



Layered Intelligence™ Smart Grid Solutions

Today's distribution grid is transforming into the Smart Grid of tomorrow. The future grid will grow increasingly complex and dynamic, as utilities work to meet renewable energy portfolio standards and improve grid reliability, efficiency, and capacity.

According to the U.S. Energy Information Administration, solar, wind, geothermal, hydroelectric, biomass, and waste sources currently provide nearly 12 percent of the country's electricity supply. Many regions and states across the U.S. have set ambitious renewable energy targets of 20 to 30 percent in the next 10 to 20 years. California, for example, has mandated that all retail sellers of electricity serve 33 percent of their load with renewable energy by 2020. And other countries have targets for renewable energy sources and/or CO₂ reduction, and are looking at ways to incentivize the use of electric vehicles.

As grid complexity increases, the challenge of balancing generation and load, i.e., supply and demand, is growing as well. The application of layered intelligence throughout the grid is essential for transforming aging transmission and distribution infrastructure, to permit it to meet 21st-century requirements for reliability, efficiency, capacity, and

stability. Layered intelligence ensures that the right decisions are made at the right time, at the right level of the grid. It yields quicker decisions than centrally controlled systems, resulting in faster reaction to changing conditions on the grid.

Investments in layered intelligence solutions will enable utilities to improve reliability and efficiency today, while also laying the foundation needed to meet evolving energy demands. It is highly scalable and offers practical, economical solutions for a variety of issues. It can provide the self-healing technology needed to improve reliability on problem feeders. It also provides the foundation needed to meet future requirements. For example, the expected increased deployments of electric vehicles and distributed and renewable power sources will require local intelligence in the grid, along with automated switching devices, to rapidly respond to changing system conditions.

White Paper

S&C ELECTRIC COMPANY
Excellence Through Innovation



Layered intelligence will make the grid more resistant to cyber-security threats as well. Unlike other critical systems, such as banking networks, the grid cannot simply be shut down if an attack is detected. The remainder of the grid must continue to operate if a portion of the system is shut down.

The number and types of devices that measure and capture data for the Smart Grid are rapidly expanding. If all of this data—from simple status information to detailed waveform oscillography—were constantly streamed back to a single centralized location, severe congestion would result, overloading the grid's communication networks and preventing many applications from working properly. Distributed intelligence at each device eliminates this problem. It turns data into intelligence that can be acted upon in the field, in real time, while still reporting overall status to the centralized location. This approach dramatically reduces communication congestion, while allowing central control to maintain complete awareness for grid optimization and efficiency.

Smarter Power Restoration

As consumers and businesses face rate increases to pay for Smart Grid technology, it is imperative that distribution system performance improve to levels that warrant the added expense. To address this concern, utility commissions have begun to decrease the duration of countable outages. But even a short outage can have a big impact. It can decrease productivity of an industrial facility. It can result in lost sales when shoppers leave a retail store. Or it can mean that TV viewers miss a big play during a playoff game.

An automatic restoration system utilizing distributed intelligence is ideally suited for handling the decreased duration of countable outages. It responds rapidly to changing system conditions. Switching decisions are made quickly and effected at the point of occurrence, so fewer customers notice the tell-tale blink of lights associated with a fault.

Centralized systems, on the other hand, are inherently slower and are less adept at handling the complexity of automatic restoration. And if multiple faults occur on a feeder during a storm, a centralized system will struggle to fully assess the situation and then restore service.

Systems utilizing distributed intelligence are also less prone to single-point failures, such as malfunctioning substation controls. In such instances, automated restoration efforts may be hampered or even fail.

Distribution system protective devices such as circuit breakers have long used embedded intelligence to detect overcurrent conditions. With the improved intelligence provided by microprocessors, these protective devices can now respond to fluctuations in voltage and overloads, and autonomously take action when appropriate. By combining overcurrent protection with intelligent, self-healing technologies, utilities can greatly improve system reliability and minimize equipment stress. Embedded intelligence also makes it possible to better coordinate the response of protective devices, reducing the scope of even momentary outages.

Perhaps the biggest advancement in intelligent distribution system devices is the advent of PulseClosing Technology™. This technology is superior to traditional reclosing because, following a short-circuit, it tests the line by analyzing a low-current pulse to determine whether a fault is present. By contrast, a conventional recloser simply closes again . . . exposing the line to full fault current again if the fault is still present. Pulseclosing reduces energy let-through by 98% compared to a typical recloser, greatly reducing the damage to equipment if the fault is permanent.

The combination of distributed intelligence with centralized supervision can provide a truly smart service restoration approach. Distributed intelligence throughout the grid provides the rapid initial response needed to ensure reliable service and minimize damage from short-circuits. Centralized supervision then comes into play, helping to rebalance loads across unfaulted distribution feeders and substations. Rebalancing of the loads helps minimize wear and tear that equipment might otherwise experience from carrying overloads over sustained periods of time. And real-time information from each device can be shared with a back-office outage management system. Such information sharing can help utilities pinpoint outage locations, and thus facilitate faster repair of damaged sections of the system.

Managing Peak Load by Bringing Intelligence to Stored Energy Sources

Nations around the world are faced with critical energy choices for meeting ever-increasing peak load demands. They can add additional carbon-emitting peak power plants and replace transmission and distribution lines to ensure adequate capacity. At the same time, the application of renewable generation sources is growing . . . and utilities are compelled to

accept excess power from them at certain times of the day, typically in the early morning hours when electricity demand is low.

To handle both issues, utilities have begun looking to change consumer behavior through demand response programs. These programs attempt to influence usage through real-time pricing alerts. But it will take years before real-time pricing data is available to most consumers, and these programs essentially rely on customers to adjust power consumption on their own . . . giving utilities only limited control.

Energy storage or “virtual” power plants can address increasing peak load demands. Energy storage, located either at the substation or the community level of the grid, can have the same or better effect as shifting consumer habits, while providing greater control, predictability, and reliability. Utilities can use this storage to shift system loading and generation patterns, positively affecting grid asset utilization and increasing overall grid reliability.

While community energy storage systems are just now going into pilot installations, it is clear that layers of intelligence throughout the grid will be essential to coordinate and utilize these dispersed stored energy resources. Each storage unit requires its own intelligence to manage the complex battery charging/discharging process, and enable quick response in the event of an outage or other local problem on the distribution system. If a communication problem occurs, the storage units can restore power without the need for centralized supervision.

By applying centralized supervision to multiple storage units, a virtual power plant is created. Substation-level controls provide a single “lever” for a distribution management system that permits management of aggregations of community energy storage units. Such controls allow the distribution management system to monitor the status of each storage unit, and make system-wide decisions on charging and discharging based on capacity forecasts, weather, pricing, and available generation sources.

Volt-VAR Optimization to Improve Efficiency and Boost Available Capacity

As energy demand increases and power-hungry new technologies such as electric vehicles proliferate, utilities need to maximize generation. Today, up to 7% of electricity is lost during distribution. Volt-VAR optimization reduces these electricity losses, freeing up much-needed capacity to help meet demand.

Distribution capacitor banks are typically applied for VAR optimization. They can be furnished with “one-way” or “two-way” controls. One-way capacitor controls have no local intelligence. Switching decisions are made at the substation level. In the event of a communication issue, no real-time information on line conditions is shared (as is required to ensure optimal Volt-VAR performance), and the utility does not have the ability to control their capacitor banks.

Layered intelligence solutions utilizing intelligent, two-way capacitor controls provide a better approach. These controls can make switching decisions locally. They can also communicate real-time data to the substation. The latest technology features substation-level controls that can verify capacitor banks are switched in or out through real-time measurements. This approach allows utilities to optimize VARs across all feeders served by a substation, eliminating a common scenario wherein one feeder is in a leading power factor situation and another is lagging, with too many capacitor banks turned on or off.

Centralized supervision allows utilities to consistently manage the grid to achieve maximum efficiency. Centralized supervision applied with distributed, intelligent controls combines autonomy with the flexibility to revert to local control in the event of a communication issue.

Supporting Time-Critical Applications and Enterprise-Level Utility Systems Through More Efficient Communications

One of the major challenges in implementing the Smart Grid is managing the data generated by devices in the field. With a layered intelligence approach, these devices capture data and can help determine what data is needed to support back-office outage management systems, utility operations and maintenance systems, distribution management systems, etc.

Distributed intelligence in the communication system, further, can ensure that data for critical applications is sent more quickly and with higher priority than data supporting other grid functions. Since networks of intelligent switching and protection devices can communicate peer-to-peer and take autonomous action to optimize the network and ensure system reliability, the bulk of the data does not need to be sent back over SCADA, thus freeing up valuable bandwidth and increasing overall system efficiency.

Intelligent communication devices allow segmentation of communications bandwidth as well, so utilities can designate routes for specific users, applications, or destinations. This enables much more efficient use of data captured from the grid devices, which can support a multitude of centralized or enterprise-level systems and applications.

Integrating Back-Office Systems: The Final Layer

Interoperability with centralized utility software systems is essential to maximize the benefits of the Smart Grid. Centralized back-office utility systems represent the last “layer” in a system relying on layered intelligence. As Smart Grid deployments increase in scale and complexity, tight integration of real-time operations, asset data, and device configuration at the system level becomes increasingly important.

A fully integrated back-office system dramatically improves management of the Smart Grid and significantly enhances grid reliability and efficiency, while minimizing the duration of customer outages. Field devices can use and automatically share information with geospatial imaging systems (GIS), allowing both grid-based applications and the GIS to operate more accurately and effectively. Grid devices can access and employ the most up-to-date asset data while minimizing maintenance of centralized databases. This makes large-scale deployments of self-healing technology more economical.

Grid devices that provide self-healing response can also be integrated with utility outage management systems. Such integration allows utility operations crews to more readily identify outage locations, and thus accelerate system repairs to restore power.

Conclusion

To make good on the promise of a truly “smart” grid, the industry must continue to implement equipment that employs distributed intelligence, out to the edges of the distribution system.

Distributed intelligence allows the grid to deal with problems locally, when and where they occur, and allows rapid response to system issues that can impact grid reliability or stability. Centralized supervision can help optimize performance of the grid, improving efficiency, asset management, and utilization.

As the grid becomes increasingly complex, balancing generation sources and load demands is becoming progressively more challenging. Layered intelligence offers utilities the optimal approach for improving reliability and grid efficiency, and provides a foundation capable of meeting future energy demands.