172 Efficient Transmission and Distribution Systems for a Low-Carbon Future

Program Overview

Program Description

This program builds upon the work completed in 2008 when this program was launched. In 2008, EPRI developed the technical foundation and analytical framework for increasing transmission and distribution system efficiency to reduce the industry's overall greenhouse gas footprint. The program is helping utilities prepare for operating in a carbon-constrained business environment and dealing with related impacts on transmission and distribution (T&D) system operation, maintenance, and planning. Key R&D activities include integrating energy efficiency and demand response into a comprehensive planning process; assessing the costs, benefits, and performance of technologies capable of reducing T&D losses; and assessing the implications of climate change on future T&D systems to improve risk management of assets and improve reliability modeling.

Industry Needs and Issues Addressed

- Assess various methods for evaluating average T&D losses and the temporal and spatial variation of T&D losses
- Assess the value of reducing losses on T&D systems to limit carbon emissions
- Develop consistent and verifiable methods for quantifying the CO_2 reduction potential from various T&D loss-reduction methods
- Quantify costs, benefits, and risks of including energy efficiency and demand response resources in transmission planning processes
- Integrate energy efficiency and demand response resources into T&D planning processes
- Apply consistent and verifiable criteria for comparing energy efficiency and demand response resources with other traditional "wires" alternatives to meet growing demand
- Assess implications of climate change (for example, increase in frequency of extreme weather, longer sustained high temperatures and humidity conditions) on T&D system design, planning, operation, and maintenance

Impact

- Demonstrates utility commitment to environmental issues through more efficient use of T&D resources
- Provides a framework for loss reduction on T&D systems, resulting in financial savings for utilities and improved life expectancy of equipment
- Helps utilities prepare for operating in a carbon-constrained business environment and dealing with related impacts on T&D system operation, maintenance, and planning
- Defers capital costs associated with new T&D construction
- Supports regulatory actions with regard to energy efficiency mandates or monitoring
- Provides possible contribution to utility CO_2 emission reductions and overall greenhouse gas footprint
- Improves risk management of assets to better prepare for climate change

Key Accomplishments

- Credible assessment of technology and cost to improve transmission and distribution system efficiency
- Best practices report on integrating dynamic energy management into T&D planning
- Methods to quantify CO_2 reduction potential from various T&D loss reduction methods

- Validation of existing loss estimation algorithms against actual calculated losses through case studies and detailed simulations

Current Year Objectives

- Assessments to quantify temporal and spatial variation in losses across T&D systems
- Strategic intelligence and technology watch newsletters
- Quantification of costs, benefits, and risks of using energy efficiency and demand response in T&D planning
- Case studies on energy efficiency and demand response in deferring T&D infrastructure buildup
- T&D system efficiency technology assessments and cost feasibility
- Workshops on potential impacts of irreversible warmer temperature and humidity, or other extreme weather conditions, on T&D operations, maintenance and planning practices
- Strategy report on the impact of climate change on T&D systems

Industry Involvement

- Estimated 2009 funding: $1.4M

Program Technical Lead

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Summary of Projects

PS172A Efficient Transmission System (065412)

Project Set Description: Adequate transmission capacity is a critical element to ensure overall grid reliability and proper functioning of electricity markets. However, building new transmission infrastructure is more difficult than ever. Increasing the efficiency of existing transmission systems, and integrating energy efficiency and demand response as part of the overall transmission planning process, could defer the need for new transmission infrastructure and reduce the CO_2 footprint of the electricity sector.

Utilities are under increasing pressure to evaluate all possible options to meet growing demand and energy transfer requirements. When load growth forecasts show that capacity limits of the existing transmission system may be exceeded, prudent planners evaluate both block and incremental solutions for providing energy. While a new transmission line or a new substation can add significant capacity, it also requires substantial capital investment. Deferring that investment for several years, or even indefinitely, by applying alternative solutions to meet demand could potentially save millions of dollars.

This project set builds on the work started in 2008 and continues to focus on constructing and operating more efficient transmission systems and integrating demand response and energy efficiency resources into a comprehensive planning process. The three projects comprising this set address all aspects of an efficient transmission system, including: reducing losses with new technologies, integrating non-wires alternatives into the planning evaluation process, and providing comprehensive risk management strategies for transmission systems in a business environment with carbon constraints.

Transmission engineers can use the knowledge contained in the project findings and products to reduce losses, support transmission and distribution planning, respond to regulatory and other outside stakeholder inquiries, evaluate available technologies, and inform senior management on technologies that could impact business operations.

Project Number	Project Title	Value
P172.001	Transmission System Loss Evaluation, Reduction: Technical and Economic Assessment	This project provides objective investigation, analysis, and strategic measures to assess costs, benefits, and performance of various technologies and methods capable of reducing losses on transmission systems and equipment. Participation demonstrates members' commitment to environmental issues through more efficient use of transmission resources. The project can help reduce utility CO_2 emissions and overall greenhouse gas footprint as well as electrical losses, resulting in financial savings and improving equipment life expectancy. In addition, this project supports regulatory actions related to energy efficiency mandates or monitoring.
P172.002	Integrating Energy Efficiency and Demand Response in Transmission Planning: Technical, Economic and Risk Assessment	This project builds upon work conducted in 2008 to develop a consistent process for integrating energy efficiency and demand response resources into traditional transmission planning processes. Project activities support a fair evaluation of demand response and energy efficiency options alongside traditional wires solutions, based on economic and technical merit. Members gain the ability to support planning decisions to technical and non-technical stakeholders, and benefit from the potential deferral of capital costs associated with new transmission construction. This project enables the implementation of energy efficiency and demand response programs to meet load growth, reduce dependence on fossil-fuel-based generation, and reduce CO2 emissions. It also helps participants promote cost-effective energy consumption options to customers, leading to reduced energy costs.
P172.003	Implications of Climate Change on Future Transmission Systems	This project provides strategic information to assess the implications of climate change on transmission systems and develop risk management strategies. It can help members improve asset risk management to better prepare for carbon-constrained transmission technologies, lower their CO_2 emissions and overall greenhouse gas footprint, and improve reliability modeling, making performance more reliable. The project also helps improve the life expectancy of major transmission components through enhanced loading practices, reduce CO_2 generation through true integrated resource planning, and improve load forecasting and reliability through feeder load relief.

Project Descriptions

P172.001 Transmission System Loss Evaluation, Reduction: Technical and Economic Assessment (065414)

Issue
Utilities need strategic and objective information on loss evaluation for reducing transmission system losses, as well as equipment using technology-based solutions.

Description
This project provides objective investigation, analysis, and strategic measures to reduce losses on transmission systems and equipment through the following activities:

- Developing industry-accepted methods for evaluating transmission losses by taking the following steps:
    - Comparing transmission loss study approaches used by transmission companies and RTO/ISO.
    - Developing efficiency accounting methodology
    - Selecting the most appropriate approach for adoption
- Developing a value proposition, from a technical and economical perspective, for implementing the following practical means of reducing losses in transmission systems and equipment:
    - Evaluating the potential of replacing existing conductors with HTLS conductors to reduce transmission losses.
    - Optimizing voltage profiles in systems, particularly during heavy load conditions, to reduce losses by using optimally located shunt capacitors/reactors, series capacitors/reactors, and secondary voltage regulation on generators to maintain higher voltage profiles at key transmission nodes..
    - Leveraging reactive power management (for example., improving load power factor and placing dynamically controlled reactive power sources such as SVCs and STATCOMs at large load centers remote from generation). These dynamic controlled reactive power compensators could be specifically designed to meet the dual objectives of improving voltage instability and reducing losses in transmission systems and equipment.
    - Utilizing power-electronics-based transmission controllers for power flow distribution to reduce megawatt losses on transmission corridors.
    - Utilizing optimal power flow analysis techniques to optimize voltage schedules, transmission substation transformer taps, and taps on phase-shifting transformers to minimize losses.
    - Evaluating the potential for reducing losses by eliminating congestion.
    - Evaluating the potential for upgrading lines to higher ac voltage levels to reduce losses.
    - Evaluating the potential to locate generation assets, such as peaking units and distributed generation, closer to load and thus reduce transmission losses.

Value

- Demonstrates member commitment to environmental issues to regulators and the general public through more efficient use of transmission resources
- Reduces utility CO_2 emissions and overall greenhouse gas footprint
- Reduces electrical losses, resulting in financial savings for members and improved life expectancy of some equipment
- Supports regulatory actions related to energy efficiency mandates or monitoring

How to Apply Results
Transmission engineers can use the knowledge contained in the project findings and products to reduce losses, support transmission planning, respond to regulatory inquires, evaluate available technologies, and inform senior management on technologies that could impact business operations.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Strategic Intelligence and Technology Watch Newsletters: Core products include strategic intelligence reports, technology assessments, and online assessment guides. New assessments, tools, and tests will be developed with advisors.	12/31/2009	Technical Update
Transmission System Efficiency Technology and Methodology Assessment: The technical report investigates practical means to lower transmission losses and document industry experience. The report provides quantifiable measures to assess the impact of loss reductions on energy efficiency improvements.	12/31/2009	Technical Report

P172.002 Integrating Energy Efficiency and Demand Response in Transmission Planning: Technical, Economic and Risk Assessment (065413)

Issue
Transmission and generation planners are tasked with ensuring that systems meet forecasted load growth in the most economical manner while maintaining specified reliability criteria. Planners evaluate various options for addressing growth in specific system areas that may result in load loss and increase the risks of failing reliability targets. They compare these options on several bases including technical merit, cost, and environmental/social impacts. More than ever, planners face competing goals and interests as system reliability increases in importance while environmental considerations limit the resources available to meet future system needs.

Altering system demand by implementing energy efficiency (EE) and demand response (DR) programs is an increasingly attractive capacity alternative considered by planners. However, questions still remain as to how planners can incorporate these options into the overall planning process while ensuring system reliability.

Description
This project will build on the work in 2008 and complete development of a consistent process for integrating EE and DR resources within the long-term supply capacity planning and operational planning processes. The 2008 project P172.002 provided a similar methodology development process for utilizing EE/DR resources for transmission delivery capacity planning. Although many of the questions addressed by generation/operational planners differ from transmission planning, the EE/DR capability data developed in 2008 will support the supply capacity planning method development. This project will provide planners an integrated framework for considering EE and DR resources and quantify the overall risks associated with these alternatives. The utility advisors group will direct particular activities conducted as part of the 2009 research. Research areas could include:

- Research to quantify costs, benefits, and risks of using EE and DR resources as long-term supply capacity options for meeting demand at specified reliability levels
- Representation of EE/DR options in generation expansion models

- Research to quantify costs, benefits, and risks of using EE and DR resources for operating reserves, such as regulating and contingency spinning.
- Assessment of the ability to accurately measure and verify adoption of EE and DR programs within the timeframe that a specified load reduction is required
- Case studies to assess actual performance of EE and DR measures in deferring transmission infrastructure buildup

Value

- Defers capital costs associated with new traditional generation
- Enables implementation of energy efficiency and demand response programs to meet load growth, reduce dependence on fossil-fuel-based generation, and reduce CO_2 emissions
- Promotes cost-effective energy consumption alternatives to customers, leading to reduced energy costs

How to Apply Results

Asset managers, generation and operational planners, and energy efficiency program managers can use the framework to quantify risk in utilizing energy efficiency and demand response resources for their specific demographics.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Lessons Learned: Evaluating Energy Efficiency and Demand Response Technologies as Supply Capacity Resources: Report will provide a consistent process for utilizing EE/DR resources for transmission delivery capacity planning.	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Energy Efficiency and Demand Response Implementation to Defer Capital Construction Costs: the Business Case: Begin Typing Here	2010	Technical Report

P172.003 Implications of Climate Change on Future Transmission Systems (065415)

Issue

As transmission systems become more constrained with increasing load growth and demand, concerns about the impact of frequent and extreme weather conditions—both hot and cold—increase. This project builds on work in 2008 related to the impact of extreme weather conditions on component failures and on forecasting methods. The 2009 project will address the effects of extreme weather conditions on transmission design criteria, required equipment capabilities, challenges in maintenance and strategies to accommodate them, and the economic implications of maintaining reliability at acceptable values. Since these may require changes in well-established paradigms, work will focus on minimizing disruption and economic impact.

Description
Based on results of 2008 work, this project will address changes in the following areas:

- Transmission systems designs needed to accommodate stresses of extreme weather conditions, including higher flows. Issues to be considered will be security of the grid, increased losses, depressed voltages, and stressed equipment.
- Changes in equipment capabilities to accommodate higher loads for prolonged periods.
- Changes in maintenance strategies, which are based on knowing the risks involved and using that knowledge to establish priorities and strategies for successful and economical maintenance management. This risk-based focus can be used to establish capital and expense allocations to preventive, predictive, and reactive maintenance management decisions that could be unique to extreme weather conditions.

Value
- Improves reliability during extreme weather conditions
- Reduces CO_2 emissions and overall greenhouse gas footprint
- Improves life expectancy of transmission components via enhanced loading practices
- Prepares members for new paradigms in planning and maintenance of transmission systems

How to Apply Results
Asset managers, energy efficiency program managers, and transmission engineers can apply project findings and products to define computational tools requirements, planning and integrated planning changes, changes needed in operations and maintenance, and training and personnel skill sets required.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Technology Risk Management Strategies for Transmission Systems in a Carbon-Constrained World: This product addresses the effects of extreme weather conditions on transmission design criteria, required equipment capabilities, challenges in maintenance and required strategies to accommodate them, and the economic implications of maintaining reliability at acceptable values. Since these may require changes in well-established paradigms, work will focus on minimizing disruption and economic impact.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Impact of Climate Change on Transmission Systems: Begin Typing Here	2010	Technical Report
Technology Risk Management Strategies for Transmission Systems in a Carbon-Constrained World: Begin Typing Here	2010	Technical Report

PS172B Efficient Distribution System (065416)

Project Set Description: There may be significant potential to reduce distribution losses and take advantage of demand response infrastructures to manage distribution systems more efficiently. These measures can directly reduce the greenhouse gas impacts of distribution system operation. Furthermore, these measures can significantly reduce investment requirements for distribution system expansion. Better analysis and planning tools are needed to include evaluation of efficiency improvements and demand response impacts on the need for additional distribution capacity and on the greenhouse gas impacts of system operation. This program builds upon the work begun in 2008 and will continue to focus on these evaluations, the tools for performing the evaluations, and the effect of distribution efficiency on reducing the CO_2 footprint of the electricity sector.

Project Number	Project Title	Value
P172.004	Distribution System Loss Evaluation, Reduction: Technical and Economic Assessment	This project provides objective analysis and strategic planning information on distribution system losses and distribution equipment efficiency, accompanied by annual technology assessments and strategic intelligence reports. Participation demonstrates members' commitment to environmental issues through more efficient use of distribution resources. The project can help reduce utility CO_2 emissions and overall greenhouse gas footprint as well as electrical losses, resulting in financial savings and improving life expectancy for some equipment. In addition, this project supports regulatory actions related to energy efficiency mandates or monitoring.
P172.005	Integrating Energy Efficiency and Demand Response in Distribution Planning: Technical, Economic and Risk Assessment	This project aids planners in developing an integrated framework for considering energy efficiency and demand response as part of traditional distribution planning processes. Furthermore, the project begins to quantify the overall risks associated with these alternatives. Project results can help defer capital costs associated with new distribution construction and enable the implementation of energy efficiency and demand response programs to meet load growth, reduce dependence on fossil-fuel-based generation, and reduce CO_2 emissions. This project also helps members promote cost-effective energy consumption options to customers, reducing energy costs.
P172.006	Implications of Climate Change on Future Distribution Systems	This project provides strategic information to assess the impact of climate change, such as unusual weather patterns and more extreme weather conditions, on distribution systems. Project activities improve reliability modeling, resulting in higher-reliability performance during extreme weather events, and reduce CO_2 emissions and overall greenhouse gas footprint. In addition, project activities can improve the life expectancy of distribution components through enhanced loading practices, and improve load forecasting and reliability through feeder load relief.

Project Descriptions

P172.004 Distribution System Loss Evaluation, Reduction: Technical and Economic Assessment (065418)

Issue
Utilities need strategic and objective information on controlling distribution system losses, implementing energy efficiency initiatives, controlling voltage and VAR, improving management of transformer losses, and easily integrating energy-efficient end-use loads.

Description
This project provides objective analysis and strategic planning information on distribution system and distribution equipment efficiency. Research results include annual technology assessments and strategic intelligence reports. Building on work in 2008 on distribution loss study guidelines and accounting for efficiency improvement, a number of options are possible. A utility advisors group will direct particular activities, which may include:

- Assessing new technologies to reduce losses on distribution circuits
- Revising distribution transformer applications, design specifications/material considerations, and loading guides based on upcoming DOE standards on transformer efficiency
- Developing operational guidelines for improved management of distribution transformers
- Conducting low-loss distribution transformer research
- Using consumer modeling from automated meters to develop end-use profiles that can be connected to the utility's load management practice, enabling better decisionmaking and more efficient practices by utilities
- Using metering data to target end-use efficiency programs
- Conducting unbiased reviews of costs associated with distribution efficiency programs
- Employing state-of-the-art tools for measuring and estimating distribution losses, such as the possible use of state estimation to quantify losses, to determine where most losses occur and help evaluate options for reducing them
- Assessing emerging end-use technologies (for example, plug-in hybrid electric vehicles) to identify impacts on distribution systems
- Evaluating the effect of conservation voltage reduction programs on both distribution losses and overall system losses
- Reviewing and testing new end-use loads to identify impacts on traditional voltage control
- Evaluating the efficiency of various future distribution system architectures under consideration, such as networked systems and microgrids
- Using monitoring to evaluate distribution systems and end-use efficiency

Value
- Demonstrates members' commitment to environmental issues through more efficient use of distribution resources
- Reduces utility CO_2 emissions and overall greenhouse gas footprint
- Reduces electrical losses, resulting in financial savings for utilities and improved life expectancy of some equipment
- Supports regulatory actions regarding energy-efficiency mandates or monitoring

How to Apply Results
Distribution system engineers and planners can use the knowledge contained in the project findings and products to reduce losses, support distribution planning, respond to regulatory inquires, evaluate available technologies, and inform senior management on technologies that could impact business operations.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Strategic Intelligence and Technology Watch Newsletters: Core products include strategic intelligence reports, technology assessments, and online assessment guides. New assessments, tools, and tests will be developed with advisors.	12/31/2009	Technical Update
Distribution Efficiency Technology Assessment: The technical report investigates practical means to lower distribution losses and document industry experience.	12/31/2009	Technical Update

P172.005 Integrating Energy Efficiency and Demand Response in Distribution Planning: Technical, Economic and Risk Assessment (065417)

Issue

Distribution planners are tasked with planning their systems to meet forecasted load growth for specific feeders and substations in the most economical manner while maintaining specified reliability criteria. If future load growth in specific system areas appears likely to exceed existing capacity and increase the risk of load loss in excess of reliability targets, planners identify and evaluate options to mitigate this possibility. They compare these various options on several bases, including technical merit, cost, and environmental and social impacts. Over the last several years, distribution planners have started to consider incremental alternatives (such as distributed generation) to traditional “wires” solutions, such as building a new substation. Similarly, with the emergence of new energy efficiency and system communication technologies, planners now need to evaluate the viability of altering system demand through energy efficiency (EE) and demand response (DR) programs as opposed to building new feeders and substations.

Distribution planners may be reluctant to consider non-wires options for the following reasons:

- Lack of sufficient methods and tools for considering non-wires alternatives in an integrated manner with traditional alternatives
- Lack of planning tools to support the methods
- Absence of demonstrated ability to target EE and DR programs to achieve required load reductions on specific feeders or substations
- Inability to confirm implementation of the solution
- Inability to quantify the risks of not achieving the desired results from non-wires alternatives

Description

This project builds upon work conducted in the 2008 project P172.005 to develop a consistent process for integrating energy efficiency and demand response resources into the distribution planning process. This project further helps planner implement this integrated framework by providing for validation and verification of the method through application to specific distribution planning objectives. Furthermore, the project will provide for specific planner decisionmaking tools based on the overall framework. The advisors group will direct particular activities of the 2009 research. Research areas could include:

- Validation/verification of analytical framework for evaluating EE/DR as distribution capacity resource
- Development of associated planner decision tools
- Application of framework to specific distribution planning issues, such as evaluation and optimal

application of service transformer and conductor sizing, improved long range comprehensive land use projections, and optimal location and sizing of distribution substations
- Development of the ability to accurately measure and verify adoption of EE and DR programs during the time frame in which specified load reductions are needed

Value
- Defers capital costs associated with new distribution construction
- Enables implementation of energy efficiency and demand response programs to meet load growth, reduce dependence on fossil-fuel-based generation, and reduce CO_2 emissions
- Promotes cost-effective energy consumption alternatives to customers, leading to reduced energy costs

How to Apply Results
Asset managers, distribution planners and energy efficiency program managers can use the framework to quantify risk in deferring construction by adopting energy efficiency and demand response for their specific demography. The case studies will provide lessons learned and validation of specific choices and concomitant risks.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Lessons Learned: Implementation of Energy Efficiency and Demand Response Technologies to Defer Distribution Construction	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Energy Efficiency and Demand Response Implementation to Defer Capital Construction Costs: The Business Case	2010	Technical Report

P172.006 Implications of Climate Change on Future Distribution Systems (065419)

Issue
As distribution systems become more constrained with increasing load growth and demand, concerns increase regarding the impact of frequent and extreme weather conditions, both hot and cold. This project builds on work in 2008 related to the impact of extreme weather conditions on component failures and on forecasting methods. The 2009 project will address the effects of extreme weather conditions on distribution design criteria, required equipment capabilities, challenges in maintenance and required strategies to accommodate them, and the economic implications of maintaining reliability at acceptable values. Since these may require changes in well-established paradigms, work will focus on minimizing disruption and economic impact.

Description

Based on results of 2008 work, this project will address required changes in:

- Primary and secondary distribution system designs needed to accommodate stresses of extreme weather conditions, including higher loads and possible equipment failures. Issues to be considered will include density of feeder, load growth, reliability and continuity of service required, and spare capacity/charges for extreme operation and losses.
- Changes in equipment capabilities as dictated by higher load factors and challenging load shapes. Topics such new insulating media will be addressed.
- Changes in maintenance strategies based on knowing the risks involved and how to use that knowledge to establish priorities and strategies for successful and economical maintenance management. This risk-based focus can be used to establish capital and expense allocations to preventive, predictive, and reactive maintenance management decisions that could be unique to extreme weather conditions.

Value

- Improves reliability during extreme weather conditions
- Lowers CO_2 emissions and overall greenhouse gas footprint
- Improves life expectancy of distribution components via enhanced loading practices
- Readies members for new paradigms in planning and maintaining distribution systems

How to Apply Results

Asset managers, energy efficiency program managers, and distribution engineers can apply project findings and products to define computational tools requirements, planning and integrated planning changes, changes needed in operations and maintenance, and training and personnel skill sets required.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Technology Risk Management Strategies for Distribution Systems in a Carbon-Constrained World: The report will address the effects of extreme weather conditions on distribution design criteria, required equipment capabilities, challenges in maintenance and required strategies to accommodate them, and the economic implications of maintaining reliability at acceptable values. All these may require changes in well established paradigms, and will therefore be addressed in fashions least intrusive to approaches and strategies.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Impact of Climate Change on Distribution Systems	2010	Technical Report
Technology Risk Management Strategies for Distribution Systems in a Carbon-Constrained World	2010	Technical Report