy contracts; collection of historical data from power and other energy markets; statistical analysis of energy market data; and mathematical modeling of costs and benefits in relation to time.
Benefits

The intended results of this phase of the research will be a framework and methods for calculating the benefits and costs of forward sales of electric energy in relation to transaction lead time, and methods to determine the tradeoffs. The anticipated public benefit will be improvements in the quality of decision making and the allocation of associated risks, resulting in lower production costs and prices. Project participants will enjoy the additional benefits of early access to framework, methods, and prototype utilization, as well as ensuring that the work addresses their business needs.
Adding Course Correction Flexibility to Medium/Long Term Generation Planning (072109)

Background, Objectives, and New Learnings

The electric power industry today faces an extraordinarily high degree of uncertainty. It is not only uncertainty about wholesale power and fuel prices but potentially disruptive factors such as environmental policy, industry regulation, and technological change. Particularly notable in this regard are SOx/NOx/mercury restrictions; natural gas pricing; carbon regulation and pricing; market penetration of automatic meter reading, smart grid and price-responsive demand; electric vehicles; and prospects for major breakthroughs in energy storage technology.

This means that plans made today for acquiring, retrofitting, or retiring power plants are subject to future uncertainties that may sharply increase or diminish the value of the generation asset and alter the relative value of different types of generation assets. For example, the coal plant that you retrofit now may be rendered “out of the money” under substantial carbon pricing or restrictions; the gas plant that you build to fill in the gaps from wind generation may hold little value if there is a substantial breakthrough in economics of electricity storage, or if there is a sharp rise in price of natural gas due to restrictions on shale extraction.

Therefore, generation asset planners face two major analytical challenges:

- **Scenario/simulation analyses should incorporate automated asset-mix “course corrections.”** Traditional simulation and scenario analysis methods presume a relatively static portfolio, or one with relatively predictable changes. Planning studies under highly disruptive uncertainty must be enhanced to reflect major changes in asset utilization and portfolio-mix strategies triggered by future “game-changing” events, such as greenhouse gas (GHG) regulation or breakthroughs in generation/storage technologies. In particular, scenarios and simulations must reflect how events such as a tax on carbon emissions would affect: a) the performance of the power generation, transmission, and storage resources in place, and b) the cost and performance of resources that would be installed in response to those events. Studies must reflect the changes in asset-portfolio behavior and managerial strategies when “game-changing” events take place.

- **Investment decision criteria should be adapted to reflect the disruptive nature of the uncertainties.** It is well established in economic theory that the traditional “net present value” rule for investment decisions is deficient when uncertainty about the returns to investment is very high. For example, price probability distributions may require “regime change” capability; the “option value” of waiting (i.e., deferring investment decisions) may become a substantial source of value; the insurance value of an asset that protects against certain contingencies becomes relevant. Therefore, the power industry needs enhanced value and decision rules derived for the market and non-market uncertainties that they face.

The objectives and new learning of this research are therefore twofold: 1) to understand how generation planning methods should be changed to accommodate disruptive uncertainties that can lead to major mid-course corrections in portfolio asset mix and strategy, and 2) to understand how investment decision criterion must be altered to reflect the potentially disruptive uncertainties — both market and nonmarket — that the industry faces.

Project Approach and Summary

The project will include three components. The first component will identify and describe the major non-market risks to be subject to further analysis. Currently these risks are anticipated to include emissions regulations/pricing, smart grid, price-responsive demand, electric vehicles, and storage technology. The second and third components will address simulation/scenario analysis and investment decision criteria, respectively.

In the first component, a “technical team” drawn from funders will work with EPRI to identify and describe the key non-market uncertainties bearing on their long-term planning. In the second component, EPRI will work with
one or more funders to adapt existing scenario/simulation planning tools to incorporate opportunities for mid-course corrections. Existing tools such as EPRI’s Energy Book System may be utilized if appropriate. In the third component, EPRI will work with planners at the funding companies and employ finance theory to develop optimal investment strategy change “triggers” for generation resources.

Benefits

The intended benefit of this research is an improved understanding of the methodological changes in generation asset planning and decision-making that is required in a power industry facing an array of potentially disruptive uncertainties. The anticipated public benefit will be more efficient power production as the industry makes better decisions regarding its huge capital allocations. Additional benefits for funders will be early access to research results, greater understanding of options and risks involved in investment decision-making, and ensuring that the research is well suited to their business needs.
Environmental Compliance Strategy Support (072068)

Background, Objectives, and New Learnings

Coal today provides over half of U.S. electricity. However, evolving environmental regulation of sulfur dioxide, nitrogen oxides, and mercury combined with possibility of regional and national climate legislation, possible new regulations on cooling technology, and a reconsideration of ash management regulations creates great uncertainty for existing and potential new coal assets. The impacts of these regulations must be evaluated against the backdrop of changing electricity markets. Electricity markets may be fundamentally changed by possible climate policy, whether market based or technology-forcing, and will almost certainly be impacted by significant additions of renewable generation in some regions. Increased abundance of natural gas may be another game-changer.

As companies consider future investments to comply with evolving environmental regulations, the answers may be clear for some older and relatively small units and they may be equally clear for newer and larger units. However for a large fraction of units that fall in the middle of the age-size distribution, the answers will be unclear and will depend critically on how public policy, regulations, and the actions of near competitors evolve to conditions in regional power markets. The basic question becomes whether the cost of investments to keep the unit running can be justified by the future, uncertain value of its output.

While the engineering and technology assessment necessary to assess the retrofit cost is difficult enough, the owner must also assess the unit’s role in the future power market and how that role changes with climate policy or swings in natural gas prices, how it changes with the introduction of new renewable generation, and how it changes as new environmental policies for air, water and ash management lead to the shutdown or curtailment of competing units.

Tens of billions of dollars of value in existing assets are at stake. Having a clear understanding of both the investment worthiness of their existing fleets and the potential value of new generation is needed to help companies make better decisions, and communicate them to stakeholders.

This project is designed to help utilities quantify the potential value of investments in retrofits or in new generation in this evolving world. It intends to give the generation owner a market-based assessment of how much investment its retrofit candidates can support, measured in dollars per kilowatt, and how robust these investments may be under a wide range of plausible futures.

Collectively, the retrofit-retire decisions for the electric sector reflect a potential impact of 100s of billions of dollars for electric customers and consumers of goods and services. This project may lead to improved decision making to help assure that this investment is well spent. Generic (non-proprietary) and general methodological insights from the individual-company analyses conducted through by this project will be communicated through an EPRI Technical Update.

Project Approach and Summary

Project participants identify for detailed study a set of candidate units, possible retrofit investment options, and a range of energy and environmental policy futures. Through past and ongoing Greenhouse Gas Reduction Options program research, EPRI has developed a broad set of analysis tools that greatly increase EPRI’s capabilities to analyze retrofit-retire decisions in a market context. Regional models of the U.S. and regional electricity markets developed as part of the Prism 2.0 project add to this capability. In this project EPRI will adapt and apply these tools to:

- evaluate how much in total one might be willing to invest in each generating unit for all the environmental controls that potentially may be required,
- examine the robustness of the specific investment options of interest across the scenarios, and
- examine the influence of timing of policies and uncertainties on the value of these investments.
The analysis will provide a detailed, bottom-up simulation of the regional power market that calculates the annual distribution of market prices, CO₂ emissions and the cash flows ascribable to each generating unit in the stack.

**Benefits**

Company generation investment strategies are subject to unprecedented uncertainty with regard to the stringency and timing of new environmental regulations, rapid changes in electricity markets driven by the introduction of intermittent renewable generation and the possibility of a future CO₂ price. Making robust investment decisions in the face of these uncertainties can save companies and the public ratepayers billions of dollars as well as provide sound and resolute outcomes which incorporate environmental drivers which may affect the public. Gaining fundamental insights about these uncertainties and possible compliance paths may also help companies inform legislative and regulatory discussions, leading to more effective and efficient regulations.

This analysis provides two features critical to accurate assessment of the value of retrofit investments.

- Market analyses extending to 2050 (encompassing a full lifecycle for new investment) are needed to fully capture the long-term effects of climate and clean energy policies on the recovery of retrofit investments and the addition and mix of new generation.
- Integrated regional market analysis is critical to quantifying the “survivor value” for units that remain in service (after retrofits) following a wave of retirements. These retirements have a direct impact on power prices and thus cash flows underlying retrofit investment worthiness.

Both of these features are outside the scope of most IRP analysis tools, yet are integral to the EPRI modeling approach. Including these issues is critical to fully capturing the value, and risks, to retrofit investments.