Power management: Automation enhances power management applications

Strategically approaching plant upgrades and automation projects can help users extend the serviceable life of their equipment while improving the efficiency, reliability, and safety of their systems.

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Power systems evolve as organizational needs shift, new standards are established, and facilities and equipment are updated and upgraded. Eventually, power systems become a disparate collection of equipment that does not work in harmony to deliver the optimal level of reliability, safety, or operating costs. As enterprise power system change, they can become more complicated, inefficient, unreliable, undersourced, and difficult to manage—even as the bar for performance, efficiency, and reduced operating costs is set higher.

A comprehensive approach to energy management yields dividends over time by helping organizations reduce energy consumption and costs, improving system reliability, and enhancing personnel safety. A key aspect of a holistic power management approach is the control and automation solutions that help industrial, commercial, institutional, and utility organizations drive efficiencies, identify problems before they cause downtime, and provide the data required to support reliable, efficient, and safe power (see Figure 1).

Whether for new or retrofit applications, power system automation can support effective power management in applications that include:

- Emergency and backup generation
- Automatic transfer schemes
- Station automation
- Distributed generation systems
- Mission critical secure power applications.

Determining project scope

Factors that should be considered when upgrading a facility include regulatory compliance, safety, reliability, capacity, cost, and operational constraints. When considering electrical and control equipment, it is important to define system goals and objectives first. Both new and existing system components in a generation facility must be evaluated to ensure that overall system requirements are met. Assessing existing equipment is a key aspect to upgrading facilities.

Equipment checklist

Categorizing equipment and evaluating each system is helpful, and ensures that new operation requirements will be met. The following is a checklist of major system components to consider.

Major electrical equipment

- Line switches
- Step-up transformers
- Cable and/or bus duct
- Generator windings
- Meters and relays
- Plant switchgear
- Generator controls, power regulation, and synchronization
- Lighting and surge protection
- Grounding systems
- Station service system
- Battery and dc distribution
- Lighting.

Plant control systems

- Machine controls
- Supervisory controls
- Excitation systems

- Governor/gate control systems
- Head works/dam controls
- Fire and security systems
- Plant ventilation
- Machine and process instrumentation.

It is imperative that each major piece of equipment is evaluated according to its operational criteria. A power system study is a crucial analysis tool used to evaluate electrical equipment, and should be performed during existing equipment evaluation and before equipment selection. A typical power system study includes short circuit, load flow, and protection studies as well as an arc flash hazard analysis.

Short-circuit study: Short-circuit studies allow system engineers to determine if the power system protection equipment is suitable for the application. They are meant to identify the key design parameters needed in the selection of new components, while ascertaining if existing components are safe and ensuring that they meet applicable electrical codes.

Load-flow study: Load-flow studies are performed to determine if equipment is properly sized for the intended application. Cables, transformers, capacitors, breakers, fuses, and other system components are modeled to ensure that they are applied within their specific current ratings. The load-flow study allows engineers to determine the effects of a generator capacity upgrade on the entire electrical system, ensuring that all components are adequate for service.

Protection study: A protection study is meant to ensure that major electrical system components are protected from system faults. This study should go far beyond a simple relay coordination study, which looks at overcurrent only.

The entire protection system must be evaluated according to today's standards, as practices have evolved. Existing protection may need to be updated. Often owners, interconnected utilities, and/or insurance companies require that protection systems meet current IEEE and ANSI standards.

Arc flash hazard analysis: An arc flash hazard analysis is required, as new additions to the National Electrical Code (NEC) require personnel to be protected from arc flash hazards associated with electrical systems. This analysis should be performed in the planning stages of a project to guide system engineers in the selection of the appropriate protection and power equipment.

Mechanical upgrades

Each subsystem in the plant must be evaluated to ensure that it can easily be monitored or controlled by the upgraded control system. Performing a complete start-up and shutdown of the generating units and noting the functions requiring operator intervention is good practice. Create a checklist and document special or contingency operating conditions that may deviate from normal start-up or shutdown. Most actions required to be performed by plant personnel—including inspections—can be duplicated or replaced by the control system. It is imperative that all systems are in good working order prior to implementing an automated control system. Instrumentation should be added to monitor key operating parameters such as temperatures, pressures, levels, and flows.

Control system specification

Control system expectations and requirements must be established before equipment selection and design criteria decisions are made. Well-defined system expectations will likely avert problems down the road. Also, defining system expectations helps simplify system design. System expectation decisions include:

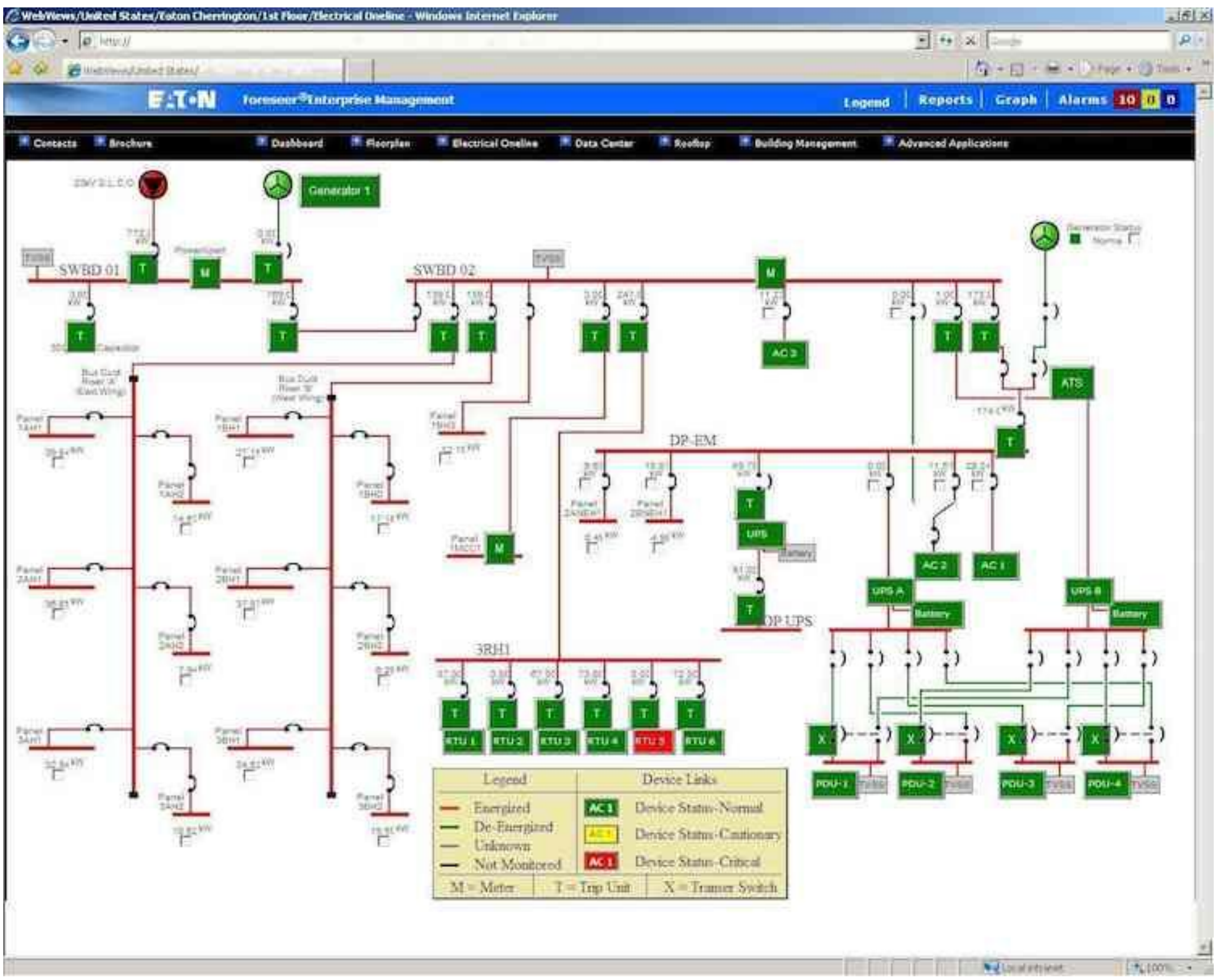
- Manned vs. unmanned
- Automatic vs. manual control
- Hardware and software expandability
- Real-time monitoring
- Remote dispatch and control
- Voltage or power factor control, which can be influenced by changing ISO and RTO requirements
- Governor vs. gate actuator
- Water resource management (pond level control, minimum flow, and bypass)
- Alarm management and maintenance requirements
- Data collection and reporting requirements
- Redundancy and reliability
- Market and regulatory obligations.

After these decisions have been made and system requirements have been defined, it is time to write a functional scope to advance the design process to the next stage: equipment selection. Existing equipment that does not meet the above criteria should be replaced or upgraded.

Equipment selection

The equipment selection process should take into consideration the specific design requirements of the project in conjunction with the overall preferences based on experience, teamwork, and local support. To guide in the equipment selection process, several roadmaps must be drawn. These roadmaps include single line, control system network architecture, and process and instrumentation diagrams.

Single-line diagram: A single-line diagram for electrical equipment must be created that defines the overall power distribution architecture and provides an overview of the entire scope of the electrical upgrade including equipment sizes, relaying and logic schemes, metering points, and data requirements (see Figure 2).



Control system network architecture diagram: The control system network architecture diagram should be created early in the process—before the equipment is specified or purchased. This diagram will guide the control and data requirements of the project and determine the communication methods to be used. Modern control and protection systems inherently include a plethora of information that can be critical to the control of the system, and aid in tuning, troubleshooting, and commissioning the plant.

Process and instrumentation diagram (P&ID): The P&ID is a useful tool in defining process-related systems for the facility, which typically include cooling and hydraulic systems, temperature monitoring, process control, batching, and other auxiliary systems that require instrumentation.

After these diagrams are complete, detailed design and equipment selection can begin. The effort put into the scoping phase will go far toward making equipment selection straightforward.

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