What You Need to Do to Be Ready
As the smart grid gathers momentum, digital technologies are being steadily incorporated into utility operations. A study by EY found that 92% of electrical utilities and power generation companies decided to invest in the digital grid in 2017. Over the next few years, that trend is only expected to accelerate. EY predicts that investment in the digital grid will reach half a trillion dollars annually. Clearly, the digital grid has moved front and center in the power and utility sector. It is being driven by the growth in renewables, increasing cybersecurity risk and the demand for greater efficiency. To realize the dream of a digitized grid, however, the equipment deployed must offer high performance and be highly reliable. That requires a network infrastructure that can not only deal with current demands, but can cope with future innovation and a massive increase in data traffic volume. The key to achieving this is the digital substation.

The Digital Substation
The digital substation lies at the cornerstone of the evolving digital utility. It is the heart of an infrastructure that must be able to withstand the evergrowing amount of data that will be generated and consumed by digital substation equipment in the coming years. To achieve this, operators must streamline the information and data exchanges in the electrical grid and supporting communication networks.

The digital substation means replacing conventional measuring equipment such as current transformers (CTs) and voltage transformers (VTs) with non-conventional instrument transformers using digitalized sensor technology. This will reduce exposure to high voltage signals. This new breed of high-performance digital sensors and merging units are much easier to install. They can pass digital outputs directly to the process bus, and preserve signal integrity.
Another element of the migration to the digital substation is the significant reduction of copper wires. Conventional copper wiring is limited to carry information from only one measurement point or control signal. It also introduces potential safety risks. Traditional circuit breakers and control equipment require time and money for manual testing and maintenance. In addition, they offer limited information about asset health and condition-based maintenance. By migrating from copper wiring to fiber optic cables as part of the transition to the digital substation the quantity of signal wiring in a substation would be reduced by 80%. Grid reliability, on-site and worker safety, and power availability will all benefit.

Further, the introduction of fiber optics will simplify utility networking requirements. Instead of separate networks for substation automation applications and video surveillance, they can be converged into one fully integrated communications infrastructure. Far from being a distant dream, this is reality for some. Power-over-Ethernet (PoE) technology enables video security cameras to operate solely on Ethernet, thereby eliminating the need for them to have a separate electrical power source.

But perhaps the biggest gain will come by integrating precise time synchronization into the substation network. Precision timing is a key concept in the modern utility. Reliable modern digital protection and control relays and smart sensors need to be synchronized and require highly accurate timing references. The IEEE 1588 v.2 standard describes a network-based precision time synchronization protocol that ensures the sub-microsecond accuracy required for modern utility applications. It also eliminates the cost to install and maintain a separate dedicated timing network. Instead, time synchronization signals can be transported over the same Ethernet network together with protection, control and video surveillance data.

**Designing the Modern Utility Network**

Most utilities today have a mix of conventional copper point to point wiring and copper or fiber Ethernet networks. Many have yet to begin the convergence journey. Therefore, network design and strategy becomes a critical element. As equipment nears end of life, replacement units must be evaluated based on the role they will play in the digital substation.

It is smarter and cheaper in the long run to invest more in network routers and switches that are future-proof and will facilitate the network convergence. Massive deployment of digital substation technology is expected to start in the next few years thus utilities should prepare and embrace this transformation.

Here are some of the top requirements for the Ethernet switches and routers required as part of the digital substation:

**Reliability and Lifecycle**

Evaluate Ethernet switches based on their level of reliability and their ability to operate without failure for a period of up to 15 years. One of the goals of the digital substation is the elimination of time-consuming manual maintenance routines. Therefore, equipment must be highly reliable, capable of self-diagnostics, capable of being monitored by asset management systems and must operate without required periodic maintenance.

**Seamless Interoperation**

The selection process must take into account the ability of equipment to seamlessly interoperate with other applications and equipment. This includes future standards, networking technologies and protocols. Legacy applications, analog-based systems and proprietary protocols need to be phased out and replaced by modern international standards.

**Higher Bandwidth**

It would be the wrong strategy to motivate purchasing decisions only based on today’s bandwidth needs. Just as bandwidth requirements have steadily risen over the past decade, that trend can be expected to continue for the foreseeable future. In fact, bandwidth needs are expected to skyrocket as the Industrial Internet of Things (IIoT) gathers steam. The IIoT expands the volume of data on the network by several orders of magnitude. Large amounts of sensors operating within a substation and in the substation equipment will collect and transmit data to be analyzed in real time by utility systems. Modern data analytics systems will turn this raw data into actionable intelligence and will enrich the organizational decision making processes, will facilitate predictive and preventive maintenance, as well as grid optimization.
Substation network with high bandwidth backbone to support a large amount of redundantly connected IEDs at the bay level

**Port Density**
Another area requiring a broader look is the device port density. Networking equipment should offer the greatest number of options. After all, it may be some time before everything is fully converged and digitalized. In the interim, Ethernet switches and routers must provide wide selection of PoE, copper and fiber Ethernet ports. Note, too, that modern protection relays and merging units are gradually being equipped with Gigabit (Gbit/s) ports. Network switches that aggregate traffic from multiple protection bays, therefore, will have to support high Gbit/s port density, with even higher data rates looming on the horizon. To future-proof any substation a 10 Gbit/s substation backbone network must be considered.

**Precise Time Synchronization**
Even if older synchronization systems remain in use, IEEE 1588 is destined to take over sooner or later. It’s prudent to replace older units as they reach end of life with IEEE 1588-enabled gear, rather than suddenly have to replace everything at once when the inevitability of the move to the new protocol becomes apparent. Hardware flexibility, therefore, is essential to enable the various types of substation architecture and topologies to interoperate smoothly.

**Traffic Prioritization**
The digital substation demands prioritization of critical application data flows. With so many data feeds and IIoT-enabled sensors flooding data into the network, factors such as grid stability, service to consumers and utility profitability have to go to the front of the queue. Data traffic from non-critical applications must be throttled back when high priority packets appear on the network and rapid action is required by mission-critical applications.
Cyber Security
Utilities are increasingly targeted by hackers and cyber-criminals. Regardless of the state of digitalization and the number of existing analog systems that are not connected to the Internet, no utility can stand aloof from cyber risk. All it takes is one person opening a compromised email or file and the entire network is exposed. Newly introduced equipment, therefore, must be implemented with adequate security safeguards. Besides that it is also important that a product supplier deals transparently with vulnerabilities discovered in their products and provides solutions, updates and patches in a timely manner to ensure maximum cybersecurity for the modern digital substation.

High Performance in Harsh Conditions
All substation equipment must be capable of meeting current performance requirements with enough headroom for expected future traffic and bandwidth expansion. Even under extreme environmental conditions such as high levels of electromagnetic interference, vibration, shock, humidity, pollution, extreme cold or hot temperatures, the digital substation has no room for component or equipment failure. By preferring rugged rated networking components, a significant amount of truck rolls, maintenance effort, repairs and failures can be eliminated.

Maintenance-Free Operation
Utility-grade networking equipment should be designed in a way to minimize maintenance. The goal of a modern digital substation is to reduce manual workload and minimize operating expenses related to traditional maintenance tasks. Condition monitoring that takes advantage of a vast network of IoT sensors can centralize maintenance, detect the beginning stages of component failure and dispatch technicians to install replacements to minimize unscheduled downtime.

Enhanced diagnostics
By digitizing equipment and installing IoT sensors in the substation yard, it is not just maintenance that can be centralized. As well as monitoring asset health, operational decisions can be made with more certainty as they are based on real-time data feeds and in-depth analytics. In addition, the IoT-enabled digital utility gains the ability to obtain, analyze, and predict electricity use. This allows it to enhance consumer experiences by ensuring the lights stay on while maintaining the highest levels of efficiency.

Hardware Flexibility
The communications network for digital substations must have sufficient hardware flexibility to accommodate the various types of substation architectures and topologies. Digital substation Ethernet switches should be available in multiple form factors. As well as standard 19-inch rack devices for protection relay panels also the compact DIN rail-mounted switches should be considered for field cabinets or enclosures in the substation yard.

The RUGGEDCOM RST2228
The RUGGEDCOM RST2228 from Siemens is an essential building block of the digital substation. It is rugged rated and can interoperate with almost any intelligent substation equipment on the market.
This 19" rack switch offers high density ports with 10 GBit/s uplinks to handle evergrowing amounts of data. Such equipment is already enabling the digitalization of thousands of substations worldwide. These switches are certified to operate reliability from minus 40°C to plus 85°C. To ease the transition to the digital substation, they include field replaceable media modules. This means that a utility can utilize these units and continue to operate on copper based Ethernet until it is ready to change to fiber optic. At that point, the RUGGEDCOM RST2228 can remain in place, the copper Ethernet media module can be removed and replaced by a fiber optic Ethernet media module. An additional benefit of such communications module replacement in the switch is that fiber optic cabling can operate reliably over far longer distances. As a result, the substation will be able to reduce the number of networking devices required. This greatly lowers the cost of deploying an Ethernet network.

Summary
Power generation sources are increasingly distributed, volatile and intermittent. For utilities to cope with ongoing market transformation, they must rapidly adopt a more intelligent and reliable grid. The answer is the digital substation. These modern substations require the highest rate of system availability and optimal performance even under the toughest environmental conditions. Their networks must be able to comfortably handle large and evergrowing amounts of data.

The RUGGEDCOM RST2228 from Siemens fits all these criteria. It has been designed to streamline the transition from the analog to the digital substation. For more information go to www.siemens.com/rst2228