

## **174 Enabling Integration of Distributed Renewables**

### **Program Overview**

#### **Program Description**

This new program provides access to the latest ideas, existing practices, planning methods, and practical implementations for integrating distributed renewable generation. Issues of enabling high penetration of distributed generation into both existing and future distribution systems are addressed. Projects cover interface devices, analytics, studies, special applications, and assessment of new technology for effective interconnection and integration of renewable and other distributed generation. The program also includes lab and field tests, demonstrations, and case studies. A primary objective is to expand utility knowledge and capability to use, leverage, and monetize the value of renewable deployment without reducing distribution safety, reliability, or asset utilization effectiveness.

#### **Industry Needs and Issues Addressed**

- Maintaining grid reliability and safety
- Strategies to engage in deploying customer-sited renewable generation
- New business models, economic analysis of ownership options, potential to rate base
- Proactive response to renewable portfolio standards (RPS)
- Planning for renewable deployment and advanced distribution automation
- Leveraging the value of the distribution system to renewable distributed generation

#### **Impact**

- Members are positioned to deploy renewable generation, realizing the important role and value of distribution and substation assets.
- Research results identify best practices and opportunities for grid modernization while helping justify needed investments.
- Evaluating new applications and hardware will support members' planning considerations and help avoid investment mistakes.
- Preparing for increased penetration levels and offering new ways to connect and use renewable generation can help members retain leadership in the delivery of electric energy.

#### **Key Accomplishments**

- This is a new program that builds on previous work on distributed resource integration in the Advanced Distribution Automation and IntelliGrid programs

#### **Current Year Objectives**

- Develop screening tools, criteria, and guidelines for increasing penetration of renewable generation in existing radial and network distribution, as well as future circuit functional requirements.
- Plan and conduct a member's' workshop to share current practices and identify future need for planning and integration tools, as well as assessment of advanced circuits design concepts.
- Survey current AMI deployment with DG and explore ways that advanced metering systems help enable, integration, including a comparison of current and expected future performance.
- Identify and provide application and design data for promising direct current use of PV energy by end users.
- Develop performance criteria, design test, and set up laboratory test stand to evaluate available inertie hardware, systems, and configurations.

### Industry Involvement

- Estimated 2009 funding: \$2.2M

### Program Technical Lead

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## Summary of Projects

### PS174A Integrating Renewables into Distribution (067431)

**Project Set Description:** This project set focuses on the distribution system's readiness for high penetration of renewable and distributed generation. The first project is related to incremental increases of distributed generation into today's existing distribution, both radial and network. The second project will assess future distribution system designs and related options for integrating the anticipated high penetration of renewable and distributed generation.

Project Number	Project Title	Value
P174.001	Planning and Design for Renewable Integration into Existing Distribution	Investigates how to make incremental increases of renewable generation into existing radial and network distribution systems without sacrificing safety, reliability and effectiveness. Starting with prior integration work, this project focuses on changes needed in planning, design, and operating criteria for high penetration of distributed and variable generation. It will also provide guidelines, impact analysis, and assessment methods as needed to determine the limits of distributed generation and analyze expansion options and system values.
P174.002	Assessing Future Distribution Options for Integration of Distributed Renewable Generation	Assesses future options for distribution planning, design, and operation with new integration devices, advanced distribution system configurations such as microgrids, and practices for wide-scale integration of renewable generation. This project will assess new concepts and methods as well as the cost and timing for accommodating high levels of variable distributed generation. This project will build on foundation work completed in the EPRI Advanced Distribution Automation Program and IntelliGrid activities.

## Project Descriptions

### P174.001 Planning and Design for Renewable Integration into Existing Distribution (067493)

#### Issue

Existing radial and network distribution systems are not designed for a significant penetration of distributed generation. The key issues are lineman and public safety, circuit protection, voltage control, and reliability. Circuit limits on the penetration of distributed renewable generation are expected due to output variability and two-way power flows. Specific problems to be addressed are planning and design for adaptability of relays, interactive voltage control, fault detection, phase-to-ground overvoltage and islanding detection, and service restoration methods.

### Description

This project looks at making incremental renewable generation additions in today's existing radial and network distribution systems without sacrificing safety, reliability, or effectiveness. Starting with prior integration work, this project focuses on changes needed in planning, design, and operating criteria for high penetration of distributed and variable generation. It will provide guidelines, impact analysis, and assessment methods to determine the limits and analyze the expansion options and potential system value.

### Value

- Enhance ability to conduct effective resource planning, improve on interconnection screening and requirements, and maintain circuit performance and reliability.
- Gain access to and exchange up-to-date information. Share best practices, state-of-the-art developments, and related information from other distribution companies.
- Benefit from collaborative R&D activities and sharing applications, experiences, lessons learned, and solutions related to integrating distributed renewable generation.
- Address current renewable power generation issues via analytical studies, developing planning methods, applying screening tools, and evaluating specific interconnection case studies.

### How to Apply Results

Utilities faced with planning or integrating new renewable generation will utilize the results of this project to ensure that the full implications of safety, reliability, and electrical performance are considered. Findings can be used to work with developers wanting to connect green buildings, construct zero-energy homes, and implement sustainable community strategies.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Workshop on current practices and related tools for screening connections of renewable generation:</b> This workshop will present ideas and collect feedback on the best practices being used to evaluate and approve renewable generation connections, as well as future needs to simplify the approval process. It will be scheduled in parallel with the workshop in 174.002 on existing advanced design concepts and options for high penetration of DG.	10/31/2009	Workshop, Training, or Conference
<b>Explore guidelines and identify criteria for advanced applications that help integrate DG:</b> This technical update explores guidelines and identifies criteria for advanced applications that can help integrate distributed generation. Key topics will include adaptive distribution relaying to accommodate DG and integration of Var control from DG with overall distribution Var management.	12/31/2009	Technical Update
<b>Prototype Screening Tool for evaluating system impacts of DG:</b> Prototype Screening Tool for evaluating system impacts of DG on typical existing distribution systems. Member feedback will be gathered in 2008 and 2009. Version 1.0 will be implemented as a stand-alone tool that can also be applied as a web-based applet in 2009.	12/31/2009	Software

### Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Guideline on applications of adaptive relaying to accommodate high penetration:</b> Technical update includes sample case studies and provides guidelines on applying adaptive relaying to accommodate high penetration of DG.	2010	Technical Update
<b>Planning methodology to determine practical circuit limits for distributed generation:</b> Technical report presents planning fundamentals to help users determine the practical substation and circuit limits for DG integration in distribution systems.	2010	Technical Report
<b>Guideline on voltage control strategies for high penetration of distributed generation:</b> Technical update includes sample case studies and provides guidelines on voltage control strategies for high penetration of DG.	2010	Technical Update

### P174.002 Accessing Future Distribution Options for Integration of Distributed Renewable Generation (067494)

#### Issue

Decisions on replacing or upgrading aging distribution systems will need to consider the potential for high levels of distributed renewable generation. Utilities would like to plan for and build in capability to support higher penetration levels of distributed renewable generation while maintaining safety, protection, and reliability. A key issue this project will address is new distribution system designs that will allow greater penetration of distributed resources.

#### Description

This project will address future distribution options for planning, design, and operation with new integration devices, advanced distribution system configurations, and practices capable of supporting wide-scale integration of renewable generation. It will assess new concepts, methods, and tools along with the related cost and timing for accommodating high levels of variable distributed generation.

#### Value

- Provides important design guidelines for future distribution systems when high penetration of distributed resources is more critical.
- Knowledge, perspective, and new ideas about what future distribution systems with significant levels of distributed generation, related communication, and automation will need to look like.
- Collaboration with other members to develop criteria, apply planning methods, and share design concepts for the distribution systems of the future.
- Results from analytical studies, modeling and simulations, case studies and demonstration of new distribution designs with high penetration of renewable generation.

#### How to Apply Results

The criteria, configurations, and designs for accommodating high levels of renewable generation will help distribution system planners think through and incorporate needed changes in system plans. Distribution engineers and operators will use results describing future options to frame recommendations and consider new operating procedures that will be required to accommodate high penetration of distributed resources.

## 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Workshop on advanced design concepts for future grid integration:</b> This workshop will focus on advanced design concepts and options, such as the SCE Avanti circuit, microgrid results from Europe and the United States, and integrating renewables and DG with automation schemes. It will be scheduled in parallel with the workshop in 174.001 on existing circuits and current practices for high penetration of DG.	12/31/2009	Workshop, Training, or Conference
<b>Report on circuit functionality and requirements for future grid integration:</b> Required new functionalities for future distribution systems to incorporate high penetration of distributed generation will be reported. Topics include the role of ADA, interface with communications architectures, and microgrids. Relative cost and timing for these deployments will also be covered.	12/31/2009	Technical Report

## Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Assessment of Cases that Demonstrate Deployment of Advanced Distribution Circuits with DG:</b> This will be an update/assessment of actual case studies showing the planning, design and implementation of advanced circuits that demonstrate future configurations and hardware needs for high penetration of DG.	2010	Technical Update
<b>Development of Advanced Circuit Guidelines (Initial Chapters for future EPRI Color Book document):</b> Initiate process of developing recommended guidelines for advanced circuits needed to integrate higher levels of renewables and distributed generation, and to evolve into an EPRI Color Book. Proposed initial chapters are: <ul style="list-style-type: none"> <li>• Overview of Impacts on Planning Tools</li> <li>• Communication Infrastructure Needs for Integration of Renewables and DG (in coordination with IntelliGrid)</li> <li>• Protection Systems to Integrate Renewables and DG</li> <li>• Voltage and Var Control with Renewables and DG</li> </ul>	2010	Technical Update
<b>Workshop on Advanced Circuit concepts for Integration of Distributed Generation:</b> This workshop will be a follow-on from 2009 and will address advanced circuit concepts for the integration of distributed generation.	2010	Workshop, Training, or Conference

## PS174B PV & Metering Integration into Distribution (067432)

**Project Set Description:** This project set focuses on end-user level, distributed renewable interface technologies. Both grid-tied and direct PV energy-to-appliance applications, as well as related hardware, will be covered. For grid-connected applications, advanced metering systems, inverters, controllers and other related inertia equipment will be evaluated. The direct use of dc from photovoltaic generators into drives, lighting, battery, PHEV and other electronic end uses will be investigated and tested.

<b>Project Number</b>	<b>Project Title</b>	<b>Value</b>
P174.003	Advanced Metering Infrastructure (AMI) Applications for Distributed Renewable Integration	Explores ways to apply advanced metering infrastructure (AMI) to help integrate distributed renewable generation. AMI provides a communication infrastructure to integrate distributed resources with the operation of the entire distribution system. Advanced meters also have the potential to provide the actual interface with some distributed resources. The project will include evaluations of combined AMI and distributed renewable design concepts and applications. Both laboratory prototype system testing and field demonstrations will be performed.
P174.004	DC Applications for Direct Use of Distributed Photovoltaic Generation	Conducts scoping studies, defines new applications, and develops conceptual designs for integrating PV generation via dc applications. Examples are adjustable-speed drives, lighting, battery storage and plug-in hybrid electric vehicles (PHEVs). The EPRI Intelligent Universal Transformer is another technology that would provide such a dc interface. Results are provided via paper studies, hardware demonstration partnerships, lab evaluations, and field deployment demos. Applications aim to simplify interconnection, increase efficiency, and reduce the cost of integrating and interconnecting PV.
P174.005	Evaluation of Distributed Renewable Grid Interface Systems	Evaluates grid integration hardware, systems, and configurations. This project will examine system compatibility (immunity, emissions and energy performance) profiles, protection settings, communication and control interface, specifications, availability, performance, and cost of existing inverters systems and other distributed renewable generation grid interface hardware. New options will be identified with related performance requirements, and tested in the lab and field. The work will evolve from concepts, prototypes, and first adapters to industry best-practice guidelines and proposed standards.

## **Project Descriptions**

### **P174.003 Advanced Metering Infrastructure (AMI) Applications for Distributed Renewable Integration (067494)**

#### **Issue**

With deployment of advanced metering infrastructure, many utilities are making a financial investment in AMI technology and timing is critical for AMI designs to take into account future requirements for integrating distributed resources. Although data capture may not be a problem, integrating data into billing and accounting software can be. To the extent that future PV system designs can employ AMI capabilities, the economics of both will be enhanced.

#### **Description**

AMI devices will be evaluated for use with PV inverter controller systems to determine synergies in functions and capabilities. For example, AMI should be confirmed as net-metering-compatible both functionally and with data acquisition. New data streams from AMI should consider what updates, upgrades, or overhauls will be needed to existing billing and accounting software. Customer-sited DG will be considered as part of this process. Interfacing methods will be explored, and where possible tested in the laboratory and demonstrated in the field.

**Value**

- Helps members specify AMI systems that will handle future requirements for DR integration.
- Provides insight in how future AMI and DG will interface with billing and accounting.
- Identifies AMI systems that provide flexibility and functionality for future DG integration.
- Avoids going back and patching later, which would incur otherwise avoidable costs

**How to Apply Results**

Using the field experience and lessons learned reported in this program, members can refine plans and adjust implementations in their own AMI deployments. The AMI criteria, new configurations, and future design concepts identified in this R&D program can be incorporated into specifications for major distribution system upgrades or new circuits accommodating high levels of renewable generation.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Survey on AMI deployment with DG and Library of AMI Use Case Experience:</b> A survey will be conducted to determine the specifics of AMI deployments relative to integrating renewables and DG with grid operation and markets. From survey results, a use case library web application for AMI applications will be developed, building on SCE AMI-DG use case and SEPA efforts in the practical application of advanced metering with solar inverters.</p>	10/31/2009	Assembled Package
<p><b>Requirements Summary and Guide for Integrating AMI with Distributed Resources:</b> This project will create a requirements summary with guidelines for integrating AMI and distributed resources, including renewables, storage, and DG. These requirements will come from applying acquired knowledge from use cases as well as communications models from IntelliGrid.</p>	12/31/2009	Technical Update
<p><b>Performance Criteria and Plans for Laboratory Evaluation of AMI:</b> This project will prepare for laboratory and field evaluation of AMI applications, and will include:</p> <ul style="list-style-type: none"> <li>• Initial laboratory configuration for testing implementations</li> <li>• Prototype demonstration of implementation in laboratory</li> <li>• Test plans for future configurations</li> </ul>	12/31/2009	Technical Update

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Expanded Web Based Library of AMI Use Case Experiences:</b> This activity provides continued management of a use case and requirements library, with appropriate updates and new case lessons learned. These results will be combined and summarized for easier use by members and to be provided in a straw-man document for future industry standards AMI development activities.</p>	2010	Assembled Package

Product Title & Description	Planned Completion Date	Product Type
<b>Field Performance Assessments for AMI used with Renewable Resources:</b> These field performance assessments will be carried out at locations where AMI is being applied with the integration of distributed resources. Attributes of these cases and future needs will be identified.	2010	Technical Update
<b>AMI System Laboratory Evaluations:</b> Lab evaluations will be conducted for selected AMI configurations and architectures based on the interest of participating members.	2010	Technical Update

### P174.004 DC Applications for Direct Use of Distributed Photovoltaic Generation (067495)

#### Issue

Utilities must take proactive and technical leadership in advancing new ways to use dc electricity at end-use customer sites. Trends toward adding power electronics to improve efficiency in many appliances, adding dc electric energy storage as in PHEV applications, and installing rooftop PV will bring new opportunities for the dc-direct applications.

#### Description

This project will conduct scoping studies, define new applications, and develop conceptual designs for integrating PV generation via dc applications, including adjustable-speed drives, lighting, battery storage and plug-in electric hybrid vehicles (PHEVs). Results will be provided via paper studies, hardware demonstration partnerships, and lab evaluations as well as lab and field deployment demonstrations.

#### Value

- DC-direct applications can greatly simplify interconnection issues for PV, increase the efficiency of PV systems, and reduce the cost of integration and interconnection.
- By providing technical leadership in identifying new applications, members can leverage other related programs and identify new business opportunities to provide end-use electric energy.
- Results from laboratory evaluation and field demonstrations will help define integration and performance requirements for these applications.

#### How to Apply Results

Members with active programs in end-use energy efficiency and demand management can apply these results to extend such programs to include integration of on-site solar power. As deployment of distributed PV becomes more widespread, results from this program will help shape utilities' future roles and identify new business options for end-use energy systems.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Report on conceptual designs for direct use of distributed PV Generation:</b> Using results from the 2008 technology innovation scoping study, this report will cover new applications and develop conceptual designs for integrating PV generation via dc applications, including adjustable-speed drives, lighting, battery storage and plug-in electric hybrid vehicles (PHEVs).	12/31/2009	Technical Report
<b>Survey of new products that can be applied in PV DC applications:</b> This technical update will categorize various applications and conduct a survey of manufacturers to determine available products and performance specifications. Results will feed plans for laboratory evaluations and system hardware demonstration partnerships as well as field deployment demonstrations.	12/31/2009	Technical Update

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Performance assessment and aggregation of Lessons-learned from PV-DC Installations:</b> This technical update will assemble performance information from site demonstrations of PV dc systems in addition to product information and evaluations. Overall knowledge acquired regarding both issues and opportunities for future utility involvement in PV-dc system deployment will be addressed.	2010	Technical Update

**P174.005 Evaluation of Distributed Renewable Grid Interface Systems (067496)**

**Issue**

Utilities need to take proactive and technical leadership in understanding and advancing new grid interface systems for future high penetration of renewable resources. Developing performance criteria, and evaluating and demonstrating new interface hardware and systems, will position members to more effectively work with developers and customers wanting to deploy distributed renewable generation.

**Description**

This project looks at system compatibility (immunity, emission and energy performance) profiles, protection settings, communication and control interface, specifications, availability, performance, and the cost of existing inverter systems and other distributed renewable generation grid interface hardware. It will identify new options, including related performance criteria, and will include lab testing and field demonstration of new configurations, systems, and devices with options for the utility's point of common coupling either on the ac or the dc side of the device or inverter. Project efforts are expected to evolve from concepts, prototypes, and first-adaptor applications to industry best practice, guidelines, and proposed standards.

**Value**

- Hands-on evaluation of new interface hardware and systems will position members to more effectively deal with interconnection requests.
- Benefit from collaborative evaluation activities and sharing results of field experiences, lessons

- learned, and solutions related to integrating distributed renewable generation.
- Address current and growing interest in the deployment of distributed renewable power generation, with concrete results on available interface systems and their performance.

**How to Apply Results**

Utilities faced with planning or integrating new renewable generation will use the results of this project to ensure that the full implications of safety, reliability, and electrical performance are considered. Findings can be used to work with developers wanting to connect green buildings, construct zero-energy homes, and implement sustainable community strategies.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Develop performance criteria and related test plans for renewable generation interface systems:</b> This project will build on prior grid interface research, performance requirements, and related test protocols in the DER area. It will develop performance criteria for different configurations and point-of-connection and design tests that address current and future utility practices for mating meters, inverters, and related intertie equipment.	12/31/2009	Technical Update
<b>Design laboratory test stand, plan performance and compatibility testing:</b> This project will build on prior grid interface test equipment, methods and related test protocols developed by EPRI for DER evaluations. It will develop the needed laboratory test stands as well as plans for performance and compatibility testing, including immunity, emission, and energy performance.	12/31/2009	Assembled Package

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Database resource on interface system configurations, functions and specifications:</b> This project provides a database for comparing different system configurations and functions that could be used for the interface/integration of renewable generation, including meters, inverters and other interconnection equipment.	2010	Technical Resource
<b>Lab evaluation reports of selected grid interface systems:</b> Selected equipment and interface systems will be set up and tested in the lab. Results are available to the manufacturer and project participants. In some cases, testing will be accomplished in the field at host utility sites.	2010	Technical Update