Utilities Technology Council

Utility Network Baseline

November 2017

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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 during September and October 2017 to characterize utilities' telecommunications in their critical operations. After consolidating multiple responses from some utilities, the survey has responses from 41 electric utilities, about 20% of UTC's member utility population. Respondents range from large to small utilities of all ownership types – investor-owned, public power and cooperative. The following pages present charts and brief analyses of the current state of UTC member utilities' telecommunications.

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 networks (distribution and transmission, respectively)
- Protective relays
- Energy management
- Outage management
- Distribution management
- Smart metering
- Substation automation

Utilities' grid modernization uses 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 sites. 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 all of that data to the right place, at the right time. Without reliable 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 all face similar challenges. However, 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.

Many utilities – electric, gas, and water – have chosen to deploy their own internally focused, private telecommunications networks to ensure the high levels of reliability expected by their customers and regulators. Utilities will from time to time use carrier-provided services or lease fiber and copper lines where those better fit a business case. The mix of in-house and outsourced telecommunications networks underpins the digital machine-to-machine technology that enables modern technologies to improve reliability and give utilities a big-picture vision of their networks.

Utility Network Baseline

Size of Utilities Surveyed, by Substations

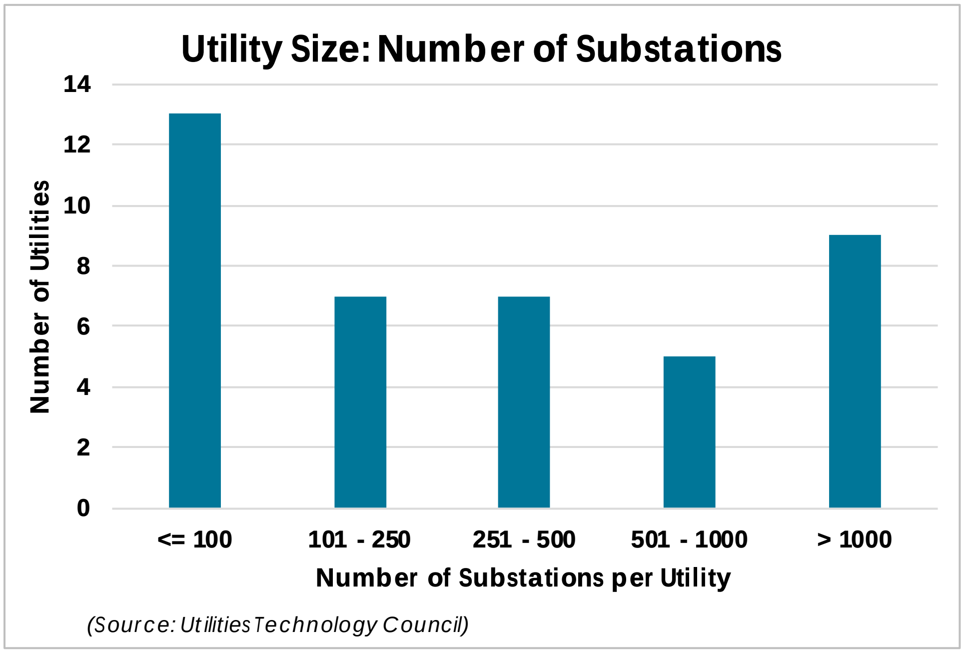

Chart 1 Responding utilities by size, number of substations

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.

As expected, nearly all the "small" substations in the distribution are smaller public power or cooperative utilities.

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

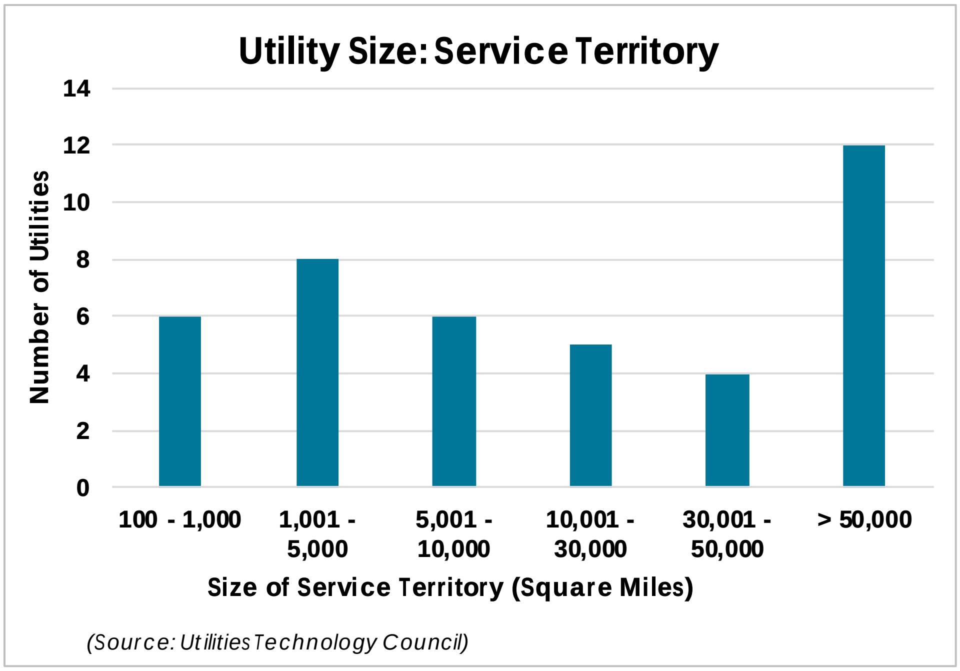

Chart 2 Responding utilities by size, service territory

Utilities also reported their approximate service territory size. This was used as an additional proxy for utility size, although a less effective proxy than number of substations.

Again, the chart shows a wide diversity of 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 a few had less than 500 substations and one utility had less than 100 substations. The last scenario is consistent with a rural utility having a large service area but a low population density.

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 (wireless) telecommunications, as shown later in Chart 7.

Utility Networks Support Critical Functions

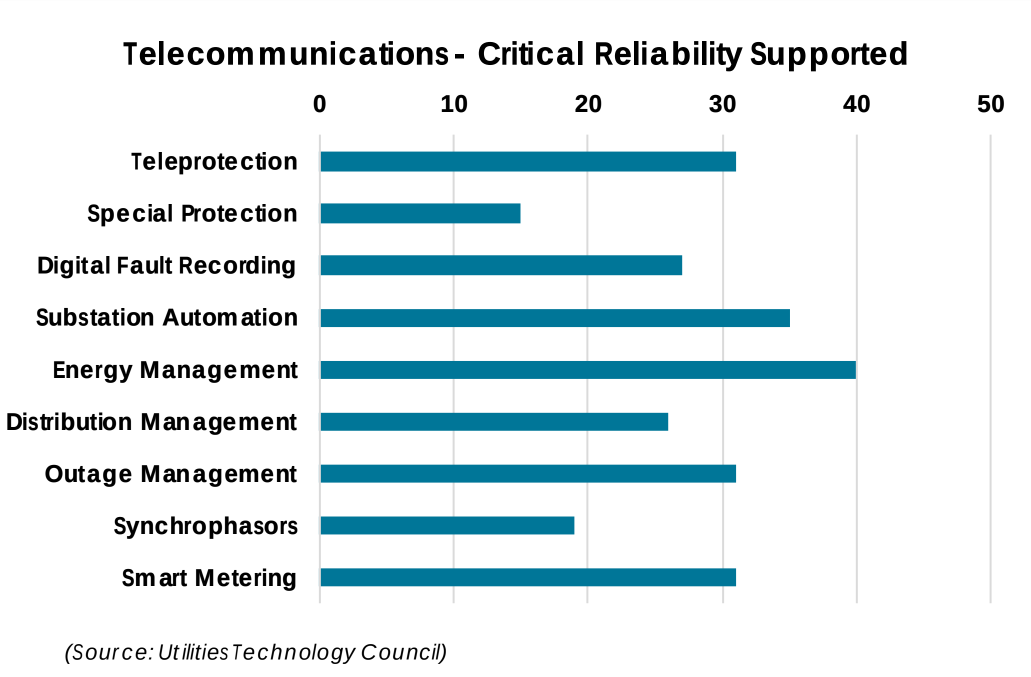

Chart 3 Utility telecommunications support critical energy reliability functions

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 focus on increased reliability, 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 hugely expensive 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

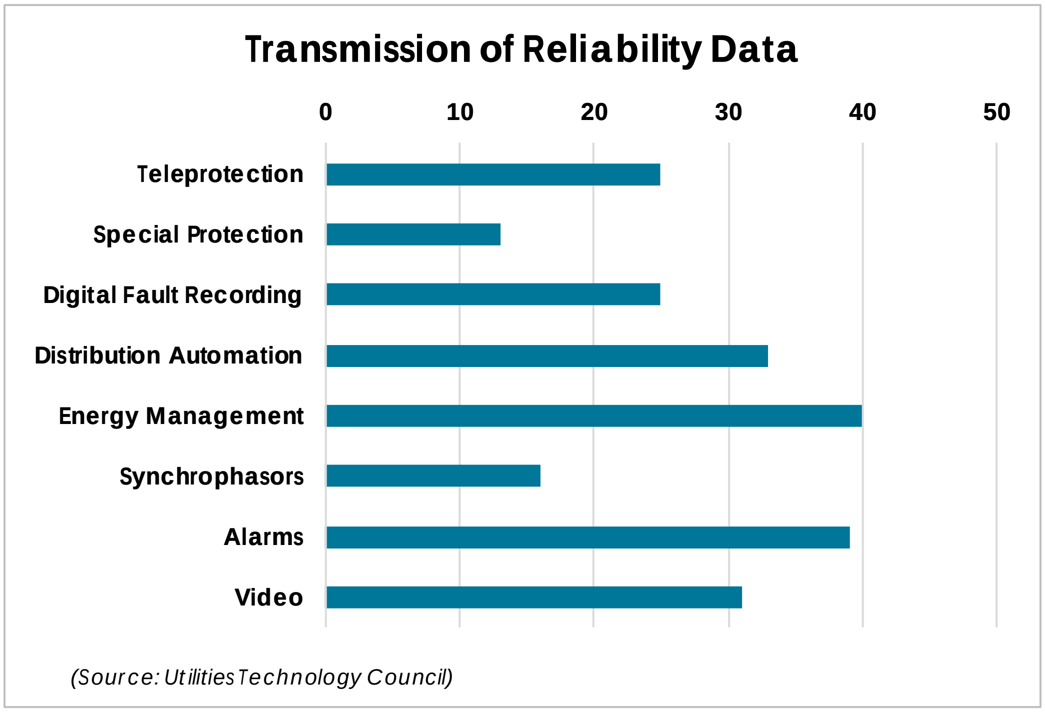

Chart 4 Reliability data transported by utility telecommunications

Much like the critical reliability capabilities described above in Chart 3, networks must transmit enormous amounts of data needed for decision-making at central sites. There, 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 that 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. Existing utility 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)

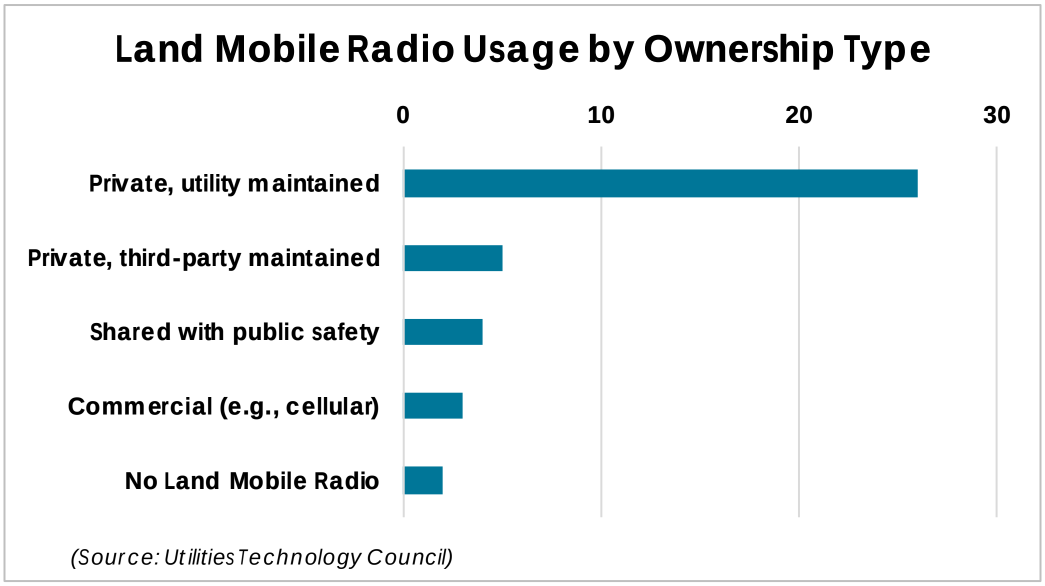

Chart 5 Land Mobile Radio (LMR) usage by utilities

Utilities rely upon their land mobile radios (LMR)--when cellular carrier service becomes unavailable during or after a natural disaster, LMR is still there. UTC member utilities that have dealt with hurricane recoveries during 2016 and 2017 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 a few cases those systems are third-party maintained, but still owned by the utility.
- Only two utilities responded that they have no LMR – both small utilities.

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

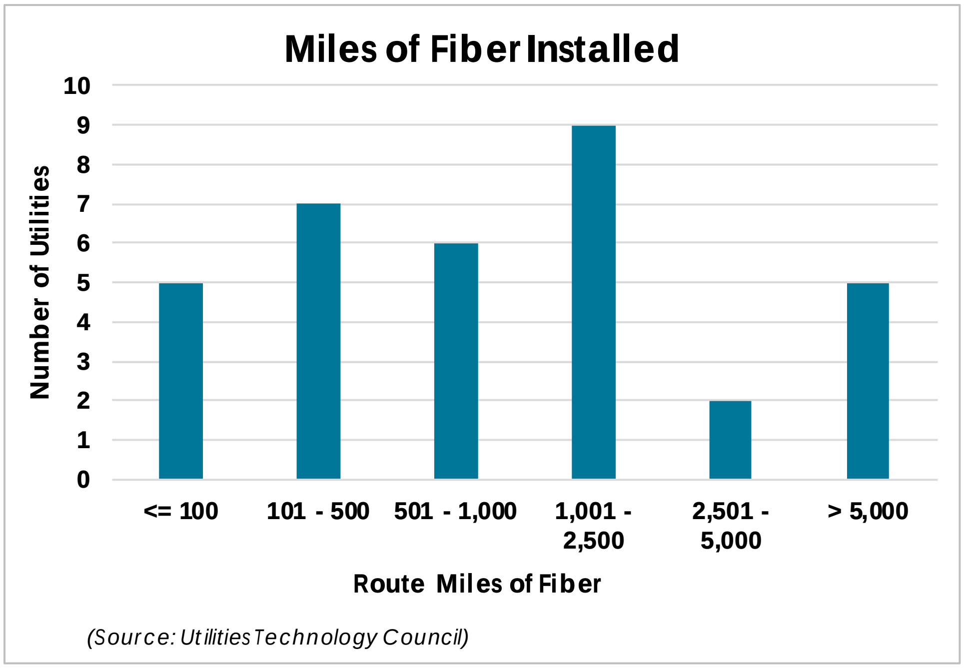

Chart 6 Route-miles of fiber installed

Chart 6 shows again the diversity of utilities that responded to UTC's survey. The utilities reporting less than 100 route-miles of fiber were all rural cooperatives that also reported a large reliance upon microwave telecommunications.

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 large data bandwidth requirements and therefore need to deploy fiber even to remote substations. Several utilities have indicated that they are putting fiber on every new transmission line that they build, given their need for highly reliable telecommunications.

Utility Number of Microwave Paths

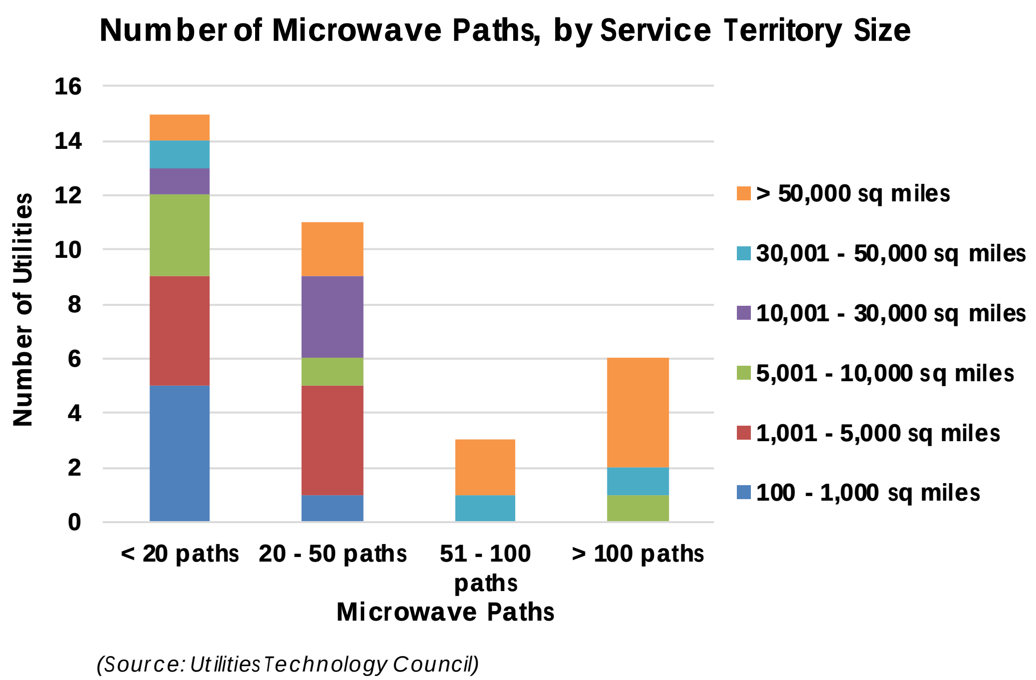

Chart 7 Number of microwave paths deployed, by service territory

Turning to wireless telecommunications, utilities of all sizes use microwave, 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 running fiber throughout a large service territory.

All of the utilities reporting 51 or more paths are large investor-owned utilities. 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

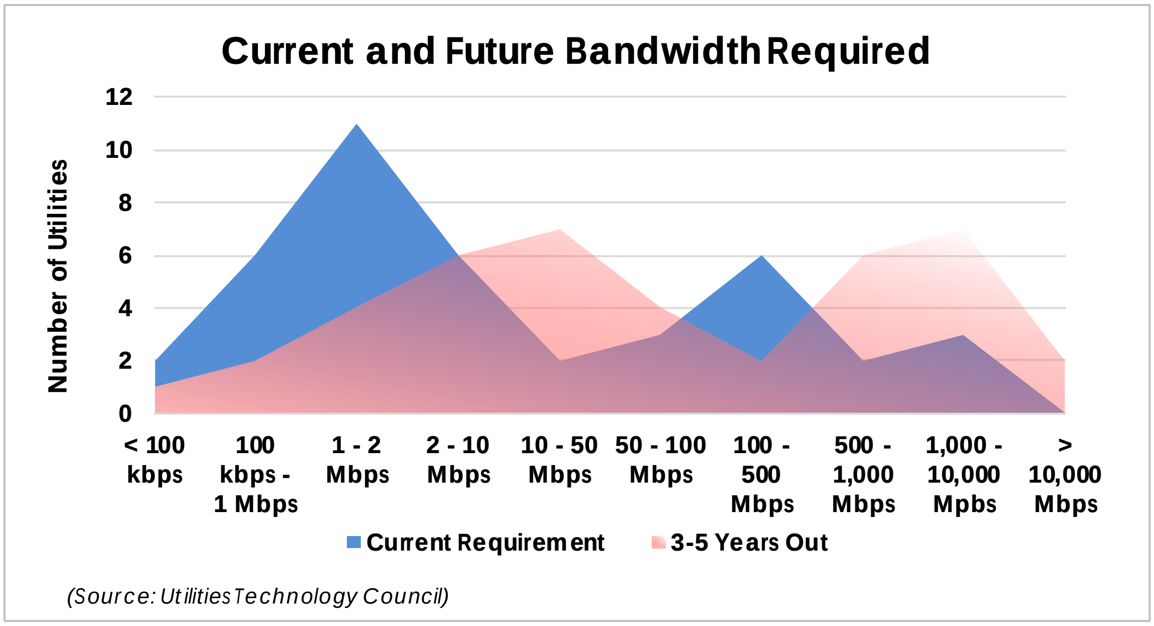

Chart 8 Utilities' current and anticipated bandwidth requirements

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. The bandwidth projections can be considered stable. Thus, a private network with a known capital and operational expenditure may present a stronger financial case than carrier-provided services. Utilities will also consider exceptional operations such as disaster recovery when debating private versus carrier services. Utilities may still need telecommunications carrier services for outlier use cases.

Network Composition: Current and Medium Term

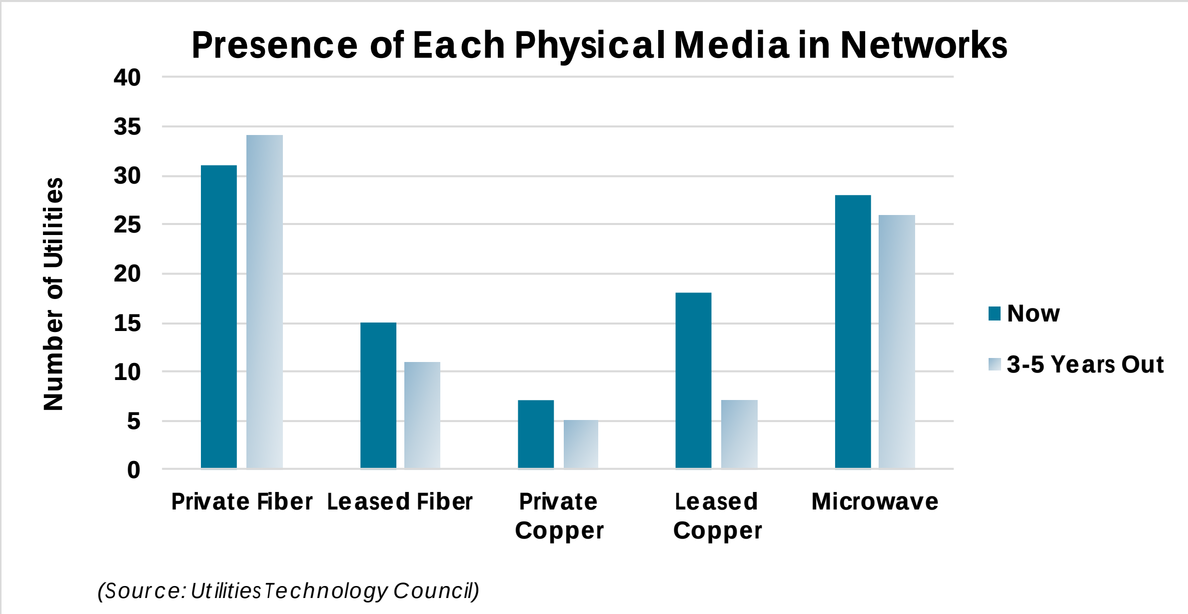

Chart 9 Make-up of utilities' telecommunications networks

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 particular note is the move away from leased copper over the medium term. That migration results from grid modernization, which is built upon software that communicates using the Internet Protocol (IP), and which requires bandwidth that fiber and microwave can deliver more efficiently.

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 satellites are at too high an altitude (22,000 miles) to meet the latency requirements of protective relays, which typically require a response within 4 milliseconds.

Fiber and Microwave Are the Dominant Network Media

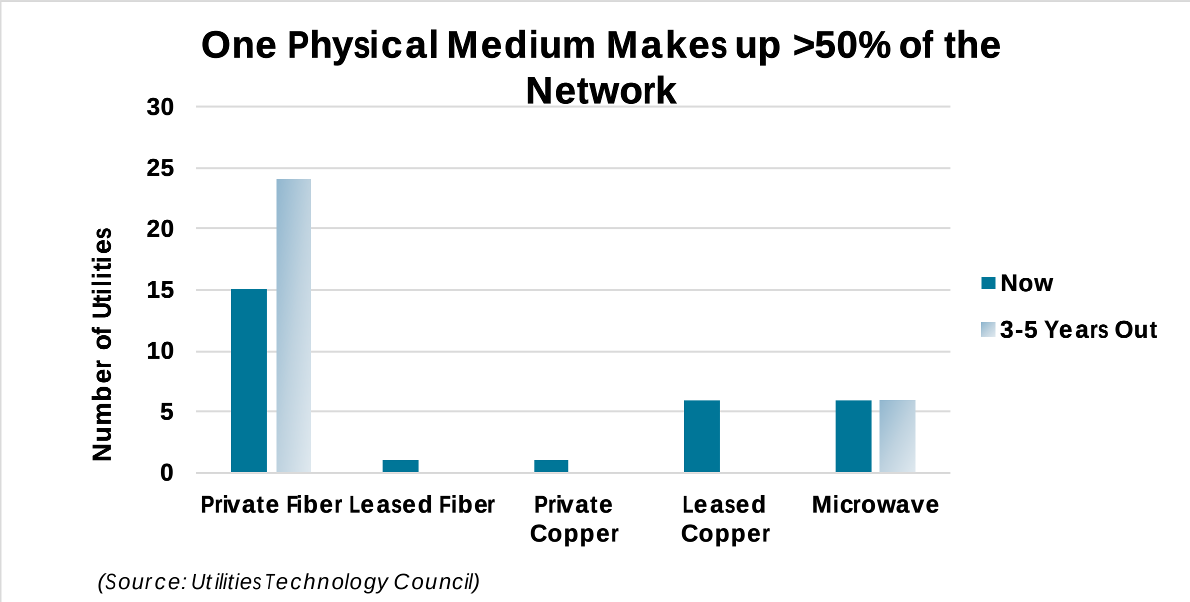

Chart 10 Dominant network media, current and medium term

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 identical).

Implied in this chart is a substantial 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.

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

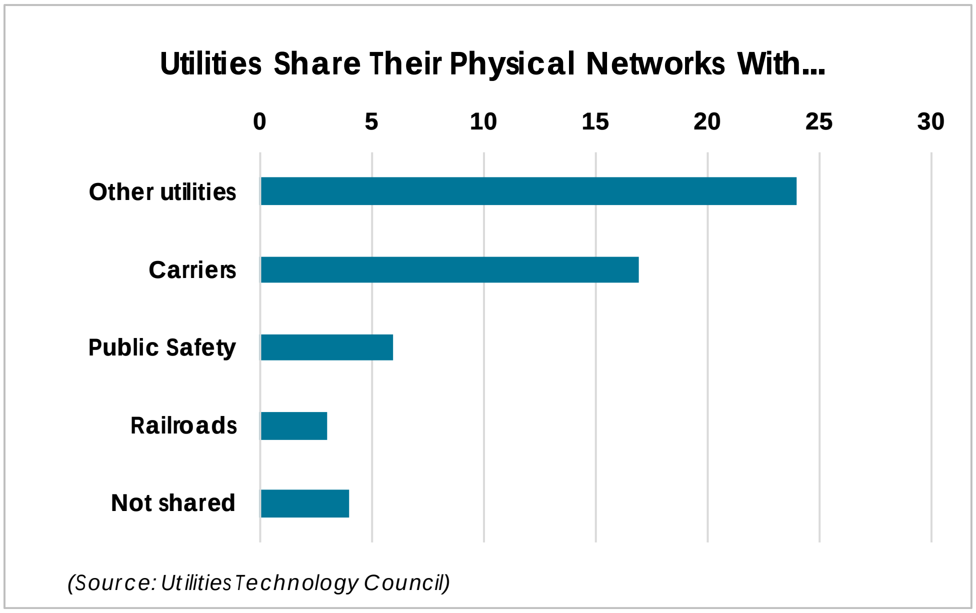

Chart 11 Utilities sharing physical networks

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

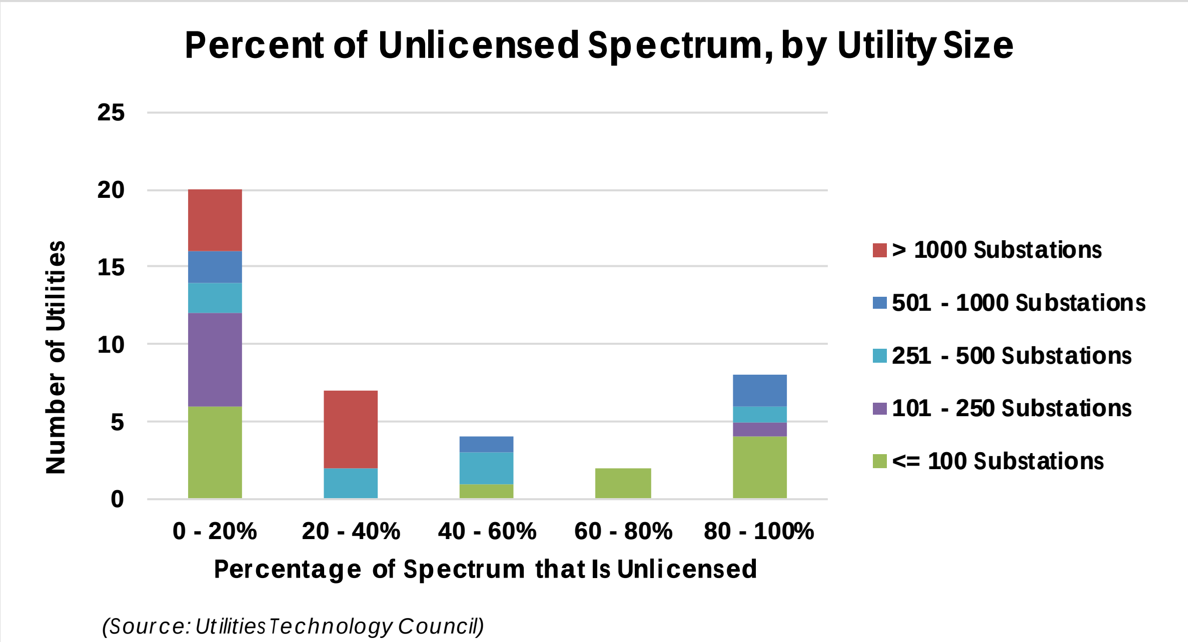

Chart 12 Use of unlicensed spectrum, by utility size

Unlicensed spectrum is freely accessible to utilities, and they must adhere to Federal Communications Commission (FCC) requirements to not cause harmful interference and to transmit at one watt or less. Licensed spectrum is not restricted to low-watt transmission and the FCC actively polices interference. Licensed spectrum, which requires a fee for access, limits the number of users and offers clearer data transmission over greater distances. Chart 12 shows that utilities of all sizes prefer licensed spectrum. Additionally:

- Half of the responding utilities stated that 80% or more of their wireless telecommunications networks use licensed spectrum.
- One-fourth of the utilities said that licensed spectrum accounts for 95% or more of their wireless telecommunications networks.

Life in the unlicensed spectrum can be an adventure. As one UTC member utility responded, “I’ve lost my frequency three times in 30 years.” Each time this utility was forced to move the affected telecommunications to a different frequency range. Different ranges have different propagation characteristics, which in the worst case could require re-engineering microwave paths, building additional towers, and acquiring new radios that work in the new spectrum.

Utilities Rarely Outsource Network Ownership

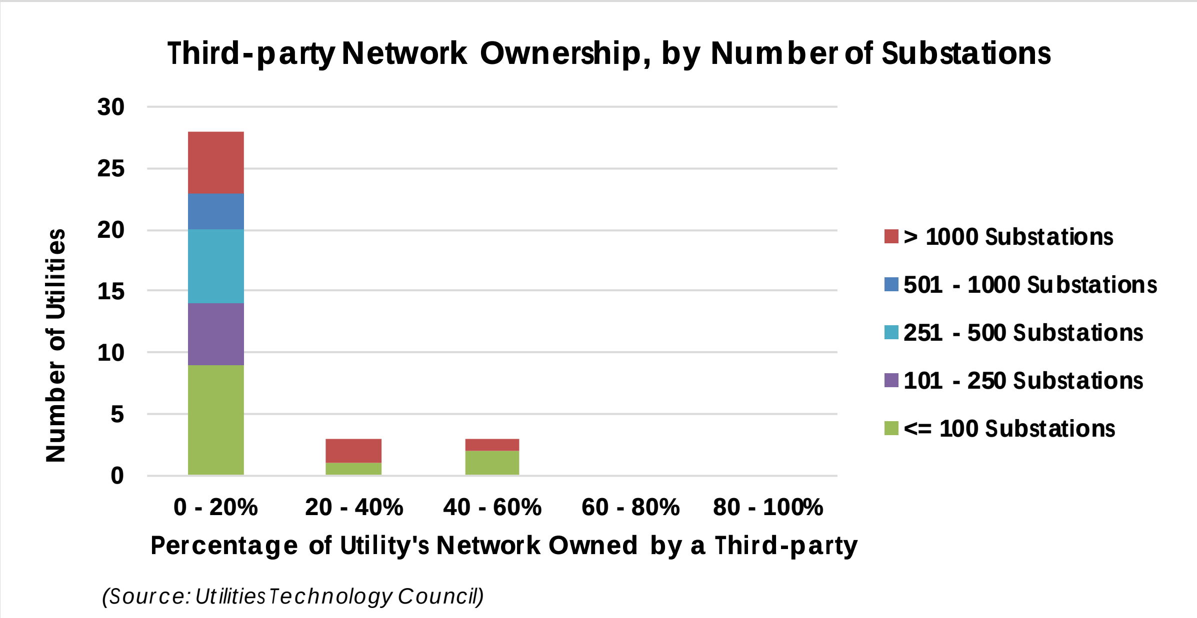

Chart 13 Utility network ownership, by service territory size

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. Two-thirds of the utilities responded that they own 80% or more of their networks; only one utility reported as low as 40% ownership.

Utilities Rarely Outsource Network Monitoring

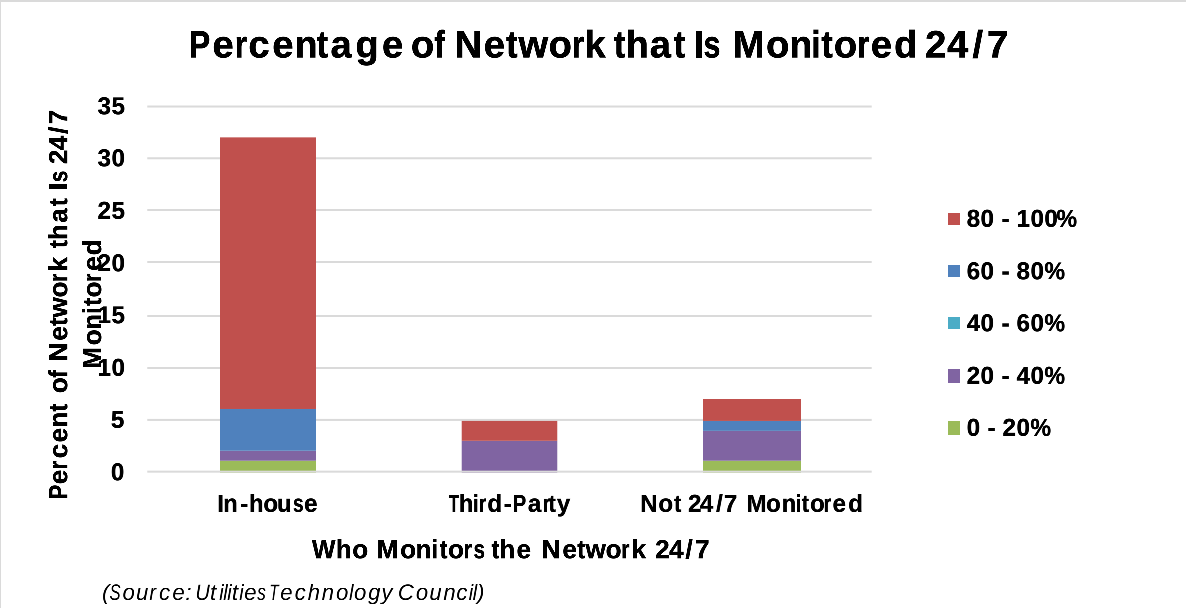

Chart 14 Utility network monitoring

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

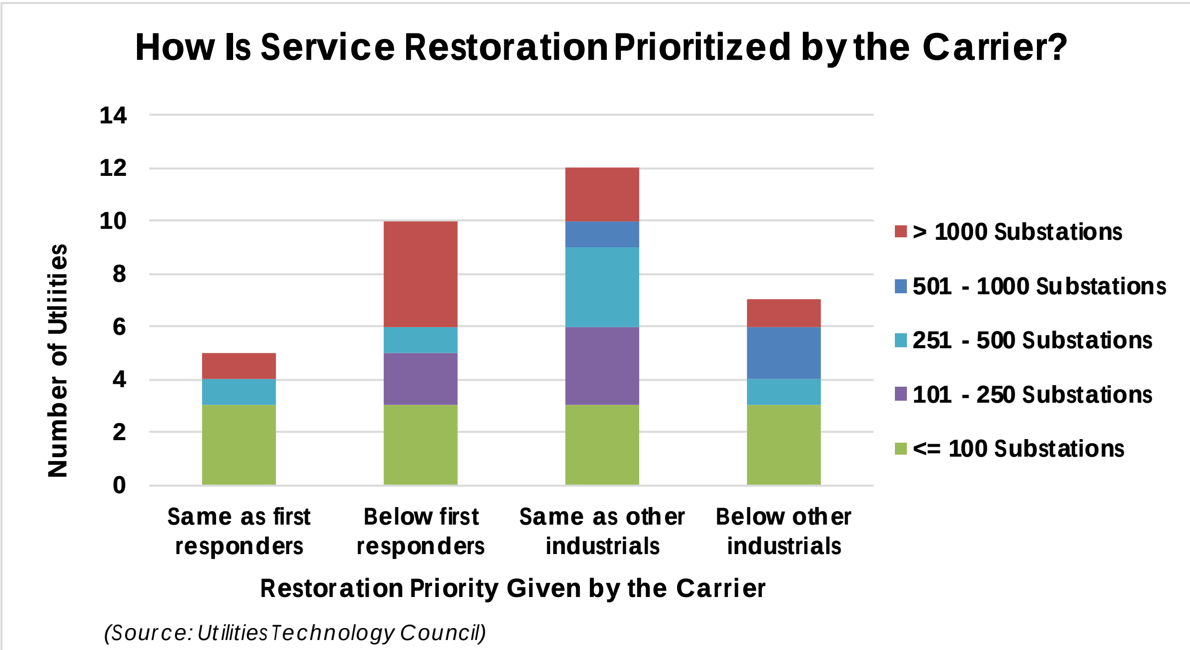

Chart 15 Utility service restoration priority by carriers

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 disaster recoveries such as after 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 to prioritize service restoration increases the risk that critical telecommunications may be not be available when they are 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. Aerial surveillance mitigates a lack of telecommunications to some degree. In some cases, lack of visibility into the grid status can lead to increased personnel safety risk.

Lead Time to Enable New Services

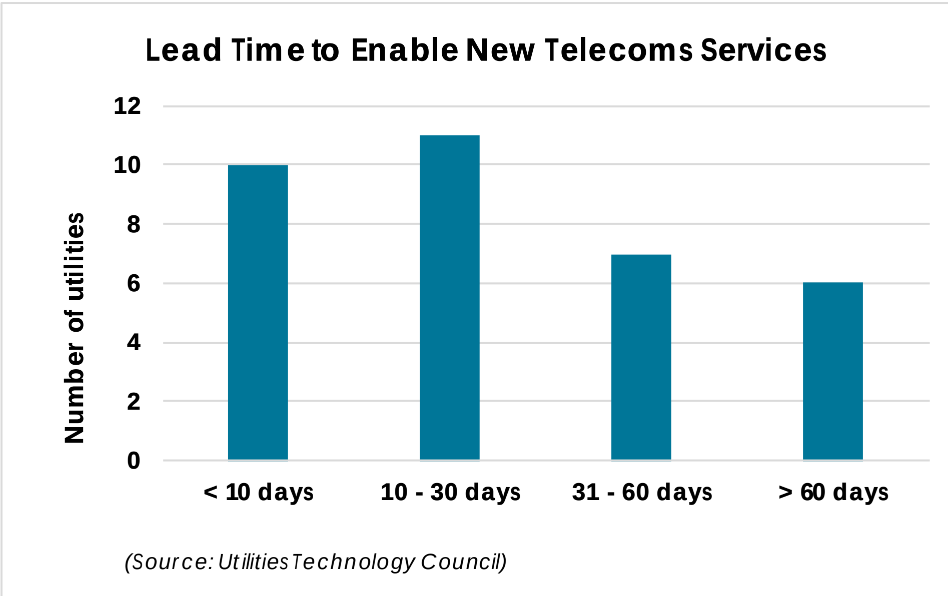

Chart 16 New service lead time, by size of utility

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 received. But they may also have less process overhead, with fewer decision gates and approvals needed, which allows them to move more quickly.