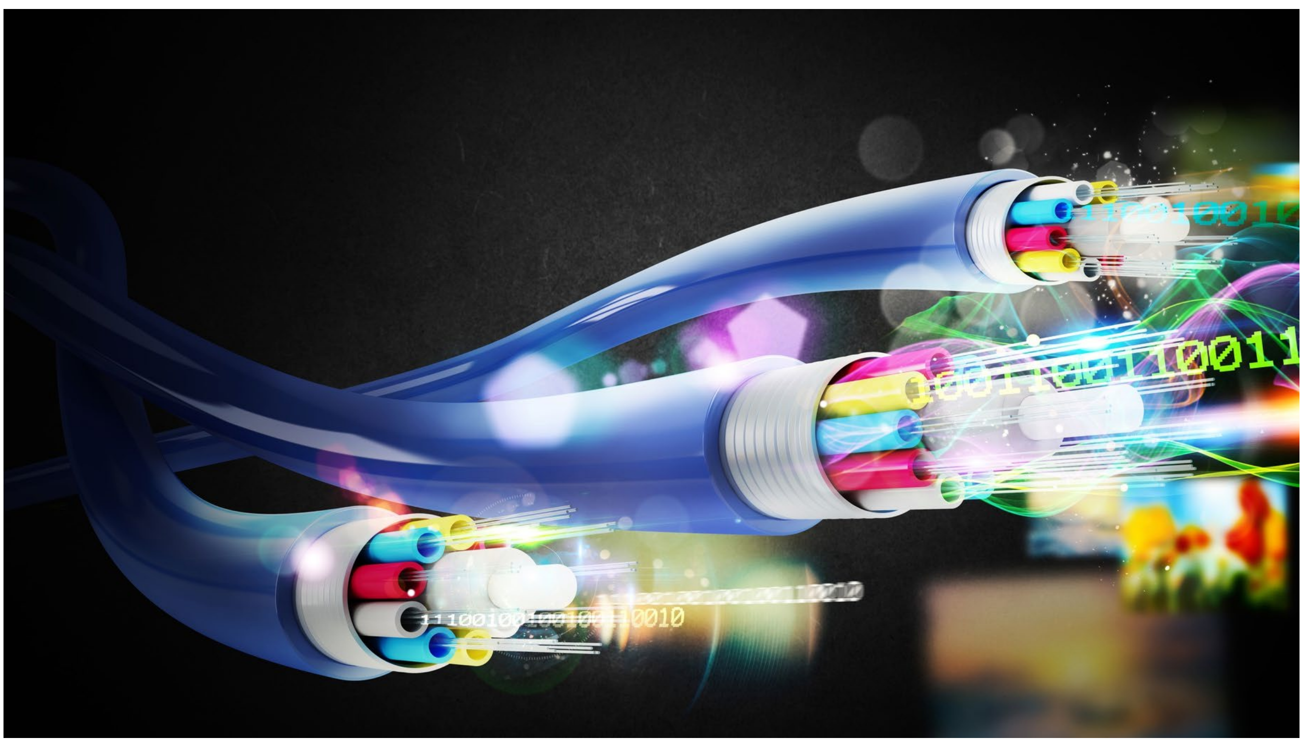
Utilities Technology Council



Utility Network Baseline – April 2019 Update

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Introduction and Context

The Utilities Technology Council (UTC) conducted a Network Baseline Survey of its member electric, gas, and water utilities in 2017 to characterize utilities' telecommunications usage in their critical operations. Following a successful release of that survey's report, UTC conducted a second round of the survey during late 2018 and early 2019, with assistance from the Edison Electric Institute (EEI) and the American Public Power Association (APPA), who shared the survey with their members.

After consolidating responses from the two surveys, the responding utilities in this report represent delivery of electricity to approximately 50% of residential electric meters in the U.S., plus responses from several Canadian utilities. Respondents range from large to small utilities of all ownership types – investor-owned, public power, cooperative and provincial. The following pages present charts and brief analyses of the current snapshot of utilities' telecommunications requirements.

Utilities reported that their telecommunications networks support capabilities that are critical to the reliable supply of electricity, including:

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

Utilities' grid-modernization programs use telecommunications networks and digital technology to improve reliability of supply as intermittent distributed energy generation increases. Telecommunications networks are critical to moving data between remote grid sensors and data-based decision making at utilities' central control centers. Utilities need huge amounts of data from the field in order to make their power delivery more reliable and efficient. Telecommunications networks are essential to getting this critical data to the right place at the right time. Without reliable and sufficient bandwidth telecommunications, grid modernization is impossible.

The survey responses show little differentiation of the telecommunications and technology requirements between large and small utilities. All are interconnected and face similar challenges. One significant difference, however, is that the large utilities have the resources to deploy sophisticated telecommunications networks, while smaller utilities may not. Large utilities easily attract the attention and support of nationwide telecommunications carriers such as AT&T, Verizon, and Sprint, even if those carriers cannot provide optimally reliable service. Smaller utilities, though facing many of the same needs, are sometimes challenged to receive adequate support from those same carriers. Unfortunately, utilities large and small report that telecommunications carriers do not often prioritize recovery of utilities' telecommunications after a natural disaster or other outage.

Many utilities – electric, gas, and water – have chosen to deploy their own private telecommunications networks to ensure the high levels of reliability expected by their customers and regulators. Whereas telecommunications carriers design their networks as profit centers, utilities' private networks are designed primarily for availability, and are treated as a cost of doing business. Utilities will from time to time use carrier-provided services when those services better fit a specific use case, such as remote locations where build-out of a private network cannot be cost-justified. The mix of in-house and outsourced telecommunications networks underpins the digital, machine-to-machine technology that enables modern technologies to improve reliability and gives utilities a big-picture vision of their networks.

The following pages present key findings from the Utility Network Baseline Survey, in the form of charts made from utilities' responses, followed by a short analysis of each chart's data.

Utility Network Baseline

Size of Utilities Surveyed, by Substations

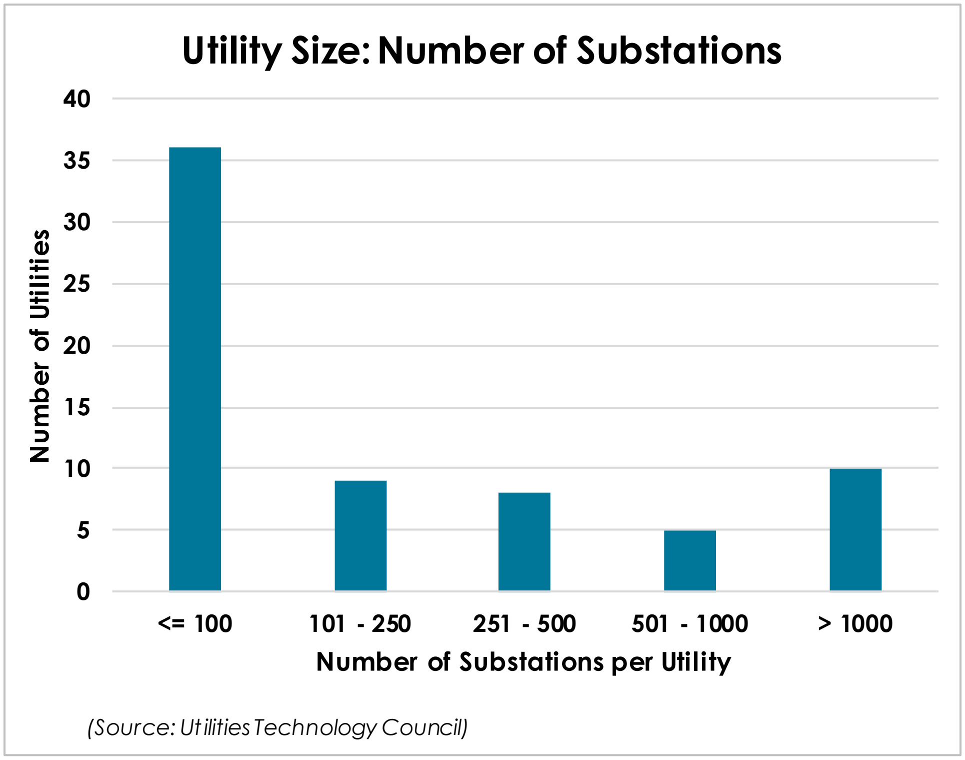

Chart 1 Responding utilities by size, number of substations

Chart 1 shows that UTC received responses from a diverse range of utilities, ranging from smaller utilities with less than 100 substations, up to larger utilities with over 1,000 substations.

The preponderance of small utilities, those with less than 100 substations, accurately reflects the U.S. Energy Information Administration's (EIA) data that nearly 60% of all electric utilities in the U.S are public entities, many of which are smaller cities and towns. The partnership with APPA was critical in hearing their voice in this survey. Meanwhile, all the utilities with over 1,000 substations are "household name" investor-owned utilities.

Throughout this analysis, the number of substations is used frequently as a proxy for size of the utility. Later charts display particular attributes, broken down by size of utility – that is, the number of substations.

Size of Utilities Surveyed, by Service Territory

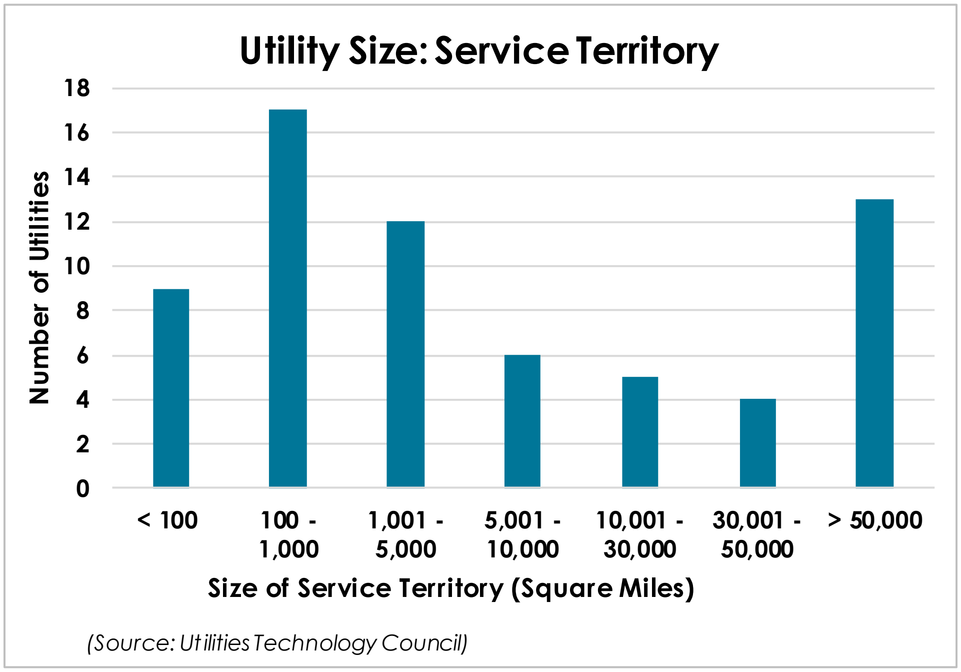

Chart 2 Responding utilities by size, service territory

Utilities also reported their approximate service territory size. This was used as an additional proxy for utility size, although often it was a less effective proxy than the number of substations. Again, the chart shows a wide diversity of responding utilities when measured by size of their service area.

Among the utilities with a service territory exceeding 30,000 square miles, most had more than 1,000 substations, but several had fewer than 500, including two with fewer than 100 substations. All those utilities are generation and transmission utilities, which have relatively few substations, all operating at higher voltages, and no lower-voltage distribution substations serving electricity to end customers.

As expected, utilities with the largest service territories tended to have the largest amount of optical fiber deployed. Large service territories also correlate to greater use of microwave telecommunications, as shown later in Chart 7.

Utility Networks Support Critical Functions

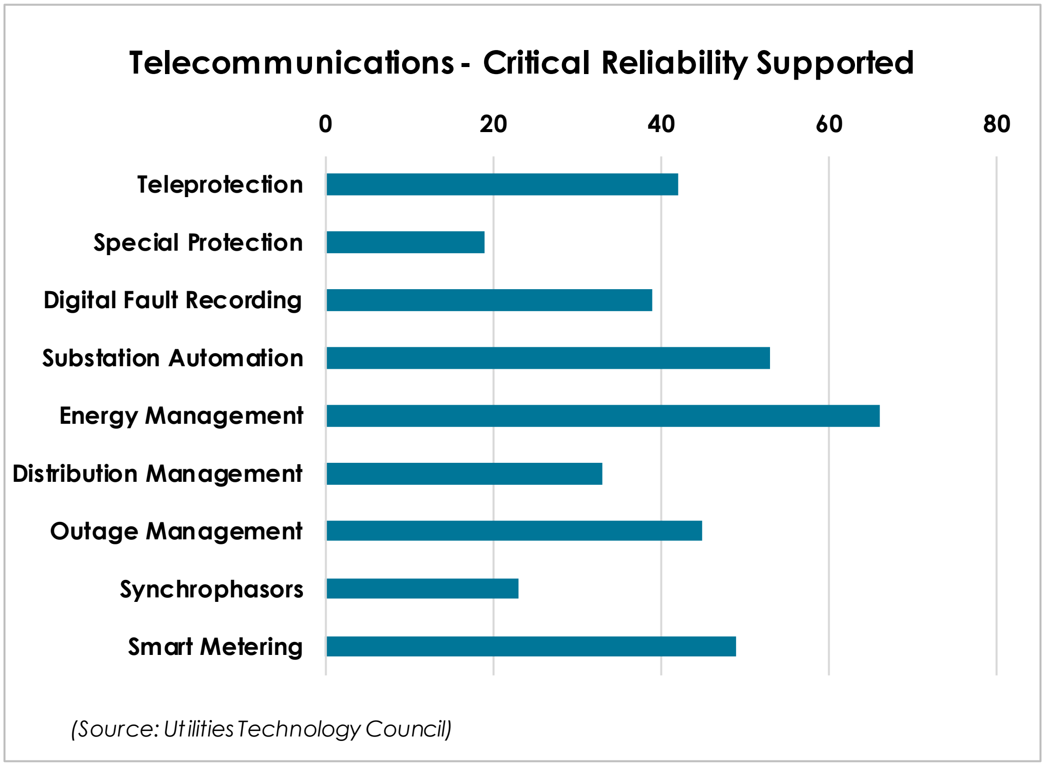

Chart 3 Utility telecommunications support critical energy reliability functions

The survey asked utilities which critical reliability functions are supported by their telecommunications networks. The typical answer was "all of the above." This chart shows some of the key capabilities supported by telecommunications.

These capabilities enable increased reliability of energy supply, decreased or eliminated outages, and improved efficiency – which together translate into more reliable energy, delivered at a lower cost. For example:

- Teleprotection is key to minimizing the impact and duration of network faults.
- Energy Management Systems optimize generation and high-voltage transmission of energy, both of which are capital-intensive operations.
- Distribution Management Systems keep neighborhood distribution grids balanced as more and more residential solar energy and other distributed generation resources are introduced into the grid.
- Smart Metering delivers a multitude of benefits, including reduced expense of recording consumption and the ability to charge consumers lower rates for off-peak energy consumption.

Utility Networks Transport Data That Is Critical to Reliable Energy Supply

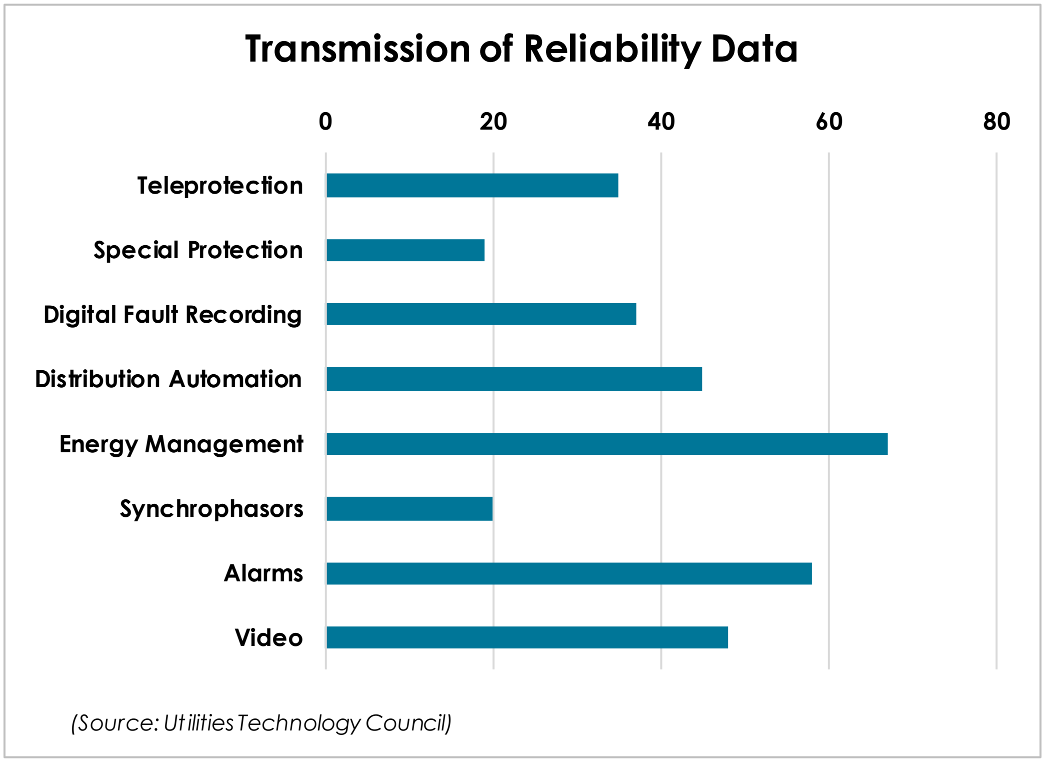

Chart 4 Reliability data transported by utility telecommunications

Much like the critical reliability capabilities described above in Chart 3, utility communications networks must transmit enormous amounts of data needed for decision-making at central control centers. Operational data from the utilities' field networks is combined with enterprise data and external inputs such as weather forecasts or even social media to determine current and near-term energy required by consumers.

The final two rows of the above chart are critical for physical protection of substations and other facilities: streaming video and alarms. These technologies are essential for reliability as utilities begin to place substantial computing and storage capabilities at unmanned substation locations.

Streaming video data rates dwarf those of any other data that utilities are likely to capture. Utilities often restrict video data to wired networks, because wireless networks are unlikely to support the bandwidth required for video data. This may be a challenge for remote substations with only wireless telecommunications connectivity, where spectrum availability and access determine bandwidth.

Utilities Rely on Land Mobile Radios (LMR)

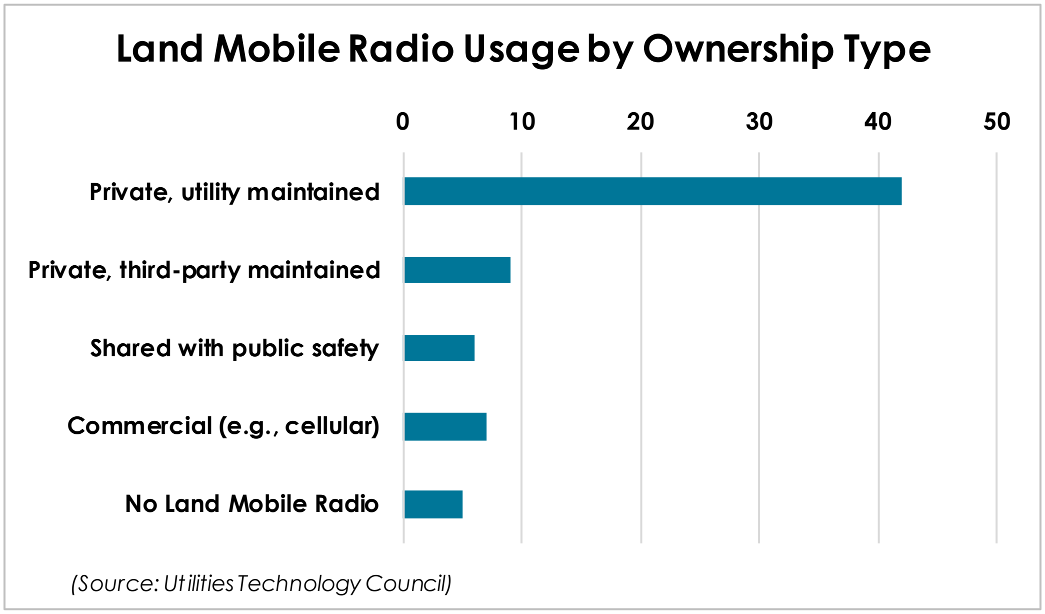

Chart 5 Land Mobile Radio (LMR) usage by utilities

The survey results made clear that utilities rely upon their land mobile radios (LMR). When cellular carrier service becomes unavailable during or after a natural disaster, LMR is still there. Responding utilities that have dealt with hurricane recoveries during 2016-2018 reported consistently that when all else failed, they could still depend on LMR.

This chart points out two key aspects of LMR usage:

- Nearly all responding utilities use private LMR systems. In only a few cases those systems are third-party maintained, but still owned by the utility.
- Only five utilities responded that they have no LMR at all.

Notwithstanding carriers' claims that their cellular services can provide the same level of reliable service as LMR, UTC expects that utilities will continue to use and possibly increase their use of LMR. LMR can provide more reliable communications than carrier services during and after disasters. Additionally, LMR can reach remote areas, where carriers may not provide coverage.

Utility Miles of Fiber Installed

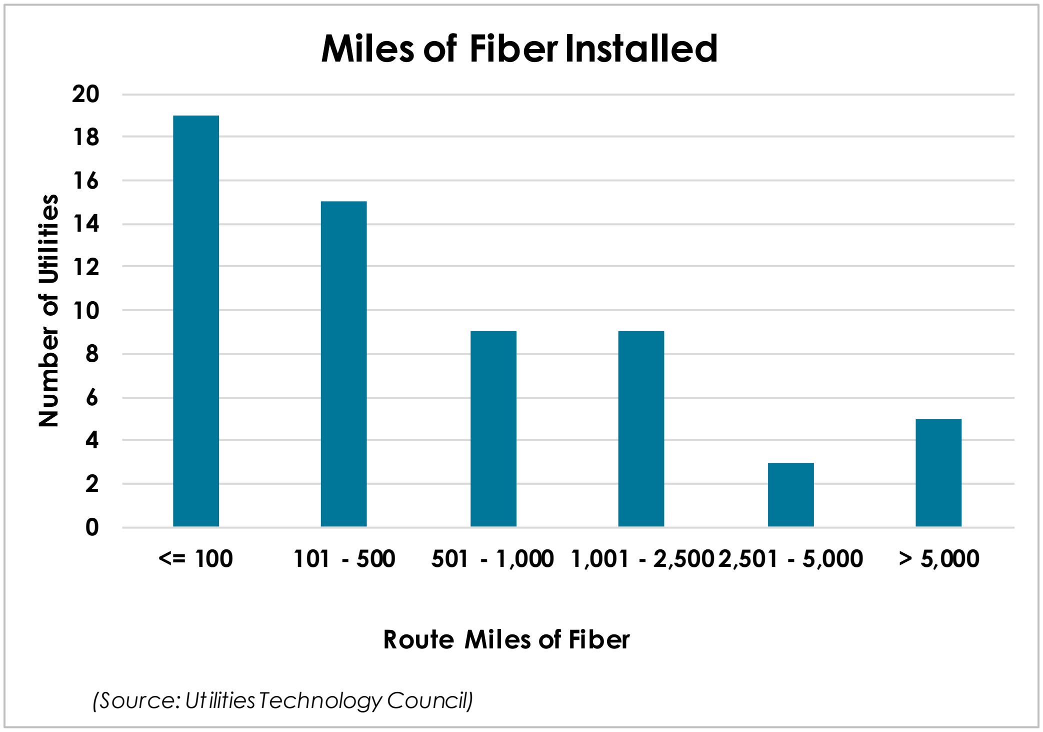

Chart 6 Route-miles of fiber installed

Chart 6 shows again the diversity of utilities that responded to UTC's survey. The utilities reporting less than 100 route-miles of fiber are small public power utilities or cooperatives. Many of the utilities reporting less than 100 route-miles of fiber also reported that fiber was 90% or more of their total network, reinforcing that those utilities have small networks overall.

By contrast, smaller utilities with large service areas are almost forced to use wireless telecommunications because wireless microwave telecommunications are cost-effective and operate effectively over large open areas. However, diverse geographic features such as trees and terrain can render microwave deployments challenging as well.

All the utilities that reported more than 5,000 route-miles of fiber deployment are large investor-owned utilities. A recurring finding from the survey is that large utilities have invested in these often expensive but highly reliable fiber wireline buildouts, while some smaller utilities have not. Large utilities have massive data bandwidth requirements and therefore may need to deploy fiber even to remote substations.

Utility Number of Microwave Paths

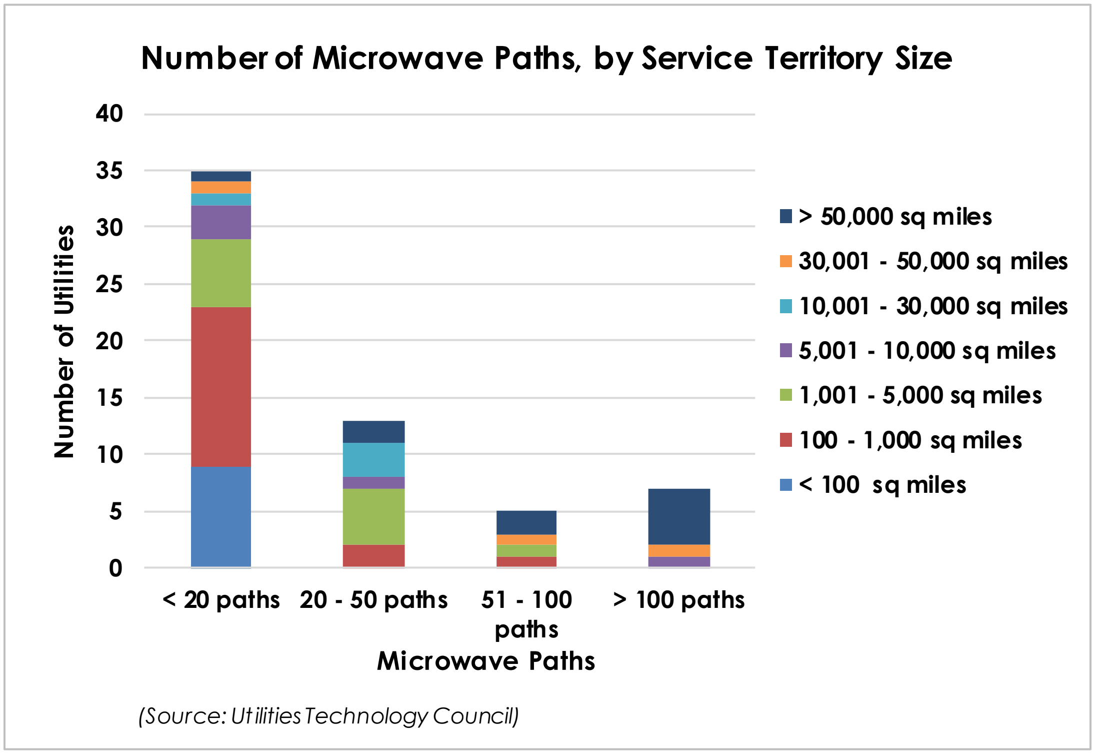

Chart 7 Number of microwave paths deployed, by service territory

Turning to wireless telecommunications, utilities of all sizes use microwave radio transmissions, but as the rightmost bars in Chart 7 show, larger service territories correlate to more microwave paths. This decision is likely driven by the logistics and capital expense of deploying fiber throughout a large service territory.

Utilities reporting 51 or more paths are large investor-owned utilities, and one Canadian Provincial utility. Most likely this is due to the sheer amount of data that they must move and the size of their service territories.

Utilities – large or small – with lower bandwidth requirements may determine that microwave is more financially viable. When bandwidth requirements permit, microwave telecommunications may offer acceptable data transmission with less infrastructure build-out (capital expenditure) and ongoing maintenance (operational expenditure) required.

Utility Bandwidth Needs Are Growing Quickly

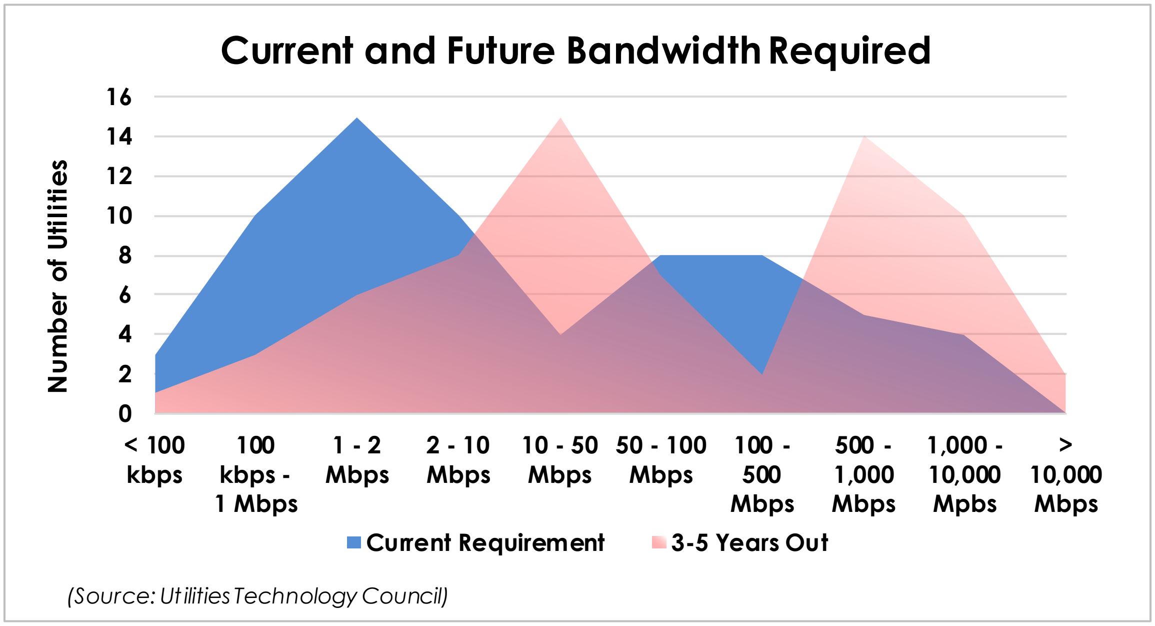

Chart 8 Utilities' current and anticipated bandwidth requirements

Chart 8 shows utilities' current bandwidth requirements and their anticipated requirements in 3-5 years. The solid blue area represents current requirements, while the pastel red overlay represents the anticipated bandwidth needed in 3-5 years.

The right-facing motion from the blue to red chart areas shows a growth in bandwidth requirements over the near-term. Whereas the two current peaks occur at 1-2 megabits per second (Mbps) and 100-500 Mbps, the peaks in the future bandwidth demand occur at 10-50 Mbps and 1,000 – 10,000 Mbps. Both cases represent a tenfold increase in bandwidth requirement over the next 3-5 years.

As mentioned earlier, grid modernization and streaming video drive this medium-term growth in bandwidth consumption. Future bandwidth requirements are based upon current grid modernization projects, typically having a 5-10-year outlook, so bandwidth projections can be considered stable. Thus, a private network with a known capital and operational expenditure may present a stronger financial case than relying upon carrier-provided services. Utilities will also consider exceptional operations such as disaster recovery when debating private versus carrier services. That said, utilities may need telecommunications carrier services for outlier use cases.

Network Composition: Current and Medium Term

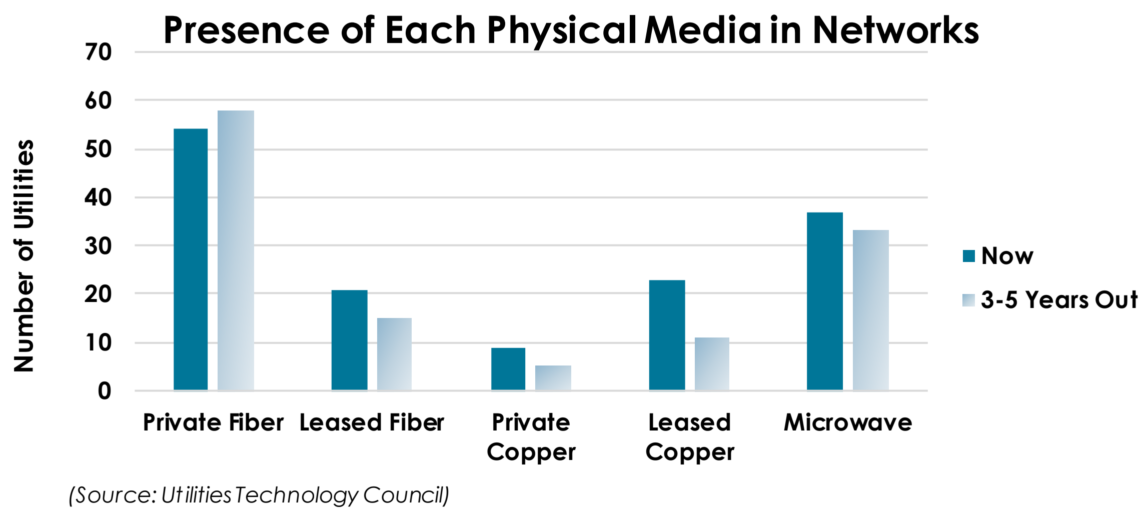

Chart 9 Make-up of utilities' telecommunications networks

This chart combines the different physical media present in utilities' telecommunications now, and those utilities' forecasts of what their networks will look like in 3-5 years. Of note is the move away from leased copper over the medium term, as carriers decommission copper circuits and equipment providers follow suit. Additionally, grid modernization is built upon software that communicates using the Internet Protocol (IP), and which requires bandwidth that fiber and microwave can deliver more efficiently than copper.

Microwave and fiber usage appears stable, although there is a slight move from leased to private fiber. Importantly, utilities will continue to add capacity into their wireline and wireless network as demands increase. Private utility networks are here to stay for the long-term.

Respondents also had the option to select satellite telecommunications, but the responses were negligible. Satellite can serve some niche requirements such as short-term solutions until a permanent link can be built, or reaching extremely remote and geographically isolated locations. However, geostationary satellite orbits are at too high an altitude (22,000 miles) to meet the latency requirements of protective relays, which often require a response in less than eight milliseconds.

Fiber and Microwave Are the Dominant Network Media

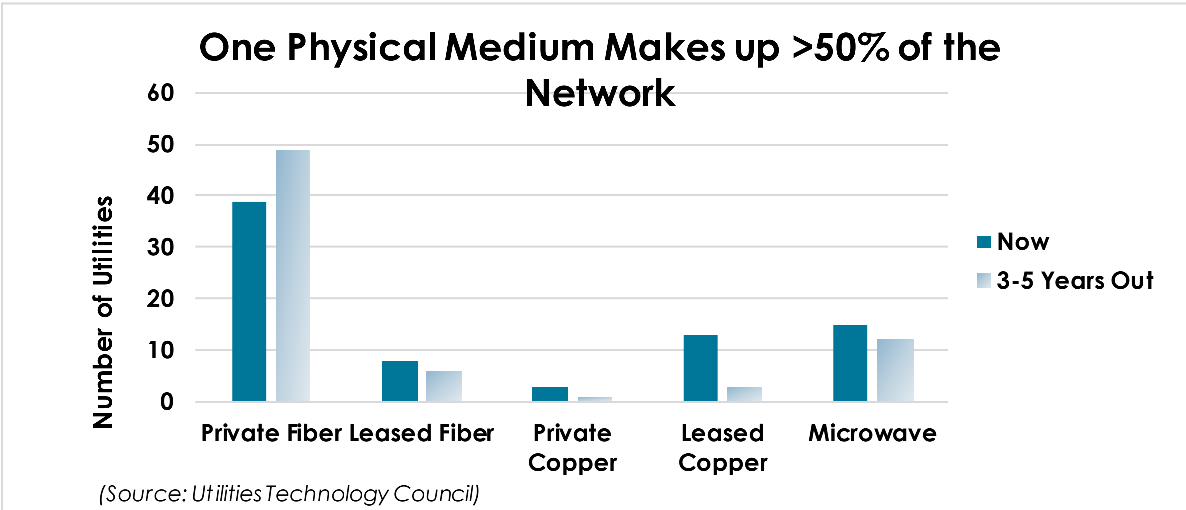

Chart 10 Dominant network media, current and medium term

Chart 10 is a derivative of the chart on the previous page. This chart shows only those utilities where a single physical medium constitutes more than half of their telecommunications capacity. This chart shows more dramatically the move away from copper wire telecommunications, all of it in the direction of private fiber. (Note that the two microwave bars are nearly identical).

This chart suggests a substantial mid-term future capital expenditure for utilities, as they decommission copper wire and replace it with fiber – either Optical Ground Wire (OPGW) or All-Dielectric Self-Supporting (ADSS) cable. Regardless of OPGW or ADSS, UTC members have anecdotally mentioned installation expenses exceeding $100,000 per mile for fiber refits onto existing circuits.

Microwave telecommunications will remain as critical to utilities as they are now. The need for wireless telecommunications with mitigated interference or other operational risk will remain constant, possibly increasing as wireless communications transmit more of the critical reliability data mentioned earlier in this report.

Utilities Mainly Share Networks with Other Utilities

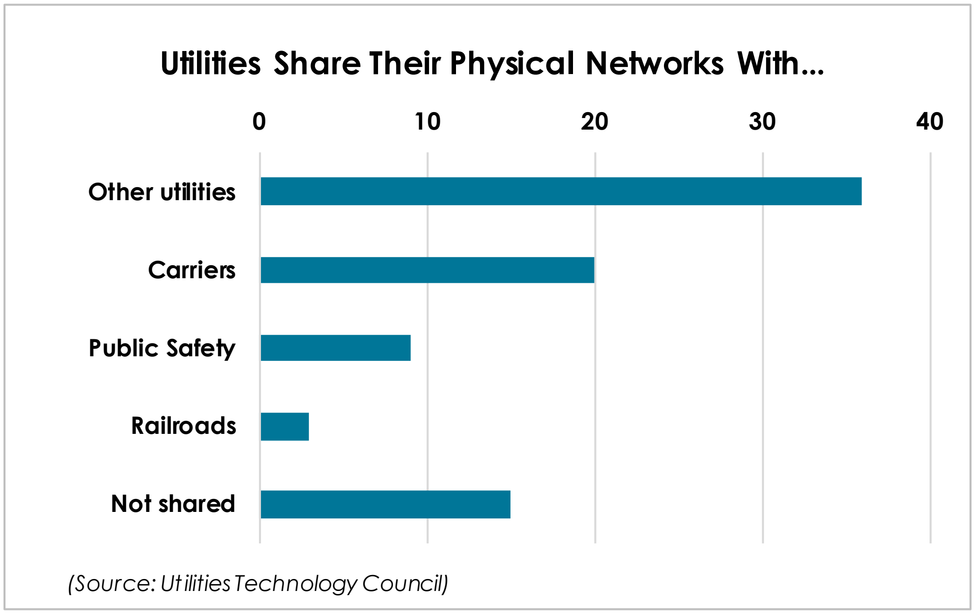

Chart 11 Utilities sharing physical networks

Some utilities have a separate line of business in which they lease unused telecommunications capacity to third parties. This is usually fiber, not wireless telecommunications. As the chart shows, that arrangement is most likely to be made with another utility, although a substantial number of responding utilities also lease unused capacity to carriers.

The overwhelming trend in the responses is that for utilities that do lease unused capacity, they do so to multiple third parties. Most often, a utility that shares its physical network with carriers is also sharing it with other utilities.

Conversely, some utilities steadfastly refuse to lease unused telecommunications capacity. A frequent reason provided is, "That is not our line of business. We are an electricity company."

Licensed vs. Unlicensed Frequency Usage

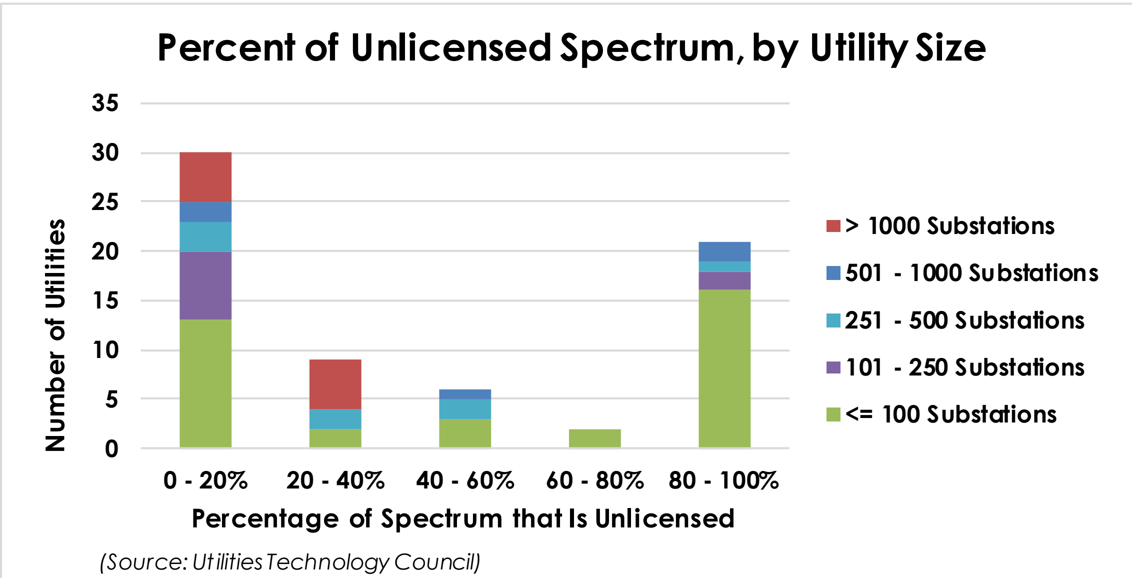

Chart 12 Use of unlicensed spectrum, by utility size

Although unlicensed spectrum is easily accessible to utilities, Chart 12 shows that utilities of all sizes prefer licensed spectrum, even though there is an expense to acquiring this spectrum. Licensed spectrum limits the number of users and offers clearer data transmission over greater distances. Users of unlicensed spectrum, on the other hand, must adhere to Federal Communications Commission (FCC) requirements to not cause harmful interference and to transmit at one watt or less. Additionally:

- More than half of the responding utilities stated that 75% or more of their wireless telecommunications networks use licensed spectrum.
- Nearly one-fourth of the responding utilities said that licensed spectrum accounts for 95% or more of their wireless telecommunications networks.

Life in the unlicensed spectrum can be an adventure. One utility told us, "We've lost our frequency three times in 30 years." Each time this utility was forced by the FCC to move the affected telecommunications to a different frequency range. Different ranges have different propagation characteristics, which may require re-engineering microwave paths, building or acquiring space on additional towers, and acquiring new radios that work in the new spectrum.

Utilities Rarely Outsource Network Ownership

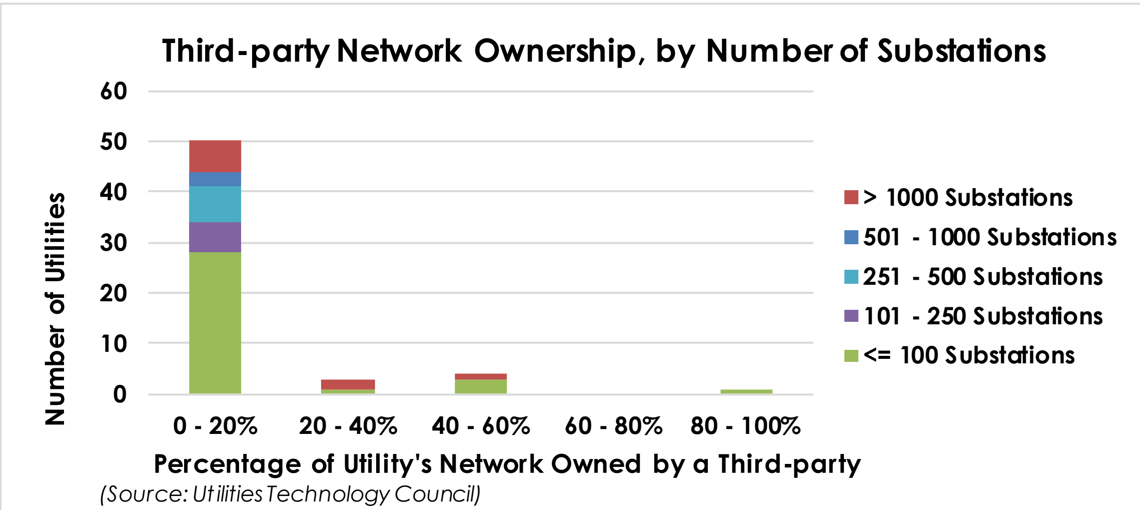

Chart 13 Utility network ownership, by service territory size

This chart shows categorically that utilities do not favor third-party ownership of their telecommunications networks. Interestingly, only the smallest and largest utilities reported any more than 20% of third-party network ownership. Situated at both ends of the spectrum, large and small utilities may be outliers for different reasons and each may have unique reasons for increased third-party ownership.

In the case of large utilities, this may be due to large service areas, as discussed earlier, where some extremely remote sites are best reached with someone else's existing network.

The overriding conclusion from this chart is that utilities prefer to own and operate their own telecommunications networks. Three-fourths of utilities responded that they own 80% or more of their networks; only one small public power utility reported less than 40% ownership of its network.

Utilities Rarely Outsource Network Monitoring

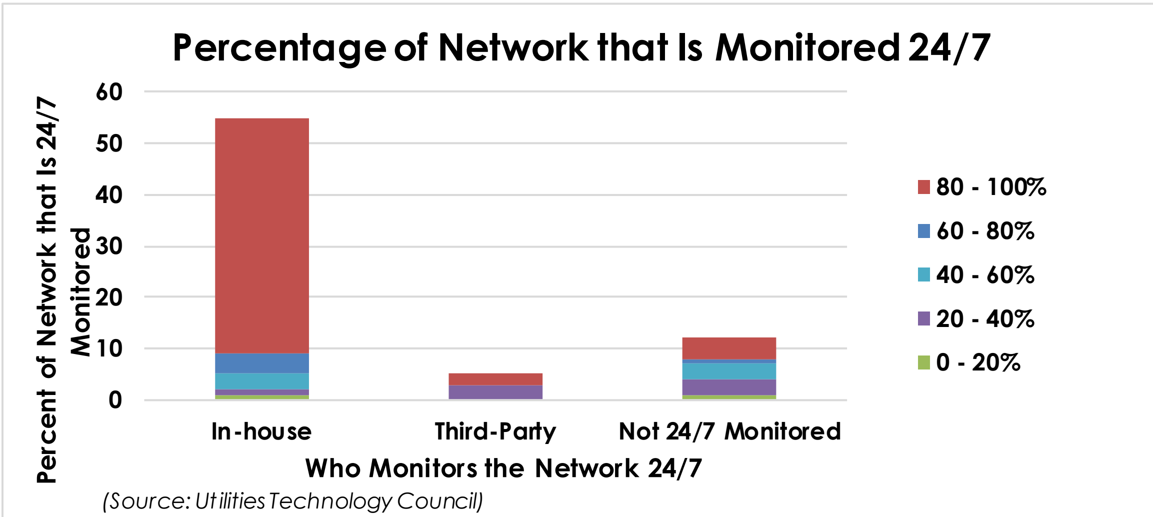

Chart 14 Utility network monitoring

Chart 14 shows that utilities by and large perform their own telecommunications network monitoring. Only two utilities reported that their network is 100% monitored by a third-party.

The vast majority of utilities monitor all of their network in-house. Unlike many other trends in this report, size of utility was a not a factor in whether or not the network is monitored in-house.

Combined with the previous slide's indication that utilities are far more likely to own their own network than to outsource it, the conclusion is that utilities have been able to cost-justify both building and operating their networks in-house. There is additionally a feeling of greater control with in-house ownership and operation – recall the critical energy reliability capabilities supported by these networks.

Carriers Do Not Adequately Prioritize Recovery of Utility Telecoms

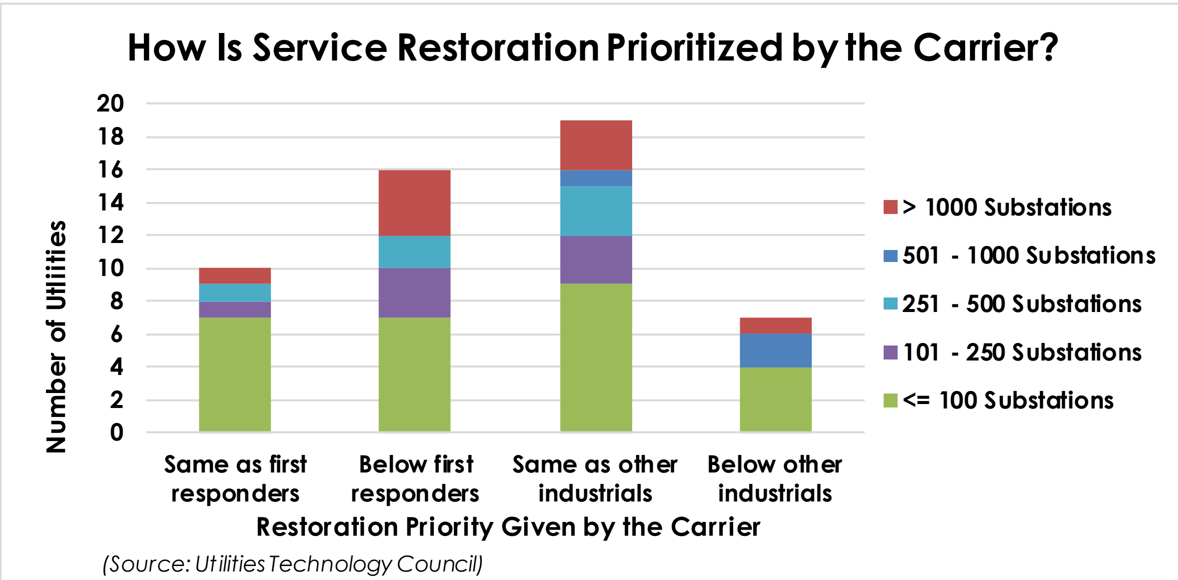

Chart 15 Utility service restoration priority by carriers

Perhaps the most disturbing information from our survey, this chart shows that carriers do not highly prioritize restoration of cellular and other services to utilities. This is ironic given that carriers are highly dependent upon reliable electricity supply for their operations. Especially during recovery from disaster such as hurricanes, energy and telecommunications must operate in a symbiotic relationship. Each needs the other.

This chart shows a contributing factor to utilities' preference to own and operate their own networks, as shown on the previous two pages: carriers' inability or unwillingness to prioritize service restoration for utilities increases the risk that critical telecommunications may be not be available to utilities when most needed.

Lack of reliable telecommunications impedes a utility's ability to perform disaster recovery. Without reliable data it is difficult to understand the condition of the grid and which facilities need attention first. In some cases, lack of visibility into the grid status can lead to increased personnel safety risk.

Lead Time to Enable New Services

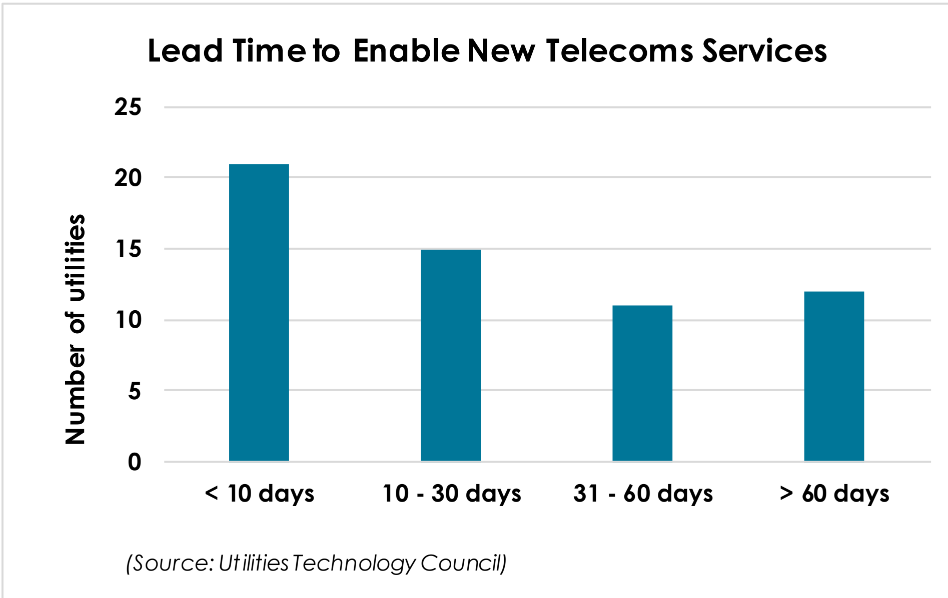

Chart 16 New service lead time, by size of utility

In this chart, the leftmost bar is the place to be: short lead time to enable new services. Curiously, there is little differentiation of lead time by size of utility. Although the survey responses do not provide data to explain this riddle, there are several scenarios to consider:

- Large utilities can have a short lead time because they can afford to outsource service enablement, with short lead times mandated in the service agreements.
- Conversely, large utilities, like nearly all large organizations, are likely to have more sophisticated processes for new service enablement, which can reduce risks but also increase the number of approvals necessary and the elapsed time needed to navigate those more sophisticated processes.
- By comparison, small utilities are on the opposite side of both those scenarios. They may be less able to outsource new services, or to demand the same lead times that large utilities receive. But they may also have less process overhead, with fewer decision gates and approvals needed, which allows them to move more quickly.

Conclusion

The overriding conclusion to draw from the charts is that telecommunications are critical to the reliable delivery of electricity to end consumers. Utilities have engineered telecommunications networks that are large and complex. Those networks are at the core of utilities' day-to-day operations, and disruption of utility networks risks disruption of reliable energy delivery. Telecommunications and electricity are inexorably intertwined.

An equally important conclusion is that utilities do things their own way. Telecoms carriers build their networks to maximize return on investment and therefore their networks are profit centers. By contrast, utilities design and engineer their networks to maximize reliability even in the face of natural disasters, and therefore utilities' networks are cost centers, not profit centers. Both industries take a logical approach to building their networks, based on their differing objectives. Those differences show up when comparing utilities' own networks with those of the telecommunications carriers, especially when analyzing the percentage of networks that utilities own and operate by themselves. Anecdotally, large UTC member utilities often report that they have telecommunications staffs exceeding 300 personnel.

The data assist with adjacent analyses too. For example, the large base of utility-owned and operated telecommunications equipment suggests the challenges of migrating a utility from its current networks to an emerging technology such as 5G. Beyond the complexity of reengineering such a large network, data presented in this report show that migration to a new technology such as 5G could result in a tremendous amount of stranded assets – those assets that would have to be written off while still having remaining book value – which could wreck a utility's Income Statement.

Utilities cannot deliver electricity reliably without reliable communications. As grids become smarter and more data-driven devices appear in the field, communications will continue to become more critical to utilities' day-to-day operations. To protect the reliable delivery of electricity, we must also protect the telecommunications that enable that delivery.

Glossary of Terms

Interference

Interference occurs when reception of communications through a spectrum band is blocked, temporarily disrupted, or the quality of the communication is diminished. There are a variety of reasons for interference, including co- and adjacent-channel interference that can come from other users within the same spectrum band. In addition, different signals sometimes can intermix with each other to cause interference. Finally, some interference can simply overpower the reception of a signal by its proximity and power in relation to the radio receiver (near/far). No matter the cause of the interference, the practical effect is the same in that communications reliability is diminished. In a utility's communications network, diminished communications ability can in turn threaten the safety and security of utility personnel or infrastructure, as well as the safety of the general public.

Land-Mobile Radio System (LMRS)

A push-to-talk wireless communications system usually used in vehicles or in the hands of users such as a two-way radio system or walkie-talkies. These systems allow utility employees to communicate with each other to perform routine maintenance on equipment and restore service after a natural or manmade disaster.

Licensed Spectrum

Licensed spectrum is assigned by the FCC to a particular licensee. Licensed spectrum can be assigned to an applicant by auctioning it to the highest bidder or it can be assigned by the FCC's granting of an application. In any event, having a license provides the licensee with authorization to operate on a frequency or a frequency block over a period of time, typically 10 years for private (non-federal) wireless licenses. The licensee has rights to complain about interference from other licensed and unlicensed operations. Depending on the frequency band, the license also prevents other operations from being coordinated within a given distance from the coordinates of the licensee's operations. Generally, having a license provides greater protection against interference than is extended to unlicensed operations. In addition, licensed systems are permitted to operate at higher power than unlicensed operations, which provides better coverage than unlicensed operations. Ever since Congress gave the FCC auction authority in 1994, the agency has increasingly allocated new spectrum or reallocated existing licensed spectrum for commercial communications services and has assigned licenses through such auctions. Because of the costs of the licensed spectrum and the size of the geographic areas involved, utilities (even very large utilities) have typically been unable to successfully compete against commercial communications service providers in spectrum auctions.

Microwave Communications

Microwave communications are wireless communications delivered in narrow beams from antennae devices pointed directly at each other (point-to-point). Microwave communications can carry large amounts of data, but are limited to line-of-sight communications (i.e.; the antennae must be pointed directly at each other to communicate, as microwave transmissions cannot pass through or around hills or mountains). Utilities use microwave communications for outage management, energy management, teleprotection, smart metering, among other functions.

Radio Frequency Spectrum

Referred often only as "spectrum," radio frequency spectrum refers generally to the multiple bands of naturally occurring airwaves used to send wireless communications between transmitters and receivers. A finite commodity, spectrum is essential for all wireless communications, such as cellular phones, Wi-Fi, radio, over-the-air television, and utility private telecommunications networks. Spectrum access for non-federal use is regulated by the Federal Communications Commission, and spectrum for federal use is managed by the National Telecommunications and Information Administration

Unlicensed Spectrum

Unlicensed spectrum is available in certain designated bands, including the 902-928 MHz band, the 2.4 GHz band and the 5.8 GHz band. FCC rules permit unlicensed operations in licensed spectrum bands on a non-interference basis – which means that unlicensed operations must not cause interference to licensed systems and they must accept interference from licensed systems. Generally, unlicensed spectrum bands provide an easy way for entities to deploy networks and operate with flexibility at lower cost, compared to licensed spectrum, which can entail auctions that are costly and time consuming. The drawback to unlicensed spectrum is that operations are not protected from interference and users must comply with FCC requirements prohibiting them from causing harmful interference to licensed systems. Any entity interested in building or supplying wireless communications can acquire unlicensed spectrum. Unlicensed spectrum can be used for household devices such as baby monitors, garage door openers, Wi-Fi, and for larger entrepreneurial uses as well. Utilities operate communications in both licensed and unlicensed bands, depending on the need and costs involved.