

40 Grid Planning

Program Overview

Program Description

Grid planning is a fundamentally important function for utilities, transmission companies, and ISOs/RTOs. EPRI's Grid Planning program has been providing critically needed technologies and information for its members over many years. In 2009, the Grid Planning program will offer its members a focused research portfolio that will help improve the reliability of the transmission grid through better planning and a more robust network.

The program includes three major focused areas:

- Modeling and Standardization helps system planners improve modeling and data preparation capabilities.
- Reliability Assessment helps system planners assess the reliability of future transmission networks by considering the uncertainties of generation, load and market.
- Engineering Study and Economic Benefit Assessment helps system planners address emerging engineering issues and perform cost-benefit analysis on transmission network enhancement options.

By providing state-of-the-art technologies that enable a robust power grid, this program will allow members to take technical leadership in the industry.

Industry Needs and Issues Addressed

- Robust transmission network designs to handle future uncertainties
- More accurate models and modeling standardization for planning studies
- Ensured reliability through better planning methods and tools
- Facilitated transmission investment cost and benefit allocation
- Maximized transmission asset value, expansion, flexibility, and use
- Compliance with Electric Reliability Organization (ERO) standards

Impact

- Design robust transmission grid to handle future uncertainties
- Build consensus on transmission investment
- Strategically and optimally allocate transmission investment funds
- Maximize the utilization of existing assets and extend the life of equipment
- Improve productivity and retain knowledge and expertise
- Meet reliability standards and avoid NERC penalties

Key Accomplishments

- Developed methods and tools to estimate parameters of load models using measurement data (Load Model Parameter Derivation (LMPD))
- Developed methods and prototype software to estimate the parameters of generator dynamic models using field test results (Power Plant Parameter Derivation (PPPD))
- Developed Probabilistic Risk Assessment (PRA) methodology and tools
- Developed Probabilistic Load Flow (PLF) program for identifying the potential overloaded transmission lines with consideration of future generation and load uncertainties
- Developed transmission reliability evaluation tool (TRELSS)
- Developed power system analysis package (PSAPAC) that can analyze power flow, voltage stability, small signal stability, and dynamic stability

- Developed component-base load modeling tool (LOADSYN)
- Supported NERC through technology investigation, white paper publication, and joint workshops

Current Year Objectives

- Model reduction workshop and guidebook
- Technical report on CIM/GID interoperability tests in conjunction with current IEC revisions
- *Methodology of Sensitivity Studies for Transmission Planning* technical update
- ERO Reliability Standards technical conference
- Technical report on transmission network design to manage short-circuit issues
- Technical report on economic aspects of advanced transmission technologies
- Function specification of next generation PMU

Industry Involvement

- Estimated 2009 funding: \$1.5M

Program Technical Lead

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Summary of Projects

PS40A Modeling and Standardization (067425)

Project Set Description: The modeling and standardization project set is to help system planners improve modeling and data preparation capabilities

Project Number	Project Title	Value
P40.001	Load and Generator Modeling	This project will finalize and implement the load and generator modeling approaches. This project will complete system validation utilizing measured system data collected over a two-year period and make any necessary adjustments to load and generator modeling methodologies. The project will also finalize revision of load class to model component mapping for the load modeling tools. In addition, this project will upgrade prototype Load Model Parameter Derivation (LMPD) and PPPD software tools to commercial-grade through the EPRI SET process.
P40.002	The CIM Standard Development Activities for Transmission	This project will continue the work EPRI has done on developing the CIM standard. This project will work within multiple areas and will provide direction to extending the CIM where necessary. It will also assist members in providing the data sharing design among both applications and systems that meet the IEC standards. EPRI will provide initial help to guide utilities in developing flexible designs for data sharing projects. EPRI will utilize its team of CIM and technical experts to work with IT departments and operational departments regarding the state of the art available in the industry.

Project Descriptions

P40.001 Load and Generator Modeling (067447)

Issue

Utilities and system operators across North America are engaged in efforts to better plan and operate their transmission systems. Developing and maintaining simulation-based planning models that accurately represent the behavior of the system is obviously critical to these efforts. Furthermore, NERC is in the process of specifying requirements for validating planning models. System planners must determine the load and generator modeling and validations methods and processes that provide for reliably planning their systems in the most economical manner.

Description

EPRI has responded to load and generator modeling needs through separate research efforts in previous years. In 2008, EPRI is finalizing the development of a hybrid load modeling methodology that combines the strengths of the measurement-based and component-based approaches. Similarly, in 2008, EPRI is evaluating whether the generator testing and model validation methods implemented through the Power Plant Parameter Derivation (PPPD) software can be extended to utilize permanent disturbance-based measurement data in place of staged test data.

In 2009, this project will finalize and implement the load and generator modeling approaches. EPRI will work with the project funders to accomplish the following:

- Completing system validation utilizing measured system data collected over a two-year period, and making any necessary adjustments to load and generator modeling methodologies.
- Finalizing revision of load class to model component mapping for the load modeling tools, which may include incorporating test data of specified end-use devices.
- Upgrading prototype Load Model Parameter Derivation (LMPD) and PPPD software tools to commercial-grade through the EPRI SET process

Value

- Improved system reliability derived from improved planning models
- Lower costs in meeting NERC model validation requirements by utilizing developed methods and tools rather than consultants
- Increased staff expertise derived from internal model development and validation rather than outsourcing to consultants

How to Apply Results

Transmission planners will utilize the developed modeling methods and tools to obtain load and generator models in their existing planning software platforms to conduct power flow and stability simulations to ensure reliable and economical grid operation that meets anticipated future demand. The tools will allow planners to validate and revise the models on an on-going basis to satisfy NERC model validation requirements.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
EPRI Load and Generator Modeling Implementation Report: A final report detailing all research conducted as part of the project will be produced. This report will include the results of additional validation and model development adjustments, additional efforts to refine the load composition database and associated mapping to load model structures, and changes to the associated LMPD and PPPD software tools.	12/31/2009	Technical Report
LMPD Software: Final implementation version of LMPD software with associated documentation	12/31/2009	Software
PPPD Software: Final implementation version of PPPD software with associated documentation	12/31/2009	Software

P40.002 The CIM Standard Development Activities for Transmission (062082)

Issue

Most utilities have disparate applications and systems within their operations that prevent easy data exchange both within departments and across system boundaries. The Common Information Model (CIM) is an international standard approved by the International Electrotechnical Commission (IEC), and provides the only power system information model available covering the power system from the customer meter to the transmission system. Accompanied by the associated Generic Interface Definition (GID) standard, the CIM allows a utility to add new or upgrade old applications while providing long-term data exchange capabilities within a system (e.g., an EMS), between systems (e.g., EMS to DMS to CIS), or between utilities.

Description

This project will continue work EPRI has done on developing the CIM standard. It will also work within multiple areas and provide direction to extending the CIM where necessary, and assist members in providing the data sharing design among both applications and systems that meet the IEC standards. EPRI will provide initial help to guide utilities in developing flexible designs for data sharing projects. EPRI will utilize its team of CIM and technical experts to work with IT departments and operational departments regarding the state of the art available in the industry.

Value

- Supports IEC technical working groups developing additions and revisions to the CIM Standard affecting the transmission community
- Reduces costs and stabilizes cash flow for participants by providing alternatives to replacing aging systems using CIM capabilities
- Fosters ongoing development and improvement of vendor system designs through the performance of annual independent interoperability tests
- Enables greater data sharing capabilities and streamlines data entry
- Provides guidance for implementations and expert help to address CIM evaluations and expansion

How to Apply Results

Utility control center information technology project managers, operators, and transmission planners will use the tools and knowledge produced in this project to apply the CIM Standard within their organization. This application will help members anticipate future requirements for upgrades to their energy management systems and integration of advanced applications. In addition, as the standard is revised to incorporate additional areas where necessary, standard committees will be notified and potential revised standards will be written. Participants will be able to use the tools and products from this research through tutorials, training courses, and collaborative application services. Projects will utilize portions of the latest CIM design standard; as necessary, new extensions will be designed and submitted to the IEC for addition to the standard. In general, application of the results of such a project will require assistance from EPRI, which is usually provided through supplemental funding by members.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Conduct industry CIM/GID interoperability tests in conjunction with current IEC revisions: The interoperability test validates the use and acceptance of the CIM standard. This report describes a set of interoperability tests that demonstrated the exchange of complete and incremental power system models and proved the validity of the updated CIM standards as provided by the International Electrotechnical Commission (IEC) working groups.	4/1/2009	Technical Report

PS40B Reliability Assessment & Standards (067426)

Project Set Description: The reliability assessment and standards project set helps system planners assess the reliability of future transmission networks, taking into account the uncertainties of generation, load and market. It will also help system planners meet ERO standards and compliance.

Project Number	Project Title	Value
P40.003	Advanced Transmission Reliability Assessment and Planning Tools	This research project will develop methods to perform advanced probabilistic reliability assessment for comparing alternative transmission expansion plans over the wide ranges of Category A, B, C and D contingencies, to quantify the expected consequences of extreme events so that alternative transmission expansion plans will be compared over the entire range of the Reliability Performance Curve.
P40.004	ERO Standards, Compliance and Best Practices	This project will set up a forum for EPRI members and other interested parties to regularly meet through conferences, conference calls, or webcasts to discuss current issues related to the ERO and electric reliability standards. Work will be done to propose new standards, improve or revise existing standards, and perform research to support these changes in reliability standards. A technical conference will be held each year to disseminate the information from this project to the public and regulators.

Project Descriptions

P40.003 Advanced Transmission Reliability Assessment and Planning Tools (062079)

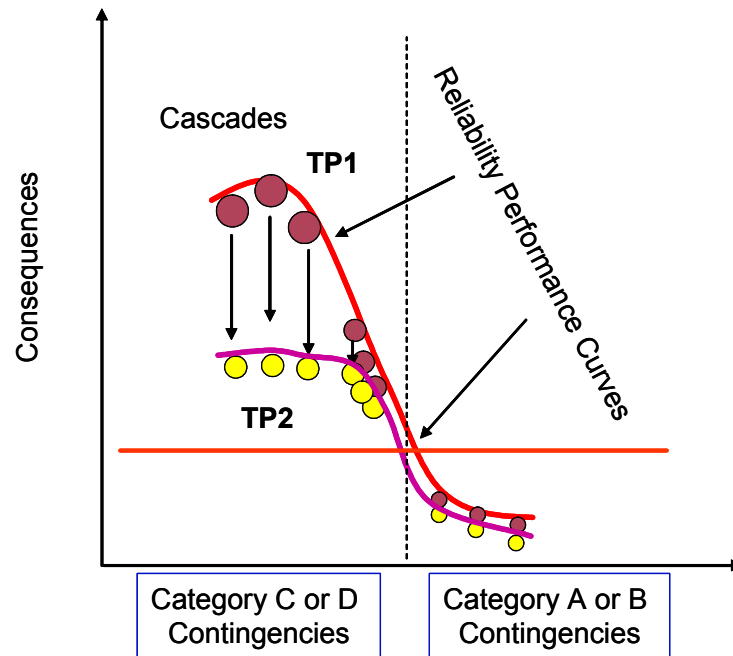
Issue

After the North American Electric Reliability Corp. (NERC) became the Electric Reliability Organization (ERO), the Federal Energy Regulatory Commission (FERC) directed NERC to develop version 1 of a comprehensive set of reliability standards, indicating a need to raise the bar on them. In response, NERC and the standard drafting teams are developing new reliability standards. The industry's move from deterministic transmission planning criteria to probabilistic criteria will result in a transition period. Also, as NERC implements the collection of transmission outage statistics, there will be good probability data available to enable probability reliability assessment (PRA) studies to be performed with credible data sources. New tools and transmission reliability assessment and planning methods are needed to enable transmission planners to conduct studies that comply with whatever reliability criteria will be adopted. The direction of these emerging reliability standards is toward more comprehensive assessment of single and multiple contingencies with or without cascading effects, with ranges of consequences in terms of overloads, voltage violations, and load curtailments to prevent voltage collapse.

Description

This research project is a new project that builds on EPRI's previous successful research in Probabilistic Reliability Assessment (PRA), probabilistic load flow, probabilistic congestion forecasting, critical operating constraints forecasting, Holistic Planning, and the Community Activity Room. The fundamental innovation in this project is the inclusion of high-order and dependent contingency conditions that are potential cascading modes into the reliability assessment. Traditional methods of contingency analysis have exhaustively enumerated N-1 contingencies. Exhaustive N-2 contingency analysis is computationally feasible even for fairly large power systems. However going above N-2 will not be feasible if brute force enumeration is the only method to be used. Monte Carlo simulation of high order contingencies is also not practical because it would require an extremely large number of statistical samples to allow high-order contingencies to appear. Instead, EPRI has tested the method of judiciously identifying critical interfaces of interdependent transmission lines that may become candidates for cascading outages under stressed conditions. Such a method enables a finite set of potential cascading modes to be identified. Then the need to simulate such high-order contingencies can be satisfied by simulating a finite set of them. By associating the probabilities of the initiating events and the probabilities of each tier of cascade happening, it is possible to estimate the probabilities of these cascading events. For each tier of cascade, it is possible to estimate the consequences by the amount of load curtailment needed to prevent the cascade from going to voltage collapse. Thus, it has been shown to be feasible to perform a PRA analysis of a transmission grid for the potential cascading modes and to relate these PRA indices with the loading level or the stresses on the power grid.

With this extended approach for PRA, which includes high-order contingencies with or without cascading effects, the problem of transmission reliability assessment and planning is transformed into an approach which lends itself to the quantification of the property of "robustness." A robust transmission grid exceeds the requirements that no overloads or no unsatisfactory voltages occur after N-1 or N-2 contingencies. A robust transmission grid should also contain or limit its exposure to cascading outages. The idea is shown in the following figure.



Comparing the two transmission plans TP1 and TP2 in the figure, TP2 is more robust. Although both satisfy current NERC criteria in that they show no overloads or adverse consequences for all Category A and B contingencies, the two plans exhibit different performances or consequences for extreme event Category C or D contingencies. TP1 shows much greater consequences on the cascading events than TP2.

This research project will develop methods to perform advanced probabilistic reliability assessment for comparing alternative transmission expansion plans over the wide ranges of Category A, B, C and D contingencies, and quantify the expected consequences of the extreme events so that alternative transmission expansion plans will be compared over the entire range of the Reliability Performance Curve.

Value

- Enable planners to quantify the degree of robustness of a transmission grid
- Enable more comprehensive reliability assessment of transmission plans
- Enable planners to meet and exceed existing reliability standards

How to Apply Results

The advanced probabilistic reliability assessment method can be directly used by utilities, independent system operators (ISOs) and regional transmission organizations (RTOs) to evaluate the robustness of their transmission plans and the extent to which they satisfy existing NERC reliability standards.

EPRI will offer supplemental project opportunities to apply the methods and tools developed through this project to help members perform expansion planning studies and design economical, efficient, reliable, and robust transmission systems.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Guidebook on Advanced Transmission Reliability Assessment and Planning: A report containing guidelines on how to perform advanced transmission reliability assessment and transmission planning to ensure that the transmission system is robust and satisfies holistic reliability criteria.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Methodology for Advanced Transmission Reliability Assessment and Planning: The technical update will provide detailed information on the methodology for advanced transmission reliability assessment and planning, with example case studies for illustration.	2010	Technical Update
Tools for Advanced Transmission Reliability Assessment and Planning: The software will provide the tools to apply the methodology for advanced transmission reliability assessment and planning, with example case studies for illustration.	2011	Software

P40.004 ERO Standards, Compliance and Best Practices (065351)

Issue

As a result of the U.S. Energy Policy Act of 2005 (EPAAct), previously voluntary reliability programs administered by the North American Electric Reliability Corp. (NERC) are transitioning to mandatory standards under the Federal Energy Regulatory Commission (FERC), with substantial financial penalties for non-compliance. FERC certified NERC in 2006 as the Electric Reliability Organization (ERO) with full oversight for enforcing reliability standards compliance, while retaining full authority to approve all reliability standards. To date, NERC has submitted more than 100 standards to FERC for approval; many have been approved, while numerous others await approval pending further refinement. Many approved standards received conditional approval and require further updating. Any entity involved in producing, transporting and distributing electricity must comply with these new mandatory reliability standards.

Description

This project will set up a forum for EPRI members and other interested parties to regularly meet through conferences, conference calls, or webcasts to discuss current issues related to the ERO and electric reliability standards. Work will be done to propose new standards, improve or revise existing standards, and perform research to support these changes in reliability standards. A technical conference will be held each year to disseminate the information from this project to the public and regulators.

Value

- Improve the usefulness of reliability standards through extensive industry discussions from various perspectives
- Provide a collaborative forum for the industry to develop and enhance reliability standards, through objective and scientific research, sharing of experiences, and documentation of case studies

- Bring forth best practices from various reliability entities to enable sharing of lessons learned
- Enable regulators and the public to learn about the industry's proactive efforts to enhance reliability standards

How to Apply Results

Participation in the technical conference will provide utility planners and operators with the opportunity to learn from other utilities about their experiences and feedback on ERO reliability standards. These experiences, best practices, and case studies from all organizations with an interest in reliability standards will be documented in conference proceedings or presentations. Project participants may proactively propose new approaches for the ERO reliability standards. Research results will be available to members through regular task force meetings, conference calls, webcasts and a public conference.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Technical Conference on ERO Reliability Standards: Technical Conference on ERO Reliability Standards: Conference on ERO reliability standards, best practices, and case studies.	12/31/2009	Workshop, Training, or Conference

PS40C Engineering Study and Economic Assessment (067427)

Project Set Description: The engineering study and economic assessment project set helps system planners solve specific engineering issues and perform economic assessment.

Project Number	Project Title	Value
P40.005	Economic Assessment of Advanced Technologies with case study examples	While numerous advanced transmission technologies have been developed and field demonstrated, there is still uncertainty as to which technological solution is most appropriate for a specific location or function. How can the benefits and costs of using these advanced technologies be quantified? How do these advanced technology options compare with traditional upgrades in specific cases? This project will evaluate the economics of more effective management and control of transmission grids with the appropriate deployment of advanced transmission technologies.
P40.006	Next Generation PMU	Phasor Measurement Units can be viewed as a new technology that enables major advances in power system operation, protection and maintenance. However, the configurations and data transmitting protocols are still 10-year techniques. Current PMUs lack the necessary security, remote configuration, class of service and other services that would allow for broad dissemination of data. This project will gather industry inputs and develop the functional specifications on the next generation PMU.
P40.007	Integrated Resource Planning	This project develops and demonstrates an integrated planning methodology that combines existing planning methods in generation, transmission, and distribution to achieve the proper balance between centralized and decentralized planning.

Project Descriptions

P40.005 Economic Assessment of Advanced Technologies with case study examples (065551)

Issue

The transmission system has been described as the most complex machine ever devised. Its management increases in complexity as the marketplace continues to evolve, incorporating a greater diversity of resources and squeezing out new efficiencies. While numerous advanced transmission technologies have been developed and field demonstrated, there is still uncertainty as to which technological solution is most appropriate for a specific location or function. Existing advanced technologies include power-electronics-based transmission controllers and converting existing AC lines into HVDC transmission or building new HVDC lines.

- How can the benefits and costs of using these advanced technologies be quantified?
- How do these advanced technology options compare with traditional upgrades in specific cases?

Description

The objective of this project is to evaluate the economics of more effective management and control of transmission grids with the appropriate deployment of advanced transmission technologies. The project will focus on the following:

- Modeling the use of advanced technologies to increase grid capacity, robustness, and integrity in areas of “weak” buses and transmission corridors.
- Focused studies and analysis coordinating the application of technically and economically viable technologies.

Economic assessments of comparable technologies utilizing detailed models of the alternative transmission components are conducted as follows:

- Derive information for small-scale case studies.
- Form appropriate models to determine economic cost and benefit of advanced and traditional enhancement options.
- Conduct training and webcasts to transfer this technique to practitioners.

Value

- Provides an economic basis for strengthening grids and deferring investment in new transmission.
- Documents improvements in robustness of the transmission grid through the application of technology-based tools
- Provides a method to forecast reduced risks of major outages
- Demonstrates how advanced technology can relieve transmission bottlenecks and extend the reach of competitive generation
- Helps quantify higher quality maintenance, protection, and operation information for increased robustness and integrity of transmission grids

How to Apply Results

Project reports and case studies will help transmission planners include advanced transmission technologies in their menu of options for enhancing the transmission grid in the future. They will learn how to develop business cases documenting the potential benefits of applying these advanced technologies. By knowing about these potential options, transmission planners will ensure that their transmission plans include all options that could make the transmission grid more reliable and operate with higher performance and efficiency, ensuring that their companies will be regarded as best-of-class transmission companies.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Economic Assessment of Advanced Transmission Technologies: Technical and Economical Aspects of Robust Configured and Managed Electric Grids: Development of highly utilized and robustly structured transmission grids, implementing new transmission technological concepts such as HVDC technology, segmentation techniques, voltage-sourced converter-based ties and links, and power-electronics-based transmission controllers (FACTS technology).	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Case Studies of Advanced Transmission Technology Deployment	2010	Technical Report

P40.006 Next Generation PMU (067448)

Issue

Wide Area Measurement System (WAMS) can be viewed as a new technology that enables major advances in power system operation, protection, and maintenance. Key building blocks of WAMS are Phasor Measurement Unit (PMU) and Phasor Data Concentrators (PDC). However, the configurations and data transmitting protocols are still 10-year techniques. Current PMUs lack the necessary security, remote configuration, class of service, and other services that would allow for broad dissemination of data.

Description

The next-generation PMU is a new research project starting in 2009. Its objective is to gather industry inputs and develop the functional specifications on the next generation PMU.

Task 1: Organize workshop to gather industry input on the requirements for next-generation PMUs.

Task 2: Develop functional specifications for the next-generation PMU. The project team will consider the following issues:

- Remote Control Function
- Communication Protocol
- Data Management
- Security

Developing the next-generation PMU requires multi-year research efforts. The future R&D direction will be influenced by members.

Value

- More cost effective maintenance of PMU
- Improved management of PMU
- Improved PMU security
- Improved data management

How to Apply Results

This project will identify features and functions that members may use to influence future purchase specification requirements for PMUs from vendors.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Development of Next Generation PMU features: This technical report will document the features and attributes essential to the next-generation PMU that will deliver an enhanced remote control function, communication protocol, data management, and security.	12/31/2009	Technical Report

P40.007 Integrated Resource Planning (067449)

Issue

Utilities are evolving, driven by changing regulatory structures, high energy prices, and the introduction renewable resources and energy storage. Well-placed capacity additions can reduce uncertainty, overall system costs, and long-term investment risks across generation, transmission, and distribution-level systems.

Description

This project will investigate ways to provide financial signals in a deregulated environment to help IPPs plan and build generation at the right time and place to achieve the global optimization results needed in an integrated regulated environment. The approach combines existing planning methods in generation, transmission, and distribution to achieve the proper balance between centralized and decentralized planning. This project will coordinate efforts across other EPRI planning programs to

- Develop an integrated planning methodology from existing planning resources
- Test the method on a realistic example utility to prove the concept, and to explore the criteria for positive benefits.

Value

Transmission companies (utilities, ISOs/RTOs) will gain the ability to provide IPPs, generation companies, and load aggregators with the analytical data needed to build new system resources in the right location at the right time, so that the benefits of overall system investments are maximized in the long term. The integration process

- Focuses on economic and technical benefits, costs and risks.
- Improves communication, enhances teamwork, and produces better solutions to old problems
- Improves the work of separate planning groups by incorporating related perspectives into each decision area.
- Gives participants a more global perspective of business operations and the ability to make better informed decisions.

How to Apply Results

Members can follow the documented process, which identifies key information exchanges and impacts on separate planning processes. Data collection is specified to the level of detail needed for each planning exercise to be able to incorporate the costs and benefits of the others. This distributed yet integrated exercise involves individual planners quantifying and communicating what is important to their processes and having the ability to quantify and understand how others will be impacted by small changes to their

own plans. This project shows how to integrate investments to strike the best balance between local and system-wide issues.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
The Practice of Integrated Resource Planning: This report develops and demonstrates an integrated planning methodology centering on transmission planning to provide temporal and locational signals for new system resources to ensure system reliability and long-term economic benefits. The report documents how existing planning methods in generation, transmission, and distribution can be individually enhanced and coordinated to achieve a proper balance between centralized and decentralized planning.	12/31/2009	Technical Update
