WHITE PAPER

Multi-service Substation WAN Backbone

Ready for Broadband

Historically, the deployment of broadband services has been limited in rural communities as it is difficult for traditional providers to justify a broadband business case in more sparsely populated areas. Consequently, the use of internet services and lack of adequate bandwidth present a challenge to residents—from work, retail, and entertainment services to accessing critical healthcare and advanced education services. The COVID-19 pandemic has only accelerated these trends, propelling high-speed, reliable broadband into the essential category rather than simply optional.

Rural utilities are in the unique position of having physical infrastructure in place that can be leveraged to fill the void. However, their core business remains the supply of electrical power, which needs to be delivered more cost-effectively, and often with fewer staff who are covering multiple roles. This fuels the need to emulate the larger utilities in modernizing their grid—along with automating their operations and billing—with initiatives such as the deployment of smart meters.

The shift towards renewable energy generation, the growth in smart devices in the home, and the expanding electric vehicle ecosystem all create further challenges that place more strain on their communications solution.

Managing the significantly increased volume of broadband traffic, while allowing critical teleprotection traffic to be prioritized, demands a modern combined packet optical network. For rural utilities, this is a key driver when considering investing in a multi-service substation backbone that can address both the core utility operations challenges and leverage new opportunities for the provision of rural broadband in the communities they serve.

How is broadband becoming an essential service?

A good reference point on the state of broadband services is the Sandvine State of the Internet Survey*, which is published biannually. It reports on internet usage trends in terms of which applications are consuming bandwidth. The latest publication deals with the effect of COVID-19 during the first global lockdown period at the start of 2020.

The overnight shift in traffic consumption due to nationwide lockdowns, along with the shift to remote working and learning, resulted in significant traffic growth (40 percent in less than three months). A further shift was due to the phenomenon of consumers changing the way they access content by cutting their broadcast cable packages and starting to stream shows via services such as Netflix and Hulu.

This is partly because access to live sports, one of the key drivers for consumer spending on traditional cable packages, stopped during the lockdown period. Instead, consumers turned to pure entertainment platforms that supply movies and TV series.

Entertainment is only one contributing factor. The move to working from home—both for employed adults and for students in schools, colleges, or universities—has dramatically increased traffic and created a step change in the use of video calling and conferencing. Collaboration applications such as Zoom and Microsoft Teams have seen exponential growth in usage. While it is expected that schools, colleges, and universities will ultimately fully reopen, many believe that a significant proportion of the home-working trend will become permanent.

Additionally, lockdowns have meant that healthcare and other critical services have had to adopt remote modes of working using web portals and video calling platforms. Travel restrictions

*The Global Internet Phenomena Report COVID-19 Spotlight (May 2020).

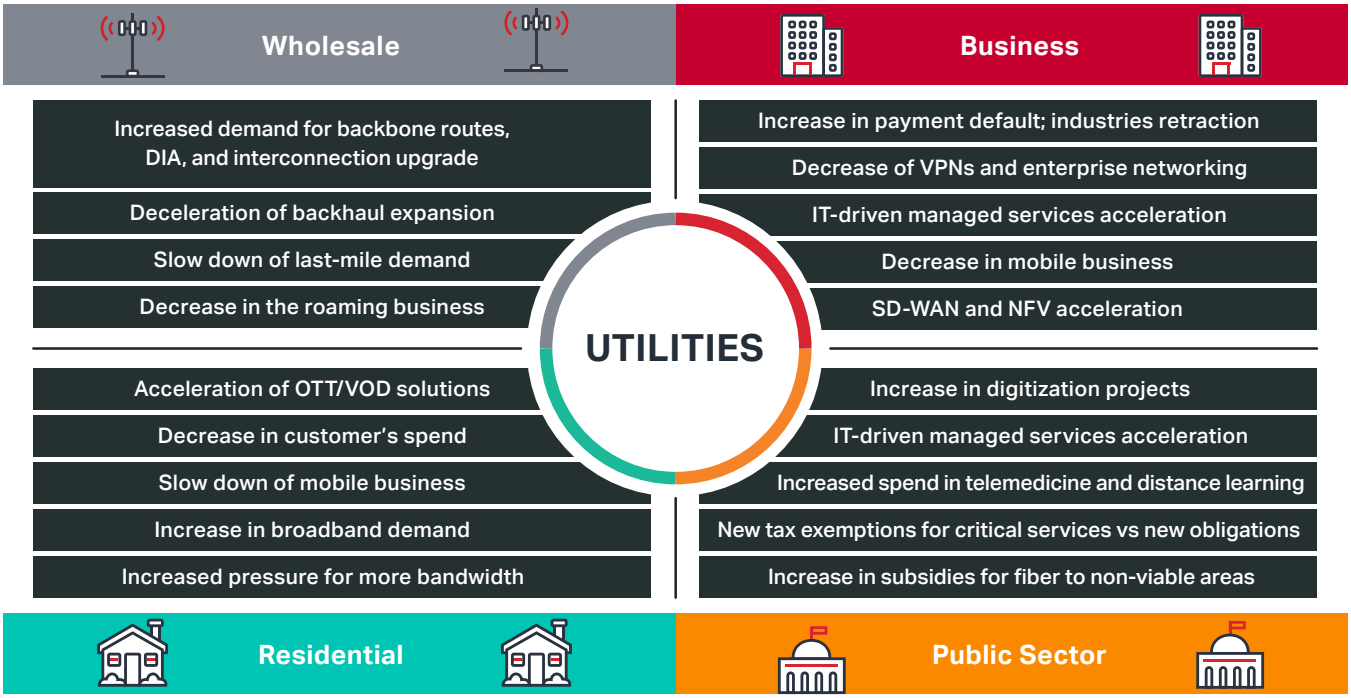


Figure 1. Sectored opportunities for rural utilities

have created even more demand for high-capacity broadband services in rural areas.

Despite the rise in traffic levels, traditional service providers' core networks have coped well, and connectivity for consumers and businesses in urban areas remains a well-served market. However, rural areas were already lagging in terms of network reach, access speeds, and cost. Despite government incentives, it is difficult for traditional service providers to justify the capital investment across the more dispersed population that characterizes rural broadband. Yet there is demand there, and crucially, the changes seen recently make high-speed broadband essential for those living in these locations. The need for reliable broadband is now a fundamental part of their working and recreational lives.

The multi-service opportunity for rural utilities

Utilities have an existing core business justification, and a consequent business case, for investment in high-capacity packet-optical transport between their substations. It makes sense for utilities to leverage this infrastructure to aggregate internet traffic from broadband services to meet the needs of their new residential and business customers. Not only does it create a new revenue stream, but also provides an essential service for their rural communities.

The wholesale market provides further opportunity to resell additional network capacity. For example, the rollout of the new 5G mobile network technology means a ten-fold increase in capacity for existing cell sites and for many additional new sites. This is a great opportunity for wholesale in areas where the cost of a new build would be prohibitive for mobile carriers. The business sector has also had to adapt during the pandemic, the economy overall is beginning a recovery, and many businesses have become more focused on digital transformation, which in turn requires improved connectivity. Rural utilities are well positioned to help businesses achieve the high-performance connectivity they need to support their network modernization plans.

Some of the biggest impacts of COVID-19 in rural communities has occurred in the public sector, which represents a significant opportunity for utilities. This sector often has funding programs in place for investment in communications, but there are additional drivers, too. One example is telemedicine, which requires reliable three-way communication between the health provider, the patient, and their Electronic Medical Records (EMRs) residing in a data center. Another example is the increasing sophistication of medical imaging technology, which requires extremely large files to be transferred very quickly between rural areas and centers of expertise for rapid diagnosis.

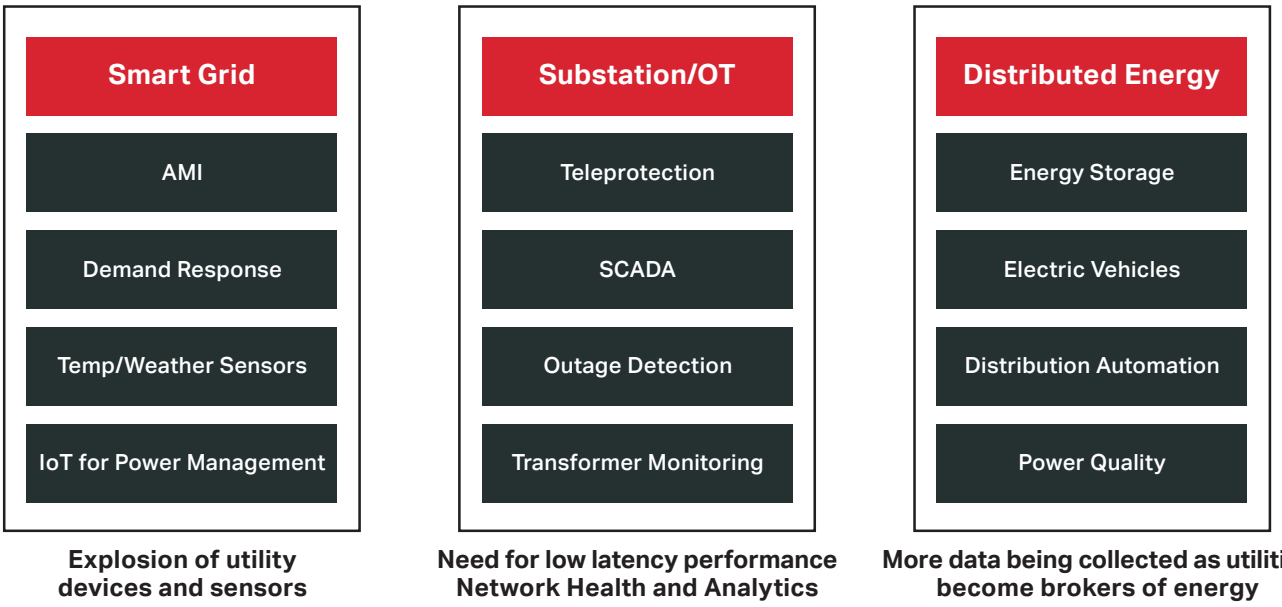


Figure 2. Factors driving utility network demand

Remote learning is another increasingly important public sector development. It demands high speed, low delay connectivity between learning centers and learners. In rural areas, this can be difficult and very costly to achieve. Utilities are ideally placed to meet this need.

Opportunities for broadband, wholesale, business, and public sector communications increase the demand placed on the utility communications network, while changes to the core business of power distribution also increase demand.

The evolution to 'smart grid' encompasses a number of changes and innovations. For example, it includes strategies such as Advanced Metering Infrastructure (AMI) or 'smart meters', which are not only used for billing purposes, but also to manage energy consumption and balance the power grid during times of peak demand.

Utilities are also deploying other sensors across their distribution network, including temperature and weather sensors to manage weather events such as wildfires or hurricanes.

The Internet of Things (IoT) is having an impact on power management. For example, the Nest System for smart heating and cooling control in homes can be linked to the utility network to create innovative billing services whereas, a utility could intelligently lower heating thermostats during times of peak demand in exchange for a lower cost per kWatt hour.

Smart grid also impacts a utility's traditional substation Operational Technology (OT) services, such as teleprotection for power lines. For example, it means faster and more widespread monitoring and control at substations so that the network can respond to failures with corrective action. All the while, the modernized network must continue to support, secure, prioritize, and deliver ultra-low delay connectivity for these essential, mission-critical services.

And finally, the shift to distributed energy with the growth in renewable energy sources means a more complex generation and distribution network that must be responsive to changes in demand and supply. Put simply, this means that utilities must collect a lot more data. They become a broker of multiple energy sources, not only from the grid, but also from consumers and businesses who increasingly have their own solar, wind, or hydro micro-generation sources. Renewables as well as traditional energy sources need to be balanced for an efficient energy supply that meets more variable demand trends.

All of this results in millions of new IP endpoints to manage, which drives the need for a resilient and scalable fiber optic broadband network.

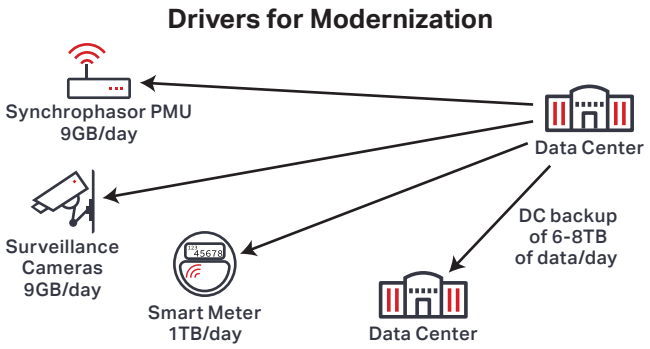


Figure 3. Example data volume in a utility network

Considerations for data volume

How much data would the modernized network have to carry? Ciena considered the top three applications in the distribution network to assess potential total data volume:

- Substation PMUs
- Surveillance cameras
- Smart meters

Traditional Supervisory Control and Data Acquisition (SCADA) systems used at substations would only sample the state of the grid every four seconds. In the past, this has resulted in minor failures escalating into very serious incidents because the initial failure was missed. Today, many utilities have deployed a Synchrophaser Performance Measurement Unit (PMU), which samples the state of the grid 30 to 60 times per second. As a result, each PMU can generate up to 15 gigabytes of data per day. A utility may have thousands of PMUs in their grid, all contributing data that must be analyzed centrally.

The second application relates to security, and the deployment of surveillance cameras at critical equipment sites. In the past, video was stored locally, and relevant footage only viewed after a security breach had occurred. Today, the strategy is to backhaul security footage to a central data center where advanced AI processing can be used to recognize the characteristics of a security breach in near real time.

Each camera can generate nine gigabytes of video data per day, and a single substation could have many cameras.

The last application is smart meters. The data contribution from a single smart meter is modest, but a typical smart meter measures energy consumption every 15 minutes. For a utility with one million smart meter customers, that could add up to a total of one terabyte of data per day.

When scaling a substation WAN to handle this amount of data, it becomes very apparent that utilities can no longer use legacy SONET/TDM networks. They need to modernize into packet rings that can support multiple tens of gigabits at the substation, and hundreds of gigabytes in the core.

It is also clear that adding broadband services will increase capacity requirements even more. A typical rural community with only a few thousand broadband customers could easily need backhaul capacity in the order of tens of gigabits per second.

Evolving the substation WAN

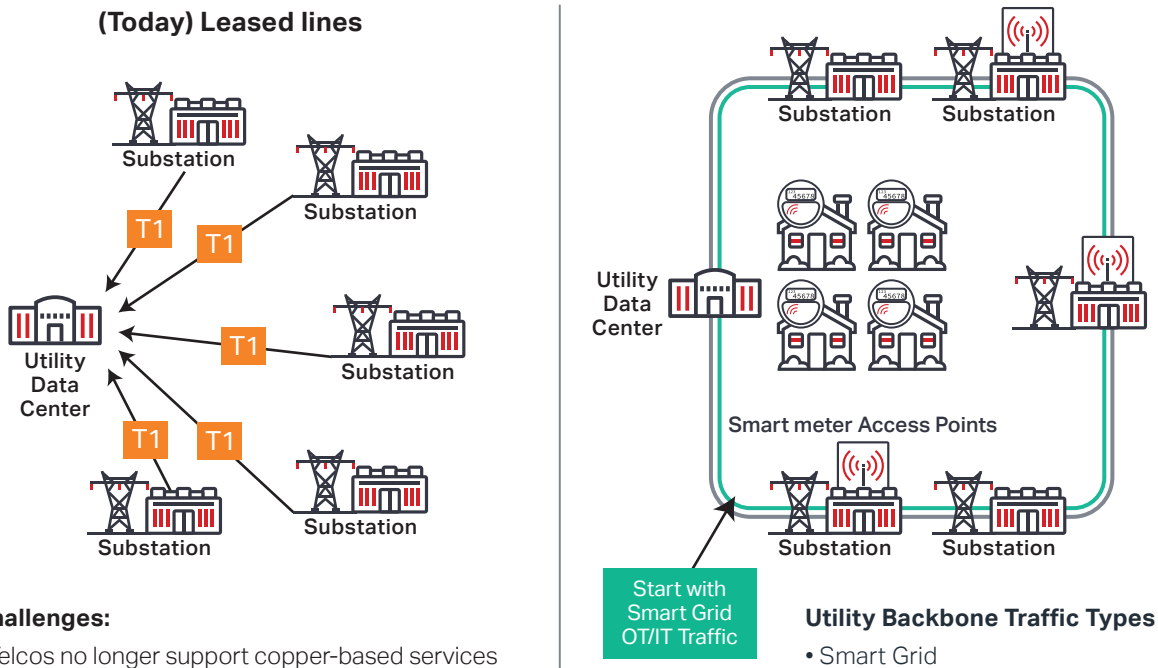
Today, many of the rural utilities are still heavily dependent on TDM for their substation WAN with T1s (1.5 Mbps) to backhaul their basic SCADA traffic into their control centers.

However, this approach does not scale to meet the demands of smart grid and broadband services. Additionally, these copper-based services are at end of life and service providers are no longer supporting them, often setting pricing deliberately intended as a disincentive. In many cases, it is not possible to order a new T1 per service and, if there is a maintenance issue, it becomes difficult and costly to resolve. The result is an increasing monthly recurring cost for a service that is not fit for purpose.

The good news is that utilities have a very compelling business case to modernize their substation WAN with connections back to their data center using a fiber optic backbone, even if they are only running their existing smart grid traffic.

If smart meters are also considered, then the case becomes even more compelling. These are typically connected wirelessly to access points on the substation WAN. From there, data is backhauled to the main data center. With this large amount of data, traditional TDM architecture will not scale sufficiently.

Once this business case for a modernized optical substation WAN is established, then the utility is also ready to support broadband services in the future.



Challenges:

- Telcos no longer support copper-based services
- Cannot scale to support new applications
- OPEX cost

Utility Backbone Traffic Types

- Smart Grid
- Substation/OT (Teleprotection)
- IT Traffic (Internal)
- Broadband (Future)

Figure 4. The case for moving away from TDM

Developing a rollout plan for a modernized substation WAN

A change of this magnitude in the network, combined with the introduction of completely new service types at the same time, may be viewed as high risk. There are also cultural factors to consider when merging the traditionally separate OT and IT network and teams. However, this can be mitigated with a plan that divides the transition into three steps.

The first step is to build the optical backbone to support smart grid traffic. This provides confidence that the solution performance meets the needs of mission-critical telecontrol traffic and other high-volume traffic such as surveillance cameras and smart meters.

The second step is to offer wholesale and business connectivity services. For example, in regions with 5G rollout in progress, mobile carriers will be looking for a significant amount of additional capacity. Similarly, in both the business and public sectors there are opportunities for capacity to support business applications, telemedicine, or remote learning. These are all credible services that a utility can provide through their modern backbone.

The third and final step is to offer true residential broadband services in rural communities. This is now all provided through the same network. The utility network can be viewed as a multi-service network that starts with smart grid, adds business services, and then finishes off with residential broadband services.

Specific network architecture to deliver a three-step rollout of services

Ciena can help with products that are specifically designed to support the modernization of the substation WAN. Ciena's 5171 Platform is a universal aggregation device for the backbone that meets the modernization requirements of utilities.

The 5171 Platform with WaveLogic™ 5 DWDM can be used to build an advanced middle-mile network with 100GbE packet aggregation. It is temperature hardened for the varied, remote, and often hostile environment in which substations must operate.

The 5171 addresses the multi-service needs of utilities who wish to offer residential optical broadband (PON), high-bandwidth services to enterprises, and wholesale applications such as mobile backhaul, by delivering high-density 10GbE aggregation.

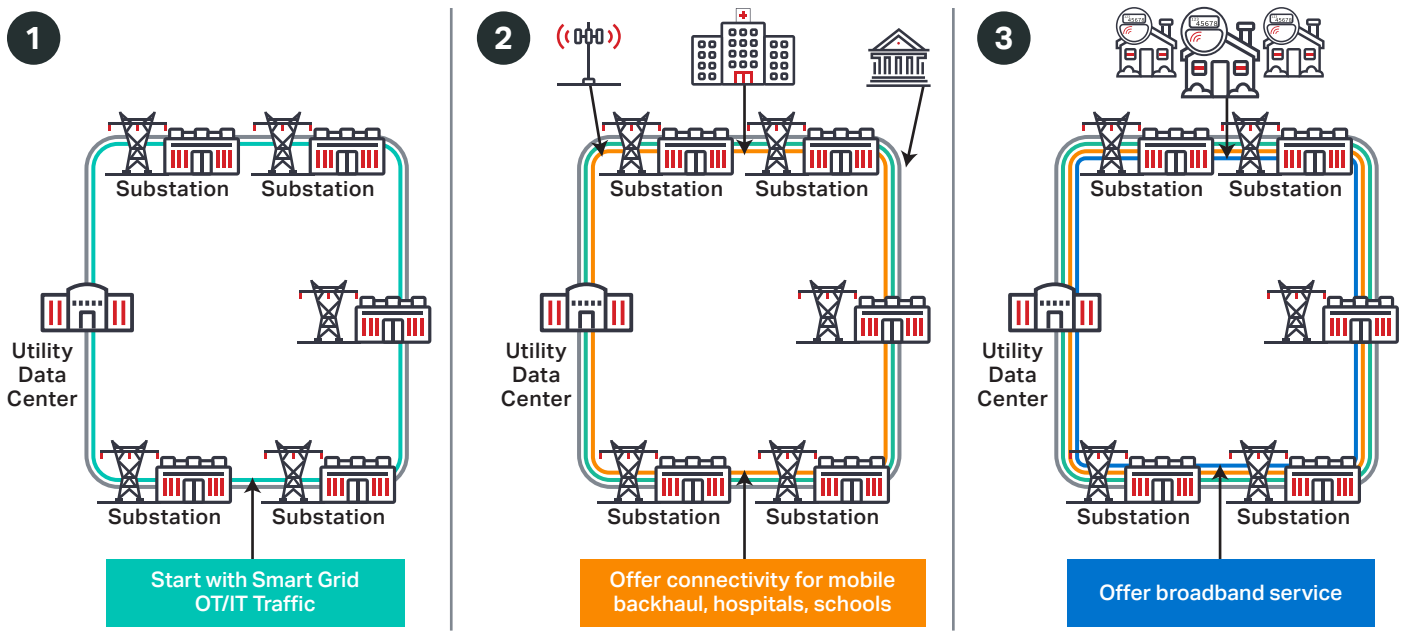


Figure 5. Evolved rollout plan for a converged packet-optical substation WAN

Ciena's partnership with Schweitzer Engineering Labs (SEL) provides the ability to converge mission-critical teleprotection traffic with smart meter traffic into the substation backbone network.

The final piece in the puzzle is the capability to backhaul a variety of residential Passive Optical Network (PON) solutions that can be used to deliver broadband to customers' homes.

Our aim is to provide a best-in-class, middle-mile substation network that can support all traffic types, and easily scale to support smart grid, business services, and broadband to the home.

Ciena's 5171
Gain insights

The importance of aggregation

Ciena's 5171 provides a vital link between traffic sources and the optical backbone. It is critical that the performance on both sides is optimal.

In terms of the interface onto the substation WAN, the 5171 can support high speed coherent optics starting at 100G, and it can scale up to 200G. This ensures that the backbone has sufficient capacity and performance to meet the needs of the proposed mixed service traffic.

In terms of aggregation, an important factor for the successful support of multiple services is the ability to demarcate traffic and to provide separate and appropriate Quality of Service (QoS) for each traffic type. Utilities must be able to guarantee that mission-critical teleprotection traffic is given the highest QoS and is therefore prioritized over any other traffic types that are being aggregated onto the backbone. The 5171 enables utilities to do this.

Another key advantage of the 5171 is that both residential PON and business PON services can share the same fibers. This means that a utility does not have to run a separate fiber for residential and business services. If there is a potential business customer in a residential area, they can still have full business services without the need for a separate fiber.

Funding programs

While a utility may recognize the business benefits and even the long-term cost benefits of investment in a modernized substation WAN, for smaller utilities immediate funding for an upgrade project can present a challenge. However, there are several funding programs available to help utilities transition to smart grid.

Firstly, the U.S. Renewable Energy Association (REA) manages a program that has a $5.5 billion annual budget. This program provides loans to support utilities in building a fiber optic

backbone for smart grid and internal communication facilities, and it is also intended to promote readiness to support broadband in the future.

Additionally, the U.S. Government has set up a fund called the Rural Digital Opportunity Fund (RDOF) to encourage the provision of broadband services in unserved areas. The fund has $16 billion over ten years at its disposal. Qualifying areas are defined as those without access to at least 25 Mb/s downlink and 3 Mb/s uplink. There are a substantial number of areas that are eligible for this funding and utilities are ideally placed to show that they can service these locations with the least amount of government support.

Summary

Even pre-pandemic, there was a need for broadband services in rural communities. The COVID-19 pandemic has only served to accelerate the need for those services, not simply just for entertainment but also to support work at home, and to enable remote access to education and healthcare services.

Outside of the pandemic, utilities are facing paradigm shifts such as the growth in renewables and the shift to smart grid that create a need to modernize their substation WAN. This is especially true for those still dependent on leasing copper-based TDM circuits, which have reached end-of-life and cannot meet future demands. The need to embrace smart grid, therefore, makes a very compelling business case for a fiber-based backbone to support these new services.

Modernizing the network requires investment, so it is critical that utilities make sure that the new backbone is fit and ready for all the services that it must carry. They must also ensure that it can scale to support not just smart grid traffic, but also residential broadband and business services—bringing benefits to rural communities to support work at home, enable business growth, and support health and educational services. Wholesale services can also be provided to support the rollout of the 5G mobile backhaul, further improving connectivity in the rural setting.

Funding need not be a barrier due to the funding options specifically targeted at smart grid evolution and the provision of rural broadband. As utilities embark on this journey to build a network to support both internal smart grid and external broadband services, they need to consider building a solution with the best-in-class components. This may be a big step for smaller utilities, and they need a partner with extensive experience, who understands their needs and their goals, and who can provide the right solutions. They need a solution that is the most scalable, that has the ability to support multiple services, and that can ensure their mission-critical teleprotection services remain secure and are carried at the highest QoS.