

# Power Quality - Program 1

## Program Overview

### Program Description

Electric utilities worldwide consistently report that power quality (PQ) is a fundamental component of the three key utility business performance metrics: system performance, economic performance, and customer satisfaction. By applying EPRI's extensive PQ expertise, the Power Quality research program may help to improve these three metrics, allowing PQ managers and transmission and distribution (T&D) asset utilization and system planning professionals to use PQ-related technology, knowledge, and expertise to help improve their organization's bottom-line performance.

### Research Value

With the knowledge acquired through this research program, members will have access to information that can help them in the following ways:

- The program is developing ways to estimate future grid PQ harmonics and other PQ levels (Grid-IQ Framework, Project Set 1A) based on changing grid configurations and load behaviors, which may allow improved estimation of future PQ levels on modern utility systems. The program is addressing this goal by developing a library of open-source grid models and conducting structured analyses of future PQ levels.
- The program is creating a library of end-use and distributed energy resources (DER) models (Project Set 1C), which may allow assessment of the PQ impact of different and changing load configurations. The program is addressing this goal by updating existing end-use models and developing new ones based on laboratory testing at EPRI facilities.
- The program is developing the PQ Investigator (Project Set 1C), which is intended to capture EPRI expertise in end-use investigations in an expert system that may allow expedited and thorough investigation, diagnosis, and documentation of end-use PQ issues.
- The program is applying models and tools to improve benchmarking of system performance (Project Set 1A). The program is addressing this goal by developing updated benchmarking methods based on more robust PQ severity metrics and experience from previous EPRI studies.
- The program is in the forefront of helping modern utilities cope with the "data tsunami," which will make the integration of data from many different sources very attractive. The program is addressing this goal by developing methods for integrating data streams from a variety of sources, including relays, smart meters, and others (Project Set 1B).
- The program is identifying ways to apply PQ data and other data sources to detect incipient faults and equipment failures and assess equipment health and overall system performance (Project Set 1B). The program is addressing this goal by developing methodologies for identifying key signature characteristics in PQ data.
- The program is supporting the development of key industry standards that may increase compatibility between electric power and customer loads. The program is addressing this goal through active support in International Electrotechnical Commission (IEC) and Institute for Electrical and Electronics Engineers (IEEE) standards committees, including IEEE 1648 (Project Set 1C).
- The program is providing direct support of funder PQ teams. The program is addressing this goal through access to over 50 PQ experts on EPRI's staff via the EPRI PQ Hotline (Supplemental PS1D).

### Approach

EPRI research in power quality will yield a variety of data and knowledge that will be beneficial to program members. This information will be offered in several forms and is expected to include the following:

- The MyPQ.epri.com website
- Software updates

- New and updated information and tools
- Publications and forums, technical support, and web-based services via Supplemental PS1D

### Accomplishments

In the past, the Power Quality program has delivered valuable information that has helped its members and the industry. The following are some examples:

- EPRI has created the first open-source-based grid model database to allow the structured estimation of future grid harmonics and other PQ levels.
- EPRI's laboratory testing of many end-use technologies has enabled the development of a detailed load model library for new and changing loads such as compact fluorescent lamps (CFLs), light-emitting diode (LED) traffic lights, hybrid electric vehicle chargers, and rooftop photovoltaics (PV).
- EPRI's Integrated Power Quality Diagnostic System (IPQDS) is a compilation of tools that allows PQ engineers to perform basic power quality analyses such as transient and harmonics analysis, voltage sag simulations, and motor-starting calculations. This report discusses three specific IPQDS modules—the capacitor switching module, flicker analysis module, and motor-starting module—as well as the tap fusing worksheet, a Microsoft Excel spreadsheet.
- The PQ Investigator combines the expertise of over a decade of PQ auditing and site surveys to give power quality engineers an expert system for diagnosing, solving, and documenting PQ issues for commercial and industrial customers. The web-based approach offers investigators a powerful, easy-to-use format.
- Many of EPRI's past research developments have been implemented over time into PQView<sup>®</sup>, a multi-component software system jointly developed by EPRI and Electrotek Concepts for building and analyzing databases of power quality and energy measurements.
- The Power Quality Online Resource Center is a member-focused website with the latest information on events, program deliverables, PQView software downloads, power quality tools, and more.

### Current Year Activities

In the coming year, this research program expects to accomplish these objectives:

- Expand the Grid-IQ grid model library and incorporate new load models.
- Apply the Grid-IQ Framework to predict harmonics and other PQ levels for a variety of grid and load configurations.
- Update techniques for benchmarking grid power quality, especially harmonics levels.
- Enhance techniques for applying PQ and other data sources such as improved data-based fault location techniques, equipment failure (or near-failure) detection, and grid diagnostics.
- Develop new techniques for integrating data from multiple sources.
- Update PQ Investigator, incorporating the latest equipment sensitivity and mitigation performance curves and PQ monitoring data import functions. Add Investigator functionality to build custom PQ audit cases, solutions, economics, and reporting functions.
- Assess the PQ contribution of new or changing loads such as CFLs, rooftop solar inverters, and hybrid electric vehicle chargers.
- Enhance the MyPQ.epri.com website, including additional technical resources for the PQ Online Resource Center comprising more than 500 documents.
- Expand the PQ Newsletter capability, including the addition of new articles, newsletter templates, and online tools.
- Provide quality assurance testing of PQView and opportunities for enhancement through focused projects based on input from the PQView Users Group and members.

### Estimated 2012 Program Funding

\$2.4M

**Program Manager**

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**Summary of Projects****PS1A Improving PQ in Transmission and Distribution (062088)****Project Set Description**

The Improving PQ in Transmission and Distribution Project Set is developing the Grid-IQ Framework, which combines a growing library of grid models, testing-based models for new loads and other grid-connected devices, and query engines to allow the prediction of future PQ performance under varying scenarios. This project set is also developing new models and tools for improving system performance benchmarking by updating benchmarking methods based on experience from previous EPRI studies.

Project Number	Project Title	Description
P1.001	PQ Issues and Solutions for Transmission and Distribution	This ongoing project builds on years of research and application guide development, drawing on the PQ expertise of EPRI as well as that of project members. The project builds on the Grid-IQ Framework developed in P1.003 and represents the practical application of that research.
P1.002	PQ Benchmarking and Standards	Work planned for 2012 includes capturing key actionable conclusions from the TPQ/DPQ III project, a combined distribution and transmission power quality benchmarking study. This study will move beyond EPRI's previous benchmarking studies by developing the infrastructure to automatically collect and benchmark data. This work will begin to inform future standards that presently use PQ and reliability metrics and provide more useful, precise information for the various T&D voltage classifications for those standards and for comparative benchmark efforts.
P1.003	Support and Development of PQ Analysis Tools	This project will continue the development of an open-source grid model library (Grid-IQ Framework) to enable the estimation of future grid harmonics and other PQ levels. The Grid-IQ Framework combines a growing library of grid models, testing-based models for new loads and other grid-connected devices, and query engines to allow the prediction of future PQ performance under varying scenarios.

**P1.001 PQ Issues and Solutions for Transmission and Distribution (055700)****Key Research Question**

Management of power quality is a key core competency for electrical transmission and distribution systems around the world. Power quality issues on the T&D system are often complex, wide reaching, and expensive to mitigate. Increasingly, utilities have been trying to assess future PQ levels for their T&D systems but are finding few resources.

**Approach**

This project focuses on developing and executing techniques for estimating future grid harmonics and other PQ levels through the application of grid models based on changing grid configurations and end-use loads.

Work in 2011 will focus on:

- Assessing future harmonics levels based on changing grid configurations and end-use loads
- Modeling the grid impact of new or changing loads such as CFLs, rooftop solar inverters, and hybrid electric vehicle chargers as prioritized by members

**Impact**

- Models and predicts future PQ levels (especially harmonics) using actual grid and load models
- Predicts future PQ levels, allowing members to anticipate, manage, and prevent grid issues~

**How to Apply Results**

Power quality and T&D engineering, design, operations, and maintenance professionals can best apply the results of this research by assimilating them prior to undertaking investigation or mitigation of a PQ issue on the T&D system.

**2012 Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Modeling of Future Harmonics Levels on T&amp;D Grids:</b> This ongoing project builds on years of research and application guide development, drawing on the PQ expertise of EPRI as well as that of project members. The project builds on the Grid-IQ Framework developed in P1.003 and represents practical application of that research.</p>	12/31/12	Technical Report

**P1.002 PQ Benchmarking and Standards (058585)**

**Key Research Question**

Reporting PQ performance is a critical requirement for electric utilities in informing internal planning processes, enabling performance benchmarking, and accommodating external reviews required by regulators. Benchmarking of existing PQ standards offers opportunities for improved system performance at reduced capital cost.

**Approach**

This project area provides tools and guidelines for effective performance assessment and reporting methods. It helps members better understand and adopt industry standard approaches for performance assessment and provides coordination with new industry standards development. The project will track and contribute to industry standards development related to PQ and reliability indices and reporting methods. It will also develop tools and advanced methods for analyzing system performance as a way to help improve performance. These tools and methods include advanced approaches such as the service quality index pioneered in this program, statistical characterization methods, and methods for normalizing performance according to system characteristics (for example, lightning).

The project will also track regulatory issues and standards development around the world to understand priorities for benchmarking and characterizing performance. New methods for applying statistical characterization methods and normalizing results will be documented and addressed in an annual workshop on reliability and PQ benchmarking developments.

Work planned for 2012 includes capturing key actionable conclusions from the TPQ/DPQ III project, a combined distribution and transmission power quality benchmarking study. This study will move beyond EPRI's previous benchmarking studies by developing the infrastructure to automatically collect and benchmark data.

**Impact**

- Helps members effectively apply industry standard methods for characterizing performance, which can significantly reduce the cost of these activities
- Provides advanced system performance measures to help provide a better basis for making system performance improvement investment decisions, improving the cost-benefit ratio of these activities.

**How to Apply Results**

Power quality and T&D engineering, design, operations, and maintenance professionals can best apply the results of this research by assimilating them and applying them to recommended PQ and reliability characterization and reporting methods in their external reviews of—and internal planning for—reliability and power quality performance.

**2012 Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Power Quality Benchmark Results and Analytical Tools:</b> Work planned for 2012 includes capturing key actionable conclusions from the TPQ/DPQ III project, a combined distribution and transmission power quality benchmarking study. This study will move beyond EPRI's previous benchmarking studies by developing the infrastructure to automatically collect and benchmark data. This work will begin to inform future standards that presently utilize PQ and reliability metrics, and provide more useful and precise information for the various T&amp;D voltage classifications for those standards and for comparative benchmark efforts.</p>	12/31/12	Technical Update

**P1.003 Support and Development of PQ Analysis Tools (048303)**

**Key Research Question**

Expert software resources for PQ are difficult to find in the industry, but they are essential for understanding complex phenomena and cost-effective problem solving. The time and cost of developing these tools are prohibitive, and the technical expertise required to create them can be difficult to find.

**Approach**

This project will continue the development of an open-source grid model library (Grid-IQ Framework) to enable the estimation of future grid harmonics and other PQ levels. The Grid-IQ Framework combines a growing library of grid models, testing-based models for new loads and other grid-connected devices, and query engines to allow the prediction of future PQ performance under varying scenarios.

**Impact**

- Expands the grid model library and incorporates new load models
- Applies the Grid-IQ Framework to estimate future harmonics and other PQ levels for a variety of grid and load configurations

**How to Apply Results**

Power quality and T&D engineering, design, operations, and maintenance professionals can best apply the results of this research by assimilating them and applying Grid-IQ as part of their grid management and planning strategies.

**2012 Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Grid-IQ Framework:</b> This project will continue development of the an open-source grid model library (Grid-IQ Framework) to enable estimation of future grid harmonics and other PQ levels. The Grid-IQ Framework combines a growing library of grid models, testing-based models for new loads and other grid-connected devices, and query engines to allow prediction of future PQ performance under varying scenarios.</p>	12/31/12	Assembled Package

**PS1B Integrating PQ Monitoring and Intelligent Applications to Maximize System Performance (062089)**

**Project Set Description**

This project set focuses on techniques and resources for gathering, storing, analyzing, and visualizing many types of data, in particular, PQ data. The project set provides for quality assurance testing of PQView<sup>®</sup>, a multi-component software system jointly owned by EPRI and Electrotek Concepts, for building and analyzing databases of power quality and energy measurements. Its components build measurement databases, write summary reports, compute power quality indices, view waveforms and root-mean-square (rms) samples, and trend steady-state quantities.

Project Number	Project Title	Description
P1.004	Integration of Data from Multiple Sources	This project integrates PQ and system data from multiple and federated sources to enable improved decision making.
P1.005	Advanced Applications for Monitoring Systems	This project expands the value of PQ monitoring systems by using the data to develop important information about the health of the overall system and individual components.
P1.006	Monitoring System Development and Management	<ul style="list-style-type: none"> <li>Advanced features and capabilities for managing and analyzing PQ data and large power quality monitoring databases</li> <li>EPRI quality assurance testing of PQView gives funders access to software with additional validation.</li> </ul>

**P1.004 Integration of Data from Multiple Sources (060443)**

**Key Research Question**

The EPRI PQ program has identified issues relating to PQ data and monitoring as important to the success of electric utilities in the coming years. One challenge is to take data from many different sources and integrate it into common resources that can be used to inform decision making and offer close support for operation of modern utility T&D systems. Another challenge addressed by this project is interfacing with federated data resources.

**Approach**

In this project, EPRI will expand the ability to integrate data sets to enable informed decision making. This effort includes not only data acquired from PQ monitors, but also other data sets and federated data sets, including smart meters, reliability, maintenance, recloser and switchgear operations, lightning, and weather.

## Impact

- Integrates data from multiple and federated resources, which is of great value to utilities
- Data integration enables analysis and decision making that can significantly improve operational efficiency

## How to Apply Results

Power quality and T&D engineering, design, operations, and maintenance professionals can best apply the results of this research by assimilating them and capturing the added monitoring capability routinely being integrated into such non-monitoring components as smart meters, relays, meters, switches, reclosers, circuit breakers, and regulators. Such integrated devices are often referred to as *intelligent electronic devices*. The addition of federated data resources enables advanced diagnostic and analysis functions.

## 2012 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Integration of Data from Multiple Sources:</b> This project integrates PQ and system data from multiple and federated sources to enable improved decision making.	12/31/12	Technical Update

## P1.005 Advanced Applications for Monitoring Systems (062153)

### Key Research Question

The EPRI PQ program has identified issues relating to PQ data and monitoring as fundamentally important to the success of electric utilities in the coming years. Power quality monitoring systems capture significant amounts of data that describe the performance of the power system and the condition of power system equipment. These data have traditionally been available only for historical analysis and reporting. However, advances in communications systems are making these data available in near real-time, and the integration of data from additional intelligent devices in the system is resulting in the ability to collect data from across the system. However, considerable barriers to realizing the benefits of these advances remain.

### Approach

This research may increase the value of PQ monitoring systems through the development of advanced applications that can directly benefit system operation and maintenance. The applications build on existing monitoring system platforms to minimize the additional investment required to achieve these benefits. They also take advantage of the data available in PQ monitoring systems that can be used to assess equipment and system condition with appropriate analytical methods and system interfaces.

This project expands the value of PQ monitoring systems by using the data to develop important information about the health of the overall system and individual components. Alarms and reports can then be integrated with system maintenance procedures and operations to more efficiently resolve problems and improve equipment reliability. The net effect can be a dramatic improvement in system reliability and a reduction in maintenance and operation expenses—the most important justifications for monitoring systems in the future.

Work will focus on the following:

- New data visualization techniques
- Better methods to port useful PQ information to mobile devices (smart phones and tablets)
- New waveform compression and analysis techniques
- New fault analysis and incipient fault identification techniques
- Data mining for equipment and hardware problems
- New indices and performance modules

- Fault protection and coordination assessment module
- Customer information modules

**Impact**

- Analysis techniques using PQ data offer tremendous economic value to utilities.

**How to Apply Results**

Power quality and T&D engineering, design, operations, and maintenance professionals can use the results of this research by assimilating them and applying them to existing and future PQ data resources.

**2012 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Advanced Applications for Monitoring Systems:</b> This project expands the value of PQ monitoring systems by using the data to develop important information about the health of the overall system and individual components.		Software

**P1.006 Monitoring System Development and Management (058586)**

**Key Research Question**

Acquiring, storing, and analyzing PQ data are increasingly important but daunting tasks for modern electric utilities. The challenges of this process are many, including dealing with massive amounts of data in varying formats and quickly analyzing these data to acquire the knowledge necessary to make informed decisions that can save utilities many millions of dollars in expenses, troubleshooting, and reduced downtime.

**Approach**

This project provides for research on new, advanced features and capabilities for managing and analyzing PQ data and large PQ monitoring databases to enable quick and expert decision making. Specific focus areas are prioritized annually by funders.

Past focus areas have included the following:

- Fault location
- Data visualization
- Incipient fault and equipment failure analysis
- Voltage regulator performance module
- Fault protection and coordination assessment module
- Automated PQ and reliability reporting methods
- Transformer loading and lifetime assessment, including harmonics
- Arrester performance for transient events
- Capacitor switching data analysis

This project also provides for quality assurance evaluation of PQView<sup>®</sup>, a multi-component software system jointly owned by EPRI and Electrotek Concepts, for building and analyzing databases of power quality and energy measurements. Its components build measurement databases, write summary reports, compute power quality indices, view waveforms and rms samples, and trend steady-state quantities through workstations and web browsers. The software is being used by more than 50 utilities around the world.

**Impact**

- Utilities implementing preliminary EPRI-developed fault location algorithms have reduced average feeder downtime by approximately 1 hour per fault event.
- Other methodologies such as lightning and capacitor switching analysis have provided economic benefits for funders.

**How to Apply Results**

Power quality managers, engineers, and technicians receive new analysis capabilities for PQ data, which can be implemented in new or existing PQ analysis tools, including PQView. In addition, EPRI quality assurance testing of PQView gives funders access to software with additional validation.

**2012 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Monitoring System Development and Management:</b> Advanced features and capabilities for managing and analyzing PQ data and large power quality monitoring databases	12/31/12	Technical Update
<b>Quality Assurance Testing of PQView:</b> EPRI quality assurance testing of PQView provides funders with access to software with additional validation.	12/31/12	Software

**PS1C Achieving Cost-Effective PQ Compatibility Between the Electrical System and Loads (062092)**

**Project Set Description**

This project set will help EPRI members ensure electrical compatibility between the power system and the end-use customer's equipment. Power quality mitigation solutions significantly reduce electrical disturbances at the transmission, distribution, and end-use level by integrating advanced energy storage technologies with power electronics. The PQ Investigator is intended to capture EPRI expertise in end-use investigations in an expert system that may allow expedited and thorough investigation, diagnosis, and documentation of end-use PQ issues. This project set is also creating a library of end-use and DER models, which may allow assessment of the PQ impact of different and changing load configurations.

Project Number	Project Title	Description
P1.007	System Compatibility Research	This research area characterizes compatibility issues between end-use equipment, power conditioning technologies, and power system performance. Activities include establishing evaluation criteria (for example, testing protocols), evaluating failure mechanisms, and identifying solutions. This research will acquire and distribute seminal compatibility information and knowledge.
P1.008	Impact Assessment and Modeling of Grid-Connected Loads and Power Supplies	This project creates a growing library of end-use and DER models, which may allow assessment of the PQ impact of different and changing load configurations. The load models developed in this project set are the best available and based on actual testing in EPRI's Knoxville laboratory.
P1.009	System Compatibility Resource Tools	Updated PQ Investigator Software: The PQ Investigator captures EPRI expertise in end-use investigations in an expert system that may allow expedited and thorough investigation, diagnosis, and documentation of end-use PQ issues.

## P1.007 System Compatibility Research (062349)

### Key Research Question

The EPRI PQ Program has identified several objectives related to understanding and improving the compatibility between electric power supply and end-use loads. A key barrier to achieving such successes is understanding the sensitivity of today’s end-use loads as well as new and emerging end-use loads.

### Approach

This research area characterizes compatibility issues between end-use equipment, power conditioning technologies, and power system performance. Activities include establishing evaluation criteria (for example, testing protocols), evaluating failure mechanisms, and identifying solutions. This research will acquire and distribute seminal compatibility information and knowledge. As issues are studied and uncovered, solutions will be developed and applied by the other projects in this project set.

A second area of research will continue previous work with end users, vendors, and energy companies to establish PQ standards in the automotive, machine tool, and food-processing industries. Work has been ongoing in the food-processing area, where food-processing groups have already expressed an interest in adopting the SEMI F47 standard as a beginning step. In addition, work is progressing in the automotive industry, where standards are an important platform for their operations. One promising approach is to work toward the adoption of a ride-through recommendation, which is used by organizations such as IEEE. This approach allows the adoption of standards for many industries simultaneously rather than one industry at a time. These efforts can be coordinated with IEC to ensure international acceptance. Another approach is to press for the expansion of electrical codes to encompass performance issues. As more industries become willing to adopt the F47 curve, the end result could be a universal, one-size-fits-all type of standard.

A third research area involves developing a guidebook for designing equipment to avoid power quality problems.

### Impact

- Improves customer satisfaction among key industrial and commercial customer categories
- Reduces the incidence of end-use customer process interruptions
- Enables more efficient and cost-effective development by end-use equipment manufacturers of equipment that meets PQ performance standards using the equipment design guidebook

### How to Apply Results

Power quality and T&D engineering, design, operations, and maintenance professionals can best apply the results of this research by using the results of system compatibility testing and the associated guidelines to help end-use customers solve PQ-related issues and achieve higher productivity.

### 2012 Products

Product Title & Description	Planned Completion Date	Product Type
<p><b>Development and Promotion of PQ Compatibility Standards:</b> This research area characterizes compatibility issues between end-use equipment, power conditioning technologies, and power system performance. Activities include establishing evaluation criteria (e.g., testing protocols), evaluating failure mechanisms, and identifying solutions. This research will acquire and distribute seminal compatibility information and knowledge.</p>	12/31/12	Technical Update

## P1.008 Impact Assessment and Modeling of Grid-Connected Loads and Power Supplies (062350)

### Key Research Question

The behavior of new and changing end-use loads and grid-connected power supplies is beginning to affect grids around the world. Utilities need resources to test and evaluate these technologies so that their impact today and in the future can be assessed and managed.

### Approach

This project creates a growing library of end-use and DER models, which may allow the assessment of the PQ impact of different and changing load configurations. The load models developed in this project set are the best available and based on actual testing in EPRI's Knoxville laboratory.

### Impact

- Tests and evaluates technologies so that their PQ impact today and in the future can be assessed and managed
- Creates a growing library of end-use and DER models, which may allow the assessment of the PQ impact of different and changing load configurations
- Applies load models in the Grid-IQ Framework for the prediction of future grid PQ levels, including harmonics

### How to Apply Results

Power quality and T&D engineering, design, operations, and maintenance professionals can best apply the results of this research by using them to better understand the PQ impact of loads today and in the future.

### 2012 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Impact Assessment and Modeling of Grid-Connected Loads and Power Supplies:</b> This project creates a growing library of end-use and DER models which may allow assessment of the PQ impact of different and changing load configurations. The load models developed in this project set are the best available and based on actual testing in EPRI's Knoxville laboratory.	12/31/12	Technical Report

## P1.009 System Compatibility Resource Tools (048281)

### Key Research Question

Project members will benefit from expert systems that help them show customers the causes of and solutions for the PQ problems they are facing. This challenge is particularly acute in the industrial sector, which consists of a diverse range of processes, equipment, and power quality issues.

### Approach

EPRI's system compatibility resource provides a wide range of support to detect, mitigate, and prevent end-user PQ issues. The PQ Investigator is an expert system for investigating and solving end-user PQ issues. It is based on 500 person-years and hundreds of facility audits worth of experience.

**Impact**

- Captures EPRI expertise in end-use investigations in the PQ Investigator expert system to conduct expedited and thorough investigation, diagnosis, and documentation of end-use PQ issues
- Helps members train new PQ engineers, refresh experienced representatives, and enhance the credibility of all employees
- Improves the relationship between the customer and energy company by demonstrating that the company has invested the time and resources needed to research these problems in depth

**How to Apply Results**

Power quality and T&D engineering, design, operations, and maintenance professionals can best use the results of this research by assimilating them and applying the Industrial Design Guide with industrial customers to show the causes of and solutions for PQ-related issues they are facing.

**2012 Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Updated PQ Investigator Software:</b> The PQ Investigator captures EPRI expertise in end-use investigations in an expert system that may allow expedited and thorough investigation, diagnosis, and documentation of end-use PQ issues.</p>	12/31/12	Software

## Supplemental Projects

### PQ Knowledge Development and Transfer (Formerly PS1D) (072185)

#### Background, Objectives, and New Learnings

Management of power quality issues has never been an easy task, but it has grown even more difficult with deregulation, reregulation, increasingly scarce technical and strategic tools, and a conspicuous lack of unbiased resources for information, collaboration, advice, and problem solving. Moreover, with the ever-increasing use of sensitive digital and electronic equipment in today's economy, end-use customers are not only demanding higher quality power, but also are calling upon utilities to help resolve PQ problems within customer facilities.

#### Project Approach and Summary

This project seeks to find new information that electric service providers can use to cost-effectively meet customer and internal demands. It utilizes EPRI's extensive collaborative research in power quality to provide a wealth of easy-to-use, informative PQ resources for utility staff as well as materials they can use to inform end-use customers. It offers a comprehensive collection of technical and informational publications and products, educational forums, technical support, and web-based services. In addition, the project provides information and resource tools needed to help minimize economic losses and more effectively compete in today's marketplace. It also serves to build a foundation of knowledge regarding the latest PQ products and expert insights into power quality.

#### Benefits

This program offers a number of benefits for members. Some examples include:

- Provides extremely high value to PQ managers, engineers, and technicians, using individual participants' contributions by at least a 20-to-1 ratio
- Provides the ability to access EPRI experts and network with industry peers both inside and outside the utility industry~

## **Distribution and Transmission Power Quality Benchmarking (TPQ/DPQIII) (069592)**

### **Background, Objectives, and New Learnings**

Power quality is affected by the load as well as power delivery components and operations methods. Both load composition and the power deliver system are changing and have affected the levels of various PQ phenomena. Previous benchmarking studies are reaching an age at which they may not serve as a realistic benchmark for comparison. This study aims to update existing benchmarks to include changes in load composition affecting the grid, including a shift to plug-in loads and an increase in the number of power supplies as well as peak shifting equipment and emerging efficient technologies. A second focus will be on impacts caused by changing power delivery system designs and compensation that have affected the PQ levels in both transmission and distribution. There is a need to re-create the definition of acceptable levels of power quality for key phenomena—including harmonics, flicker, and voltage sags—that can be applied at the T&D level. IEEE has a working group with the task of defining typical and expected PQ levels for the electric supply system. This project may help the task force by providing a wealth of factual information as a basis for recommendations.

### **Project Approach and Summary**

This project will gather T&D system PQ monitoring data sets from a wide range of utilities and systems and perform a meta-analysis of the data and other PQ studies, including previous EPRI power quality surveys and monitoring efforts.

### **Benefits**

The information learned from this project may be used by a variety of utility functions. Management may use it to set performance goals and engineer for better understanding of requirements. Utilities may use the result of the benchmarking efforts to discuss the expectation and economic impact of PQ levels. The expected results may also provide a factual baseline for the benchmarking of power delivery system performance required by regulatory bodies and may help in understanding the following:

- Utility-specific performance for T&D power quality and how these standards compare with a national baseline
- Power quality trends for T&D created by power electronics and emerging efficient technologies
- Power quality trends caused by increased distributed and renewable generation technologies

Using data industry standards will enable the integration of data from many diverse sources into a common database for analysis. This project is ideal for collaborative research, allowing the collection of significantly more data and reaching statistically representative samples for the load and delivery system. This benchmark is expected to offer T&D system managers a way to compare system performance against a national empirical benchmark.

Understanding the power quality benchmark performance may benefit the public by helping utilities to optimize resources in achieving expected and levels.

IEEE has a working group that is defining typical and expected PQ levels for the electric supply system. This project may help the task force by providing a wealth of factual information as a basis for recommendations.

## Smart Electromagnetic Interference Problem Solver and Detection System (071986)

### Background, Objectives, and New Learnings

Failing equipment may cause interference problems when generating detectable emissions with unique signatures. In many cases, a power or signal filter or a shield begins failing with no way to detect the failure. Failure mechanisms progress until complete equipment shutdown occurs, resulting in plant shutdown and an electromagnetic interference (EMI) investigation. EMI investigators consistently point out that prior detection of internal failures would have avoided a shutdown.

Automated emissions measurement techniques and systems are gaining interest in power and electromagnetic compatibility (EMC) communities. Standard EMC measurement systems are too large to use in cramped environments in consumer and power plant facilities. This research will seek to develop a portable lightweight EMI detection system and problem solver to detect radiated and conducted emissions from 10 kHz to 10 GHz, identify emissions sources, and determine their distance to industry limits. Research will develop algorithms to determine which emissions sources are causing EMI problems. A miniature walk-around device with these capabilities could offer utility engineers an efficient and intelligent way to identify the cause and location of EMI problems.

This project explores new technologies and methods to identify sources of electromagnetic interference and may enable mitigation of these phenomena before they lead to malfunction of electronic equipment.

### Project Approach and Summary

Automated and programmable emissions measurement systems used in previous EPRI research have demonstrated that emissions measurement equipment can be programmed to make long-term emissions recordings and perform basic analyses on recorded emissions.

Computing power, functionality, and data handling capabilities of high-speed platforms used in spectrum analyzers along with broadband antennas capable of kHz-to-GHz detection will be evaluated for use in the new detection system.

Smart algorithms that can detect problem-causing emissions leading to an EMI problem and identify their sources, proximity to industry standardized limits, and rate of occurrence will be developed. Participating utilities will be asked to identify up to three utility or customer sites where the new system can be field tested. The on-board tools to analyze emissions and determine the likelihood of an EMI problem will also be tested in the laboratory and at the field sites.

### Benefits

The public may benefit from the results of this project by enabling identification of the root cause of equipment malfunction, and implementation of corrective action before actual malfunction which may lead to power outages or lower power quality.

- Offering the utility a technology that can identify a source's location will help avoid equipment failures, improve equipment reliability, enhance occupational safety, and lower cost.
- Leaky shielded cables and equipment usually go undetected until an EMI problem occurs. Avoiding one EMI problem may save utilities and their consumers the cost of equipment downtime and repairs, lost productivity, and other potential consequential damages. Finding root causes of EMI problems may help to quickly repair the problems and mitigate the associated risks.
- Detecting an ongoing but unknown emissions source will help identify potential safety problems when radio-frequency energy is used in an industrial process.