Optical Fiber and the Future Electric Utility

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INTRODUCTION

The modern day electric utility, whether investor-owned, a municipality, or a cooperative, is faced with a challenge. The legacy electric grid is trying to keep up with a rapidly-changing energy market. The linear flow of electrons from generation to the consumer is quickly turning into a more complex and distributed power flow with even the consumer now generating energy (Figure 1). Falling prices of distributed energy resources (DERs), improved energy efficiency by the consumers, and many other factors are also leading to stagnant load growth for many utilities. The consumer's needs are changing, and will continue to change. Regardless of all of the added complexity to the electric grid, the expectation from the consumer is for the "lights" to be on all the time. Electric utilities recognize that they have to embrace these changes and adapt by improving reliability and lowering their cost of producing, transporting, and operating their electric networks. In order to achieve this reliability and efficiency, electric utilities need a two-way communication flow that matches the two-way flow of electricity.

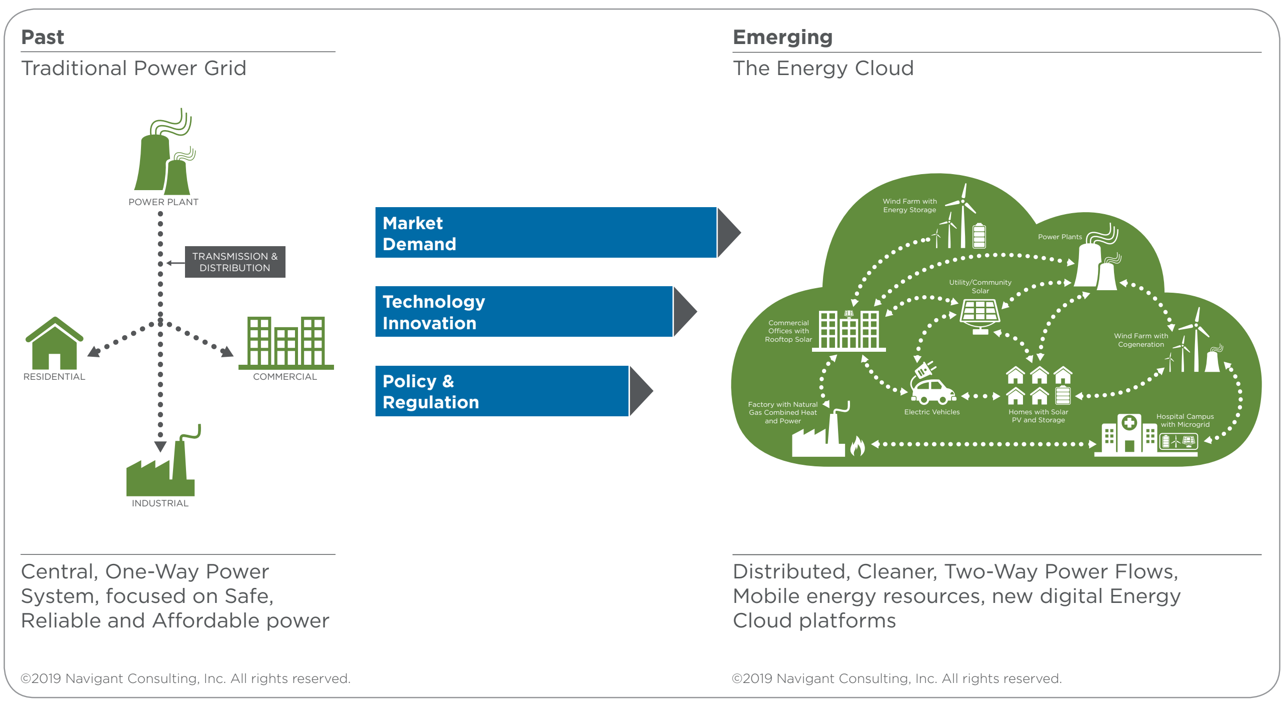

Figure 1—Traditional power flow compared to the current and future distribution of power. *(Image courtesy of Navigant Consulting)*

A robust communications network truly is the enabling technology for the smarter grid. These grid modernization efforts are driving the need for higher bandwidth, faster speeds, lower latency (lag time), more reliability, and more security that is unsurpassed in optical fiber communication. Many electric utilities are responding to these communication requirements of the future by pushing fiber deeper into their networks, closer to devices and equipment with which they need to communicate. Electric utilities of all sizes, and in all geographic regions, should be considering fiber deeper in their networks as they look to the future.

THE EVOLUTION OF FIBER IN ELECTRIC UTILITIES

Electric utility communications have come a long way since early supervisory control and data acquisition (SCADA) systems started providing communication over 60 years ago. Early SCADA networks were primarily copper circuits leased from telephone companies. Optical fiber became a viable means of communications around 40 years ago, and its use and deployment has been increasing ever since.

Optical fiber communication cables have been specifically designed for utility transmission and distribution rights-of-way. Some primary examples include optical ground wire (OPGW) and all-dielectric self-supporting (ADSS) fiber optic cables, which were both introduced over 30 years ago. OPGW is a dual purpose cable that provides a communications path while also acting as a traditional shield wire on overhead transmission lines. Electric utilities have been using fibers in OPGW cables for internal operations as well as leasing fibers for third-party use. ADSS cable is used by electric utilities in high voltage transmission as well as distribution applications. ADSS does not contain any metallic components, which is advantageous to utilities for flexible attachment location in transmission and distribution environments. Aerial deployment of fiber for electric utilities also includes strand and lash fiber cables in their distribution lines. Underground fiber cables can be installed either in conduit or directly buried. Installation costs tend to be higher for underground installation, which is one reason that electric utilities often take advantage of their existing aerial rights-of-way for fiber deployment.

More recently, electric utilities have been increasingly deploying communications networks for distribution applications. Many electric utilities have been using fiber for a number of years to connect substations and major electric utility offices within their distribution networks. These wired fiber connections provide reliability and security to critical infrastructure, and a backbone for wireless communications. Advanced metering infrastructure (AMI) is one example of a headlining technology for smart grid applications in the last decade. This enhancement for meter reading has provided significant operations and maintenance savings for electric utilities. Distribution automation is also being utilized today by monitoring and controlling devices in reclosers, switches, and capacitor banks to improve the efficiency and reliability of the grid. AMI and distribution automation are just two examples of many current smart grid applications with which increased data requirement has led many electric utilities to build or expand a fiber backhaul.

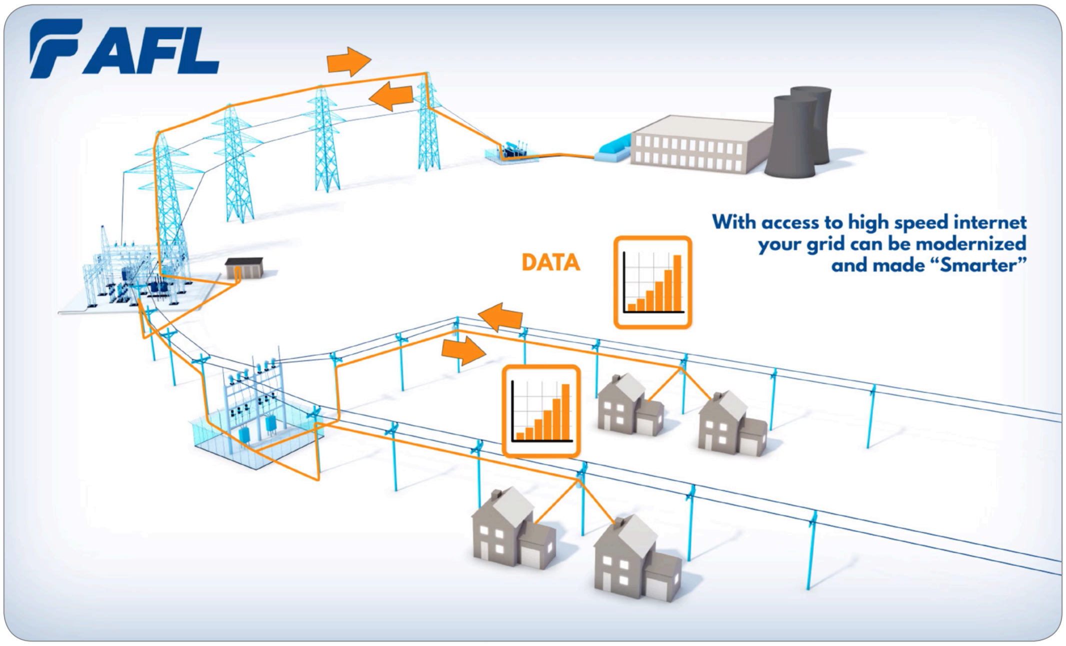

Figure 2 — This simplified grid overview — from generation to the end user — shows that the same path used for electricity can be used for communications that provides the two-way flow of data to run the grid "smarter".

Rural electric cooperatives are looking to fiber to provide broadband access for their members that are underserved by traditional providers because low population densities lead to slower payback for the larger broadband service providers. However, electric utilities are in a unique position to provide broadband in a cost-effective manner and many are taking fiber all the way to the meter. Broadband access is rapidly becoming a necessity for economic development, healthcare, education, and overall quality of life. Providing broadband to their members offers added benefits to the electric utility in an alternative revenue source and internal uses of fiber for current and future grid modernization. Many investor-owned utilities are starting to consider providing broadband as well.

FUTURE FIBER USES IN ELECTRIC UTILITIES

Although the exact applications of the future smart grid will continue to change and innovate, the trajectory is pointing toward a lot of data. Real-time data acquisition of more components will become necessary for monitoring and automation of grid applications. As the volume of data and need of reliability is increasing, the need for more wired fiber connections follows. In just the next 3 to 5 years, electric utilities are seeing a step change in bandwidth requirements from what is needed today (Figure 3). Looking even further to the future, some estimates of a fully implemented smart grid show 10,000 to 100,000 times the data of today's grid (Communications – The Smart Grid's Enabling Technology).

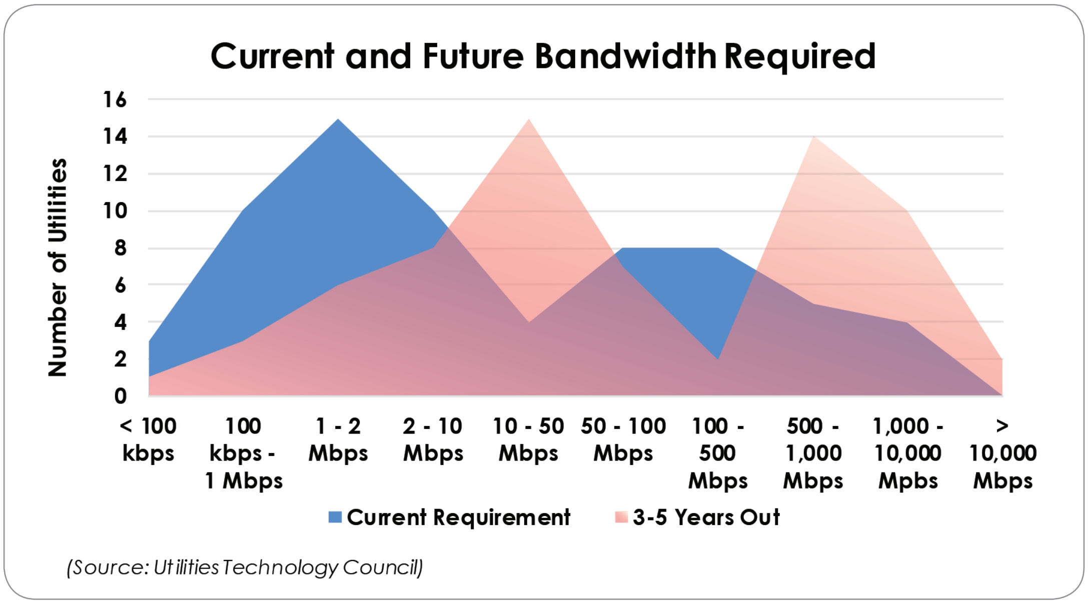

Figure 3—This graphic shows the increased bandwidth need from a utility survey for just the next 3 to 5 years. These needs will continue to increase over time. *(Data from UTC's "Utility Network Baseline — March 2019" report)*

The increase of video applications is one category that shows the need for high bandwidth and low latency networks. Security through video surveillance of substations, power plants, general monitoring of assets, among other areas is growing, with opportunities also for asset monitoring with thermal imaging. Electric utilities are aware that the savings potential of monitoring major assets, such as transformers within substations, to prevent failures can be significant, as just one example. The bandwidth requirement for video applications is significant, and most often wireless is not even considered. Fiber is the primary solution for video applications. Unmanned aerial vehicles, or drones, are another remote monitoring application that is gaining traction. These types of remote monitoring technologies will continue to improve and provide more opportunities for use in the electric utility.

The implementation of DERs (solar panels, electronic vehicle charging, geothermal, biomass, and many others), microgrids, and smart cities will require more robust communications networks for electric utilities. For DERs and microgrids, accurate and real-time data monitoring will be necessary to effectively implement these components into the grid. These technologies are penetrating the edge of the grid, and electric utilities need to further integrate and optimize these resources to operate the grid at a higher efficiency and reliability.

When discussing the future of IoT and smart cities, 5G wireless and small cells are often mentioned; but behind these technologies is a fiber backhaul. Higher bandwidth wireless technologies have a shorter operating distance, so they need to be closer to where they are collecting data and likely require a fiber backhaul. As grid modernization continues, the fiber connection will need to be deeper in the network to support wireless. The race to 5G will continue over the coming years, and utility rights-of-way could be well positioned to lease dark fibers to national carriers.

BEST PRACTICES FOR BUILDING FIBER NETWORK FOR ELECTRIC UTILITIES

Electric utilities have the infrastructure already in place to install fiber in their network more easily than many realize. AFL's FOLLOW THE POWER™ approach simplifies fiber installation to a network that electric utilities know very well, which is their own power network. The electric utility power network from generation all the way to the consumer is very similar to a fiber network that can go as far as that same consumer. This approach for fiber installation is not just for fiber-to-the-home networks that provide broadband to consumers either, it can be followed as deep into the network as needed for the specific application of the electric utility.

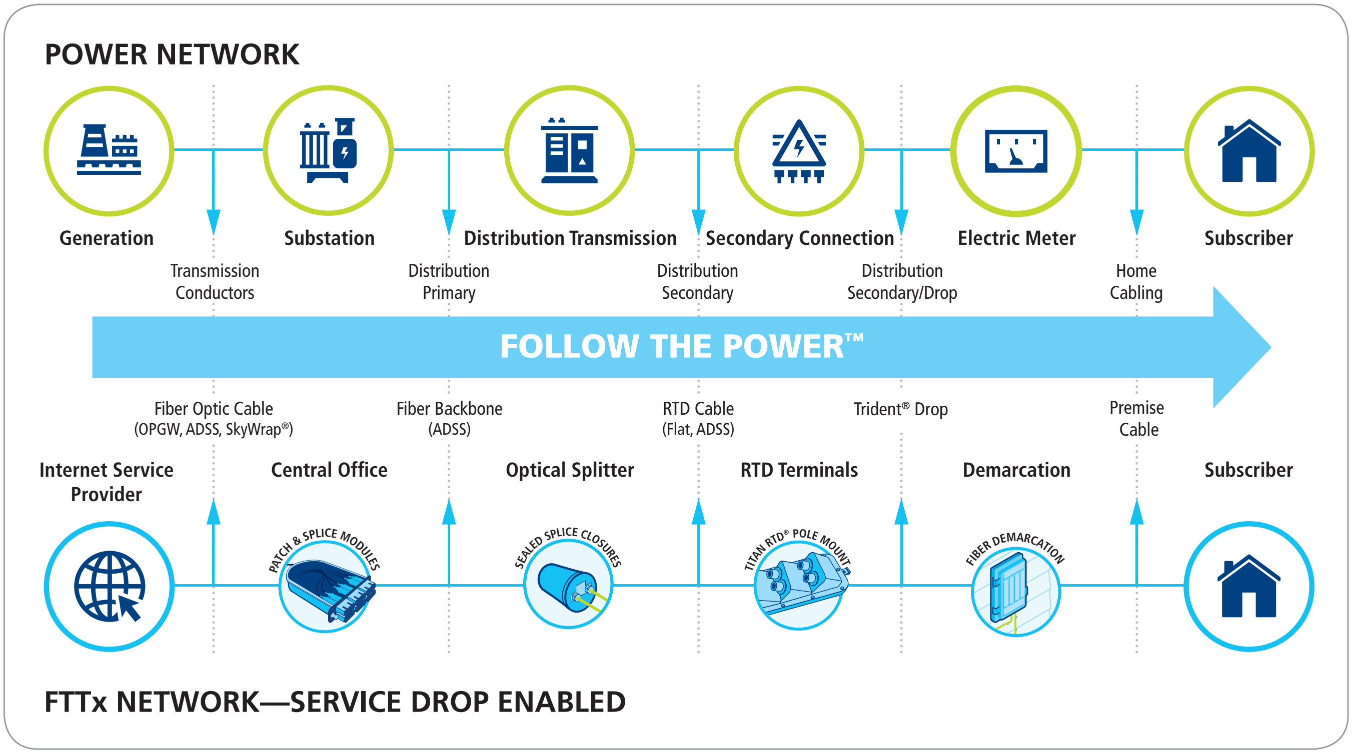

Figure 4—Following the same concept of power from generation to the consumer, electric utilities can install a fiber optic communications network using the same path.

Specifically in the distribution space, ADSS cable installed in the "Supply Zone" (above or below the neutral) allows for a fast installation with little-to-no make ready. This make ready includes guying of poles, addressing clearance issues, and moving cables that can add significant time and cost to strand and lash fiber installation. Multiport terminals also efficiently push fiber deeper into the electric utility network for point-to-multipoint applications. This technology introduces scalable and cost effective "plug and play" connectivity to avoid additional field splicing, and allows for quick and easy connections when used with hardened connector drop cables.

Passive optical networks (PON) optimize fiber usage for point-to-multipoint architecture. The optical split of a single fiber allows it to be used at multiple end point locations, while not comprising the bandwidth, speed, or latency of the signal. This method of splitting optical signals optimizes fibers for use at end consumers for broadband or monitoring of electric utility distribution assets. With the right optical splitter configuration, PON networks can be designed to be 100% redundant, which is critical for electric utilities. AFL's FOLLOW THE POWER™ approach follows the fundamental concepts of point-to-multipoint design, but maximizes the inherent advantage of the electric utility already having a direct path to the consumer. This leads to effective, efficient, and lower cost deployments than traditional telecom carrier fiber deployments used for utility companies.

Figure 5 — Multiport terminal with hardened drop connectors installed.

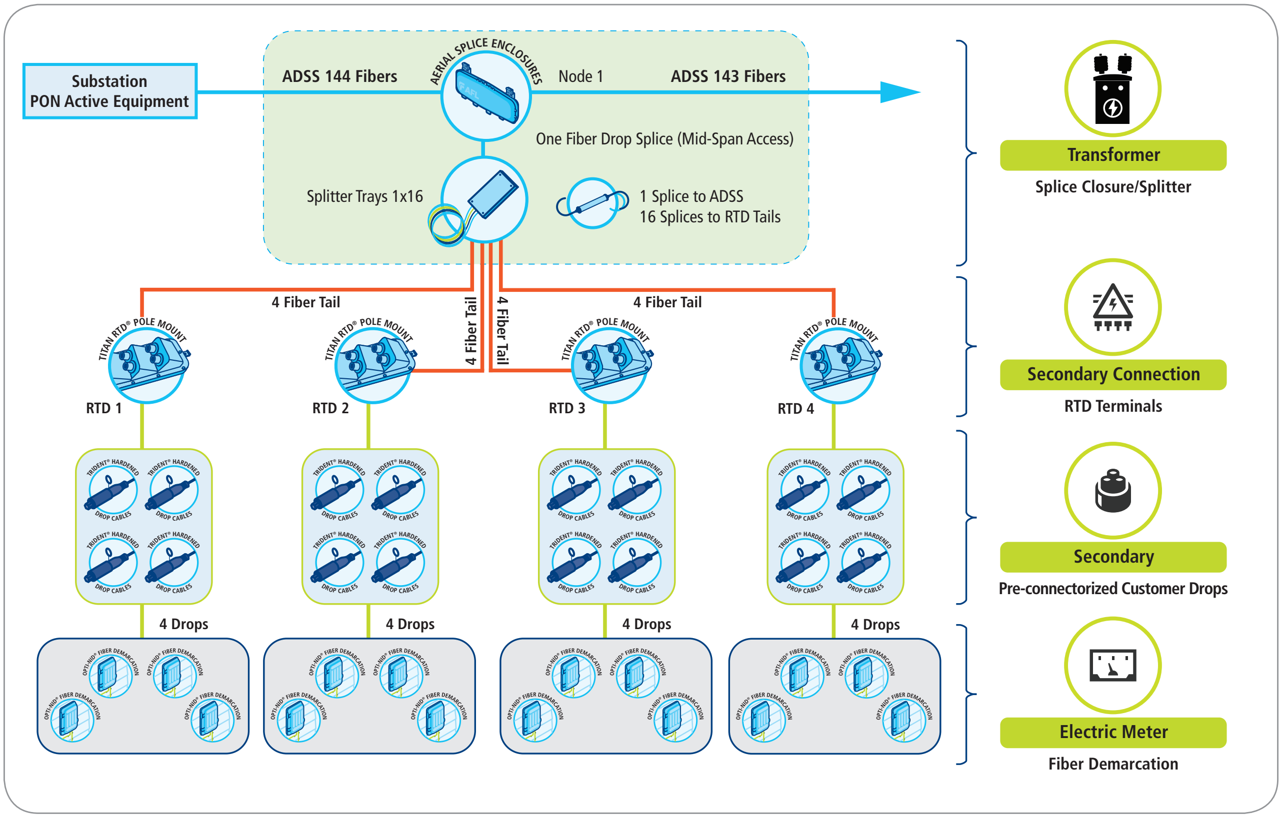

Figure 6 — Optically splitting a fiber allows the utility to use one fiber for typically up to 32 end users without compromising the performance of the fiber. This graphic shows an example of one backbone fiber serving 16 meters using multiport terminals, so there is only splicing at the optical splitter.

CONCLUSION

The modernized grid means collecting more data, more often, from more locations. Looking at the trajectory of communication needs of this future grid for electric utilities is similar to that in our personal lives, where bandwidth, speed, and lag time are at the forefront of the conversation. But even more important than those characteristics for electric utilities is reliability and security. Fiber provides for all of these needs with a future-proof ability found in no other communications medium. As electronics that transmit the data in fiber continue to improve, the capability and value of a fiber backbone to the utility and their customers will only increase. In addition to the technical case for fiber, electric utilities are in a unique position with clear rights-of-way to deploy a fiber network in a cost effective and timely manner. These rights-of-way could be well positioned for leasing fiber to third-party companies as well.

The initial cost can be high for fiber deployment when compared to wide ranging wireless or leasing options. However, when looking toward the applications in the smart grid of tomorrow, fiber for electric utilities is truly an investment and not an expense. Electric utilities of all sizes should consider opportunities to push fiber deeper into their grids in order to better service their customers and effectively operate the grid of tomorrow.

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