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Transmission Efficiency Initiative

Key Findings, Plan for Demonstration Projects, and Next Steps to Increase Transmission Efficiency

1017894

Transmission Efficiency Initiative

Key Findings, Plan for Demonstration Projects, and Next Steps to Increase Transmission Efficiency

1017894

Final Technical Update: October 2009

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ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

Electric Power Research Institute (EPRI)

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CITATIONS

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PRODUCT DESCRIPTION

The electric power industry is expected to meet growing demand cleanly, reliably, sustainably, and at low cost. It also has the potential to make a major contribution to achieving a lower carbon future by improving its own energy efficiency. While energy efficiency measures have traditionally focused on end-use efficiency, the energy industry is itself the largest user of electricity in the nation; and there may be significant opportunities to realize significant efficiency gains from the Transmission and Distribution system while continuing to ensure the reliability demanded by consumers in the Internet age. To this end, EPRI is working with a number of leading utility organizations to explore needs and research gaps that could lead to reducing delivery losses in transmission, thereby improving efficiency and reducing the carbon footprint. As part of this effort, EPRI's Efficient T&D Systems research has focused on understanding technology options for potential improvements in power delivery efficiency; and a large collaborative demonstration effort, Distribution Green Circuits, is identifying and implementing a variety of distribution efficiency options and evaluating their effectiveness by comparing the results with previously established baselines. EPRI's Transmission Efficiency Initiative has the same objectives but focuses on transmission.

Results and Findings

EPRI facilitated a number of regional and international workshops championed and hosted by leading industry organizations to solicit industry input for research needs to realize higher efficiency and reduced losses in transmission. The key findings from the workshop series include:

- Efficiency is more than simply reducing losses.
- Efficiency initiatives require that reliability remains a primary focus.
- Efficient transmission will be built on the shoulders of new and upgraded systems.
- Efficiency will be part and parcel of future business cases.
- A new regulatory framework is needed to unlock efficiency improvements.

Challenges and Objectives

Collaborative effort is needed to demonstrate and evaluate technologies to identify their potential for reducing transmission losses and enhancing efficiency. Many efforts are already in progress; this project sought to share experiences among a larger collaborative and develop common demonstration protocols and loss evaluation frameworks. A shared framework may help quantify the attained savings to be included in efficiency mandates.

Applications, Values, and Use

Three focus areas for improving efficiencies have been identified:

Focus Area 1. Potential System Loss Reduction Projects: There are numerous approaches to reduce system losses. These include increasing nominal voltage (new lines or voltage upgrades), dispatch considerations to relieve flows from overloaded or higher loss lines to less congested

and/or lower loss lines, coordinated voltage control across the system to reduce VAR flow, and other means of power flow control.

Focus Area 2. Potential Line and Component Loss Reduction Projects: The key contributors to transmission losses are the lines and the substation equipment. The transformer is the principal loss contributor within the substation. Electricity providers are investigating low loss lines and configurations and low loss transformers and auxiliary equipment. Superconductivity may also be applicable in some cases.

Focus Area 3. Projects with Primary Focus on Improved Utilization: As the industry retires older less efficient assets and builds out new higher voltage and more efficient systems, increasing the utilization will allow greater throughput on existing corridors by adding storage and control technologies that will enable integration of higher levels of renewable resources.

EPRI Perspective

Transmission losses account for approximately 2% to 4% of the total electricity generated in the United States. While the percentages may appear relatively low, the total amount of energy involved is considerable, equating to about 83 million MWh to 166 million MWh lost each year based on a total US annual generation of 4,157 million MWh. These wasted megawatts are an untapped resource. Improving transmission efficiency and reducing losses effectively taps that resource and allows more of the power generated to flow to customers. Reducing system losses helps utilities defer generation and transmission investment. EPRI is working with the industry to increase the awareness of Transmission as a resource for energy efficiency, facilitate and share examples of best practice for improving transmission efficiency, and reduce transmission losses.

Approach

EPRI reached out to industry leaders to help shape research priorities in the area of transmission system efficiency, to learn what others are doing in this area, and to help design a nationwide "Transmission Efficiency Pilot" program. An executive team representing the industry was formed to provide executive input and guidance. The team then undertook the development of an exploratory series of regional workshops to learn what other companies are doing to improve transmission efficiency and help plan regional demonstration projects. One important goal is to leverage framework and methodology work already begun under R&D programs in order to develop a comprehensive evaluation methodology and strategic planning framework for technologies and entire transmission systems.

Keywords

Transmission efficiency
Transmission losses
System losses
Increased utilization

ABSTRACT

Energy efficiency is an important contributor to achieving a low carbon future. Although energy efficiency measures have traditionally focused on end-users, there may be significant opportunities for the electric industry, the largest user of electricity in the nation, to itself become more efficient. EPRI is working with a number of leading utility organizations to explore needs and research gaps in the area of reducing transmission losses and to identify steps that could lead to making our transmission system more efficient and ultimately help reduce the carbon footprint.

EPRI conducted a series of workshops, championed and hosted by leading industry organizations, which provided participants an opportunity to:

1. Understand how transmission efficiency can be a contributor to achieve a lower carbon future
2. Learn what other companies are doing to improve transmission efficiency
3. Help explore and formulate regional demonstration projects to assess opportunity to improve efficiency of transmission systems

This report provides a synthesis of the key findings and conclusions from the series of workshops, including a plan for an industry-wide demonstration effort and next steps to improving the efficiency of the transmission system.

ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of the many utility companies and executive sponsors of this series of workshops which included:

Executive Leadership Team

Arshad Mansoor, V.P. EPRI Commissioner

Jon Wellinghoff, Chairman, FERC

US Executive Steering Committee Members:

- Nick Brown, President, & CEO Southwest Power Pool
- Terry Boston, President & CEO, PJM Interconnection
- Steve DeCarlo, Sr. V.P. Transmission, New York Power Authority
- Mike Hervey, V.P. T&D Operations, Long Island Power Authority
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- Magdalena Wasiluk-Hassa, Director, Innovation & International Relations, PSE Operator
- Ian Welch, R&D Strategy Manager, National Grid

The authors would also like to acknowledge the guidance and assistance of the EPRI Advisory Committee and the Technical Steering committee for their helpfulness and constructive comments during this series of workshops.

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KEY FINDINGS, PLAN FOR DEMONSTRATION PROJECTS, AND NEXT STEPS TO INCREASE TRANSMISSION EFFICIENCY

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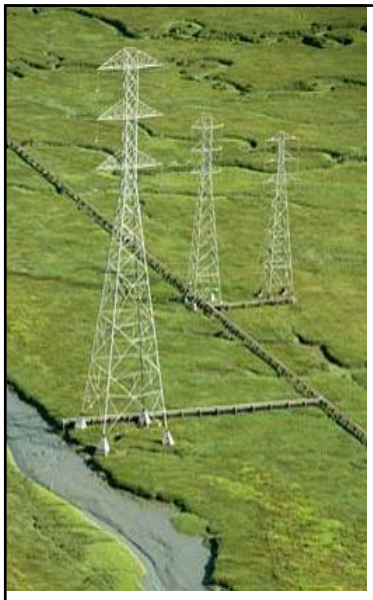

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Transmission Efficiency Initiative

Regional Workshop Series

Key Findings, Plan for Demonstration Projects, and Next Steps to Increase Transmission Efficiency

EPRI Product I.D. 1017894

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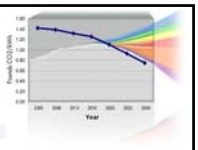
The Industry's Challenge and Expectation



The fundamental expectation of the electric power industry, in this computer-controlled, internet connected age, is to meet growing demand cleanly, reliably and sustainably, at low cost.

The current U.S. administration has called for reducing CO_2 emissions to 1990 levels by 2020, with a further 80% reduction by 2050.

Energy efficiency as policy often focuses on consumers, but the potential for future gains is throughout the electric "value chain". While energy efficiency programs are a valuable near-term option to achieve a low-carbon future, we need to think more broadly than we ever have and look for additional opportunities to achieve a lower carbon future which will impact future electric enterprise financial bottom line.

Therefore, as every other sector is striving to reduce their associated CO_2 footprint, there is a tremendous opportunity to leverage the Transmission and Distribution system as a viable resource to achieve a lower carbon future while still ensuring the reliability that sophisticated consumers demand.

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Introduction & Overview
Coordination With National And State Legislation

Emerging national and state legislation driving energy efficiency and demand management.

The American Clean Energy and Security Act of 2009 amends PURPA to establish a 20% mandatory federal combined efficiency and renewable standard (CERES) requirement by 2020.

- Energy efficiency can account for 25% of a retail seller's yearly requirement (40% via State petition).

A number of sections include elements for improved Transmission & Distribution Efficiency.

- Section 144, Smart Grid Peak Demand Reduction Goals provides requirements to establish a baseline and achieve demand reduction targets.
- Section 216A, Transmission Planning provides requirements to take into account all significant demand-side and supply-side options, including energy efficiency, Smart Grid, electricity storage.

Industry Leadership is Needed to Identify Realistically Achievable Potential, Establish Measurement & Verification Protocols (M&V) & Document Benefits.

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Introduction & Overview
End-to-End Efficiency

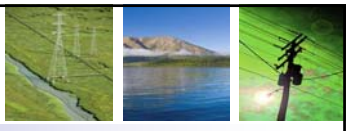
Reaching aggressive carbon-reduction goals while ensuring reliability and satisfying demand will require contributions across the entire electric utility "value chain".

The electric power industry is the largest user of electricity in the United States – using or losing approximately 12% to 15% of the electricity we produce. There are opportunities to improve efficiency from generation through transmission, distribution, and end use.

Approximately $3.1 billion per year is spent on end-use energy efficiency programs. However, we also need to increase the efficiency of generation, transmission, and distribution. A kilowatt-hour lost is one that is lost forever and there are numerous opportunities for savings, including the transmission and distribution systems. There may be areas where the cost of saving a kilowatt-hour of energy or reducing a kilowatt of peak demand through transmission or distribution efficiency is even more cost effective than an end-use efficiency measure. Therefore, we must aggressively seek opportunities to use electricity efficiently across the end-to-end chain. This comprehensive approach to efficiency will help demonstrate social responsibility, technical leadership and innovative thinking.

EPRI is Engaging the Industry to Develop an End-to-End Energy Efficiency Framework.

Introduction & Overview
EPRI Introduces New R&D Program



In 2008 EPRI added a new program focused on Efficient Transmission and Distribution Systems for a Lower Carbon Future.

To broaden the energy efficiency research portfolio beyond just end-use, EPRI launched a new research program in 2008. The research projects under the program are designed to:

1) Develop objective investigation, analysis, and technical measures to reduce losses within transmission and distribution systems

2) Develop a consistent process for integrating energy efficiency and demand response resources within transmission and distribution planning processes

3) Provide strategic information to assess the implication of extreme weather on the design, construction, planning, operations and maintenance of transmission and distribution assets

While we may not be to achieve optimal efficiency of the transmission and distribution system overnight, there are improvement opportunities that can be demonstrated and deployed based on today's technologies.

Introduction & Overview
The First Step – Distribution Efficiency

Important First Step: Distribution Efficiency Initiative…

EPRI launched a distribution system initiative to apply the research and use real life data to assess the cost, benefit and technical criteria for implementing efficiency measures in numerous distribution circuits. Opportunities include load balancing, reactive power compensation, voltage management, coordination with distributed resources for loss reduction, and load management via distribution automation.

The Green Circuits research project was launched in 2008 and is a field demonstration for the conversion of distribution feeders to reduced-loss circuits. More than 21 utilities are participating and more than 75 feeders will be evaluated for efficiency improvements. This effort is providing for a basis to establish measurement and verification procedures and valuation of distribution efficiency opportunities using real life data and field deployments.

Strong Collaboration Established with More than 21 Participants.

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Introduction & Overview
Distribution Green Circuits Launched 2008

EPRI, working with multiple utilities and feeders, will generate a comprehensive source of data that can improve the analysis with regard to modeling requirements, loss analysis methods, economics of different strategies, and general guidelines for loss management as a function of different circuit and customer load characteristics.

Distribution Efficiency Improving Opportunity	*Technologies to Improve Distribution Efficiency*
1. Reduce Distribution Line losses	1A. Re-Conductoring
	1B. Phase Balancing
	1C. Capacitor Placement, Var Control Strategy
2. Reduce Equipment Losses	2A. Distribution Transformers (High Efficiency and Amorphous Metal Transformers)
3. Improve Utilization	3A. Voltage Optimization (also known as Conservation Voltage Reduction CVR)
	3B. Smart Distribution Control

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Introduction & Overview
A Strong and Growing Collaboration

Consumers Energy Count on Us · FirstEnergy · AEP · conEdison · New York Power Authority · Xcel Energy · Northeast Utilities System · PG&E · PSEG · Southern California Edison · Dominion · SRP · Duke Energy · KCP&L · ESB · CenterPoint Energy · EDF · National Rural Electric Cooperative Association · CPS Energy · TVA · Southern Company

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Introduction & Overview
Expanding to Transmission

Improving Transmission Efficiency is Smart Business…

In 2009, EPRI, working with industry leaders, expanded the efficiency effort and turned their sights towards Transmission.

Transmission losses account for approximately 2% to 4% of the total electricity generated in the United States, according to EIA generation and consumption data. While the percentages may appear relatively low, the total amount of energy involved is considerable. The percentages equate to about 83 million MWh to 166 million MWh lost each year based on a total US annual generation of 4,157 million MWh. (EIA: *Electric Power Industry 2007: Year in Review*; report released January 21, 2009.)

For transmission owners under pressure to squeeze every last megawatt out of their assets, a megawatt lost is a megawatt wasted. To offset the losses utilities have to generate more power, which usually involves burning fuel that increases carbon footprint.

These wasted megawatts are an untapped resource. Improving transmission efficiency and reducing losses effectively taps that resource and allows more of the power generated to flow to customers. Reducing system losses helps utilities eliminate the need for additional generation capacity and can help defer transmission investment.

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Introduction & Overview
Additional Rewards

In addition to better asset utilization which can defer investment, increasing transmission efficiency offers additional rewards in the evolving political, regulatory, and societal landscape.

- Reduces CO_2 emissions and overall greenhouse gas footprint
- Increases power transfer capability
- Offers potential to relieve transmission constraints and defer capacity addition
- Demonstrates environmental, technological, and thought leadership to regulators, advocacy groups, and the general public
- Results in financial savings for utilities and improved equipment life expectancy
- Supports cost-effective compliance with emerging energy efficiency targets

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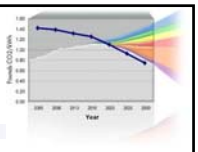
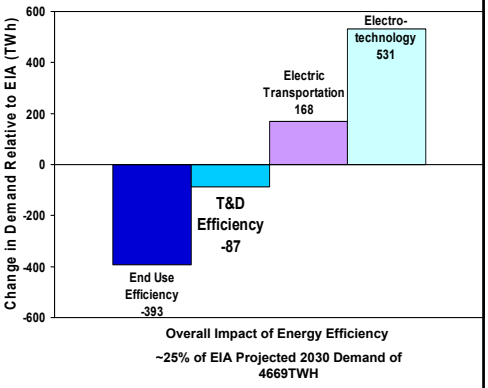
Introduction & Overview
2009 Prism Changes in Electricity Demand



Prism provides a comprehensive assessment of potential CO_2 reduction in seven key technology areas of the electricity sector.

Efficiency is one of the key technology areas. Transmission & Distribution efficiency is one of the components under efficiency.

The 2009 update includes a target of 20% improvement T&D efficiency by 2030.



Using Electricity Efficiently to Reduce CO_2…But is a Target of 20% Improvement in T&D Efficiency Achievable by 2030?

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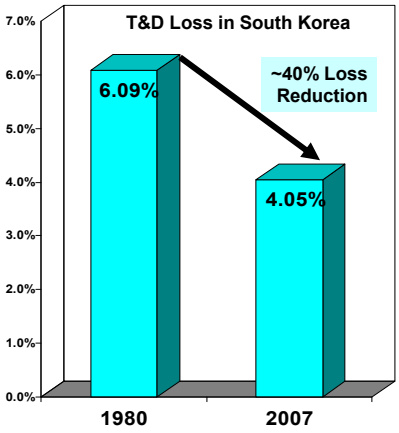
Introduction & Overview
Achieving Improved T&D Efficiency is Possible

South Korea achieved major improvements and reduced T&D Losses by 40% in less than 30 years by:

- Standardizing transmission and distribution voltages
- Building a higher voltage overlay
- Utilizing low loss conductor and transformers
- Reactive power control
- Automated feeder load balancing through multiple tie points.

T&D Efficiency Improvement is Achievable Using a Full Portfolio of Technologies.



Significant Improvement in T&D Efficiency is Achievable
But Need for Wider Deployment and Demonstrations

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Regional Workshops & Findings
Exploring the Issues

Exploring Transmission Efficiency with the Industry.

To explore this issue more, EPRI reached out to industry leaders to help shape research priorities in the area of transmission system efficiency, to learn what others are doing in this area, and to help design a nationwide "Transmission Efficiency Pilot" program.

The industry responded and as a result, an executive team representing the industry was formed to provide executive input and guidance. The team then undertook the development of an exploratory series of regional workshops that would help engage the industry in order to:

1) Understand how transmission efficiency can be a contributor to achieve a lower carbon future;

2) Learn what other companies are doing to improve transmission efficiency;

3) Help explore and formulate regional demonstration projects to assess opportunity to improve efficiency of transmission systems.

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Regional Workshops & Findings
Strong Executive Leadership Team Formed

Commissioner Jon Wellinghoff, Chairman, FERC
Arshad Mansoor, VP, EPRI

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Ian Welch, R&D Strategy Manager, National Grid

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Regional Workshops & Findings
Objectives

More than 320 gathered from the industry.

In April to June 2009, EPRI, partnering with these industry leaders, held a series of Transmission Efficiency Workshops. The objectives of the series of workshops was to:

- Increase the awareness of Transmission as a resource for energy efficiency
- Share examples of best practices for reducing transmission losses
- Understand how transmission efficiency can contribute to a lower carbon future.
- Explore and formulate regional demonstration projects to improve transmission efficiency

The workshops brought together more than 320 stakeholders from across the industry, including representatives from transmission owners and operators, vertically integrated utilities, the vendor community, public and advisory entities such as the Electric Edison Institute (EEI), The Federal Energy Regulatory Commission (FERC), North American Electric Reliability Corporation (NERC), various state public utility commissions, members of academia and research organizations and media.

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Regional Workshops & Findings
Six Workshops Held in 2009

Mid Atlantic Workshop (May 4, 2009)
Hosted by PJM and AEP
Executive Champions: Terry Boston (PJM), Michael Heyeck (AEP)

Northeast Workshop (April 29, 2009)
Hosted by NYISO, Con Ed, NYPA, LIPA
Executive Champions: Steve Whitley (NYISO), Steve DeCarlo (NYPA), Lou Rana (Con Ed), Mike Hervey (LIPA)

West Coast Workshop (June 12 2009)
Hosted by CAISO, SCE
Executive Champions: Yakout Mansour (CAISO), Pedro Pizarro (SCE)

International Workshop (June 2, 2009)
Hosted by PSE Operator, ESKOM, National Grid
Executive Champions: Magda Wasiluk Hassa (PSE Operator), Barry MacColl (ESKOM), Ian Welch (NG), Michael Heyeck (AEP)

Dallas Workshop (May 20, 2009)
Hosted by SPP, AEP
Executive Champions: Nick Brown (SPP), Mike Heyeck, AEP)

Southeast Workshop (June 15, 2009)
Hosted by Rob Manning (TVA) and Leslie Sibert (Southern)

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Regional Workshops & Findings
Key Findings based on Industry Input

Efficiency is more than simply reducing losses: An efficient system is one that is low in losses, increases utilization of existing transmission assets/resources and enables smarter integration of renewable and storage technologies.

Efficiency initiatives require that reliability remains a primary focus: There are technologies and practices available that increase the efficiency of the transmission system while maintaining or enhancing reliability.

Efficient transmission will be built on the shoulders of new & upgraded systems: More transmission is essential for enabling renewables, improving reliability and achieving optimum efficiency. As we build out a highly efficient transmission system, sensors, communications, data management, visualization, and control are key enablers to improving and achieving efficiency.

Efficiency will be part and parcel of future business cases: Proposed efficiency measures, including those to achieve capacity improvements, improve voltage stability, support clean and innovative energy technologies such as renewables and storage, will be an integral component of a comprehensive energy delivery resource plan.

A new regulatory framework is needed to unlock efficiency improvements: To incentivize stakeholder support for improving transmission efficiency, revisions to the regulatory framework will be required.

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Regional Workshops & Findings
Opportunities for Improving Transmission Efficiency

Three major areas for improving transmission efficiency were identified.

1. Reduce System Losses

System Losses: Efficiency and loss reduction must be viewed from the overall system impact. There are numerous approaches to reduce system losses. These include increasing nominal voltage (new lines or voltage upgrades), dispatch considerations to relieve flows from overloaded or higher loss lines to less congested and/or lower loss lines, coordinated voltage control across the system to reduce var flow, and other means of power flow control.

2. Reduce Line/ Equipment Losses

Line/Equipment Losses: Electricity providers are studying numerous methods to reduce losses from lines and equipment components as a way to improve overall transmission efficiency. The key contributors to transmission losses are the lines and the substation equipment. The transformer is the principal loss contributor within the substation. Electricity providers are investigating low loss lines and configurations, low loss transformers and auxiliary equipment. Superconductivity may also be applicable in some cases.

3. Increase System/ Resource Utilization

Increase System/Resource Utilization: Efficient transmission seeks to optimize utilization of assets and resources including right-of-way, materials, labor, time and dollars. As the industry retires older less efficient assets and builds out new higher voltage and more efficient systems, increasing the utilization will allow greater throughput on existing corridors, by adding storage and control technologies which will enable integration of higher levels of renewable resources.

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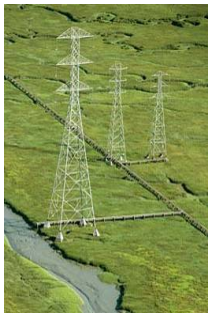
Overview Industry Wide Demonstrations

Suite of Technologies Identified to Improve Efficiency

Based on input from the workshops, seven proposed technologies have been identified to reduce transmission losses and improve the overall efficiency of the transmission system.



Transmission Efficiency Improving Opportunity	*Demonstration Technologies*
1. Reduce System Losses	1A. Voltage Upgrade/EHV AC/HVDC
	1B. Coordination Voltage Var Control
	1C. Loss Minimization Optimization
2. Reduce Line/Equipment Losses	2A. Advanced Conductors/ Superconductors/ Low Loss Design
	2B. Low Loss/LEED Substation Equipment & Transformers
3. Increase Line/System Utilization	3A. Dynamic Rating
	3B. Smart Transmission

Suite of projects developed to demonstrate what is potentially achievable in terms of efficiency and carbon reduction.

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Overview Industry Wide Demonstrations
Leveraging R&D Program as Foundation

Demonstration Projects based on these technologies will Leverage Framework and Methodology Work Already Begun under R&D Program.

The implementation of technology-based solutions for reducing transmission losses and improving overall system efficiency requires utilities to study and asses not only the technologies, but their transmission systems. Utilities need a comprehensive evaluation methodology and strategic planning framework to accomplish this.

EPRI has already been developing a framework intended to provide a tool to facilitate good decision making when evaluating methods and strategies for improving efficiency and reducing transmission losses while ensuring that reliability and other system criteria are met.

This previous work will lay a foundation for these demonstration projects and provide for a consistent methodology for quantifying criteria such as measurement and verification (M&V), cost/benefit analysis, total losses reduced, CO_2 reduced etc.

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Overview Industry Wide Demonstrations
Industry Roles and Participation

Member (Participant) will support development of the technology and learn implementation experience from hosts, receive detailed technical updates and comprehensive report including nonproprietary results, general findings and conclusions upon project completion; and will gain sufficient understanding and know-how to evaluate, select, and undertake transmission efficiency initiatives on their system. (Utilities that are members of EPRI's R&D Program on Transmission Efficiency (Project Set 172A) in 2010 and 2011 will automatically be a participant)

Host will demonstrate industry technologies through implementation and deployment of various transmission efficiency efforts and loss mitigation approaches. Hosts will receive direct, hands-on experience with the technology and system-specific information. (Host price will vary based on project scope)

EPRI at minimum will 1) work with participants to define detailed scope, methodology, work plan for each project, 2) synthesize lessons learned to provide usable information to all participants, 3) coordinate, conduct and facilitate tech transfer activities including workshops, 4) develop consistent methodology for system improvement/loss benefit evaluation, 5) individual technical report for each host site demonstration, and 6) final guidebook and summary technical report.

Vendor/Consultant/EPRI will be engaged by host members for implementation, deployment and tasks to include but not limited to 1) planning studies to evaluate various efficiency improvement opportunities, 2) detailed engineering and design studies, 3) instrumentation and measurement plans, 4) construction/installation, etc.

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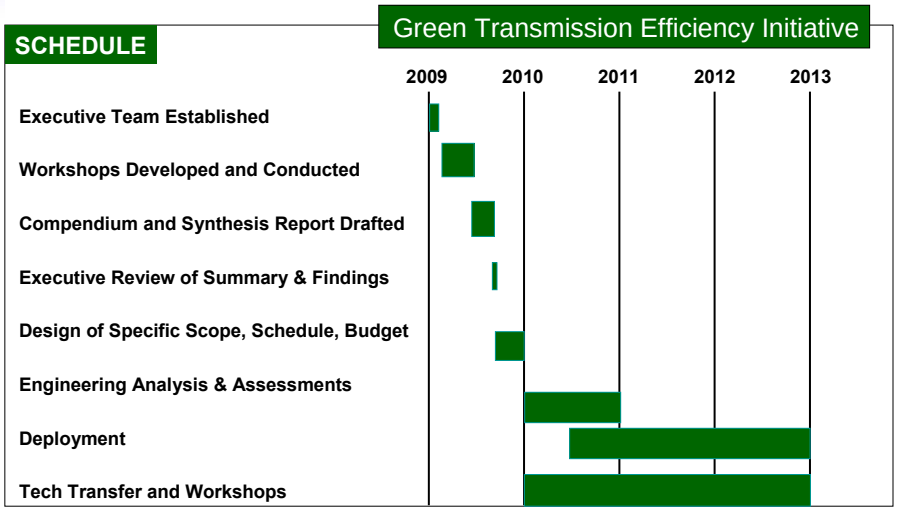
Overview of Industry Wide Demonstrations
Proposed Timeline



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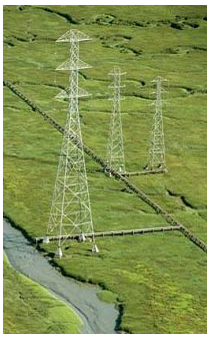
Sample Project Descriptions
Reduce System Losses



Transmission Efficiency Improving Opportunity
1. Reduce System Losses
2. Reduce Line/Equipment Losses
3. Increase Line/System Utilization

Demonstration Projects
1A. Voltage Upgrade/EHV AC/HVDC
1B. Coordination Voltage Var Control
1C. Loss Minimization Optimization
2A. Advanced Conductors/ Superconductors/Low Loss Design
2B. Low Loss/LEED Substation Equipment & Transformers
3A. Dynamic Rating
3B. Smart Transmission

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Sample Project Descriptions
1A. Voltage Upgrade/EHV AC/HVDC

***Benefits*: Increasing nominal voltage of existing lines can reduce losses while increasing power transfer capacity. This option also supports long-distance renewable integration helping low-wind states to meet aggressive renewable portfolio standards.**

Overview

The United States has about 15 transmission voltages, from 23kV through 765kV. Installing EHV overlay to enable upgrading and retirement of less efficient voltages, upgrading of voltages on existing towers and right of ways, and using HVDC lines where appropriate are all longer term approaches to reduce transmission losses and strengthen the transmission system. Similar approaches—upgrading and standardization of three transmission voltages from 154kV to 765kV—resulted in South Korea having the lowest T&D losses in the world.

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Sample Project Descriptions
1A. Voltage Upgrade/EHV AC/HVDC

Scope of Host Utility Demonstration

EPRI staff will work with participants to define appropriate projects that can fit in the 24 months to 36 months timeline of this initiative. Some of the approaches, such as planning for EHV overlay or voltage upgrading during retirement will be much longer term propositions for actual implementation and will not fit the timeline of this initiative. However, host projects could include detailed system planning studies whose results could establish the foundation for long-term transmission line retirement.

Specific host projects that could be defined under this category include but are not limited to the following:

- Voltage uprating on existing lines using existing structure
- Voltage upgrade on existing right of way
- Long-term system-wide planning study to assess the impact of upgrading during retirement of lower transmission voltages

The specific scope of each project will be fleshed out with participants by the first quarter of 2010.

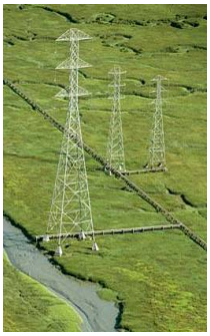
Sample Project Descriptions
1A. Voltage Upgrade/EHV AC/HVDC

Value to Participants

Voltage upgrades present numerous issues— insulation coordination, phase spacing to ground and other phases, ROW requirements, electric & magnetic fields, and terminal equipment upgrade or replacement. Each transmission line will present its own challenges due to the numerous existing line designs.

Participants will receive non proprietary results of the detail engineering planning and design studies illustrating how these challenges were overcome. Actual implementation of the designs and lessons learned from the projects will be documented to facilitate future voltage upgrading projects that could be undertaken by the participants.

Sample Project Descriptions
Reduce System Losses



Transmission Efficiency Improving Opportunity	Demonstration Projects
1. Reduce System Losses	1A. Voltage Upgrade/EHV AC/HVDC
2. Reduce Line/Equipment Losses	1B. Coordination Voltage Var Control
3. Increase Line/System Utilization	1C. Loss Minimization Optimization
	2A. Advanced Conductors/ Superconductors/ Low Loss Design
	2B. Low Loss/LEED Substation Equipment & Transformers
	3A. Dynamic Rating
	3B. Smart Transmission

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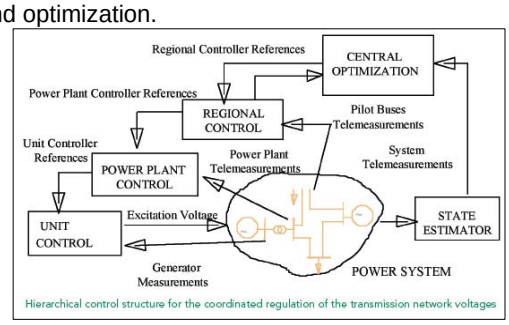
Sample Project Descriptions
1B. Coordinated Voltage VAR Control

***Benefits*: Centralized, coordinated control of bus voltages would allow a flatter voltage profile that minimizes reactive power losses**

Overview

Bus voltages are currently controlled in a decentralized manner, lacking system-wide coordination and optimization.

Optimizing voltage profile to minimize losses requires adjusting voltage control settings in response to continuously changing system conditions. For this approach to be effective, a centralized automatic process is required.



Hierarchical control structure for the coordinated regulation of the transmission network voltages

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Sample Project Descriptions
1B. Coordinated Voltage VAR Control

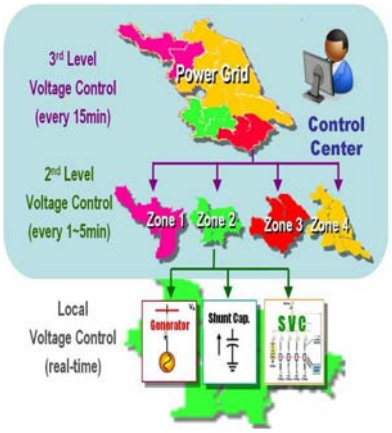
Overview

Three Levels of Voltage Control

•**3rd level**: system-wide optimization to minimize transmission loss to improve energy efficiency

•**2nd level**: coordination in each zone to control voltages at key locations to improve reliability

•**1st level**: local voltage/Var control



Sample Project Descriptions
1B. Coordinated Voltage VAR Control

Scope of Host Utility Demonstration

EPRI will work with participants to define projects that fit in the Green Transmission Initiative's 24-month to 36-month timeframe.

Potential host projects include, but are not limited to, the following:

- Voltage control by optimizing voltage profile to minimize losses, using all existing voltage control equipment
- Reactive power compensation by installing additional reactive power support equipment
- Longer term studies and demonstrations to support system-wide optimization and development of a hierarchical dynamic voltage control strategy

The specific scope of each project will be fleshed out with participants by the first quarter of 2010.

Sample Project Descriptions
1B. Coordinated Voltage VAR Control

Value to Participants

In North America, transmission system voltage control is performed in a decentralized manner at the power plant/substation level. However, system-wide automatic voltage control has been developed and applied at the control center level in China and Europe, significantly improving the voltage quality and reliability of transmission grids.

Demonstration projects will help participating utilities to understand the issues involved in developing system-wide hierarchical dynamic voltage control strategies to systematically and optimally coordinate local voltage regulators to improve both voltage quality and voltage security while reducing transmission losses caused by massive reactive power flows in the power grid.

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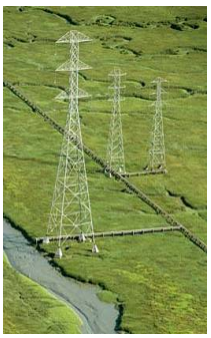
Sample Project Descriptions
Reduce System Losses



Transmission Efficiency Improving Opportunity
1. Reduce System Losses
2. Reduce Line/Equipment Losses
3. Increase Line/System Utilization

Demonstration Projects
1A. Voltage Upgrade/EHV AC/HVDC
1B. Coordination Voltage Var Control
1C. Loss Minimization Optimization
2A. Advanced Conductors/ Superconductors/ Low Loss Design
2B. Low Loss/LEED Substation Equipment & Transformers
3A. Dynamic Rating
3B. Smart Transmission

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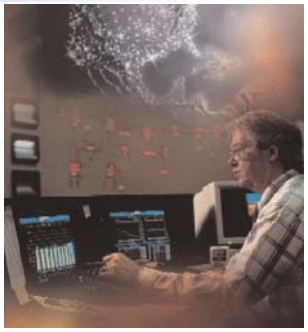
Sample Project Descriptions
1C. Loss Minimization Optimization

Benefits: ***Higher efficiencies can be attained by dispatching generation closer to the load or in a way that increases utilization of transmission lines operating at higher voltages while decreasing the load on lower voltage lines.***



Overview

In some markets it may be feasible to change dispatch criteria to include transmission loss minimization when determining dispatch orders. Achieving this capability will require changing the conventional dispatch algorithm to include a loss minimization criteria in conjunction with a trade-off analysis.

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Sample Project Descriptions
1C. Loss Minimization Optimization

Scope of Host Utility Demonstration

EPRI will work with participants to define projects that fit the Initiative's 24-month to 36-month timeframe.

Potential host projects include the following:

- Modification of economic dispatch algorithms to include the cost of losses
- Generation dispatch demonstrations to address development and implementation issues associated with the use of modified dispatch algorithms
- Study on how loss minimization could be included in centrally dispatched market scenarios
- Study comparing loss minimization dispatch with traditional approach.

The specific scope of each project will be fleshed out by participants in the first quarter of 2010.

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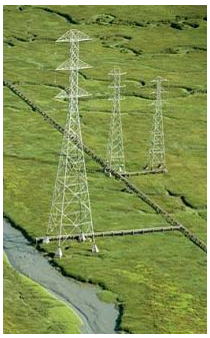
Sample Project Descriptions
1C. Loss Minimization Optimization

Value to Participants

Participants will receive nonproprietary results of the detailed demonstration studies. Lessons learned from the projects will be documented to support future projects to integrate loss minimization with economic dispatch and integrate this capability into utility operations.

Sample Project Descriptions
Reduce Line/Equipment Losses



Transmission Efficiency Improving Opportunity
1. Reduce System Losses
2. Reduce Line/Equipment Losses
3. Increase Line/System Utilization

Demonstration Projects
1A. Voltage Upgrade/EHV AC/HVDC
1B. Coordination Voltage Var Control
1C. Loss Minimization Optimization
2A. Advanced Conductors/ Superconductors/ Low Loss Design
2B. Low Loss/LEED Substation Equipment & Transformers
3A. Dynamic Rating
3B. Smart Transmission

Sample Project Descriptions
2A. Advanced Conductors/ Low Loss Design

***Benefits*: Lower system losses, increased ampacity, higher throughput. Potentially attractive alternative to more expensive system upgrades**

Overview

Advanced materials (e.g., aluminum alloys, composite cores) show promise but need to be evaluated against other options, especially at high temperature and long duration. Line changes, such as adding a conductor to the sub-bundle, or segmenting shield wires reduce losses.

Advanced conductors can reduce losses and increase capacity, in many cases without requiring expensive upgrades to the transmission structures.

Shield wire segmentation offers the potential for significant loss reduction: 3kW per mile. Losses are caused by induced currents in shield wire due to coupling from the phase conductors. Losses depend on power transfer level, phase configuration, shield wire impedance. Segmentation breaks the conductive path in the shield wires.

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Sample Project Descriptions
2A. Advanced Conductors/ Low Loss Design

Advanced conductor

3M Composite Core

ACSR/TW

ACSS/TW

ACCC/TW

Conventional Conductor

Conductor Bundle

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Sample Project Descriptions
2A. Advanced Conductors/ Low Loss Design

Conductors with an overall diameter equal to the standard ACSR conductor:

⇨ Allow reconductoring without major structure reinforcement

Conductor	Diameter	Alum Area	Weight	AC Resistance - 75° C		Ampacity Ratings*			Relative cost
	(in)	(kcmil)	(lb/kft)	(ohm/kft)	Δ%	75 [°C]	100 [°C]	200 [°C]	Aprox.
Drake ACSR	1.108	795	1093	0.0266		905	1115	---	1
Drake ACSS	1.108	795	1093	0.0258	-3.0%	919	1132	1660	1.2
Suwannee ACSS/TW	1.108	960	1317	0.0216	-18.8%	1010	1245	1831	1.3
Suwannee ACCR/TW	1.108	958	1075	0.0211	-20.5%			1812	5
Drake ACCC/TW	1.108	1020	1043	0.0206	-22.6%	1029	1267	1861	2.5
Suwannee ACSR/TW	1.108	960	1317	0.0218	-18.0%	1000	1233	---	1.1

*** Ambient temperaturaute 25° C, wind speed 2 ft/sec., full sun**

Note: Costs are relative estimates and costs for newer composite core conductor may decrease with higher volume.

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Sample Project Descriptions
2A. Advanced Conductors/ Low Loss Design

Scope of Host Utility Demonstration

EPRI staff will work with participants to define appropriate projects that fit the Initiative's 24-month to 36-month timeline.

Potential projects include the following:

- Deploy advanced conductors or conductor bundles on existing or new transmission line and evaluate technical and economic performance and impact on losses.
- Demonstrate shield wire segmentation on existing or new transmission line and evaluate technical and economic performance, impact on emissions.

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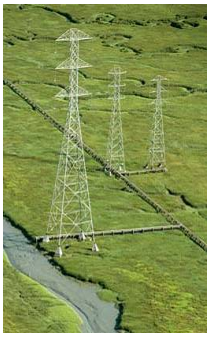
Sample Project Descriptions
2A. Advanced Conductors/ Low Loss Design

Value to Participants

Advanced conductors and low-loss designs are promising but present challenges and raise unanswered questions that may be different for each transmission line.

Participants will receive nonproprietary results of the detailed demonstration studies. Lessons learned from the projects will be documented to facilitate future projects to deploy advanced conductors and shield wire segmentation based on improved understanding of technical and economic performance relative to other options, and their impact on loss and emissions reduction.

Sample Project Descriptions
Reduce Line/Equipment Losses



Transmission Efficiency Improving Opportunity
1. Reduce System Losses
2. Reduce Line/Equipment Losses
3. Increase Line/System Utilization

Demonstration Projects
1A. Voltage Upgrade/EHV AC/HVDC
1B. Coordination Voltage Var Control
1C. Loss Minimization Optimization
2A. Advanced Conductors/ Superconductors/ Low Loss Design
2B. Low Loss/LEED Substation Equipment & Transformers
3A. Dynamic Rating
3B. Smart Transmission

Sample Project Descriptions
2B. LEED Substations

***Benefits*: Reduce substation power demand and system losses**

Overview

What is LEED®?

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ encourages and accelerates global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted tools and performance criteria.

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Sample Project Descriptions
2B. LEED Substations

Scope of Host Utility Demonstration

EPRI will work with participants to define projects that fit the Initiative's 24-month to 36-month timeframe.

Potential host projects could include:

• Demonstrations of energy-efficient technologies for new and existing substations to evaluate technical and economic performance, impact on losses and emissions; cost effectiveness of retrofit versus new construction.

Candidate technologies include transformers, switch houses, circuit breakers, HVAC, lighting, fans, water heating; and relaying, computers and communications equipment; and more.

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Sample Project Descriptions
2B. LEED Substations

Value to Participants

Substations offer numerous opportunities for improving energy efficiency and reducing losses, but questions remain. Better information is needed about the costs and benefits of the many efficient technology options (and combinations of options); their impacts on substation and power system operations; and the cost-effectiveness and practicality of retrofitting energy efficiency technologies into existing substations versus installing them in new substations.

Participants will receive nonproprietary results of the detailed demonstration studies. Lessons learned from the projects will be documented to facilitate future projects to incorporate energy efficient technologies in substations based on improved understanding acquired in these demonstrations.

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Sample Project Descriptions
Increase Line/System Utilization

Transmission Efficiency Improving Opportunity
1. Reduce System Losses
2. Reduce Line/Equipment Losses
3. Increase Line/System Utilization

Demonstration Projects
1A. Voltage Upgrade/EHV AC/HVDC
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2B. Low Loss/LEED Substation Equipment & Transformers
3A. Dynamic Rating
3B. Smart Transmission

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Sample Project Descriptions
3A. Dynamic Rating

***Benefits*: Dynamic rating technology can help increase power flow through existing transmission corridors with minimal investment, accelerate integration of renewable resources, improve situational awareness in control centers, reduce losses by redirecting energy to higher voltage lines, and increase grid reliability and safety.**

Overview

Transmission circuit capacity is generally imposed by static or "book" ratings based on conservative calculations. Dynamic ratings are based on real-time measurements of circuit loading, weather conditions and other parameters. This gives system operators accurate knowledge of grid conditions and capacity in real-time so they can safely increase and optimize power flows.

A key element of the Smart Grid, dynamic rating technology is based on EPRI-developed Dynamic Thermal Circuit Rating (DTCR) software, Video Sagometer, and other sensor and communications systems.

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Sample Project Descriptions
3A. Dynamic Rating

Scope of Host Utility Implementation

EPRI will work with participants to define projects that fit the Initiative's 24-month to 36-month timeframe.

Potential projects:

• One or more projects to implement and demonstrate dynamic rating technology to evaluate performance of software, sensors and communications systems; and to address implementation issues including integration with SCADA/EMS, instrumentation reliability, availability and reliability of communications links.

The specific scope of projects will be fleshed out by participants by the first quarter of 2010.

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Sample Project Descriptions
3A. Dynamic Rating

Value to Participants

Dynamic rating offers significant potential for increasing and optimizing power flows, as well as providing an enabling foundation for Smart Grid capabilities. But several implementation issues must be better understood before dynamic rating can be integrated into normal control center operating procedures.

Hosts will receive direct, hands-on experience with the technology and system-specific information. Participants will receive nonproprietary results of the detailed demonstration studies. Lessons learned from the projects will be documented to support informed decision-making regarding future projects to implement dynamic rating technology into utility operations and planning.

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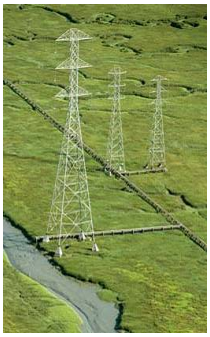
Sample Project Descriptions
Increase Line/System Utilization



Transmission Efficiency Improving Opportunity
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3A. Dynamic Rating
3B. Smart Transmission

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Sample Project Descriptions
3B. Active Power Flow Control

***Benefits*: Provides capability to direct power flow to more efficient paths to reduce system losses, relieve congestion, and mitigate loop flow.**

Overview

Grid congestion, loop flows and bottlenecks impede the efficient movement of power, reducing reliability efficiency, ad utilization. Active power flow control hardware can be used to optimize system performance and reliability based on real-time and historical information from monitoring and intelligence. These controls will include both distributed controls and centralized controls for integration with energy management systems.

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Sample Project Descriptions
3B. Active Power Flow Control

Scope of Host Utility Demonstration

EPRI will work with participants to define projects that fit the Initiative's 24-month to 36-month timeframe.

Potential host projects include the following:

• Active power flow demonstrations to address implementation issues associated with use of power flow controllers and a centralized optimal power flow algorithm to control the devices.

The specific scope of each project will be fleshed out by participants in the first quarter of 2010.

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Sample Project Descriptions
3B. Active Power Flow Control

Value to Participants

The technology needed to re-direct power flow is costly, but can be justified for increasing power transfer capacity, reducing loop flows, confining power to a specific path, and improving transient or voltage stability.

Demonstration projects will address implementation and integration issues. Hosts will receive direct, hands-on experience with the technology and system-specific information. Participants will receive nonproprietary results of detailed demonstration studies. Lessons learned from the projects will be documented to support future projects to implement active power flow control into utility operations.

Table of Contents

Evaluation Methodology
Managing Losses: The Measurement Challenge

We can only manage what we can measure.

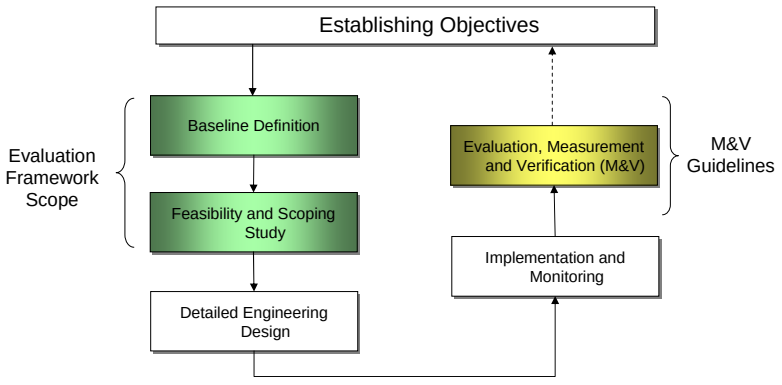
Despite the pressing need to increase transmission efficiency, the industry lacks standard methods to accurately quantify transmission losses or to evaluate the numerous options for reducing them. A consistent and uniform methodology to determine transmission system losses will help utilities identify and evaluate loss-reduction options and document energy savings so they can be properly credited toward energy efficiency savings goals.

To meet this need, EPRI has been developing a comprehensive integrated framework and methodology under its core R&D program for evaluating transmission loss reduction and efficiency improvement options. EPRI's goal is to complete the framework by the end of 2009 so it can be applied to transmission efficiency demonstration projects.

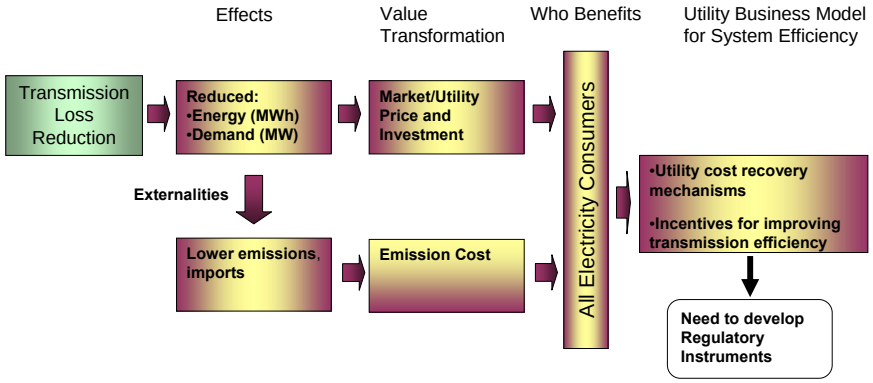
Key concepts and features of the framework are outlined on the following pages.

Evaluation Methodology
Establishing a Framework

Transmission System Efficiency Improvement Process



Evaluation Methodology
Example Valuation of Loss Reduction Options



Societal benefits from efficiency improvements and loss reduction are basis for developing necessary regulatory instruments to incent utilities.

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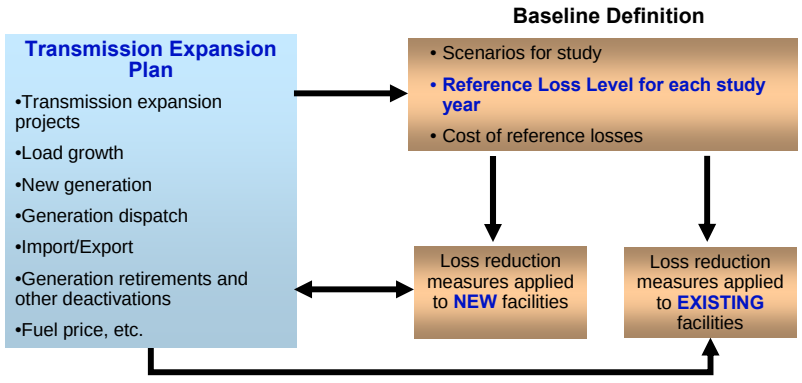
Evaluation Methodology
Baseline & Valuation

General Approach



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Next Steps and Conclusion
Consensus Received to Move Forward with Next Steps

Consensus was received by executives through meetings in Washington D.C August 27, 2009 hosted by Chairman Wellinghoff and the EPRI Power Delivery & Utilization Council meetings in Chicago, Illinois September 02, 2009. The following was approved as an action plan to move forward with development for the industry wide demonstrations.

- Engage industry in one on one meetings to identify various projects and define scope of regional host demonstration projects (Sept 2009 – Feb 2010)
- Complete comprehensive portfolio of demonstration projects under the seven technology areas including technical scope, schedule and budgets (March 2010)
- Reconvene Executive Team to review the comprehensive suite of demonstration projects to enhance transmission efficiency and assess feasibility of a national press club launch of an “International Transmission Efficiency Initiative” (March 2010)
- Establish an industry advisory committee consisting of senior executives from each host sites to guide through the execution of the projects and ensure that the lessons learned is shared with the industry in a useful and useable form (March/April 2010)

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Next Steps and Conclusion
Industry Partnering to Achieve Lower Carbon Future

We need to look for all opportunities to more efficiently use electricity.

There is significant opportunity to improve energy efficiency of the Electricity Sector including the transmission system.

We need enabling technologies, industry demonstrations and supporting regulatory framework to unlock the potential to achieve an industry wide efficient transmission system.

Industry Partnering to Design a Set of Regional Transmission Efficiency Projects

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A
TRANSMISSION EFFICIENCY: EPRI'S TRANSMISSION INITIATIVE WORKSHOPS

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Transmission Efficiency: EPRI's Green Transmission Initiative Workshops

EPRI Green Transmission Initiative workshops will provide participants an opportunity to

- Understand how transmission efficiency can be a contributor to achieve a low carbon future
- Learn what other companies are doing to improve transmission efficiency
- Help explore and formulate regional demonstration projects to assess opportunity to improve efficiency of transmission systems

A 'green' transmission system can mean a number of things in relation to improving our environment. Definitions can include integrating large scale renewable generation and storage, as well as controllable loads to help reduce emissions. While these efforts are crucial, this series of workshops will specifically focus on improving transmission efficiency.

Issues and Needs

Energy efficiency is an important contributor for achieving a low carbon future. Traditionally, energy efficiency measures have focused on end-use efficiency. Considering that the electric industry is also the largest user of electricity, there may be significant opportunity for the industry to become more efficient. EPRI is working with a number of leading utility organizations to explore needs and research gaps that could lead to making our transmission system more efficient and ultimately help reduce the carbon footprint.

The EPRI Efficient T&D Systems research has focused on understanding technology options for potential improvements in power delivery efficiency. A large collaborative demonstration effort, Green Circuits, implements a variety of distribution efficiency options and evaluates their effectiveness by comparing the results with previously established baselines. EPRI's Green Transmission Initiative will expand this overall activity on efficiency resources within the electricity sector by focusing on opportunities to maximize the efficiency of the transmission system through loss reduction and other means.

Regional Workshops

EPRI will facilitate a number of regional and international workshops championed and hosted by leading industry organizations to solicit industry input for research needs to realize higher efficiency and reduced losses in transmission.

Opportunities for Improving Transmission Efficiency

Transmission system efficiencies can be improved through a number of technical solutions and methodologies. The workshops will examine a number of long and short term candidate solutions.

Engineering and construction options may include building and upgrading transmission using designs and equipment yielding the highest efficiencies while retiring older, inefficient assets:

- Advanced low loss conductor
- Minimizing effects that may lead to losses

Operational options may include developing real time and predictive wide area monitoring and control to optimize all aspects of transmission operations including efficiency:

- Operating strategies for loss minimization
- Reducing transmission system no-load losses
- System wide coordinated voltage-var optimization

Executive Leadership Team

Arshad Mansoor, V.P. EPRI
Commissioner Jon Wellinghoff, Acting Chairman, FERC

US Executive Steering Committee Members:

- Nick Brown, President, & CEO Southwest Power Pool
- Terry Boston, President & CEO, PJM Interconnection
- Steve DeCarlo, Sr. V.P. Transmission, New York Power Authority
- Mike Hervey, V.P. T&D Operations, Long Island Power Authority
- Mike Heyeck, Sr. V.P. Transmission, American Electric Power
- Rob Manning, Executive V.P. Power Systems, Tennessee Valley Authority
- Yakout Mansour, President & CEO, California ISO
- Pedro Pizarro, Exec V.P. Power Operations, Southern California Edison
- Lou Rana, President & COO, Consolidated Edison
- Leslie Sibert, V.P. Transmission, Georgia Power
- Steve Whitley, President & CEO, New York Independent System Operator

International Steering Committee Members:

- Barry MacColl, Technology Strategy & Planning, ESKOM
- Magdalena Wasiluk-Hassa, Director, Innovation & International Relations, PSE Operator
- Ian Welch, R&D Strategy Manager, National Grid

Who Should Participate

Independent system operators, regional transmission operators, transmission owners, research organizations and other interested parties who are interested in exploring ways to improve transmission efficiency.

Contact Information

For more information on detailed logistics, contact Arlette Haddad at 865.218.8122 (ahaddad@epri.com).

Technical Contacts

Karen Forsten at 865.218.8052 (kforsten@epri.com).
Rich Lordan at 650.855.2435 (rilordan@epri.com).

Workshop Dates and Locations

Northeast Region
Date: April 29, 2009
Location: Albany, NY
Champion Organizations:
New York Independent System Operator,
Consolidated Edison Electric,
New York Power Authority
Long Island Power Authority

Mid-Atlantic Region
Date: May 4, 2009
Location: Cambridge, Maryland
Champion Organizations:
PJM Interconnection
American Electric Power

Southeast Region
Date: June 15, 2009
Location: Atlanta, Georgia
Champion Organizations:
Southern Company
Tennessee Valley Authority

Southwest Region
Date: May 20, 2009
Location: Dallas Area, Texas
Champion Organizations:
Southwest Power PoolAmerican Electric Power

Western Region
Date: June 12, 2009
Location: Los Angeles Area, California
Champion Organizations:
California ISO
Southern California Edison

International
Date: June 2, 2009
Location: Warsaw Poland
Champion Organizations:
PSE Operator
American Electric Power

Product ID: 1018784 March 2009

Electric Power Research Institute
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