WHITE PAPER

The Need for Optical Fiber in the Modern Electric Grid

Written by Carson Joye, Product Line Manager (2019)
Revised by Austin Farmer, Solutions Manager (2023)

INTRODUCTION

There's no doubt that our world is undergoing a significant transformation, especially surrounding the energy sector and upgrading the electrical power grid. The modern-day electric utility, whether investor-owned, a municipality or a cooperative, is faced with increasing complexity due to enhanced cybersecurity measures, distributed energy resources (DERs), aging infrastructures, renewable energy and the rise of electric vehicles and charging stations (Figure 1). The legacy electric grid is trying to keep up with a rapidly changing energy market. Today's emerging grid, however, is one for the future. It's a highly distributed, bi-directional mesh network that is designed to address this dynamic energy environment and made to evolve alongside technological advancements.

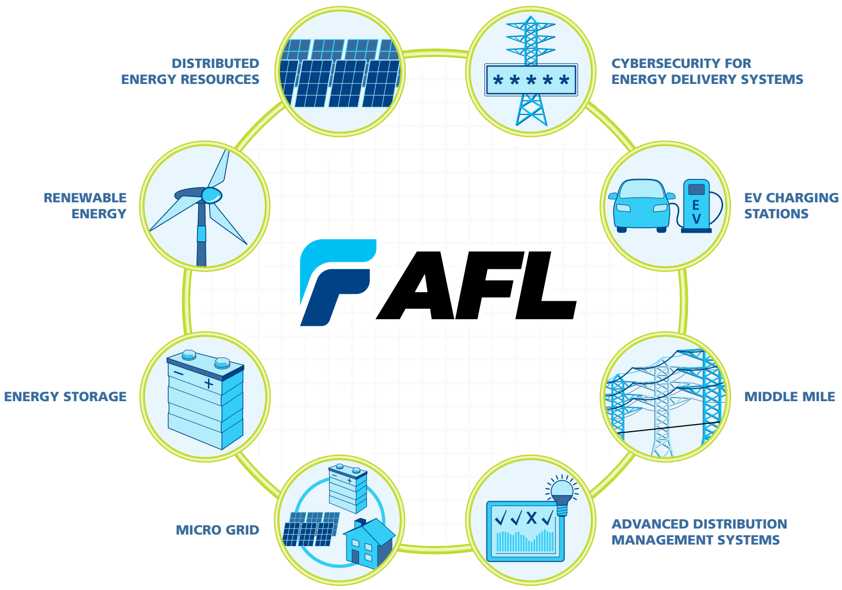

Figure 1—Drivers of Today's Grid

Electric utilities acknowledge that they must embrace these changes and adapt to an evolving energy landscape to support consumers who are benefiting from these trends. The transition towards a greener future, for example, involves the adoption of renewable energy sources and electric vehicles (EVs). A 2022 report from the Edison Electric Institute estimates that approximately 26 million electric vehicles will be traversing U.S. roads by 2030, requiring 12.9 million charging ports and approximately 140,000 DC fast charging ports [1]. Despite the intricacies around the grid, it's crucial that utilities create a seamless experience so consumers can charge their EVs when and where they want. Supporting EV requirements creates a need for utilities to gain more control over their networks so they can effectively manage the anticipated demands.

Electric utilities increasingly recognize this challenge and understand that they have to embrace these changes and adapt by improving reliability as well as 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.

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 2). Falling prices of 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 uninterrupted service, making it imperative for electric utilities to reduce energy outages.

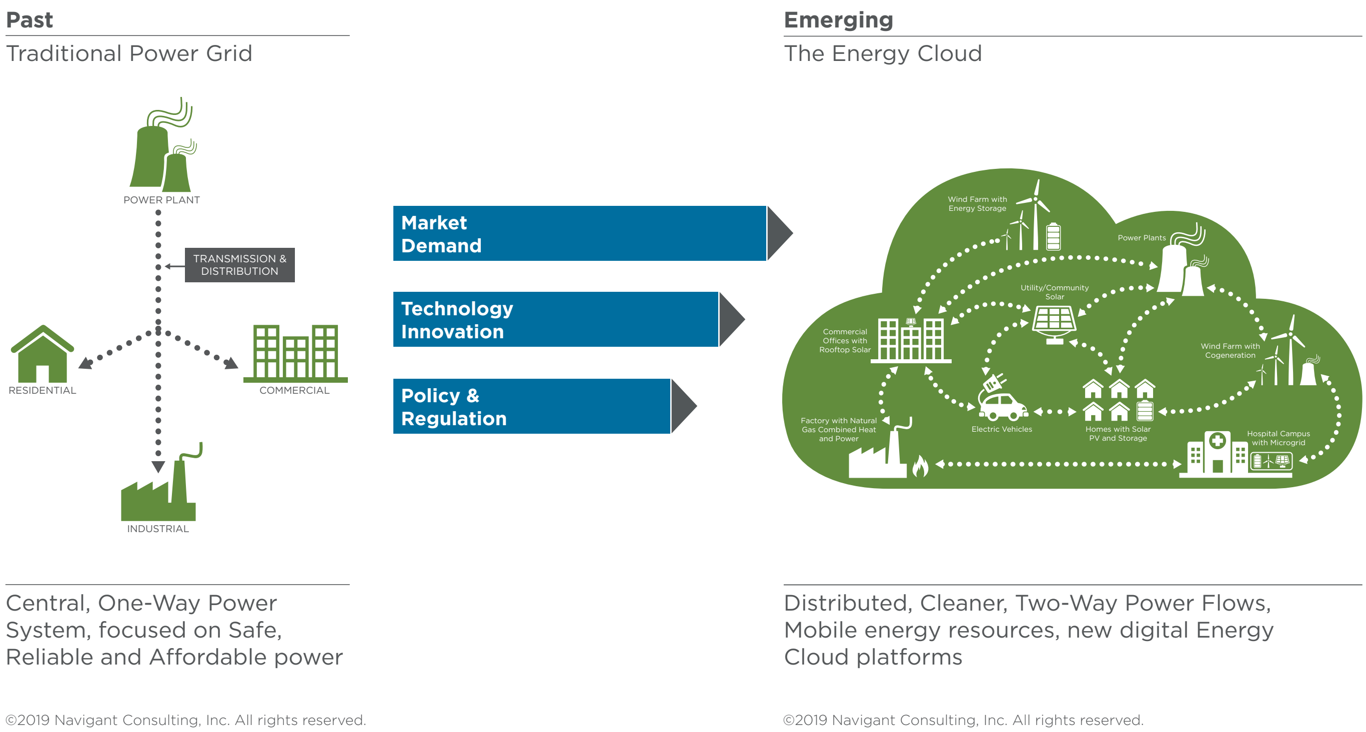

Figure 2—Traditional power flow compared to the current and future distribution of power.
(Image courtesy of Navigant Consulting. Navigant Consulting, Inc. was acquired by Guidehouse in 2019)

Resilient, reliable and modernized grids require a robust communications network, which is key to enabling a smarter grid. Such 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. As a result, 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 not only consider building a fiber-deep network, but also a SAFER™ network as they look to the future. The SAFER approach for building, expanding or upgrading the physical layer provides a more Sustainable, Accessible, Flexible, Expandable and Reliable network for years to come. When investing in a fiber-deep network infrastructure built with SAFER in mind, electric utilities enable a more resilient and reliable network and improve customer experience through improved efficiency and response time. As more and more electric utilities drive fiber into their networks, this investment will result in a density supporting not only today's needs but tomorrow's as well.

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. However, it's necessary to update and modernize the infrastructures of both transmission and distribution networks to achieve future advancements and continue meeting increasing data requirements. According to a statement released by The White House in 2022, approximately 70% of the country's transmission lines are more than 25 years old. [2] Taking action to modernize these aging infrastructures becomes an imperative to ensuring a reliable and resilient grid and provides an opportunity to smarten the electrical grid with fiber infrastructure.

Optical fiber communication cables have been specifically designed for utility transmission and distribution rights-of-way, leading to Middle-Mile and FTTH networks, which, in turn, contribute to grid modernization efforts. Some primary examples include optical ground wire (OPGW) and all-dielectric self-supporting (ADSS) fiber optic cables, which were both introduced over 40 and 30 years ago, respectively.

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 install fiber through the grid and deploy a fiber-deep network (Figure 3).

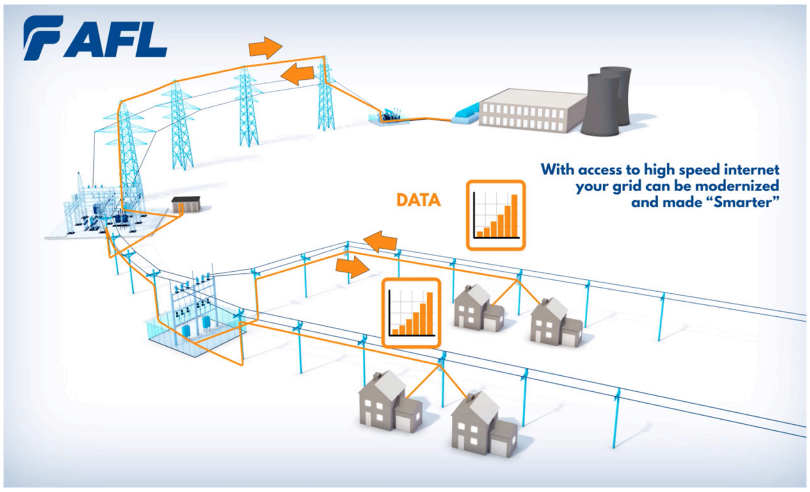

Figure 3—This simplified grid overview — from generation to the end user — shows that the same path used for electricity can be used for communications that provides the two-way flow of data to run the grid "smarter".

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 the demand for a resilient, reliable and modernized grid continue to rise, it’s crucial that electric utilities implement a fiber-deep network with a strong optical infrastructure.

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.

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.

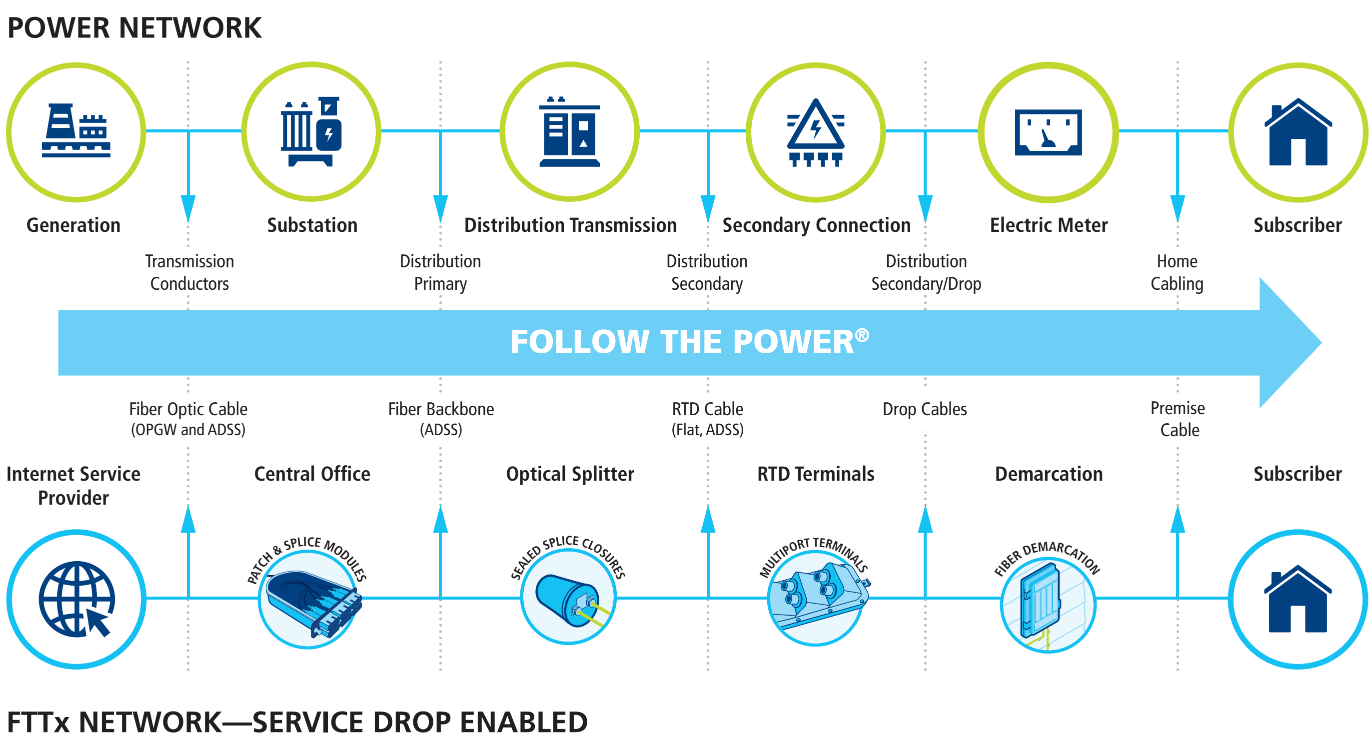

Figure 4—Following the same concept of power from generation to the consumer, electric utilities can install a fiber optic communications network using the same path.

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.

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. Aerial rights-of-way fiber deployment offers a viable option. Fiber provides for all of these needs with a future-proof ability found in no other communications medium. Pulling fiber through the grid and investing in a fiber-deep network will result in a strong infrastructure capable of accommodating both the demands of today as well of those of tomorrow. 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 SAFER approach also ensures the Sustainability, Accessibility, Flexibility, Expandability and Reliability of a network that addresses the evolving requirements and maintains a robust grid capable of serving customers effectively.

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.

REFERENCES

1. Satterfield, C., Schefter, K. (2022). "Electric Vehicle Sales and the Charging Infrastructure Required Through 2030." Edison Electric Institute. https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Electric-Transportation/EV-Forecast--Infrastructure-Report.pdf

2. The White House. 2022, November 18. "FACT SHEET: The Biden-Harris Administration Advances Transmission Buildout to Deliver Affordable, Clean Electricity." https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/18/fact-sheet-the-biden-harris-administration-advances-transmission-buildout-to-deliver-affordable-clean-electricity/

BIO

Carson Joye is a product manager at AFL. After more than 10 years at AFL, Carson has held various positions in manufacturing, applications engineering and product management. He has experience with electric utilities and internet service providers designing fiber optic solutions, supporting the installation of fiber optic cable networks in the field, training installers on the use of fiber optic cable and accessories and now overall product line responsibilities. He is an ETA certified Fiber Optics Installer and a certified FTTx outside plant designer. Carson holds a BS in Mechanical Engineering from Clemson University.

Austin Farmer is the Solutions Manager for the Energy Market Applications Engineering team. Austin and the AE team provide support on all fiber optic cable, hardware and connectivity items for AFL's utility end users. Austin has more than 10 years of experience working with utilities and has been with AFL since 2016.

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