

Instrumentation, Controls, and Automation - Program 68

Program Overview

Program Description

Utilities need to improve the capability to detect damage to plant equipment while preserving the focus of skilled instrumentation and controls staff on plant operations and system performance. Additional sensors are needed to improve equipment condition monitoring, enabling optimization of maintenance tasks. Control systems have evolved from analog to digital, with new technology available to improve plant performance and operational effectiveness.

The Electric Power Research Institute's (EPRI's) Instrumentation, Controls, and Automation program (Program 68) identifies, develops, and demonstrates state-of-the-art sensing, monitoring, diagnostics, and control system technologies that improve equipment condition assessment and plant performance, and help to accurately measure critical plant variables.

Research Value

Maintaining the availability of existing plants is critical to the future generation portfolio. EPRI's Operations and Maintenance programs address the key issues of operational effectiveness, safety, reduction of maintenance costs, and technical support for the next generation of plant staffs. The program focus is on providing integrated solutions that address the needs for processes, technologies, and skilled people, allowing members to:

- 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.

Approach

Products developed by this program provide guidance through technical reports, guidelines, process specifications, webcasts, and seminars and workshops on high-priority research projects. Program activities address the identification and transfer of new technology, and help optimize the use of existing instrumentation and control equipment, which can cost-effectively improve plant performance.

- Technology Development and Demonstrations projects address critical aspects of fossil plant instrumentation and control systems, including advanced controls, automation, improved loop tuning, and equipment diagnostics. Applied research is conducted in collaboration with universities, laboratories, equipment vendors, and host utility sites. The focus includes automation of key plant system operations to improve consistency of the startup/shutdown process while minimizing wear and tear; increasing plant operational efficiency through the development and demonstration of control system improvements; and improved tuning processes that save time and improve consistency and staff knowledge capture.
- Technology Transfer projects provide Fleet-Wide Monitoring Interest Group (FWMIG) meetings twice a year, which 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 guides EPRI research in online monitoring, wireless, and sensor technology.

Accomplishments

Successful implementation of online and automated monitoring technology for equipment condition assessment requires applied research conducted in collaboration with universities, laboratories, and equipment vendors. Field demonstrations of technology at operating plants have included combined-cycle

plant automation, equipment startup automation, advanced control, and automatic tuning. The R&D in this program has provided:

- Successful Fleet-Wide Monitoring Interest Group (FWMIG), with more than 20 member organizations
- Technical reports documenting field demonstrations of new technologies relating to advanced control algorithms, automated controls tuning, multi-loop controls tuning, and application of model predictive controls
- Technical reports documenting field demonstrations of sensors, wireless data transmission, and advanced anomaly detection algorithms

Current Year Activities

The program R&D for 2010 will focus on improving insight into equipment condition through additional sensors, data integration, and improved equipment condition assessment. Specific efforts will include:

- Software for applying improving equipment fault diagnostics using instrument signatures and technology exams.
- Technical resource for determining the feasibility of using control systems for operational flexibility.
- Continuation of the Fleet-Wide Monitoring Interest Group.
- Technical report that will serve as a guideline for instrumentation and control processes key to operations and maintenance in power generating plants.

Estimated 2010 Program Funding

\$1.0M

Program Manager

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Summary of Projects

| Project Number | Project Title | Description |
|----------------|---|---|
| P68.001 | Technology Development and Demonstrations | This project supports optimization of fossil plant instrumentation and control systems, including sensors, wireless technology, equipment diagnostics, advanced controls, automation, and improved loop tuning. |
| P68.002 | Technology Transfer | Power producers require information on emerging instrumentation and control technologies, experience with their initial use, and open peer-to-peer information exchange to identify future directions. |

P68.001 Technology Development and Demonstrations (069177)

Key Research Question

Many experienced instrumentation and 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 accurate detection and mitigation of equipment damage are vital. Plant instrumentation and control systems are critical in addressing these issues.

Approach

This project addresses critical aspects of fossil plant instrumentation and control systems, including sensors, equipment diagnostics, advanced controls, automation, and improved loop tuning. Applied research is conducted in collaboration with utility members, universities, laboratories, and equipment vendors. Field demonstrations of technology at operating plants include wireless sensor networks, equipment fault diagnostics, combined-cycle plant automation, equipment startup automation, advanced control, and automatic tuning. The research and development (R&D) effort in 2010 and future years will focus on:

- Increasing plant operational efficiency through the demonstration and evaluation of control system optimization technology, such as use of model predictive control and automated tuning methods, and
- Improving equipment condition monitoring and diagnostics activities through addition of sensors, wireless networking, and integration of component degradation knowledge into online monitoring systems.

Impact

Instrumentation, controls, and automation technology solutions can improve plant staff knowledge and provide cost-effective evaluation of state-of-the-art technology prior to full-scale implementation. Some examples of technology developments and demonstrations include:

- 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.
- Wireless sensor networking will reduce the cost of installation of additional sensors, enabling more effective detection of critical equipment failure modes.

Experience gained through this research will be directly applicable to both existing plants and new plant designs, enabling more effective application of online monitoring technology to create "smarter" components.

How to Apply Results

End users of this research include system engineers and owners, instrumentation and controls engineers, centralized monitoring staff, and technicians at fossil power plants. Some 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 instrumentation, controls, and automation technology. Other technology results will be delivered as spreadsheets, databases, and presentation materials for quick review capability and ease-of-use. Without this documented guidance, benefits of applying instrumentation, controls, and automation technology may not be realized to the largest potential. In addition, key research results will be communicated periodically through webcasts, teleconferences, and face-to-face meetings.

2010 Products

| Product Title & Description | Planned Completion Date | Product Type |
|--|-------------------------|------------------|
| Multi-Loop Tuning: Implementation Results: Multi-Loop tuning technology has been developed and refined within this program for two years. This product will document the results from implementing the method on a complex, multivariable control system such as that found in a typical coal-fired boiler. | 12/31/10 | Technical Report |

| Product Title & Description | Planned Completion Date | Product Type |
|--|-------------------------|--------------------|
| Barriers to Implementing Advanced Controls: Modern control systems include technology for advancing control system capabilities, including automated tuning parameter derivation and multivariable control. Although the technology is ready, some key barriers exist to cost-beneficial implementation. This product will identify and document key barriers and the path to overcome them. | 12/31/10 | Technical Resource |
| Asset Fault Signature Database: During 2009, a working prototype of EPRI's Asset Fault Signature (AFS) Database was released with a limited content of fault signatures sufficient to demonstrate and test functionality. In 2010, EPRI will support the prototype evaluation of the AFS Database through web training. Functionality enhancements suggested by end users will be identified and implemented. Significant effort will be applied in 2010 toward populating the AFS Database with additional design cases using available EPRI sources on fossil plant component failure modes and effects. The final result, following the 2010 work, will be a production version of the AFS Database ready for use by the industry. This product will be a supporting database to EPRI's Diagnostic Advisor tool that employs a case-based reasoning process for equipment fault diagnostics. | 12/31/10 | Software |
| Using Control Systems for Operational Flexibility: With a changing electricity production and demand landscape, some baseloaded plants today might become load-following plants tomorrow. Many challenges exist, some of which will require the use of digital control system technology for different operational profiles. This study will document the current state-of-the-art applications of controls for this purpose and the barriers that exist. | 12/31/10 | Technical Update |

Future Year Products

| Product Title & Description | Planned Completion Date | Product Type |
|--|-------------------------|--------------------|
| Best Practices for Using Wireless Technology in Power Plants: Many wireless technology demonstrations have been conducted within power plants and other industrial facilities. This product will document the best practices associated with those installations. Topics covered will include project steps, site surveys, hardware selection, difficulties, and success paths. | 12/31/11 | Technical Update |
| Adaptive Control: Technology Assessment: Important control system variables can change over time due to factors such as actuator hardware degradation, causing process variation. Adaptive control technology can help to consistently control the process variation within given constraints even while some slow degradation exists. | 12/31/11 | Technical Resource |
| Demonstration of Sensors to Address Critical Equipment Failure Mode Vulnerabilities: In 2009, a sensor gap study will be completed for selected critical fossil plant components. This project would demonstrate the addition of the identified sensors on a selected component and document the benefits and considerations for both temporary sensing and permanent sensing. | 12/31/11 | Technical Resource |

| Product Title & Description | Planned Completion Date | Product Type |
|--|-------------------------|------------------|
| Optimizing Sensor Placement to Infer Spatial Patterns: Optimal placement of heat flux and oxygen sensors in boilers is a key determination that takes place, often based on access and cost considerations. However, the most optimal placement could be determined through proper modeling for spatial patterns that can be measured through an optimized number of sensors. This project will begin an assessment of the current state-of-art in sensor placement design. | 12/31/11 | Technical Update |
| Adaptive Control: Technology Demonstration: Important control system variables can change over time due to factors such as actuator hardware degradation, causing process variation. Adaptive control technology can help to consistently control the process variation within given constraints even while some slow degradation exists. | 12/31/12 | Technical Report |
| Optimizing Sensor Placement to Infer Spatial Patterns: Optimal placement of heat flux and oxygen sensors in boilers is a key determination, often based on access and cost considerations. However, the most optimal placement could be determined through proper modeling for spatial patterns that can be measured through an optimized number of sensors. | 12/31/12 | Technical Report |

P68.002 Technology Transfer (065777)

Key Research Question

Plant owners demand more efficient operation and effective maintenance to reduce production costs and improve availability. Successful implementation of online 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 development and demonstration efforts.

Approach

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 projects on centralized online monitoring and diagnostics technology.

A technical update titled "I&C Guideline" will be issued annually on member-selected topics. These topics may include instrumentation, calibration, controls, automation, sensors, online monitoring, and wireless technology. The focus of these reports will be on best practices in the electric utility and other industries. As funding permits, assessments of emerging technologies and their early adoption in power-producing facilities will be conducted through webcasts and documentation in the form of technical updates.

Impact

- Peer-to-peer information sharing improves technology implementation in emerging areas, such as online 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.

2010 Products

| Product Title & Description | Planned Completion Date | Product Type |
|--|-------------------------|-----------------------------------|
| Fleet-Wide Monitoring Interest Group Meetings: The FWMIG meets twice annually (typically in May and October) to discuss challenges and solutions related to the implementation of online monitoring technology. Topics include thermal performance monitoring, equipment condition assessment, data integration, and technology gaps. | 12/31/10 | Workshop, Training, or Conference |
| I&C Guideline: 2010 Topical Update: 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. | 12/31/10 | Technical Update |

Future Year Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|-------------------------|-----------------------------------|
| Fleet-Wide Monitoring Interest Group Meetings: 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. | 12/31/11 | Workshop, Training, or Conference |
| I&C Guideline: 2011 Topical Update: 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. | 12/31/11 | Technical Update |
| Fleet-Wide Monitoring Interest Group Meetings: 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. | 12/31/12 | Workshop, Training, or Conference |
| I&C Guideline: 2012 Topical Update: 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. | 12/31/12 | Technical Update |