

## **68 I&C and Automation for Improved Plant Operations**

### **Program Overview**

#### **Program Description**

This program develops and demonstrates state-of-the-art control system techniques, sensors, and data analysis methods that improve plant performance, allow flexible operation, and reduce emissions. Products provide guidance on implementing and optimizing control strategies and deploying advanced multivariable control techniques. Program activities address new equipment and methods, and help optimize existing instrumentation and control equipment, which can cost-effectively improve plant performance.

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

- Utilities need to reduce damage to major plant components caused by operations.
- Reduced staffing at plants creates the need for greater automation of operational aspects and process control tuning.
- Accurate equipment condition assessment is required to optimize maintenance intervals and improve process control.

#### **Impact**

- Reduce costs through greater automation in tuning of process controls and operating point transitions.
- Improve reliability through integrated anomaly detection, diagnostics, and prognostics.
- Improve reliability through more effective equipment monitoring created through a collaborative process.

#### **Key Accomplishments**

- Formation of successful Fleet-Wide Monitoring Interest Group (FWMIG) with more than 20 member organizations
- Technical report covering application of continuous on-line monitoring technology to environmental/emissions controls equipment
- Technical reports documenting field demonstrations of new technologies relating to advanced control algorithms, automated controls tuning, multi-loop controls tuning, application of model predictive controls, and automated plant startups
- Technical reports documenting field demonstrations of sensors, wireless data transmission, and advanced anomaly detection algorithms

#### **Current Year Objectives**

- Technical report on use of distributed control technology to automate critical equipment startup
- Technical report describing the benefits of using simultaneous multi-loop control system tuning methods for complex power plant systems such as boilers
- Technical report on applying failure mode effect data contained in plant maintenance optimization tools to improve equipment fault diagnostics using instrument signatures
- Technical report documenting field testing to determine optimum wireless sensor network configuration for fossil power plants
- Continuation of the FWMIG
- Technical report that will serve as a guideline for instrumentation and control processes key to operations and maintenance in power generating plants
- Investigation of existing training materials (particularly focused toward fossil-fueled power plants) within organizations such as IEEE and ISA for I&C technicians and engineers

### Industry Involvement

- Estimated 2009 funding: \$1.0M

### Program Technical Lead

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## Summary of Projects

Project Number	Project Title	Value
P68.001	Advanced Controls and Automation	Development and demonstration of technologies used to optimize control of plant systems and complete operating units. Research areas include automated tuning, adaptive/predictive control, and automated system and plant startup.
P68.002	Monitoring and Equipment Condition Assessment	Applied research in hardware/software to facilitate equipment condition assessment. Sensors, wireless data transfer, plant historians, and anomaly detection schemes are investigated to help members increase plant availability. This project also includes development of a process framework for monitoring signal anomaly interpretation and equipment diagnostics.
P68.003	I&C Technology Transfer	Assists members deploying EPRI technologies by providing access to interest groups, technology assessment guides, newsletters, and industry conference material.

## Project Descriptions

### P68.001 Advanced Controls and Automation (052496)

#### Issue

Many experienced control system experts in the industry are approaching retirement age and less-experienced staff members are assuming their duties. At the same time, equipment is aging, and limiting damage due to unnecessary operational transients is vital. Plant control systems are critical in addressing these issues.

#### Description

This project addresses critical aspects of fossil plant control systems, including advanced controls, automation, and improved loop tuning. Applied research is conducted in collaboration with universities, laboratories, and equipment vendors. Field demonstrations of technology at operating plants include combined-cycle plant automation, equipment startup automation, advanced control, and automatic tuning. The focus of the research and development (R&D) effort in 2009 and future years will include automation of key plant system operations to improve consistency of the startup/shutdown process while minimizing wear and tear. Efforts also will focus on increasing plant operational efficiency through the development and demonstration of control system improvements, such as use of model predictive control. Research into improved tuning processes will save time and improve consistency and staff expertise knowledge capture. This project will address the need for knowledge transfer due to the anticipated decline in industry control system expertise.

**Value**

- Automation of equipment and processes improves the consistency of startups/shutdowns, helps capture expert knowledge, and reduces unnecessary equipment damage.
- Improved control system performance leads to more responsive plant operation, better efficiency, reduced emissions, and reduced likelihood of damaging temperature transients.
- Multi-loop tuning methods result in significantly better performance for control systems and lead to better, more robust tuning of boiler control systems.
- Automation of control system tuning methods improves consistency and enables the expertise of control engineers to be applied on a broad scale.

**How to Apply Results**

End users of this research include system engineers, control systems engineers, and technicians at fossil power plants. Technology results will be published in the form of technical reports, guidelines, and process specifications that will be used to specify the approach for proper implementation of control system technology. Without this guidance, benefits of applying advanced controls and automation may not be realized to the largest potential. In addition, key research results will be communicated periodically through webcasts.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Automation of Fossil Plant Components/Systems:</b> Automating plant equipment startup/shutdown procedures can provide faster startups, increase consistency, reduce wear and tear, and capture best practices. The results of automation logic applied to a selected system/component will be documented in a technical update report.	12/31/2009	Technical Update
<b>Multi-loop Tuning for Complex Control Loops:</b> A detailed model of a boiler and its control system will be used for this study. Several loops that have interactions between them will be tuned using the traditional loop-at-a-time, hierarchical method. Results will be compared to those of a multi-loop tuning method studied in 2008, with refinements necessary in 2009.	12/31/2009	Technical Report

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<b>Automated Control System Tuning:</b> Automation of control system tuning methods improves consistency and enables the expertise of control engineers to be applied on a broad scale. Some commercially available techniques have been tested but more innovative techniques are available, such as EDF's proposed "Iterative Feedback Tuning" method.	2010	Technical Report

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Product Title & Description	Planned Completion Date	Product Type
<b>Model Predictive Control:</b> Model predictive control techniques applied to existing control systems can reduce variance, with cost savings resulting from optimized processes. In 2008, a report will describe the considerations that should be addressed prior to implementation. In 2009, an example application and partnership with a commercial supplier will be established to demonstrate and quantify benefits.	2010	Technical Report
<b>Automation of Fossil Plant Components/Systems:</b> Automating plant equipment startup/shutdown procedures can provide faster startups, increase consistency, reduce wear and tear, and capture best practices. The results of automation logic applied to a selected system/component will be documented in a technical update report.	2010	Technical Report

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## P68.002 Monitoring and Equipment Condition Assessment (065776)

### Issue

Effective application of condition-based maintenance and risk-informed approaches to maintenance planning requires accurate assessment of the current condition of key plant equipment. Plant owners demand more efficient operation and effective maintenance to achieve lower production costs and improved availability. At the same time, many experienced system experts in the industry are approaching retirement age, and less-experienced staff members are assuming their duties.

### Description

Many plants employ commercial data acquisition systems. This project will improve the effectiveness of on-line monitoring systems that trend process data to establish equipment condition. Although these on-line monitoring systems are commercially available, additional research is needed to develop diagnostic capabilities, which require in-depth knowledge of system characteristics, degradation mechanisms, failure modes, and the associated detection methods. Products will cover topics such as failure signature analysis for diagnostics, sensor gaps that exist in fossil power plants, and wireless sensor networking challenges and considerations.

### Value

- Maintenance planning improvement is a direct result of early detection and diagnosis of component degradation.
- Equipment condition assessment is more effective when advanced sensors are available to detect critical failure modes.
- Wireless data transmission will reduce the costs of additional sensor channels, enabling more effective equipment condition assessment.
- Experience gained through this research will be directly applicable to new plant designs, enabling more effective application of on-line monitoring technology to create “smarter” components.

### How to Apply Results

End users of this research include engineers and other staff members at centralized plant monitoring locations who are seeking to more effectively use plant on-line monitoring data. Technology results will be published in the form of technical reports. Equipment condition assessment reports will be used as guidance in specifying improvements to existing software packages used for monitoring plant equipment. Sensor gap documentation will be used to identify and prioritize work on new sensor development and

deployment on existing fossil plant components, enabling continual improvement to equipment monitoring programs. Key research results will be communicated periodically through webcasts. Supplemental workshops and training courses will be offered on an as-needed basis.

**2009 Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Equipment Condition Assessment: Failure Signature Database</b>  <b>Development:</b> This report will identify the failure signatures recognized in information sources for one or two selected fossil plant systems, to enable development of diagnostic rules for integration with on-line monitoring systems that have diagnostic rule-building engines. This effort will be conducted jointly with Program 69: Maintenance Management &amp; Technology, with results shared between programs.</p>	12/31/2009	Technical Report
<p><b>Fossil Plant Sensor Gap Analysis:</b> Additional information sources such as sensors can provide critical information to on-line monitoring systems. This report will identify these sensor gaps for fossil-fueled power plants, suggest the sensor developments necessary, and identify existing technologies that could fill the gaps.</p>	12/31/2009	Technical Report

**Future Year Products**

Product Title & Description	Planned Completion Date	Product Type
<p><b>Wireless Technology: Integration of Localized Wireless Sensor Networks:</b>  Work in 2008 will demonstrate wireless mesh sensor networks for equipment condition monitoring. However, optimum strategies still will be needed for transmitting data from localized sensor networks to a plant LAN, Wireless LAN, or local processor.</p>	2010	Technical Report
<p><b>Prognostics and Health Management System Design for Power Plant</b>  <b>Equipment:</b> Prognostics and Health Management (PHM) systems are in use in other industries and organizations, such as the Department of Defense. The PHM design approach will be applied to a power plant component. In parallel, failure modes will be assigned a prognostic type—such as failure history-based, degradation-based, or effects-based—for reference in future PHM development activities.</p>	2011	Technical Report

## P68.003 I&C Technology Transfer (065777)

### Issue

Plant owners demand more efficient operation and effective maintenance to reduce production costs and improve availability. Successful implementation of on-line monitoring technology for equipment condition assessment requires peer-to-peer interaction among power producers and formal interaction with vendors. Technology gaps must be identified by end users to guide research and development (R&D) efforts. Power producers require information on emerging instrumentation and control technologies, as well experience with their initial use.

### Description

Held twice a year, Fleet-Wide Monitoring Interest Group (FWMIG) meetings offer open peer-to-peer information exchanges and formal presentations by vendors on member-selected subjects. Meeting materials, including presentations, minutes, and other related files, are distributed to all meeting participants. The FWMIG will guide EPRI research in on-line monitoring, wireless, and sensors technology.

Successful operations and maintenance (O&M) strategies will require effective on-line monitoring to perform accurate equipment diagnostics and, eventually, prognostics. The FWMIG will be instrumental in guiding diagnostic and prognostic research. A living document in the form of a technical update titled "I&C Guideline" will be issued annually on member-selected topics. These topics may include instrumentation, calibration, controls, automation, sensors, on-line monitoring, and wireless technology. The focus of these reports will be on emerging technologies and their early adoption in power-producing facilities, and on best practices in the electric utility and other industries.

### Value

- Peer-to-peer information sharing improves technology implementation in emerging areas, such as on-line monitoring and equipment condition assessment.
- Collaboration among utility members, vendors, and researchers results in more effective technology development.
- Sharing experiences from early technology adoption in other industries benefits power producers.

### How to Apply Results

End users of this research include system engineers and managers, control systems engineers, and technicians at fossil power plants. Interest group meetings will be held periodically to enable open information exchange among members in key strategic areas affecting utilities. I&C technology guidelines will be published in the form of technical update reports and will be used as guidance when reviewing or improving key plant I&C processes. Key research results will be communicated periodically through webcasts.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Fleet-Wide Monitoring Interest Group Meeting (Spring):</b> The FWMIG meets twice annually to discuss challenges and solutions related to the implementation of on-line monitoring technology. Topics include thermal performance monitoring, equipment condition assessment, data integration, and technology gaps. The spring meeting typically is held in Charlotte, North Carolina in May and features members-only discussions.	6/30/2009	Workshop, Training, or Conference

<b>Product Title &amp; Description</b>	<b>Planned Completion Date</b>	<b>Product Type</b>
<b>Workforce: Survey Training Materials:</b> Many training materials, courses, tutorials and webcasts exist in organizations such as IEEE, IEE, and ISA. These training materials, particularly those focused on fossil-fueled power plants, can benefit I&C technicians and engineers.	12/31/2009	Technical Resource
<b>I&amp;C Guideline: 2009 Topical Update:</b> In lieu of the technology assessment, a new document will be created in 2008 and updated annually with at least one new topic. A proposed list of sections will be developed in 2008, with topics voted on by the program advisory committee each year. The topic will be reviewed, and potential and proven industrial applications will be documented.	12/31/2009	Technical Update
<b>Fleet-Wide Monitoring Interest Group Meeting (Fall):</b> The FWMIG meets twice annually to discuss challenges and solutions related to the implementation of on-line monitoring technology. Topics include thermal performance monitoring, equipment condition assessment, data integration, and technology gaps. The autumn meeting typically is held in Charlotte, North Carolina in October and includes vendors.	11/30/2009	Workshop, Training, or Conference

**Future Year Products**

<b>Product Title &amp; Description</b>	<b>Planned Completion Date</b>	<b>Product Type</b>
<b>Fleet-Wide Monitoring Interest Group Meetings:</b> The FWMIG meets twice annually (typically in May and October) to discuss challenges and solutions related to the implementation of on-line monitoring technology. Topics include thermal performance monitoring, equipment condition assessment, data integration, and technology gaps.	2010	Workshop, Training, or Conference
<b>I&amp;C Guideline: 2010 Topical Update:</b> I&C Guideline: Updated annually with at least one new topic as voted on by the program advisory committee. The topic will be reviewed, and potential and proven industrial applications will be identified and documented.	2010	Technical Update
<b>Fleet-Wide Monitoring Interest Group Meetings:</b> The FWMIG meets twice annually (typically in May and October) to discuss challenges and solutions related to the implementation of on-line monitoring technology. Topics discussed include thermal performance monitoring, equipment condition assessment, data integration, and technology gaps.	2011	Workshop, Training, or Conference
<b>I&amp;C Guideline: 2011 Topical Update:</b> I&C Guideline: In lieu of the technology assessment, a new document will be created in 2008 and updated annually with at least one new topic. A proposed list of sections will be developed in 2008, with topics voted on each year. The topic will be reviewed, and potential and proven industrial applications will be documented.	2011	Technical Update