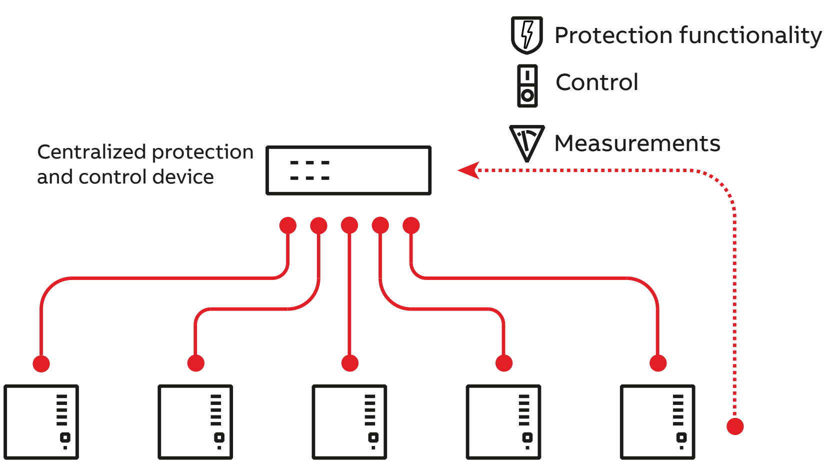
WHITE PAPER

Optimizing sustainability and reliability with digital substations

A major US utility leverages an updated digital environment to support new functionality and renewable energy integration in pursuit of sustainability goals.

As any industry observer can tell you, the US power grid is undergoing its most significant transformation since its inception. The addition of highly concentrated and flexible loads, the proliferation of distributed energy resources (DERs) and the electrification of transport will inevitably result in a much more dynamic (and multidirectional) flow of power.



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01 Protection and control functionality centralized in one device

Accordingly, grid protection and control (PAC) devices must become easier to install, service and replace in support of a generational build-out. They must also facilitate the evolution of algorithms and growth in data publishing and consumption, and they must be ready to integrate into multilevel wide-scale management systems.

Even with modern centralized PAC standards, there are challenges to overcome, particularly form factor and fixed functionality. The physical installation of relay, control and communication equipment is labor-intensive. This limits productivity both on the capital investment and maintenance sides of the utility.
At the same time, most intelligent electronic devices (IEDs) remain essentially static in terms of what can be programmed within them. They cannot be updated easily to incorporate new data feeds or new functions. Centralized protection and control (CPC) within a single device represents an advancement on several levels and will be easier for system owners to manage moving forward. However, there is still room for improvement to make deployment even simpler and provide valuable flexibility in the future.

A major US utility recently faced these and other concerns when the firm undertook a project to leverage digitalization at two new substations serving wind and solar generation facilities. The company's unregulated arm had been eying digital solutions as a way to become more cost-competitive in renewable energy project development and was ready to put forth the effort for the transition. The twin projects, slated for commissioning in 2024, will become the first non-pilot installations of centralized digital substations in the US.

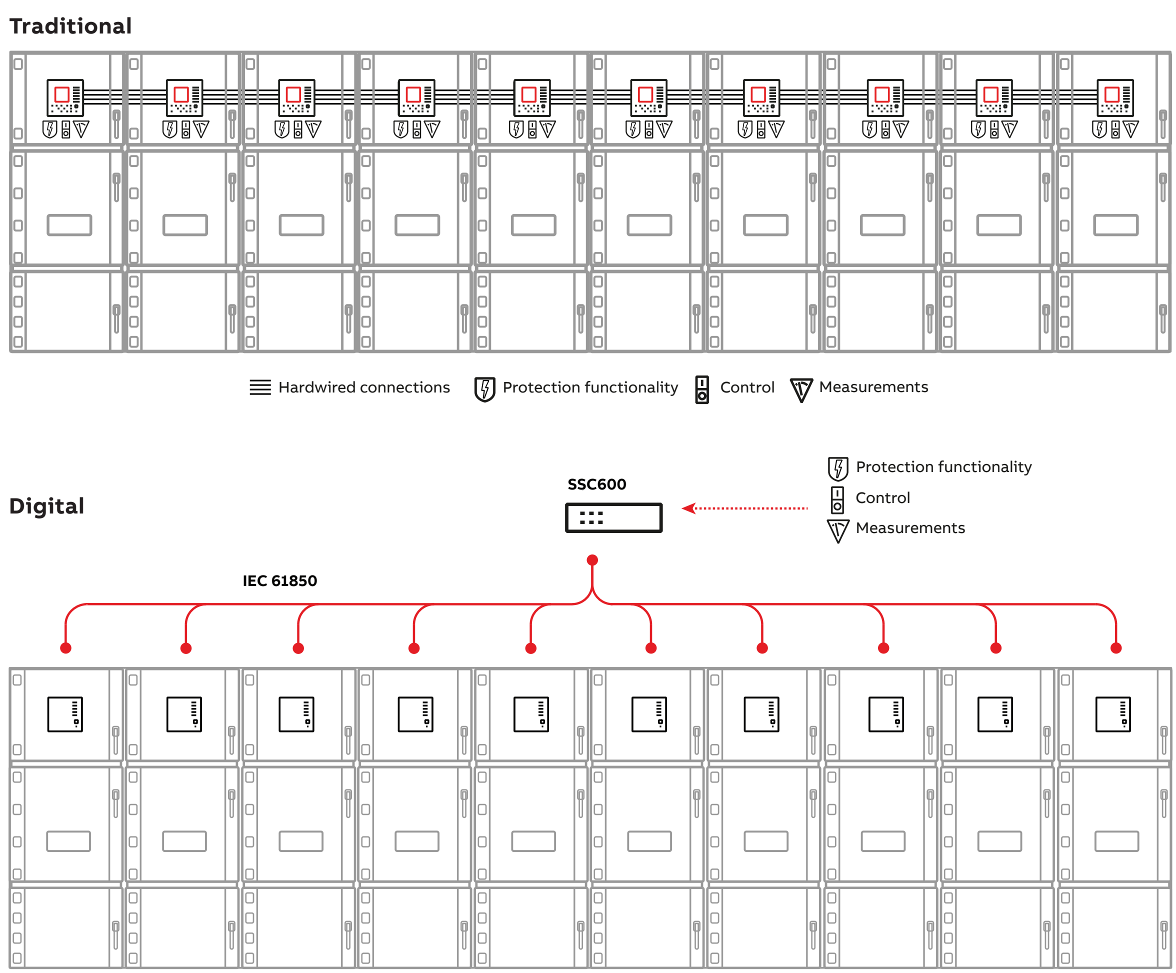
COVID-19 throws a curveball

The pandemic served as both driver and obstacle for the utility. Initially, COVID-19 drove the need for better visibility into substations from the control room in order to minimize the need for on-site work. Then supply chain disruptions precipitated by the economic slowdown pushed lead times out for many types of equipment. This put the company in the position of moving forward on substation digitalization without some of the latest technology they had anticipated using. Meeting carbon emissions goals and a financial environment of high interest rates added more incentive to digitalize.

The utility settled on a complete PAC solution from ABB, including merging units, a CPC device and all digital connections. The versatile solution incorporates multi-vendor devices as well as non-digital devices. The team realized that additional optimization would be possible with metering and event recorders, but this was a significant first step. Upcoming grid requirements will require fault recording at a sampling rate of 128 times per cycle, one example of how new functionality will be necessary to capitalize on further simplification in digital product roadmaps.

Benefits manifest

Both substations are currently in the construction phase, and several benefits have already become clear with regard to digitalization. Many of these are interrelated and come with cost savings attached. For example, configuring the PAC scheme via software rather than hard wiring means replacing miles of copper wires with much less fiber optic cable, saving on materials and installation time. Mid-project changes in system design can be accommodated with an easy-to-use software engineering tool instead of reconfiguring wires, reducing labor costs and on-site work.



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02 Traditional vs. digital substation design.

Other benefits of going digital include:

Cybersecurity is enhanced when utility industry-specific protocols and processes are replaced with widely used alternatives, taking advantage of cybersecurity investments (e.g., network communications monitoring, hardened servers) made in other industries.

Safety is baked in by design. Merging units gather data feeds and bring them back to the control room via fiber optic lines, keeping dangerous voltages and currents contained in the field device and greatly reducing the risk of electrical interference with cabling and other devices.

Troubleshooting and diagnostics capabilities warn of problems before they occur, saving on operations and maintenance costs, avoiding downtime and supporting planning processes.

Multifunctional relays can be used for many different applications. One protection and control device takes the place of multiple specific relays, so technical staff can repurpose products and execute changes faster and easier. In addition, the digital substations will require fewer spares.

Costs come down. In total, the cost of the two substation projects described here is roughly $200,000 lower than the utility expects they would have paid for a conventional solution. In fact, ABB's customer estimates CAPEX savings from going digital (excluding buildings) at 15% for small sized substations and 30% for large ones.

Time is money, too. These two substation projects are still in progress, but the scheduled time to completion is half that required for a traditional substation. As the company takes on new projects, replicating the digital installation process will become easier, freeing up technical staff to work on other things, helping improve workforce utilization and productivity.

Workforce impacts

Recruiting and re-skilling the utility workforce are major concerns for the industry, so it's worth examining more closely what effects digitalization is likely to have on staffing challenges. Managers at our host utility noted that technicians increasingly arrive already armed with more software, communications and computer skills than workers with "relay-only" talent specific to the utility industry. This makes for a larger talent pool as, for example, workers from telecom or other industries can move into similar roles in the power industry without a great deal of industry-specific training.

Similarly, using cutting-edge systems is an important factor in attracting younger workers looking to use the latest technology. Engineering tools for digital substations are simpler, too. That shortens the training step and streamlines work processes once technicians begin operating on their own. With a quarter of the utility workforce expected to retire within the next six years, the impact digitalization will have on the available labor pool cannot be overstated.

Challenges remain

The road to fully digital substations is not completely smooth, of course. Change is an issue in any context and can be especially difficult to implement in the utility world, both culturally and technologically. Upgrading existing facilities is a sticking point. Utilities are working out how to integrate a digital upgrade to a legacy substation and manage a mix of technologies.

Standards are another concern. Most are written around current technology and so must be updated, and many are IEC standards that are less familiar to US engineers.

These issues are not insignificant, but they will eventually be overcome as more utilities invest in their digital future. This is, perhaps, the most important aspect: future-proofing the grid. Ten years from now, a digital backbone that can take advantage of the latest devices and features will already be in place. Hybrid architectures are available now, and conventional IEDs can serve as backup merging units, thus squeezing more value out of previous investments even as the utility moves decisively toward full digitalization.

Advice for digital substation shoppers

Our forward-looking utility has gained valuable experience in their first implementation of CPC, and they have some advice for fellow utility planners. Before going into a cost comparison, they say, first identify the existing architecture in detail. Are the relays inside field devices or in separate relay control panels? Are the relays redundant (i.e., two relays per bay) or not?

Consider, also:

- The number of feeders and transformers that could exist in the future
- Reactive components and neutral grounding resistors
- The building and construction costs associated with a retrofit vs. an entirely new building
- What protection functions are likely to be most used
- The reduction in current and power transformers that digitalization can bring before specifying breakers and transformers

Each substation project has its own set of requirements and constraints, but armed with this information, utilities can take a meaningful first step toward realizing the benefits of digitalization.

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