Invisible Infrastructure: How Utility Telecommunications Networks Underpin the Grid

One of the most important elements of utility infrastructure is not easily seen. Unlike the large transmission towers, power lines, and utility poles dotting our landscape, this facet of the utility system is often hidden from view, embedded throughout the existing steel, wood, and wires delivering electricity to every home and business in the U.S.

Just like the electrons flowing on the transmission and distribution system, this piece of utility infrastructure is almost as important as the rest. Indeed, without the Information and Communications Technology (ICT) systems being deployed by most electric utilities in the U.S., electricity would not flow as efficiently or resiliently as it does now. Storm response and restoration would take longer, and routine maintenance would be more expensive. In addition, the transition to "Utility 2.0" would take longer to occur, if it could occur at all. And these networks are essential to protecting the grid from cyber and physical attack.

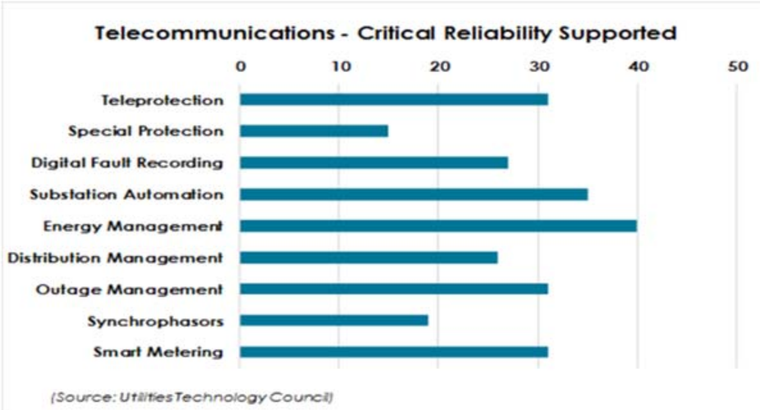
In short, these ICT networks are nearly as important to electric reliability and resiliency as the infrastructure they underpin. This pamphlet provides an overview into utility ICT networks, what they do, and how they work. It also details how communications systems are critical to enabling new technologies and the overall resiliency of utility infrastructure.

Utility Communications--The Beginnings

To understand the need and importance of utility ICT networks, we must look at how these networks started and evolved. We must also understand the unique characteristics of electric grid operations. Starting roughly after World War II, electric utilities began expanding their infrastructure, coinciding with U.S. economic growth. As utility footprints grew to cover larger, rural, and remote areas of the country, utility operators needed communications systems for their workers to safely build out, maintain, and repair electric infrastructure. Because electricity cannot be stored, utilities have to continually ensure that the available supply is equal to the demand for electricity. If that balance is not achieved, power flows will damage equipment and cause power disruptions. The communications networks being developed during this timeframe were critical to this operational control.

Reliability is the central hallmark of the electric utility industry. The reliable, near-constant delivery of electricity powers our nation's economy and wellbeing. To ensure that the infrastructure delivering this electricity stays in working order every hour of every day, utilities need communications systems to do the same. Expanding, maintaining, and repairing electric infrastructure involves working with live electricity. Any disruption of or interference to communications could threaten the safety of utility workers as well as hinder the reliable delivery of electricity to customers. After determining that traditional communications carriers would not supply the needed levels of reliability at a cost acceptable to regulators and customers, utilities began building their own. In each part of the country, utilities built private communications systems—usually "Land-Mobile" radio systems in which employees can communicate wirelessly through handheld or car-mounted devices with themselves and a central dispatch location. These systems allowed employees to stand-up transmission towers and distribution poles, string lines, and repair equipment safely.

Because many pieces of utility infrastructure are located away from the cities and towns they serve, these communications networks rely on both wireless and wireline technologies. At the time, these systems were considered "narrowband," which means generally that the networks carried voice communications along a limited number of channel frequencies. Such frequencies in turn being enabled by radio-spectrum ("spectrum").



What do utilities use their ICT networks for? For roughly 40 utilities, this chart explains

Industrial Data Communications

As communications technologies improved in the 1970s and 1980s, utilities, along with other large industries, began deploying Supervisory Control and Data Acquisition (SCADA) systems across their infrastructure. A SCADA system is a computerized industrial control network connecting large industrial pieces of equipment with centralized control centers to transmit data. Truly, the origin of the "smart grid" can be traced to the first utility SCADA systems. For utilities, SCADA systems transmit real-time information to control centers providing operators with situational awareness about the status of their infrastructure. Initially, these networks were still largely narrowband, limiting the speed and types of information that could be transmitted. Still, for the first time, utility communications systems were able to provide real-time data about their infrastructure, allowing utilities to be more efficient in their repair and maintenance activities.

New Technologies/Utility 2.0

For the most part, SCADA systems transmitted the "I" in "Information Technology." While SCADA provided greater visibility over utility infrastructure, two-way communication with the distribution system was still limited. Advances in broadband technologies and the growth of the Internet not only changed personal communications—think of how far we've come from wireless phones to smart devices—but greatly benefited utility networks as well.

Starting in the late 1990s, many utilities began deploying broadband-based ICT networks in addition to their existing systems. As its name suggests, "broadband" networks enable more types of data to be transmitted in a faster, more responsive way. Utilities have maintained narrowband networks for certain tasks—generally the land-mobile radio systems described earlier—but have used broadband communications to provide a higher level of reliability, resiliency, and efficiency in their electricity delivery.

For example, utilities use ICT networks for the following essential services:

- Real-time monitoring of medium and high-voltage networks
- Protective relays
- Energy management
- Outage management
- Distribution management
- Smart metering
- Substation automation

These networks improve the reliability and resiliency of the grid by supplying real-time situational awareness to control-room operators. Real-time situational awareness gives utilities near-constant information about how their infrastructure is performing. This enables control-room operators and other support personnel to make decisions based on the data they are receiving, thus improving electricity reliability and safety.

Utilities of all shapes and sizes, from the large investor-owned utilities to the often smaller cooperatively and publicly owned utilities, build, own, and operate these kinds of ICT networks across the country.

Utility communications networks are essential to the success of grid modernization, and energy resources such as rooftop solar and battery storage. As a result of their highly reliable communications networks, utilities can also respond to natural and manmade disasters more quickly and safely, as demonstrated multiple times during the 2017 hurricane season. Utilities in Texas shut off and restored service remotely to consumers flooded by Hurricane Harvey, saving time, money, and lives. Utilities have also used drones, which need spectrum to operate, to provide better situational awareness of the state of their infrastructure rather than sending lineworkers into potentially dangerous locations. Clearly, without utility ICT networks, the nation's electricity infrastructure would be less safe, less efficient, less resilient, and less reliable.

How ICT Systems Work--Spectrum

As already stated, utilities deploy both wireline and wireless technologies as part of their ICT networks. The advances in broadband have led utilities, among other industries, to use fiber optic-based wireline networks in addition to traditional copper-based lines. Fiber allows greater speed, greater data, and greater interaction in locations in which wireline technologies can be utilized.

In more rural and remote locations, utilities often must use wireless technologies, usually fixed, microwave, point-to-point services. Any wireless network—whether operated by a utility, a telecommunications provider, government agency or a transportation service—needs ample spectrum to operate. Spectrum generally refers to the multiple bands of naturally occurring airwaves used to send wireless communications between sources and receivers. Spectrum access for commercial purposes is auctioned and regulated by the Federal Communications Commission (FCC), and spectrum for government purposes is managed by the National Telecommunications and Information Administration (NTIA).

Spectrum is allocated in two ways—licensed and unlicensed. Licensed spectrum offers users protections against interference from others who may be operating in particular bands. Because of these protections, acquiring licensed spectrum is costly. Unlicensed spectrum is accessible to any entity seeking to operate wireless communications. Think of your personal wireless systems at home—Wi-Fi, baby monitors, garage door openers, etc. Unlicensed spectrum is less expensive and typically used for smaller communications systems, though it is subject to interference from anyone else operating in the same band. The FCC manages unlicensed spectrum in order to assure that these users do not interfere with licensed spectrum users.

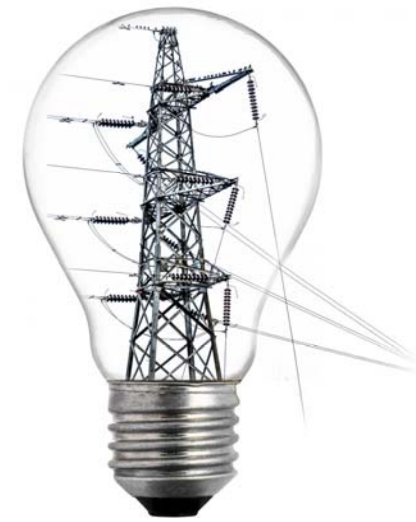

Microwave communications devices

Because utility ICT networks are essential to the reliable, resilient operation of electric grids, utilities cannot tolerate interference on their ICT networks. Interference occurs when users' communications systems in particular bands disturb or "interfere" with each other, disrupting their ability to communicate. The FCC allocates licensed spectrum through auctions, essentially leaving it up to the highest bidder. As the demand for licensed spectrum has increased to accommodate the growth of cellular phones and other wireless devices, the FCC has looked to sell spectrum in bands where licensed users already operate.

Adding more users into particular bands increases the risk of interference. Over the last several years, the FCC has auctioned spectrum off in bands housing utility ICT networks. Rather than face interference in these bands, many utilities have been forced to relocate their ICT systems into other frequencies, a costly and time-consuming endeavor.

Resiliency of Utility ICT Networks

Utility ICT networks are essential to the reliable, resilient, and safe operation of our nation's electric infrastructure. Therefore, utilities build these networks to meet the industry's stringent reliability expectations. Anyone who has used a cellular phone knows how frequently calls get dropped, no matter how strong the signal is. Just as customers would not tolerate this kind of service from their electric utility, utilities cannot tolerate disruption on their ICT networks. These networks are built to work in the most extreme circumstances—during and after natural disasters, for example. In fact, there are multiple examples of traditional telecommunications firms using a utility's ICT network to help bring their own commercial services back online. This underscores the point that telecommunications providers rely on electricity to deliver modern telecommunications services.



These networks must also be secure. Utility ICT networks are considered "private" because they are not provided or serviced by traditional telecommunications carriers. Utilities go to great lengths to ensure these private networks are protected against potential cyberattack by complying with, and often exceeding, federal security requirements.

In fact, the electric utility industry remains the only industry subject to national security and reliability standards. Typically, utilities do not use their private networks for their public-facing services such as their websites, email, and online bill payments. These services are usually supplied by traditional telecommunications providers and are as strong as the security provided by these firms. So in the rare instance that an attack on a utility's Website is successful, the utility's private network in all likelihood would not be impacted as they are separate networks.

Network resiliency is not only critical when it comes to cybersecurity and storm response and restoration, but also for daily reliability as well. Utilities use these networks for distribution management, which keep local distribution grids balanced as more distributed energy resources such as rooftop solar are introduced to the system. Utilities will be relying more on these distributed energy resources, especially as more communities look to develop so-called Smart Cities as well. Without these resilient ICT networks, transitioning to Utility 2.0 will be impossible.

Importance of Utility ICT Networks

Electric utilities are among the largest and most capital-intensive industries in the world. Utility infrastructure stretches all across the U.S., delivering life-sustaining energy and services to each and every home and business. Yet one of the most important pieces of this infrastructure—ICT networks—is practically invisible to the naked eye. These networks underpin the steel towers, poles, and lines that safely and reliably bring electricity to the world.