Electrification and Automation: The Case for Integration

A vision of on-demand data flowing freely among formerly isolated information silos is easy. Building and maintaining the custom interfaces often needed to realize the vision is hard. But one by one, the architectural barriers to painless information integration are coming down. This white paper focuses in particular on the convergence of communication protocols and underlying technologies in the arenas of process automation and electrical controls, and how this convergence is allowing industrial companies to reduce capital costs and operating expenses even as they improve overall plant reliability and energy efficiency.

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Electrical energy is a vital input to process manufacturing operations, often secondary only to raw materials. And, just as the flow of process fluids through pipes, valves and vessels typically is controlled by a dedicated process automation system, the flow of electrons through transformers, circuit breakers and motors is the domain of a dedicated electrical control system. In a traditional plant, both types of systems work largely independently to ensure safe, uninterrupted production. Indeed, the differing dynamics of electrical and process phenomena has led over the years to the development of parallel systems, suppliers and support organizations for each type of system.

Typically, the process draws what power it needs according to operational setpoints from the process automation system, and the electrical control system strives to meet those requirements in a safe, stable fashion. If there's any coordination at all between the two systems beyond manual intervention, hardwired I/O or custom interfaces are used to swap a few key variables or interlocks. Significant effort and considerable expense are required to establish and maintain even this limited connectivity in good working order.

Even as process industry management demands for improved visibility into real-time energy usage escalated over recent years in response to increasingly volatile energy prices, the electrical power transmission and distribution industry was developing a way for substation automation systems and other intelligent electronic devices (IEDs) to communicate and interoperate, regardless of manufacturer. The end result is standard 61850 of the International Electrotechnical Commission (IEC), which was first issued in 2004. At the heart of the standard are object-oriented data models designed to facilitate semantic commonality of essential electrical infrastructure functions among disparate systems and devices. The current edition of 61850 also defines an Ethernet-based, high-speed means of communicating generic object-oriented substation events (GOOSE) horizontally among IEDs for interlocks and protection schemes as well as TCP/IP-based MMS for vertical integration into supervisory systems.

And while transmission and distribution systems were the primary target users of IEC 61850, the standard also has important implications for both power generation facilities and other process manufacturing sites. For starters, it’s done much to increase the visibility of operating data and diagnostic information from plant electrical assets. The operations of many older in-plant substations are still maintained by blind controllers unable to communicate back to operations. Periodic field observations of transformer temperatures and power meter readings attempt to fill this information gap, but the practice is relatively unsafe, unproductive and untimely as well. Electrical integration via IEC 61850, in contrast, provides seamless, control room access to real-time operational data and diagnostics for all integrated system users.

The standard also has allowed leading system providers to bring added functionality to their integrated process and power offerings. The most capable system controllers on the market today can function in both domains, simultaneously speaking (and translating where appropriate) the languages of both process automation and
In effect, the process automation and electrical control systems can operate as a single unified system. And, not only can this integration be delivered cost effectively, the integrated system can actually cost less to acquire, engineer and maintain than two dedicated systems, saving up to 30% relative to a non-integrated, two-control system approach. For example, at the Presidente Getúlio Vargas (Repar) refinery of Petrobras in Brazil, engineers credit the refinery’s integrated process and power systems with a 30% savings in engineering costs, 15% savings in installation time, and 20% savings in training costs.

The improved ability to control capital costs and operational expenses is but one facet of the overall performance improvements made possible by a holistic view of plant data and asset information. A unified platform means users gain better control of overall plant productivity, availability and safety as well. Further, as individual drives, motors, breakers and relays reveal the formerly stranded details of their energy usage in real-time, opportunities to control and conserve energy come to the fore.

**Faster, Less Expensive Project Execution**

Integration projects most often are justified as investments that pay off over time. Those shiny new communication interfaces and that extra engineering work promise to be worth it because of improvements to come down the line in productivity, visibility and readier decision-making. But sometimes a system supplier’s integrated approach can also mean lower initial costs that pay off immediately—in hardware, in software, in engineering hours—compared with the old way of doing things.

System designers and end users can now leverage electrical control and process automation architecture that is effectively “pre-integrated” and tested. Greenfield plants and brownfield retrofits can reduce upfront costs even as operational savings and performance benefits accrue over time. And, as the domain of electrical control has come to rely on Ethernet and other standard, non-proprietary network protocols over recent years, they now have the power to eliminate many of the hardwired connections and custom interfaces necessary only a few years ago.

Ethernet-based connectivity also means no I/O—and no hardwiring—is required for communication among intelligent electronic devices (IEDs). For example, at one large industrial facility peer-to-peer networking of IEDs recently eliminated 110 kilometers of cabling. And for a refinery retrofit, 24 marshalling cabinets were eliminated in favor of a single cubicle. Fewer wires also mean fewer terminations, lower installation costs, and improved organization within substation cubicles. Further, fiber optic networks mean that communication links can run closer to busbars without risk of electromagnetic interference.

All this means reduced hardware, installation and commissioning costs as well as streamlined system engineering effort. Fewer representative configurations, or typicals, can be more safely tested and commissioned back at the switchgear assembler or factory rather than at the plant site. Indeed, adoption of a “bay typical” philosophy can substantially reduce factory acceptance test (FAT) and commissioning time.

Future system flexibility also improves. For example, even after the plant is up and running, IEC 61850 enables GOOSE-based interlocking among switchgear cubicles to be added through software configuration—saving time and keeping workers out of harm’s way. Plus, any late configuration changes can be readily replicated via software across multiple typicals.

Meanwhile, most process automation system architectures in use today already use Ethernet for controller communications and for integration with host-level systems. This Ethernet backbone complements automation-specific protocols such as PROFINET, PROFIBUS and FOUNDATION fieldbus for digital field device integration. With both process automation and electrical control systems converging on Ethernet, then, it’s not too hard to envision today’s unified systems, wherein IEDs and process controllers are part of a common communications infrastructure. And while an Ethernet physical layer is the common thread, network management technology such as virtual local area networks (VLANs) are used to appropriately segment and secure network traffic.
Such a unified system yields immediate cost benefits in terms of system footprint. Floor space is often a critically important consideration for space-constrained applications such as off-shore oil and gas platforms, and for plant expansions and retrofits where new equipment may need to abide by the constraints of pre-existing cabinets and control rooms. A unified host-level architecture also means that both process and electrical data can be presented on the same engineering, operator and maintenance workstations, possibly reducing the number of consoles necessary while simultaneously boosting the flexibility and capabilities of those that remain. Inventory costs are reduced, since fewer types of common spare parts are needed. Common engineering and configuration tools mean less training and higher productivity for system designers as well.

Over the past several years, the ability to configure analog input/output (I/O) module channels on an individual basis has been promoted in process automation circles as a new way to both increase system flexibility and accommodate late engineering changes in the course of project work. Configurable, single-channel analog I/O is one way of addressing the issue. But why not do away with old analog I/O altogether?

Fully digital field networks extend the digital communication infrastructure all the way down to the individual transmitter, motor or protective relay. Indeed, millions of fieldbus nodes have been installed since the late 1980s and, like configurable I/O, digital fieldbuses allow for individual channel assignment at the time of installation—without the need for any additional characterization hardware. Importantly, digital fieldbuses communicate non-process variable information much more quickly than do hybrid analog/digital loops with piggybacked HART signals, significantly improving the ability to implement control strategies that closely coordinate process and electrical system tasks.

**Improvements in Control, Coordination, Visualization and Asset Management**

While consolidating electrical control and process automation functions under a single integrated system brings clear cost benefits, it can also deliver significant improvements in overall plant performance. With added visibility into electrical equipment and access to historical data, routine preventive maintenance measures yield to predictive, condition-based activities that take into account the status of both process and electrical assets. And when equipment does need attention, easy access to more complete information means it can be repaired and brought back on line more quickly. Further, remote access to electrical system data enabled by IEC 61850 networks means that many electrical system fixes and configuration changes can be applied and replicated over the network—keeping workers well clear of potentially hazardous situations.

In addition to providing an expanded and more textured view of a plant’s maintenance needs, electrical integration can bring together process operators and electrical power specialists. Together, with a unified set of visualization and system management tools, they can better understand the interdependencies between process and power subsystems and can make more informed, big-picture decisions. In total, improved visibility and collaboration across operations, power and maintenance organizations add up to higher plant availability, improved worker safety and optimized control strategies and procedures that leverage both real-time process and electrical data.

In traditional multiple-system plants, operators and maintenance personnel often make critical decisions in silos. They have a limited view of the plant, with knowledge and visibility restricted to just one domain—their own system environment, their own asset database, and their own alarm and event lists with different time synchronization bases. Separate electrical system, maintenance and operations consoles—often in different control rooms—create additional physical and cultural barriers to the common goal of overall plant optimization.

Increasingly though, modern plants are moving to centralized control rooms where process operators, power engineers, and maintenance personnel work together more closely. A common, plant-wide system for process automation and electrical control system tasks helps to further promote collaboration and a consistent operating philosophy across functions. This can help reduce risk, increase uptime and optimize overall decision-making by all.

With one integrated system, all personnel access process and power data through a common interface tailored to that individual’s particular role. The process operator’s screens default to the flows, temperatures and pressures required to control and interact with the process. The power engineer’s displays feature key parameters of the power distribution system. Meanwhile, maintenance professionals see prioritized lists of work orders for both process and electrical equipment that need their most urgent attention. Underneath the hood, however, each system user has full access to all the same process and electrical data and pertinent alerts, including synchronized lists of alarms and events.
Further, information from the plant's electrical and process sub-systems is time-stamped to the same network clock. This means that operators and engineers no longer need to try to compare unsynchronized event lists from multiple systems to answer the question of exactly what happened when and in what order. Trouble-shooting, error analysis and even response to plant upsets happen more quickly and easily.

The same shared infrastructure that provides a common time basis for network events also facilitates remote system-wide parameterization and configuration. Disturbance records (DRs), too, are captured on the network, eliminating the need for a substation technician to trek into the field, hook up his laptop to the substation in question, and download the latest DRs. Instead, DRs are automatically uploaded to a system server, eliminating the potential loss of records due to IED buffer overloads. Technicians are able to remotely access and change parameterization and protection logic from any engineering station; faster analysis means faster root-cause analysis and issue resolution.

The integration of electrical controls into a unified system architecture also extends the scope of asset management strategies, providing a more holistic view of overall plant health—and the prioritization of corrective interventions. Historically, electrical assets in particular have been difficult to instrument in a cost-effective way. As a result, electrical asset maintenance is often neglected until a previously undetected fault begins to impinge on process operations.

But an integrated information architecture that leverages open Ethernet standards can effectively monitor the health of all equipment on a plant-wide basis—from an incoming circuit breaker in a plant substation to a temperature transmitter in a process heat exchanger. With an integrated power and process approach, the entire chain of assets that comprise a particular plant operation can be monitored and viewed, analyzed and diagnosed in the context of an integrated whole.

Maintenance engineers, process control operators and power engineers all have direct access to the information they need to better predict equipment failures and prevent plant upsets. For example, if a circuit breaker is taking too long to open, an alert is automatically generated and sent to the appropriate person for action. With further integration of the plant’s computerized maintenance management system (CMMS), a work order can be generated automatically, streamlining maintenance workflows. A single system level view of all types of integrated devices allows fast and easy access to device diagnostics as well as configuration and parameterization changes.

**A Complete Portrait of Energy Usage**

Energy management entails the visibility and control of energy usage from the plant-wide level down to the individual load, with the primary purpose of identifying and addressing sources of inefficiency. With a unified system for electrification and automation, real-time data from the site’s entire portfolio of system components—from substation automation systems and protective relays down to energy consuming equipment—is visible across the entire network.

Implementation of a unified architecture for automation and electrical systems means that detailed, real-time information on power consumption down to the individual load is available at the system level. Analysis down to the individual motor level allows plant personnel to pinpoint and address sources of inefficiency that aren’t identifiable in area-wide consumption data. For example, if the data shows an individual motor’s energy consumption trending upward, a maintenance call can be scheduled automatically.

Plant personnel can see and understand power usage in a more coordinated manner, allowing the exploration of new energy-saving opportunities and the validation and extension of existing energy-saving initiatives. Better visibility into power consumption and real-time energy usage and costs also allows for easier energy auditing and benchmarking against industry standards.

In a larger context, electrical integration can represent the final element of a holistic view of all energy flows within a plant. The flow rates, temperatures and pressures needed to quantify in real time a plant’s consumption of fuel and steam as well as energy-intensive plant utilities such as compressed air and process water often already are collected in the process automation system. The real-time integration of power consumption—in aggregate and in granular detail—delivers the final brushstrokes required for a complete portrait of energy use.
The primacy of energy as a process input even has some industrial operations redefining their key performance indicators (KPIs) in terms of unit energy consumption, rather than overall production rate: in tons of product per kWhr rather than in tons of product per day or year. This KPI, in turn, sometimes has a more direct correlation with plant profitability than does overall production rate. Energy consumption visibility, enabled by an integrated approach to process automation and electrical controls, is making this approach possible.

All told, an integrated approach to electrical controls and process automation can substantially reduce capital and operating expenses while improving overall plant performance. First, an integrated system costs less to acquire, install, commission and maintain over time relative to two standalone systems. Second, an integrated system tears the blinders from formerly isolated decision-makers, allowing them to collaborate more closely, better understand the big picture, and act more quickly, decisively and correctly. Third, an integrated system provides a ready platform for implementing energy management strategies that advance plant performance in both economic and environmental terms.

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