

38 Increased Transmission Capacity

Program Overview

Program Description

This program offers a unique, integrated, and comprehensive portfolio aimed at helping transmission owners and operators get the most power through their existing systems while keeping system equipment and components safe and reliable. As such, this program provides customers with a one-stop shop for significantly reducing new capital expenditures for both transmission and substation equipment by optimizing the use of existing assets. Key efforts include development of methodologies for real-time rating calculations and complementary software and hardware for implementing real-time rating schemes; increasing power capacity of existing transmission lines through technological upgrades such as high-capacity conductor and voltage upgrades, as well as through integration of various advanced technologies such as power-electronic based controllers; and the integration of superconducting components into the transmission and distribution system to deal with bottlenecks. In 2009, issues related to different increased transmission capacity schemes from planning and operation perspectives will be addressed more extensively than in the past under a new Project Set 38C "Integration of IPF Technologies for System Planning and Operations." The program will also address the impact of integrating green power, such as wind farms, on a transmission system.

Industry Needs and Issues Addressed

- Imbalance between growth in electric power demand and new transmission construction (demand increase of 25% versus new transmission construction of 4% per decade)
- Bottlenecks created from power industry deregulation
- Difficulties in acquiring rights-of-way
- Needs optimized use of existing assets
- Needs rating methods to satisfy mandatory FERC reliability requirements
- Needs immediate solutions to increase transmission capacity
- Needs comprehensive short- and long-term practical solutions to improve transmission capacity

Impact

- New transmission rating methodologies maximize system capacities by 15–20%
- Research results for line components guide operation and enhance reliability of overhead lines
- Use of advanced conductors boosts capacity gains by 100%
- Superconductors increase underground cable capacity by 3 to 5 times
- Voltage upgrades provides an alternative solution to current upgrades and doubles transmission capacity
- Power flow management technologies provide 50–100% increase in capacity and improvement in system performance

Key Accomplishments

- Engineering and planning guide to increasing power flow through transmission circuits: overhead line case studies and Quasi Dynamic Rating (QDR)
- Development and enhancement of Dynamic Thermal Circuit Rating (DTCR) software and functional specifications of the DTCR data analysis program
- Development of instrumentation for increasing power flow: needs, concepts, feasibility, and benefits
- Increased power flow conference
- Voltage upgrade guide

- Methodologies for power flow management
- Technology watch for superconducting power technologies

Current Year Objectives

- Guidebook and “rating wizard” for implementing increased power flow
- Additional development of instrumentation for increasing power flow
- Completion of thermal and corona models of overhead conductors operating at high temperatures
- Continued evaluation of the effect of high-temperature cycling on conductor systems
- Development of a “wizard” for evaluating candidates for voltage upgrades
- Evaluation of aging and maintenance methods for advanced conductors
- Tools for integrating power flow upgrades into EMS (Energy Management System)
- Power flow upgrades and green power integration for system planners
- Continued technology watch for superconducting power technologies

Industry Involvement

- Estimated 2009 funding: \$2.5M

Program Technical Lead

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Summary of Projects

PS38A Increased Power Flow (065548)

Project Set Description: This project set focuses on current upgrades—that is, increasing transmission capacity by raising the current. It develops methodologies for real-time rating of transmission line equipment and complementary software and hardware for implementing real-time rating schemes. The impacts of raising the current of a transmission line on its components are studied. The results produce more accurate conductor thermal and corona models for rating calculations and electrical performance evaluations, as well as guidelines for safe and reliable operation at high conductor temperatures.

Project Number	Project Title	Value
P38.001	IPF Guidebook	This project will continue to develop a reference document that provides transmission and substation engineers an overview of the electrical, mechanical, thermal, and system concerns important to increased power flow (IPF), as well as all possible IPF options, with case studies to illustrate several IPF choices and compare their potential economic benefits. New information on methodologies and research results are added to the guidebook each year. A “rating wizard” assists users in evaluating options and selecting a proper choice for implementation.
P38.002	DTCR Technologies	This project will continue to develop software and methodologies for optimizing the power ratings of transmission circuits. For example, the project will develop a new software product, the DTCR Data Analysis Program (DAP), to facilitate applications of DTCR, as well as update EPRI’s well-known DTCR software.
P38.003	Instrumentation for Managing IPF	This project will continue development of viable instrumentation tools for increasing power flow safely and reliably.
P38.004	Impact of Increased Power Flow on Conductor	This project will assess the applicability of existing thermal and

Project Number	Project Title	Value
	Thermal and Corona Models	corona models to elevated operating temperatures, update empirical models to account for new data, and develop new algorithms to update prediction software products.
P38.005	Impact of High-Temperature Operation on Conductor Systems	This project will continue to investigate premature aging of conductors and conductor accessories from increased power flow, enabling power companies to operate overhead lines safely and reliably, perform on-time maintenance, and implement appropriate maintenance measures to avoid transmission line failures. An applet has been developed for users to retrieve appropriate information quickly for reference.

Project Descriptions

P38.001 IPF Guidebook (062099)

Issue

Energy companies around the world are redefining the use of existing power equipment in electric transmission networks due to limited incentives for new construction. Under these circumstances, companies must find new ways to increase power flows through existing transmission corridors with minimal investment.

Description

This project directly responds to the needs of transmission designers, engineers, planners, and operators to capitalize on existing equipment in today's competitive electricity business. To this end, the IPF Guidebook project documents various technical options for increasing power flow on transmission and substation equipment. Past development of stand-alone reports based on the foundational work culminated in the 2005 publication of EPRI's *Increased Power Flow Guidebook*, which was later updated in 2006 and 2007. The guidebook covers increased power flow (IPF) from the design, engineering, system planning, and operations perspectives. In 2008, the IPF Guidebook will be published with a "platinum" color and will become part of the EPRI's color book series. This reference documented the state of the science for increasing power flow capacities of overhead transmission lines, cables, and substation equipment. The project provides an overview of the electrical, mechanical, thermal, and system concerns important to increased power flow and presents all possible IPF options. Case studies will illustrate several IPF options and compare their potential economic benefits. This guide also summarizes other developments in both hardware (e.g., video sagometers) and software (e.g., the DTCR program) instrumental for IPF.

In 2009 EPRI will publish an update of the IPF Guidebook. This update will include case studies related to design and engineering aspects, as well as system planning and operations aspects of IPF. In addition, improved thermal models of lines, cables, and substation equipment such as current transformers will be included. New hardware equipment developments to measure conductor temperature, sag, and tension will be documented. Also the IPF Guidebook tutorial (a PowerPoint presentation) will be updated with these changes.

The IPF Line Rating Wizard, a software package that identifies the most attractive uprating alternatives on the basis of answers to a few simple questions, was started in 2007 and a prototype will be released in 2008. This tool will be further enhanced in 2009 and beyond to provide uprating alternatives for cables and substation equipment so that the utility engineers can use this tool to come up with the best power flow upgrade option for the entire transmission circuit consisting of overhead lines, underground cables,

and substation equipment. The Wizard software also provides the summary of various uprating methods with appropriate references to the relevant IPF guidebook sections.

Value

- Enhance reliable operation of transmission networks at higher power levels by operating within risk tolerance limits and avoiding unnecessary system outages
- Contribute to a safe and healthy environment for utility crews and the general public through effective evaluation of electric and magnetic fields (EMF) and siting issues at high power levels
- Reduce costs of grid transmission, potentially lowering electricity rates to end-use customers
- Improve customer satisfaction by reducing interruptions and lowering energy costs
- Defer construction of new transmission lines to avoid capital costs
- Increase power flows on existing assets up to 15–20%, potentially increasing revenues by millions of dollars

How to Apply Results

By implementing one or more of the IPF technologies, members can increase asset utilization at minimal cost. Utilities can use the *IPF Guidebook* to train their engineers in this technology. The *IPF Guidebook* compares the economic benefits of each available IPF technology, enabling members to make informed decisions when choosing IPF options for their applications. IPF Transmission Circuit Rating software will also help utility engineers decide on power flow options, depending upon their specific needs.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Updated IPF Guidebook: The <i>IPF Guidebook</i> will be updated with the latest hardware developments that can be installed on the existing transmission circuits to measure temperature, sag, and tension. Also thermal models for lines, cables, and substation equipment (such as current transformers, circuit breakers, and switches) will be updated based on other EPRI research. Operational and planning issues that arise while implementing IPF tools will be updated as well.	12/31/2009	Technical Update
Updated IPF Guidebook Tutorial/Training: The PowerPoint presentation based on the <i>IPF Guidebook</i> material will be also updated based on the latest updates to the guidebook. This presentation will benefit utility engineers by enabling them to learn various IPF options much faster than they would by going through the guidebook. This presentation, which includes notes, can be used for individual training or in a classroom. This EPRI presentation will train utility engineers.	12/31/2009	Technical Update
IPF Line Rating Wizard: The IPF Line Rating Wizard software will provide all the available options for increasing power flow in an overhead transmission line.	12/31/2009	Software

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Updated IPF Guidebook: A technical report will be published as the next version of the <i>IPF Guidebook</i> (also known as “Platinum book” as part of the EPRI color book series), with all the latest developments included.	2010	Technical Report

Product Title & Description	Planned Completion Date	Product Type
IPF Cable Rating Wizard: The Wizard software will be enhanced to include power flow upgrades for underground cable circuits.	2010	Software
Workshop on IPF Guidebook & Wizard: A workshop will be conducted to disseminate the results of the <i>IPF Guidebook</i> , as well as the Wizard software.	2011	Workshop, Training, or Conference
IPF Transmission Circuit Rating Wizard: The Wizard software will be further enhanced so that a transmission circuit which consists of overhead line, underground cable, and substation equipment can be simulated.	2011	Software

P38.002 DTCR Technologies (062098)

Issue

The demand for electric power over transmission circuits is increasing at a faster rate than the construction of new transmission facilities. This trend has pushed the capacity of many existing transmission circuits to their design limits. In addition, much of the grid has already aged beyond its original design specifications, resulting in an increasing number of bottlenecks, brownouts, and other severe reliability issues. However, because original design specifications were conservative, most transmission assets have significantly greater power capacity than previously assumed. With the proper technology, greater power capacities can be reliably and safely realized.

Description

This project continues to develop software and methodologies for optimizing the power ratings of transmission circuits. A new software product for dynamic thermal circuit rating (DTCR), the DTCR Data Analysis Program (DAP), will have its first version released in 2008, and a second version in 2009. Also, EPRI's well-known DTCR program will be updated to version 5.0 in 2009. These software products can provide real-time ratings or be used with innovative methods for quasi-dynamic, probabilistic, and predictive ratings. The project also explores these innovative methodologies for optimizing transmission circuit ratings. One focus for 2009 will be to use existing weather prediction technologies for accurate forecasting of transmission circuit ratings.

Value

- Increase and optimize power flow through entire transmission circuits (including lines, cables, transformers, and substation equipment)
- Defer capital expenditures
- Operate transmission circuits reliably and safely
- Meet new mandatory FERC requirements for circuit ratings
- Optimize energy transactions through rating forecasts

How to Apply Results

Transmission planners, designers, operators, and engineers will use this project's results of to gather the necessary data to enable the software products to provide real-time ratings of circuit components or entire circuits. Further, the same data and rating simulations can be analyzed to provide optimal static rating assignments through the quasi-dynamic rating process. In addition, these products provide an ideal way to fulfill the new mandatory FERC reliability requirements regarding the determination and documentation of ratings.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
DTCR Technology Workshop: This workshop covers the DTCR software and related technologies. It will focus on the following topics: Background/Overview of DTCR, Overhead Lines, Field Instrumentation, Quasi-Dynamic Rating, Underground Cables, Transformers, Substation Equipment, Operating with DTCR, Set-up and Tutorial Test Cases, Analysis of Calculation Results, Upcoming Developments, Hands-on Exercises, and Using DTCR Technology to meet FERC 2007 Reliability Standards.	12/31/2009	Workshop, Training, or Conference
DTCR 5.0: Dynamic Thermal Circuit Rating Version 5.0 will include updates that reflect the latest findings. The software computes ratings of all individual transmission circuit components, and/or entire circuits, in real-time or in simulated real-time. The software can be used for rating studies or for forecasting ratings.	12/31/2009	Software
DAP 2.0: Following its first year of release, DAP will be updated to version 2.0. This new version will include auto-calibration of conductor temperature as a function of sag or tension.	12/31/2009	Software

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Increased Power Flow Conference	2010	Workshop, Training, or Conference
DTCR 5.1	2010	Software
DAP 3.0	2011	Software
Field Testing of DTCR and DAP: DTCR and DAP will continue to be developed and field tested. It is expected that the technology will gain in acceptance by the industry, and applications and refinements will continue to grow.	2011	Technical Update

P38.003 Instrumentation for Managing IPF (062100)

Issue

The demand for electric power over transmission circuits is increasing at a faster rate than is construction of new transmission facilities. This trend has pushed the capacity of many existing transmission circuits to their design limits. In addition, much of the grid has already aged beyond its original design specifications, resulting in an increasing number of bottlenecks, brownouts, and other severe reliability issues. However, because original design specifications were conservative, most transmission assets have significantly greater power capacity than previously assumed. With the proper technology, greater power capacities can be reliably and safely realized. EPRI has been in the forefront of instrumentation development for managing increased power flow strategies, and significant developments will continue to take place in this project.

Description

This project explores the need for instrumentation to support increased power flow technologies and operation. It also assesses the feasibility that such instrumentation could be successfully developed. With ongoing input and recommendations from advisory bodies, instrumentation will be developed methodically, from conception and design to prototype fabrication and testing, and then on to advanced field testing and commercialization.

Value

- Increase and optimize power flow
- Defer capital expenditures
- Enable operation of transmission circuits reliably and safely

How to Apply Results

Transmission engineers can use this project's results to field test the instrumentation to assess applicability, reliability, and practicality. Implementation can then increase power flow through existing assets while maintaining safety, reliability, and risk control.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Technical Guide for New Instrumentation: This guide documents the progress made in instrumentation development and helps power industry engineers assess needs and applicability at their companies.	12/31/2009	Technical Update
Hardware Installations Workshop: This workshop demonstrates, with hands-on training, the installation and application of increased power flow instrumentation.	12/31/2009	Workshop, Training, or Conference

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
IPF Instrumentation	2010	Hardware
IPF Instrumentation Field Applications	2010	Technical Update
IPF Instrumentation	2011	Hardware
IPF Instrumentation Workshop	2011	Workshop, Training, or Conference

P38.004 Impact of Increased Power Flow on Conductor Thermal and Corona Models (063384)

Issue

The demand for electric power over transmission circuits is increasing considerably faster than is construction of new transmission facilities. This trend has pushed the capacity of many existing transmission circuits to their design limits. To squeeze more power out of existing assets, the power industry has in many cases resorted to operating components, particularly overhead transmission lines, at higher temperatures than normally done in the past. There is reason to believe that the empirical models developed in the past for determining conductor temperature and corona performance are in error at these elevated temperatures. To push more power, utilities will need to understand the temperatures at which overhead lines are operating, for safety and reliability reasons and to avoid generating corona problems where none existed previously.

Description

The project assesses the applicability of existing thermal and corona models to elevated operating temperatures. Required tests will be identified and performed. In addition, the empirical models will be updated to account for the new data, and algorithms will be provided to update prediction software products.

Value

- Operate circuits at elevated temperatures reliably and safely
- Defer capital expenditures by maximizing use of existing transmission networks
- Increase and optimize power flow

How to Apply Results

Members will use this project's results to accurately determine the temperatures at which overhead conductors are operating and the corona performance when current levels are pushed beyond previous normal levels. This will assure members that the conductors are not creating a safety hazard by sagging beyond required limits or that the conductors are not losing strength due to the annealing of aluminum. Members can also gain assurance that lines will not become a public nuisance due to higher than normal corona levels.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Thermal and Corona Models of OHTL Conductors Operating at High Temperatures: The results of work during 2007, 2008, and 2009 will be included in the Technical Update. This report will include the needed algorithms to create thermal model software libraries used in several EPRI software products (e.g., Dynamic Thermal Circuit Rating, PTLOAD, STLOAD, TLWorkstation).	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Impact of IPF on Corona and Thermal Models – Workshop	2010	Workshop, Training, or Conference
Impact of IPF on Corona and Thermal Models – Final Report	2010	Technical Report

P38.005 Impact of High-Temperature Operation on Conductor Systems (058548)

Issue

Electric power utilities often increase the power flows of transmission lines by raising the limit of allowable conductor operating temperatures. Some of the effects of high operating conductor temperatures are loss in conductor strength and reduction in conductor ground clearance. Research is needed to investigate the premature aging of conductor and conductor accessories, including conductor fittings, dampers, spacer dampers, and other hardware resulting from thermal cycling of these components. With accurate data, electric power companies can determine the temperature limits at which overhead lines can operate safely and perform on-time maintenance and take other appropriate measures to avoid transmission line failures.

Description

This project addresses the mechanical integrity of overhead systems subjected to high operating temperatures. Performance of two-stage compression fittings, the most common fittings in an electric power system, is studied at various conductor temperatures above 100°C. As these fittings are the weakest links in transmission systems, the project focuses on establishing temperature and duration limits beyond which these fittings may encounter thermal or mechanical failures. Subsequent studies involve other critical line components and address knowledge gaps for high-temperature operations. The project also updates all relevant information on performance of conductors and conductor accessories operating at and beyond conductor annealing temperatures (e.g., 93°C). Data will be summarized in a matrix format, with easy retrieval facilitated by the application of a high-temperature conductor (HTC) matrix applet. Various methods of detecting potential conductor failures will be investigated and evaluated for applications. Remedial measures will be developed for alleviating deteriorated compression fittings.

Value

- Avoid potential line failures
- Enhance confidence in operating transmission lines at increased conductor operating temperatures
- Achieve increased power flows

How to Apply Results

Members can use information and evaluation methods generated from the project as guidance in determining temperature limits of overhead lines. Transmission engineers can evaluate the risks of raising conductors to specific temperatures more accurately. Detection methods and mitigation measures will ensure that an overhead line system operating at high temperatures is reliable.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
HTC (High-Temperature Conductor) Matrix: Version 3.0: The HTC Matrix software complements the Technical Update. It is an applet (mini-program) that facilitates the retrieval of information in the technical update. Major upgrade of features and functionalities of the applet will be conducted in 2009. EPRI plans to continue to update the applet in the future as additional test results, both from EPRI and others, become available.	6/30/2009	Software
Impact of High-Temperature Operation on Conductor Systems: The technical update provides the most up-to-date information on conductor and conductor accessories at elevated temperatures. It provides utility personnel with access to information on how elevated temperature may affect the performance of the conductor system. It provides methodologies to evaluate and predict the performance of the conductor splice at a given temperature. The update will also include the risk and potential damage to the transmission system that may occur when a conductor operates beyond its design temperature, as well as detection methods for potential line failures and remedial measures to enhance the integrity of compression fittings.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
HTC (High-Temperature Conductor) Matrix: Version 3.1: The features of the HTC Conductor Knowledgeable Matrix will be enhanced further in 2010. It will also be updated with new information, data and research results.	2010	Software
HTC (High-Temperature Conductor) Matrix: Version 4.0	2011	Software
Guide for Operating Overhead Lines at High-Temperature - Draft: Based on information, data and research results from previous years, a guide will be developed to assist the electric power industry to raise the current capacity of an overhead line to an acceptable level. The guide will first developed in draft form in 2010 and then in final form in the following year.	2010	Technical Update
Guide for Operating Overhead Lines at High-Temperature - Final: The HTC Conductor Knowledgeable Matrix will be completely revamped in 2011 to include basics background information, theories, formulas and Help menus for inexperienced users.	2011	Technical Report

PS38B Major Power Flow Upgrades (065549)

Project Set Description: The objective of this project set is to enable utilities to achieve a large increase in power capacity of existing transmission lines through more extensive upgrades such as re-conductoring an overhead conductor with an advanced conductor or upgrading the existing system to a higher voltage. In 2009, the projects in this project set are:

- Advanced Conductors
- Voltage Upgrade of Transmission Lines

Advanced conductors are studied to improve the confidence of power utilities in the applications of these new types of conductors. Voltage upgrades provide an alternative to transmission systems that will not benefit from current upgrades due to current flow restriction imposed by the line impedance. The project helps users to identify potential candidates for voltage upgrade as well as ignore lines for such an upgrade.

Project Number	Project Title	Value
P38.006	Advanced Conductors	This project evaluates the longevity of advanced conductors (high-temperature low-sag or HTLS conductors) and develops methods to maintain lines that use these types of conductors. New advanced conductors will be evaluated as they emerge.
P38.007	Voltage Upgrade of Transmission Lines	This project identifies electrical, mechanical, and structural elements that must be addressed in voltage upgrades. It will develop methodologies for voltage upgrades and address issues related to the construction, operation, and maintenance of the upgraded line. A "wizard" will be developed to assist utilities in evaluating suitability of voltage upgrade for a given overhead line.

Project Descriptions

P38.006 Advanced Conductors (065550)

Issue

A field demonstration on the application of high-temperature low-sag (HTLS) conductors (also known as advanced conductors) was successfully conducted under a supplemental project with 20 participating utilities. While positive, the field trial raised a number of issues, such as the long-term performance of some of these advanced conductors and maintenance methods for these conductors that must be addressed before they will be used with confidence. Further, a new aluminum conductor steel supported (ACSS) "advanced" conductor with a high-strength steel core has since been developed. This conductor should be evaluated and compared with other HTLS conductors to determine what advantages this conductor offers.

Description

This project addresses the outstanding issues identified in the HTLS conductor field demonstration project: long-term performance of some of these HTLS conductors and maintenance of lines using HTLS conductors. The cores of these advanced conductors are different than conventional ACSR conductors and some must be handled differently. The operating temperature of these advanced conductors will be much higher than that of conventional conductors. The tool requirements and maintenance procedures will be different. This project will first investigate the longevity of carbon fiber composite cores. It will evaluate and establish methods that are suitable for maintaining overhead lines using HTLS conductors.

The integrity of different HTLS conductor-splice systems will also be examined. A field trial of the high-strength ACSS conductor may also be carried out under a supplemental project.

Value

- Provide engineers with a tool to evaluate the long-term performance of different HTLS conductors
- Ensure the safety of utility personnel and reliability of transmission lines with proper maintenance procedures

How to Apply Results

With aging methodologies, utilities can more accurately evaluate different HTLS conductors when selecting conductors for new lines. Transmission line maintainers can use the procedures developed in this project for HTLS conductors and include them in their company's maintenance procedure and method manuals.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Guide for Maintenance of HTLS conductors: Maintenance procedures for advanced conductors are developed and evaluated under this project. Issues unique to the maintenance of this type of conductor will be addressed. A utility will be able to adopt these procedures in maintaining overhead lines with HTLS conductors. These procedures could form part of a utility's corporate methods and procedures manual.	12/31/2009	Technical Update
Methodology for Aging Evaluation of a HTLS conductor: The cores of advanced conductors are different than conventional ACSR conductors. Methodologies for evaluating these conductors are therefore different. The project will provide specifications or testing procedure to the utilities to enable them to evaluate and qualify these conductors for their applications.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Demonstration of Maintenance Procedure for HTLS conductors: Preliminary procedures developed for maintenance of HTLS conductors in the previous year will be demonstrated and re-fined in the laboratory or in the field in 2010 in order to produce a practical and useful guide for maintenance of HTLS conductors in 2011.	2010	Technical Update
Methodology for Aging Evaluation of Carbon Fiber Composite Core Conductor: In 2010, the methodology for evaluating the long term performance of the carbon fiber composite core conductor will be developed. It will include specifications for an accelerated aging test.	2010	Technical Update
Guide for Maintenance of HTLS conductors - Final: In 2011 the methodology for evaluating the long term performance of the metallic fiber composite core conductor will be developed. It will include specifications for an accelerated aging test.	2011	Technical Update
Methodology for Aging Evaluation of Metallic Fiber Composite Core Conductor	2011	Technical Update

P38.007 Voltage Upgrade of Transmission Lines (063314)

Issue

Upgrading transmission line voltages can achieve power increases comparable to those possible through constructing a new transmission line. Voltage upgrades also provide a solution to lines that do not benefit from current upgrades due to the current limit imposed by the line impedance. Voltage upgrades are quicker and less expensive options than building a new transmission line, as the environmental process takes only a fraction of the time required for a new line. Thus, voltage upgrades can provide a quick solution to overcome bottlenecks. For certain transmission lines, voltage upgrade may not be practical. In those cases, new lines may be the only solution and are justified.

Description

This project explores potential overhead lines for upgrading to higher voltages and thus increasing their power transfer capacity. The project investigates alternative voltage upgrade schemes and develops methodologies for upgrading the voltage of existing transmission lines. It identifies potential lines to be upgraded, provides proper design and construction procedures, and addresses issues related to operation and maintenance (O&M) of an upgraded line and its associated substation equipment. The project also identifies major obstacles that may be encountered for certain types of lines. The project capitalizes on past experience to produce practical solutions for engineers involved in transmission line upgrade applications. The process can also be used to eliminate the feasibility of voltage upgrade for certain overhead lines and provide justification for the construction of new lines. In 2009, a "wizard" will be developed to assist utilities in evaluating suitability of voltage upgrade for a given overhead lines. The project also explores the feasibility of a field demonstration in subsequent years to test the technologies developed under this project.

Value

- Achieve a substantial and quick increase in power capacities to overcome transmission bottlenecks
- Avoid the large capital costs involved with construction of new transmission lines
- Ensure a simpler and shorter regulatory process
- Substantiate the needs for a new line for cases where voltage upgrade is not practical

How to Apply Results

Practical examples and approaches will be provided to identify candidate lines to be upgraded. Transmission engineers can apply the methodologies for overhead line upgrades and evaluate the risks associated with each alternative. A guide will be prepared for member use in upgrading overhead lines. A “wizard” will be developed to assist utilities in evaluating the suitability of an overhead line for voltage upgrade.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Voltage Upgrade Wizard: The project addresses electrical, mechanical, and structural elements for voltage upgrades. The voltage upgrade wizard will help a utility evaluate the suitability of a voltage upgrade for a given overhead transmission line. The result will guide users in how to upgrade the overhead line, along with the costs, benefits, and risks associated with such an upgrade. Users can also employ the wizard to eliminate lines that are impractical to be upgraded, and thus justifying the construction of a new line.	12/31/2009	Technical Update
Tutorial for Voltage Upgrade Methodologies: The tutorial will provide training on the use of the “wizard” in evaluating the suitability of an overhead line for voltage upgrade. The tutorial will also review background information on identifying potential candidates for voltage upgrade and typical examples of voltage upgrades for various voltages that is necessary to apply the wizard properly and effectively.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Tutorial for Voltage Upgrade: In 2010, the tutorial will focus on the application of the voltage upgrade wizard in identifying and eliminating potential overhead lines for upgrade. In 2011, the tutorial will focus on the details of line design, upgrade implementation and upgraded line performance evaluation.	2010	Workshop, Training, or Conference
Voltage Upgrade Demonstration - Site Selection & Design: Using the voltage upgrade wizard developed in 2009, a typical overhead line is selected for voltage upgrade. This line can either be in an operating system or a simulated line in the field or laboratory. Detail design will be performed for changes to be made for the upgrade. The actual implementation will be carried out in 2011. The line will then be energized and monitored in the following years.	2010	Technical Update

Product Title & Description	Planned Completion Date	Product Type
Voltage Upgrade Demonstration - Implementation	2011	Technical Update
Tutorial for Voltage Upgrade	2011	Workshop, Training, or Conference

PS38C Integration of IPF Technologies for System Planning and Operations (067421)

Project Set Description: This is a new project set replacing project 38.006 “Economics, Risk Assessment, EMF and Guidebook of Increased Transmission Capacity” from 2008 that addressed system issues related to increased power flow. In addition, Project 38.009 “Technologies for Power Flow Improvement” from 2008 has been integrated into the new Project 38.009 “Impact of Dynamic Ratings, Major Power Flow Upgrades, and Green Power Integration on System Planning” since the applications of technologies for power flow improvement are closely related to the system planning function. This project set was created to address issues and impact from increased transmission capacity schemes such as dynamic circuit ratings, major power flow upgrades, and integration of green power from the planning and operation perspectives. There are two projects in this project set. Issues unique to planning and those unique to operation are addressed separately. Yet, the projects are coordinated to ensure that schemes and technologies are integrated smoothly into the system from planning and engineering to operation.

Project Number	Project Title	Value
P38.008	Integration of Power Flow Upgrade Options in System Operations/EMS	This project addresses operational issues related to the adoption and integration of increased transmission capacity schemes such as dynamic ratings, voltage upgrade, and other power flow upgrades into a power control system such as the EMS. It ensures proper coordination with the planning and engineering processes.
P38.009	Impact of Dynamic Ratings, Major Power Flow Upgrades, and Green Power Integration on System Planning	This project addresses planning issues related to the impact of dynamic ratings and major power flow upgrades on a transmission system. It also addresses the impact of the addition of green power such as wind farms. It ensures proper coordination with the engineering and operation processes.

Project Descriptions

P38.008 Integration of Power Flow Upgrade Options in System Operations/EMS (067442)

Issue

With new transmission construction difficult to pursue in many areas, incremental upgrades such as dynamic ratings and major power flow upgrades such as voltage upgrade, power flow management using FACTS (Flexible AC Transmission System), and advanced high-temperature low-sag conductors may be the only alternative for some time. The ability to increase transmission capability through such upgrades is tremendous. As a major challenge, the commonly applied single contingency reliability criteria may not adequately capture the risk of system failure caused by overload cascading and voltage collapse after a series of major upgrades. Thus, the risk of such severe events may be the most critical limitation on energy companies' pursuit of incremental and major upgrades as an alternative to new construction.

Understanding the special demands on system operations caused by extensive use of incremental and major upgrades helps operators maximize methods of increasing power flow limits.

Description

This project will be of value to engineers involved in system operations, as well as those in charge of operating the system economically and reliably. This project addresses the following tasks:

- Economics and risk assessment: Increased power flows increase potential revenues. However, system failure rates may also increase due to increased operating temperatures. Systematic analyses will identify risks versus rewards when operating systems at increased power levels.
- Improved Operator Tools for integrating increased ratings into the Energy Management System (EMS): This project provides ways of integrating dynamic rating data as well as increased rating data due to major power flow upgrades into EMS. Dynamic rating program could be integrated along with other EMS application programs such as state estimator. A successful integration of increased rating data into EMS will provide improved options to system operators to perform increased rating dispatch along generation and load dispatch. In this respect, the dynamic rating forecast (hourly and especially next day) based on the historical data will be more beneficial to system operations.
- Enhanced Operator Displays with Increased / Dynamic Ratings: Presently system operators display the static ratings of the transmission circuits. However as the dynamic ratings are available to the system operator, it will be beneficial to show the dynamic ratings on the displays as different contingencies occur. It is also important to consider emergency (short term and long term) ratings using the dynamic rating data. Different methods of display will be explored and the pros and cons of these methods will be documented.

Value

- Enhance reliability of system operation at higher power levels, avoiding unnecessary system outages
- Reduce overall costs of grid transmission, potentially lowering electricity rates for end users
- Improve customer satisfaction by reduced outages and lower energy rates
- Defer construction of new transmission lines and avoid capital costs
- Enable transmission companies to increase power flows on existing assets up to 15–20% (incremental upgrades), 50-100 % (major power flow upgrades) , providing opportunities for increased revenue

How to Apply Results

Using project results, transmission operators can improve their operating decisions to minimize the risk of equipment failure when operating transmission systems at increased power levels. Dynamic rating forecaster results can be used to perform economic generation dispatch with dynamic ratings of the circuits rather than static ratings. Improved operator displays will help operators run their systems reliably while running them at increased power levels.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Economics & Risk Assessment of Power Flow Upgrade Options: Increased power flows and the subsequent increased revenues for various power flow options will be documented along with the risks associated with each option.	12/31/2009	Technical Update

Product Title & Description	Planned Completion Date	Product Type
Improved Operator Tools for integrating Power Flow Upgrade options into EMS: Improved operator tools such as dynamic rating forecaster will be provided so that these tools will be integrated with EMS to come up with real-time operating decisions to increase power flow on the existing corridors.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Improved Operator Tools for integrating Power Flow Upgrade Options into EMS: Improved operator tools for different power flow options will be developed and integrated with the EMS software as an application program so that the system operator can make use of the power flow options in real time as and when needed.	2010	Technical Report
Enhanced Operator Displays with Increased Ratings: Enhanced display of power flow upgrade options and the increased ratings that can be shown on the operator console will be documented.	2010	Technical Update
Workshop on Improved Operator Tools and Enhanced Operator Displays: EPRI will organize a workshop for system operators, to help them better implement improved operator tools and enhanced operator displays for various power flow upgrade options.	2011	Workshop, Training, or Conference
Utility Applications of Improved Operator Tools and Enhanced Operator Displays: This project will involve specific utility applications of various power flow upgrade options, to test them in real-system operations.	2011	Technical Update

P38.009 Impact of Dynamic Ratings, Major Power Flow Upgrades, and Green Power Integration on System Planning (067443)

Issue

With new transmission construction difficult to pursue in many areas, incremental upgrades may be considered first and followed by some major upgrades, such as voltage upgrade, FACTS (Flexible AC Transmission System), and advanced high-temperature low-sag conductors to the existing system, as demand increases. The ability to increase transmission capability through such upgrades is tremendous, and these upgrades need to be considered in system planning decisions. Understanding the implication of incremental and major upgrades in system planning will help planners to make economic planning decisions while considering the costs and limitations of these upgrades. Increased power flows of transmission circuits can be achieved by controlling circuit parameters, such as current, voltage, phase angle, or timing of current flow. Often, upgrade of a single parameter, such as current or voltage, provides increased power flows. However, controlling more than one parameter, while typically more expensive than a single parameter upgrade, offers distinct benefits. This option not only allows a utility to increase the capacity of an overhead line, but also enhances the power flow performance of the entire transmission system.

Description

This project will be of value to power system planners, as well as to design and standards engineers involved in the planning, design, and implementation of incremental upgrades (dynamic ratings) and major upgrades (voltage upgrade, FACTS, and advanced high temperature low-sag conductors). It addresses power flow upgrades by controlling more than one of the system's parameters. The project selects different advanced technologies at various stages of maturity for evaluation in power flow management applications. It examines the economics of applying such technologies to develop a tool for making the financial decisions associated with implementing such technologies. The viability of each technology will be further demonstrated at a host utility. Some of the technologies that may be evaluated are dynamic ratings, voltage upgrade, advanced high-temperature low-sag conductors, FACTS, Static VAR Compensators (SVCs), series capacitors, series reactors, and phase shifters.

The tasks addressed in this project are as follows:

- Develop planning methodologies to integrate incremental and major power flow upgrades: Existing transmission planning tools are focused on new equipment additions and new line construction. It is important to review the existing planning methodologies (both deterministic and probabilistic methods) and propose new ways of considering the incremental and major power flow upgrades in the transmission planning.
- Green power integration to the main transmission grid: Many green power resources such as wind power are proliferating, and transmission planning and system expansion issues are a crucial component of integrating these green power resources into the main grid. The possibility of incremental upgrades and major power flow upgrades shall be considered first, before considering the new transmission construction under the green power integration scenarios.
- Develop case studies for different upgrade options and simulate the planning scenarios using the developed methodologies.
- Document the technical and economic benefits of each upgrade option and provide the data required for engineers to design such an upgrade.

Value

- Provide cost-effective upgrade option for a given load growth scenario
- Reduce overall costs of grid transmission, potentially lowering electricity rates for end users
- Improve customer satisfaction by reduced outages and lower energy rates
- Defer construction of new transmission lines and avoid capital costs
- Facilitate flexible and controllable power flow
- Relieve transmission bottlenecks
- Improve system performance and potentially increase capacity improvements several fold
- Enable transmission companies to increase power flows on existing assets up to 15–20% (for incremental upgrades) and 50–100% (for major upgrades), providing opportunities for increased revenue

How to Apply Results

Using project results, transmission planners can improve their planning decisions to optimize the use of existing transmission corridors using the incremental and major power flow upgrades. Case studies will provide some realistic examples for utilities to consider incremental and major power flow upgrades during the planning stage. Design and engineering studies can be carried out using the data for the specific power flow upgrade options.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Planning Methods to integrate Power Flow Upgrades: This project will document deterministic and probabilistic system planning methods while considering both incremental and major power flow upgrades as part of system expansion plans. It will also present costs versus benefits of these options, considering present worth of future increased energy sales.	12/31/2009	Technical Update
Power Flow Upgrade Options for Green Power Integration: Optimal upgrade options will be provided while considering green power integration such as wind, which is intermittent.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
System Planning Methods to integrate Power Flow Upgrades: This project will present system planning methods with different load growth scenarios, while considering both incremental and major power flow upgrades as part of system expansion plans.	2010	Technical Report
Green Power Integration Strategies: This project will provide possible green power integration strategies as well as the cost versus benefits for each strategy.	2010	Technical Report
Workshop on System Planning Methods for Power Flow Upgrades including Green Power Integration: A workshop will be conducted on system planning methods for power flow upgrades, including green power integration.	2011	Workshop, Training, or Conference
Utility Applications of System Planning Methods for Power Flow Upgrades: System planning methods for power flow upgrades will be applied to real-world utility systems.	2011	Technical Report

PS38D Superconductivity (063315)

Project Set Description: This project set provides longer-term solutions for a large increase in transmission capacity. It was created to deal with transmission bottleneck problems through the integration of superconducting components into the transmission and distribution system. This project's research study paves the way for and validates early adoption technologies that are currently technically and economically feasible and that can establish the foundation for a superconducting power grid of the future. This project set consists of one project: Develop and Deploy Superconducting Technologies.

Project Number	Project Title	Value
P38.010	Develop and Deploy Superconducting Technologies	This project promotes informed business decisions related to the assessment, procurement, deployment, and operating and maintenance of superconducting assets in the power delivery

Project Number	Project Title	Value
		system through support of research, development, and demonstration of superconducting technologies.

Project Descriptions

P38.010 Develop and Deploy Superconducting Technologies (102090)

Issue

Substations of the future will likely use technologies vastly different from those applied for more than half a century. Already, both solid-state switching devices and superconductors are making their debut in transmission and distribution substations. As transmission corridor constraints increase, studies and demonstrations confirm the value of high-capacity high-temperature superconductors (HTS) cables in the power grid. However, the design, fabrication, and installation of superconducting equipment present challenges, particularly in a utility substation environment. There is a need for hardware demonstrations to validate equipment performance and cost, stakeholder dialogues to increase understanding, and business case development to justify investment. Education of utility personnel in these areas is paramount.

Description

This project supports research, development, and demonstration (RD&D) of superconducting technologies for the power delivery system. The project also promotes informed business decisions related to the assessment, procurement, deployment, and operation and maintenance (O&M) of superconducting assets in the power delivery system. It utilizes the extensive investments of the U.S. government, host utilities, and other organizations in emerging technology demonstrations by reporting the results to inform a wider audience and solicit a larger base of support for such activities. Project tasks include technology watch reports, assessments, guidelines, annual conferences, and stakeholder workshops as needed by both early adopters and mature market participants to take full advantage of the new superconducting systems.

In 2009, according to prioritization by members and available funding, the tasks planned are as follows:

- Publish a Technology Watch on HTS cable system demonstrations in the United States and overseas, with reports on operations and performance of three U.S. cable projects, as well as on international projects as available. New projects sponsored by the U.S. Department of Energy (DOE), if initiated, will also be reported.
- Publish a Technology Watch on HTS fault current limiters. Available information on expected DOE-sponsored demonstrations of this technology will be gathered and reported, including project goals, design specifications, installation, and operation experience.

Value

- Alleviate existing transmission corridor capacity constraints through integrating superconducting components into the transmission and distribution (T&D) system
- Reduce energy losses due to higher efficiency of superconducting cables and transformers
- Improve system reliability and security through deployment of superconducting equipment (e.g., fault current mitigation, voltage compensation, and immunity from external factors such as weather and heat)

How to Apply Results

This project provides transmission owners and operators with the tools to understand and evaluate the technical, economic, business, and operational issues associated with the deployment of

superconducting technologies into the T&D system. Through economic comparisons with conventional alternatives, field performance results from demonstrations, reliability and availability assessments, and studies of the impact of superconducting equipment on system operations, members can make informed decisions on how to position themselves as this technology matures. Overall results support a range of possible courses of action to take, from a simple "technology watch" posture to an aggressive "first adopter" strategy.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Technology Watch—Superconducting Cables: This final technical report will discuss the operation and performance of three U.S. HTS cable projects, including lessons learned and future plans. Status of ongoing projects in the United States and abroad will be also reported.	12/31/2009	Technical Report
Technology Watch—Fault Current Limiters and Superconducting Synchronous Condensers: This technical update will describe U.S. and international demonstrations of superconducting fault current limiters and synchronous condensers, including their background and current status.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Guidelines for Developing a Business Case for Superconducting Substation Equipment: This interim report will provide results of a survey on the experience of first-adopter energy companies in justifying procurement and operation of superconducting substation and power delivery equipment.	2010	Technical Update