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The Coming Convergence of Broadband, Energy, and Transportation

A Technical Paper prepared for SCTE by

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1. Introduction

The coming convergence of broadband, energy, and transportation has the potential to transform all three industries in unexpected and powerful ways – with significant impact on CAPEX, OPEX, and value creation opportunities. However, the potential of this transformation cannot be fully realized without successful collaboration across these three industries. The purpose of this technical paper is to raise awareness of this coming convergence and to stimulate conversations across these industries to take advantage of what, to this point, may be nonobvious synergies.

In the United States, the Infrastructure Investment and Jobs Act (IIJA) represents a once in a generation investment in infrastructure for these three sectors and a unique opportunity to speed this convergence by creating an opportunity to completely reimagine the country's underlying infrastructure. Historically, each industry has developed its infrastructure independently. However, as broadband has been a key driver in the transformation of many industries, as they digitize and move to the cloud, rethinking shared infrastructure can change the capabilities that the three industries can bring to market. It is the increased connectivity, reliability, bandwidth, and security of broadband that is enabling innovation at scale across virtually all sectors, not only in the U.S., but globally. Most importantly, the Energy and Transportation sectors are already poised for massive disruption and transformation and, as we will show, broadband is and will be a key enabler for this.

This technical paper will identify the key drivers of this cross-industry convergence and explore how it will come about by focusing on the three most important contexts for this convergence:

- Home: How will convergence impact services and behaviors in the home?
- Urban: How will cities and suburbs change and develop?
- Rural: How will rural areas adapt and thrive?

This technical paper serves as a call for cross-industry collaboration on the opportunities of this cross-industry convergence. As the Broadband Industry's innovation engine, CableLabs has decades of experience in bringing industry-transforming innovation to market through collaboration within and across industries and looks forward to uncovering and collaborating on nonobvious synergies across the industries.

One obvious area where cross-industry collaboration could stimulate innovation are the common expectations of communications capabilities that are limited to the "lowest common denominator", as opposed to envisioning the possibilities and needs of the future. The cable industry is in the midst of its 10G [10 Gbps] industry initiative[1], addressing not only speed, but reliability, security, and latency. What applications and services could be developed for the transportation and power industries if they were not constrained by the limits of today's broadband technology?

This technical paper identifies several possible synergies and opportunities. We are certain that you will envision many more. We welcome your feedback or interest by contacting the authors here: Ralph W. Brown <ralph@brownwolfconsulting.com>, Scott Caruso <s.caruso@cablelabs.com>, and Hunter Albright <hunter@curve10.com>.

[1] See: CableLabs 10G Platform: https://www.cablelabs.com/10g

2. Background

Perhaps the most important insight into this coming convergence is from an understanding of how broadband access network technology (both fixed and wireless) intersects with the power grid and the shared opportunities that exist. Today, energy companies have a lack of visibility into the performance in the last mile of their power distribution grid. On the contrary, while less well known, broadband access network providers are consumers of energy from the grid, particularly in the last mile, which provides great insight into the last mile of the grid. To deliver broadband services to consumers and businesses, broadband access networks have active network elements that are powered by the grid. To provide broadband services in periods where there may be a power outage, broadband network operators integrate resilient, battery-backed power systems to keep these network elements operational (see figure below). These points of connection between the broadband network and the power grid provide unique insight into the performance of the power grid where power companies lack visibility. As an example of what is possible from these points of connection, Gridmetrics, Inc.[2] leverages them to provide visibility into the status and performance of the power grid at a geographical and temporal resolution not previously available.

The figure below provides an example of the convergence of broadband and energy utilized by Gridmetrics. It shows the power distribution grid along with a Hybrid Fiber-Coax (HFC) network and mobile small cell. It also shows their connection to the home with an EV charging station and potentially distributed energy sources. The HFC node and the mobile small cell are among the active elements in the fixed and mobile networks. The HFC network can act as a backhaul network for the mobile small cell and provide broadband services to the home. A backup power system monitors the power grid and provides backup power to both the HFC node and mobile small cell in case of power outages. These backup power systems are connected to the broadband network to report on their operational status. The backup power system can not only monitor the availability of power from the grid but can also monitor the quality of the power signal and more. Because this is part of the broadband access network, it can harness this broadband connectivity to aggregate information where it can be analyzed. This aggregated power measurement data provides high quality, fine grain insight into the health of the power grid. With the growth in distributed energy resources (DERS) this insight will be critical for the management of the power grid. It should be noted that the EV charging station at the home or the distributed energy resources (e.g., battery, solar, wind) shown in this figure can serve a similar function for monitoring the grid if they are connected to the broadband network and have some form of backup power.

[2] See *Gridmetrics White Paper by CableLabs® and Gridmetrics™* and https://gridmetrics.io/

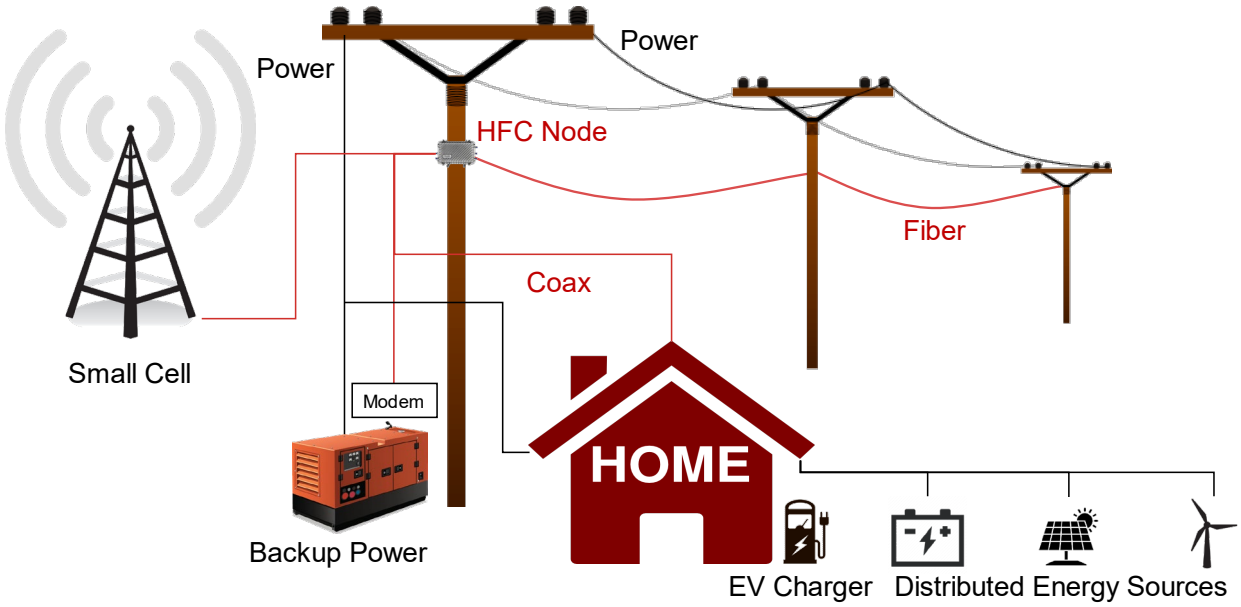

Figure 1 - Point of convergence of broadband and energy at the home

In subsequent sections we will show how this point of convergence between broadband and energy is extended to include transportation and how it fits into the Urban/Suburban and Rural contexts. First, we will cover the key drivers of this coming convergence of broadband, energy, and transportation.

3. Key Drivers of Convergence

There are multiple drivers of the convergence of broadband, energy, and transportation, including:

1. Two-Way Flow - Grid Modernization, the digital transformation to enabling the bi-directional flow of electrons along the distribution power grid
2. Distributed Energy - The shift from centralized to distributed energy resources (e.g., solar, wind, battery, etc.)
3. Charging Infrastructure - The electrification of vehicles and the deployment of the supporting EV charging infrastructure, both at home and through commercial EV charging networks
4. Energy Transactions - The evolving EV charging requirements for connectivity to support "reservations and payments"
5. Transactive Energy - The evolving Transactive Energy Ecosystem that is tightly coupled to a modernized grid and EV needs
6. Electrification - The shift from natural gas to electric for traditional uses of natural gas (e.g., heating, hot water, cooking, etc.)
7. Autonomous Vehicles - The evolution of autonomous vehicles with the resulting transformation of public transit and shipping
8. Cyber Threats - The need to address cyber threats to critical infrastructure
9. Broadband Demand - Increasing demand for ubiquitous broadband connectivity with the pressing need to address the digital divide and rural broadband
10. Investment - Substantial investment resulting from the Infrastructure Investment and Jobs Act (IIJA)

Any number of these drivers could be sufficient to stimulate convergence, the combination of them all makes it essential that we envision this convergence now and take the appropriate steps to realize it in the coming years. Any investment in infrastructure should anticipate the future vision for these industries.

4. The Point of Convergence Across Contexts

It is important to understand where the physical point of convergence occurs across these three industry segments within the identified contexts. The insight here is that the power grid and the broadband network physically come together at those points where a broadband network connection is made that draws power from the grid, e.g.:

- At the home with the broadband modem/gateway, home EV charging stations, and/or distributed energy resources, such as solar and/or battery
- At public, commercial or fleet managed EV charging stations
- At the access points for commercial and MDU buildings
- Along roads and highways where Vehicle to Infrastructure (V2I) small cells are placed

It is these points of connection that enable the convergence of the broadband, energy, and transportation industries. To further illuminate the convergence, consider the deployment of an EV charger, either for use at home, commercially or publicly. Along with supplying power to the charging station, implicit is a communications link. Communications is essentially required to monitor and manage the EV charging (scheduling, notifications, troubleshooting, payments, etc.) The communications component is understood to be part of the delivered power charging solution, and with forethought and collaboration, the opportunity exists to create a more secure, robust, and efficient charging solution as well as a comprehensive data exchange capability. There is a natural, symbiotic interdependence among the industries. Consider:

- Real time monitoring of the quality of the power available and delivered to a vehicle
- Manage the sources of power available to the charging stations
- Scheduling charge times, particularly to optimize costs of power
- Reserving charging stations (public or commercial)
- Payments for on-demand charging
- Securing the charging stations, including video observations
- Providing data uploads to vehicles (including manufacturer specific updates, on-board entertainment, current navigation data, etc.)
- Providing data downloads from vehicles (telemetry data to manufacturer, insurance companies, fleet operators, etc)

Underlying each of these considerations is the communications network. Considering the protocols, security, resilience, and reliability of the communications networks as a key component of the complete solution benefits the entire EV charging ecosystem. In essence, addressing the complete solution with a holistic view can prevent the creation of inherent silos that fail to provide the optimal power delivery, reduce the costs, improve the software interfaces for the EV manufacturers and their consumers, ensure the security of the charging stations and its users and secure the power transactions. Minus an intentional desire to collaborate, the likely outcome is fractured solutions designed by the EV charger suppliers, car manufacturers, state/local specific solutions. The loser is the consumer who must manage the various interfaces with inconsistent outcomes.

4.1. Convergence at the Home

A primary point of convergence and one that is taking on increased importance with the changes in where and how people work, is the home. Figure 1 shows the diversity of assets that convergence at the home and we can expect these to grow.

The convergence of vehicle charging and distributed energy sources at home enable:

- Grid monitoring at the home
- Grid management for home-based energy sources (solar, battery, etc.)
- Automated Demand Response (ADR) for the home
- Secure broadband services for both consumer, grid monitoring/management, and autonomous EV connectivity (stationary)
- Consumer & commercial visibility into energy consumption & contribution
- Two-way power transactions between grid and EVs

It should be noted that there are also potential construction synergies (dig once for resiliency) in green field and new housing developments or in areas where investment is being made to upgrade or harden the grid and broadband infrastructures.

4.1. Convergence in Urban Areas

Moving outside the home, there are significant opportunities for convergence in urban areas across private, public, and fleet assets. The figure below shows the points of convergence across Urban areas.

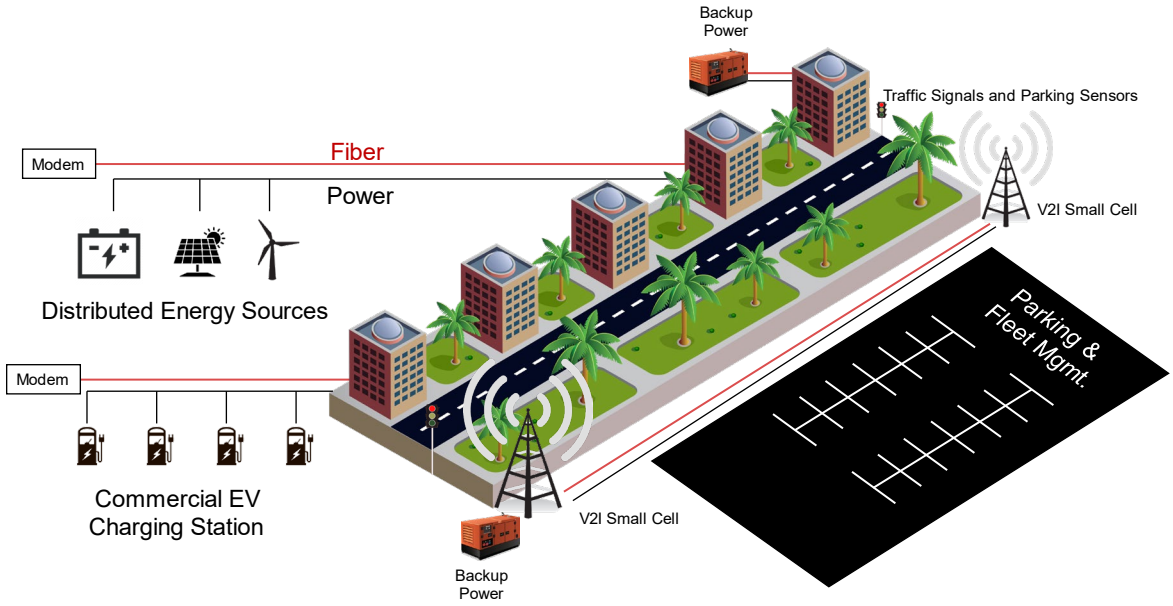

Figure 2 - Point of convergence of broadband and energy in urban areas

In this context, V2I communication enables:

- Addressing traffic safety, congestion issues, and traffic signal management
- Parking and fleet management

- Transformation of public transit
- Transformation of package delivery
- Broadband connectivity to autonomous vehicles (in motion)
- Grid monitoring at the transportation V2I small cell location

Urban EV charging infrastructure enables:

- Grid monitoring at the charging station
- Security monitoring at the charging station (safety concern)
- Secure broadband services for autonomous EV connectivity (stationary)
- Two-way power transactions between grid and EVs

Vehicle charging and distributed energy sources at the commercial building or MDU enables

- Grid monitoring at the enterprise
- Grid management for enterprise-based energy sources (solar, battery, EV, etc.)
- Automated Demand Response (ADR) for the enterprise
- Secure broadband services for enterprise
- Secure broadband services for grid monitoring/management and autonomous EV connectivity (stationary)
- Commercial visibility into energy consumption & contribution

Similarly, there are construction synergies (dig once for resiliency) during construction or maintenance of transportation infrastructure.

4.1. Convergence in Rural Areas

Lastly, there will be convergence in rural locations that will be driving by engagement with devices while in transit and shifting population with a reimagining of the future of work with recent technology and behavior shifts. The figure below shows the points of convergence across Rural areas.

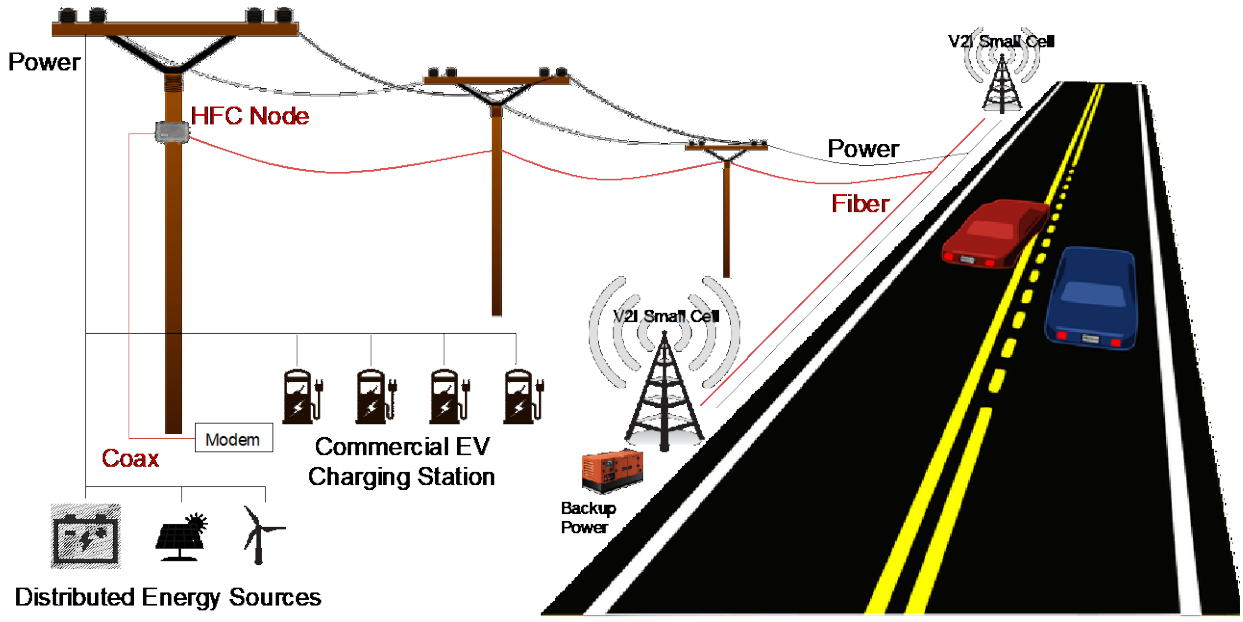

Figure 3 - Point of convergence of broadband and energy in rural areas

Like the Urban and Suburban contexts, V2I Vehicle to infrastructure communication enables:

- Addressing traffic safety and congestion issues
- Transformation of long-distance public transit
- Transformation of long-haul shipping
- Broadband connectivity to autonomous vehicles (in motion)
- Capability to identify and reserve charging stations (in motion)
- Grid monitoring at the transportation V2I small cell location
- Middle mile broadband connectivity for rural communities

As in the previous context, there are construction synergies (dig once for resiliency) during construction or maintenance of transportation infrastructure.

5. Conclusion

As noted in the Introduction, we are at a unique point in time to maximize the impact of investment into smart infrastructure across three major industries. This impact can only be fully realized through cross-industry collaboration. While we do not minimize the challenges of this kind of cross-industry collaboration, we do know that collaboration cannot occur unless the lines of communication are opened, both literally and figuratively.

CableLabs has a long history of creating standards and specifications to leverage communications infrastructure across broad markets. As the electrification of the transportation markets evolves, CableLabs is an ideal point of interface to ensure the communications networks are prepared to deliver the underlying protocols, transport, security, reliability, and resilience of this critical infrastructure.

Abbreviations

IIJA	Infrastructure Investment and Jobs Act
HFC	Hybrid Fiber-Coax
DERS	Distributed Energy Resources
V2I	Vehicle to Infrastructure
ADR	Automated Demand Response