SCTE STANDARDS
JOURNAL

VOLUME 1 NO. 2 SEPTEMBER 2021

SCTE TECHNICAL JOURNAL

SCTE
a subsidiary of CableLabs®

Table of Contents

Editorial Correspondence: If there are errors or omissions to the information provided in this journal, corrections may be sent to our editorial department. Address to: SCTE Journals, SCTE, 140 Philips Road, Exton, PA 19341-1318 or email journals@scte.org.

Submissions: If you have ideas or topics for future journal articles, please let us know. All submissions will be peer reviewed and published at the discretion of SCTE. Electronic submissions are preferred, and should be submitted to SCTE Journals ,journals@scte.org.

Foreword

One of our industry's biggest success stories in recent years is how cable broadband has become the preeminent foundational platform that makes Internet communications, information and applications possible. More and more, the innovations of cable and Silicon Valley have worked in parallel to enrich the lives of consumers.

Like SCTE Cable-Tec Expo next month, our SCTE Technical Journal reflects that enormity of purpose with a diverse mix of topics covering existing infrastructure, emerging technologies, and the applications that will run across our networks. This latest edition of the quarterly volume includes articles on cable's bread-and-butter sectors – the access network and video – as well as next-generation data and AI/ML capabilities and the layers of new services they enable. Here's how the lineup shapes up:

- **Drivenets' Clayton Wager** takes you deep inside Distributed Disaggregated Chassis networks, including technical and business impacts and physical placement and power consumption advantages.
- Longtime contributor **Robert Cruickshank and the team at GRIDIoT** explain how electric load sensing, forecasting and shaping can open up new markets for the industry.
- **NCTA's Matt Tooley, Piracy Monitor's Steve Hawley, and Charter's Kei Foo** outline how AI/ML can arm the industry against piracy.
- **Charter's Srilal Weera** bridges cable's present and future with a piece on the technical intricacies of digital advertising and video metadata
- **CableLabs' Andy Dolan** discusses how Wi-Fi Alliance Easy Connect can streamline onboarding for Open Connectivity Foundation IoT specification devices.
- **Sudheer Dharanikota, his team at Duke Tech Solutions, and Cox Communications' Bruce McLeod** weigh in with two articles on telehealth: the business case and the market landscape for cable operators.

There is also a letter to the editor from **Cox Communications' Kristina Waters** and **Ubuntu's Ananya Gupta** posing novel ideas regarding the age-old problem of recycling coaxial cable.

We'd like to express my gratitude to all those who contributed to this month's edition, as well as those who will be speaking on scores of relevant topics next month at Cable-Tec Expo. We urge you to take advantage of this Journal, the virtual Expo program, and all of the resources that make SCTE so valuable to our industry. At the same time, we hope you will consider authorship in a future edition of the SCTE Technical Journal. Working together and sharing expertise is vital to the continued ability of our technical workforce to achieve new objectives.

Thanks for your participation in SCTE; we look forward to connecting with you during Expo and in the future.

The SCTE Editorial Staff

SCTE STANDARDS
JOURNAL

SCTE
a subsidiary of CableLabs®

Optimization of Electric Load Shaping, Sensing, and Forecasting

A Guide to Operational Savings and New Business Models

A Technical Paper prepared for SCTE by

Dr. Robert F. Cruickshank, III, CTO, GRIDIoT® by RCA, SCTE Member
132 Cruickshank Rd #269
Big Indian, NY 12410
rfciii@cruickshank.org
+1-703-568-8379

Laurie Asperas-Valayer, CSO, GRIDIoT by RCA, SCTE Member
AsperasValayer@gmail.com
+1-631-335-9197

Francis R. Sandoval, Principal, GRIDIoT by RCA, SCTE Member
francisrsandoval@gmail.com
+1-720-338-1988

James Sandoval, Architect, GRIDIoT by RCA
sandoval.jim@gmail.com
+1-435-602-0046

Table of Contents

Title **Page Number**

List of Figures

Title **Page Number**

List of Tables

Title **Page Number**

Abstract

In the face of increasing demand for electricity and extreme weather events, the aging electric grid is increasingly failing to provide broadband operators and society at large with safe, low-cost, reliable power. During droughts, sparks from failing power lines start wildfires that disrupt operations and result in loss of life and property. Similarly, during severe heat waves and cold snaps, electricity supply can't meet increased demand and utilities are forced to use rolling blackouts that interrupt broadband services and result in catastrophic losses. Building more power generation, transmission, and distribution infrastructure hasn't resulted in a more resilient grid or more reliable power—but it has raised the cost of electricity. To reliably support broadband operations and enable new business models, what's needed are new solutions that monitor the grid and enable the demand for electricity to be shifted in time to follow the cleanest and lowest-cost supply. Time-shifting creates economic value by discouraging consumption at certain times and encouraging consumption at other times, thereby creating virtual power plants that optimize and extend the life of existing grid assets. Furthermore, time-shifting reverses the supply-follows-demand relationship by allowing flexible demand, such as battery storage, to anticipate and follow supply. The goal of this work is to empower the broadband industry with software-centric technologies that increase network reliability and reduce the cost of broadband operations while spearheading profitable business models that scale quickly to modernize the global electric utility ecosystem while reducing harmful heat and carbon emissions.

1. Introduction

It is evident that severe weather and the ongoing electrification of the world will cause the global demand for electricity to increase by nearly 2/3 through 2040.[i] One might argue that the increased use of renewable generation will decrease the cost of electricity, but there is mounting evidence that without modifying the way electricity is distributed and used, increases in renewables can lead to higher costs.[ii] [iii] [iv] [v]

Case in point, today's energy management technology uses storage and time-of-use pricing to control load. Yet, the increased demand for cheap electricity can cause grid congestion when prices are low and then raise prices to unreasonable highs when energy is less available, as in the February 2021 Texas Power Crisis.[vi] It has become evident that load control technologies need to evolve to provide cost effective energy management. Moreover, it has been suggested that network-enabled virtual power plants that aggregate renewables, batteries, and flexible loads could be orchestrated to mitigate grid congestion.[vii] [viii] [ix]

Indeed, in a multi-industry approach, all stakeholders will have to take measures to better manage energy generation, procurement, distribution, and use. Furthermore, the U.S. Department of Energy's latest play for connected communities and consumer-side energy management will necessitate new communications tools to orchestrate operation of the grid. The broadband industry is strategically positioned to help monitor and manage the grid, identify congestion, improve load forecasts, optimize loads, and provide benefits directly to its operations, other industries, and utilities.

2. Load Shaping for Broadband Operations

Much of the increase in the cost of electricity for operations will come from the construction of backup power systems and from charging the exponentially increasing number of batteries throughout the broadband operator infrastructure in electric vehicles, depots, data centers, customer care facilities, and neighborhood power supplies.

2.1. Batteries and Thermal Storage: A Partial Solution

Batteries are increasingly taking on the role of grid-interactive flexible distributed energy resources (DERs). In an instant, and without prior planning, batteries can flexibly switch from charging to discharging, taking power from the grid, or giving power back. Yet, as the broadband industry increases its use of batteries and thermal energy storage, such as water heating and air conditioning, to reduce electricity costs, a new problem will emerge: Without supervisory control, batteries can be charged using any energy resource, not necessarily a least expensive or renewable resource.[x]

2.2. Status Quo in Orchestrating Supply and Demand

To date, the status quo in the orchestration of supply has focused on faster automatic transfer switches that ensure uninterrupted power will be available to many loads in broadband operations such as servers, air conditioning, hybrid fiber-coax (HFC) nodes, and amplifiers. Transfer switches allow backup power to come online quickly in the event of grid outages but do so in a binary on/off fashion, switching batteries and generators on whenever the grid shuts off—and vice versa.

To date, the technology to manage demand has focused on powering only critical loads during grid outages. As such, non-critical loads remain unpowered during outages, thus reducing the loads on batteries and local standby generators. So-called “transactive energy” and “automatic demand response” often have complexities that require close cooperation with utilities, and have promise, but have only seen very limited deployment since their introduction nearly 20 years ago. What’s been missing until now is rapidly scalable technology to continuously orchestrate both supply and demand in real-time across DERs to cost-optimize purchases of electricity from utilities and reduce carbon footprint while improving the resiliency of broadband microgrids.

2.3. Continuous Load Shaping

It should be noted that a distinction in jointly optimizing supply and demand is that the flow of electricity should be considered infinitely variable in time, as opposed to the binary instantaneous on/off operation of emergency backup power that is in widespread use today. More specifically, using an infinitely variable 24/7 paradigm, the load from charging storage is continuously modulated—and even reversed to aid in supply—as batteries cycle between charging and discharging to meet the emergency and the non-emergency day-to-day needs for electricity.

2.4. Wholesale Time-of-Use (TOU) Electricity Pricing

Today, in the U.S. there are some 3,200 electric grid distribution system operators (DSOs) that deliver power to residential, commercial, and industrial consumers. Most DSOs and other large consumers of electricity do not have generation assets and must purchase wholesale electricity from one or more independent system operators/regional transmission operators (ISOs/RTOs) shown in Figure 1.

Figure 1 - U.S. Independent System Operators/Regional Transmission Operators

It is important for broadband providers to understand that within an ISO/RTO geographic area, the wholesale price of electricity varies spatiotemporally by hour and day across tens of thousands of nodal locations in the grid. For example, Figure 2 shows average hourly pricing across all nodes in the Southwest Power Pool (SPP).

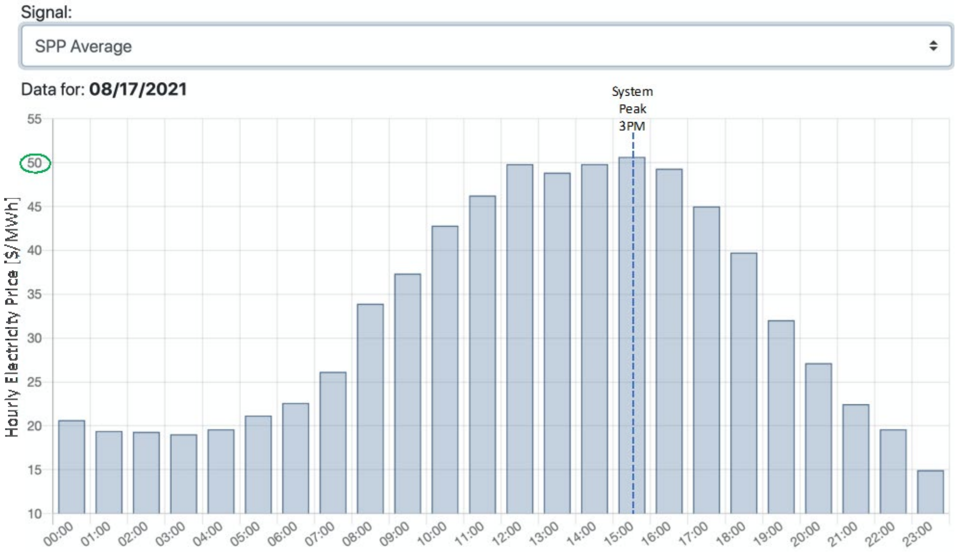


Figure 2 - Hourly Wholesale Electricity Pricing in the Southwest Power Pool

In Figure 2, note the roughly $50/MWh peak price of electricity at 3 PM. Local times are shown in Figure 2 and Figure 3. To provide a sense of spatiotemporal differences across the U.S., Figure 3 shows average pricing in 9 different U.S. regions with peak pricing reaching nearly $100/MWh during the evening in California. In Figure 3, a miniature of Figure 2 is included at the upper left for reference, and the vertical lines at 3 PM aid in comparing differences in regional pricing.

Figure 3 - Hourly Wholesale Electricity Pricing Across 9 U.S. Regions

In Figure 3, note the different shapes and times of peak pricing. By modulating individual loads, broadband operators can shift demand to the times of the day with lower electricity prices and/or lower carbon emissions.

2.5. ANSI SCTE 267 2021 Cost-Optimized Load Shaping

Referring to Figure 2, broadband providers can reduce their electricity cost by purchasing less electricity during the day and more electricity in the overnight, early morning, and late evening hours. To reduce cost, what is needed is a simple and scalable way to shift load away from peak hours to off-peak hours using a cost-optimized load shape as shown in Figure 4.

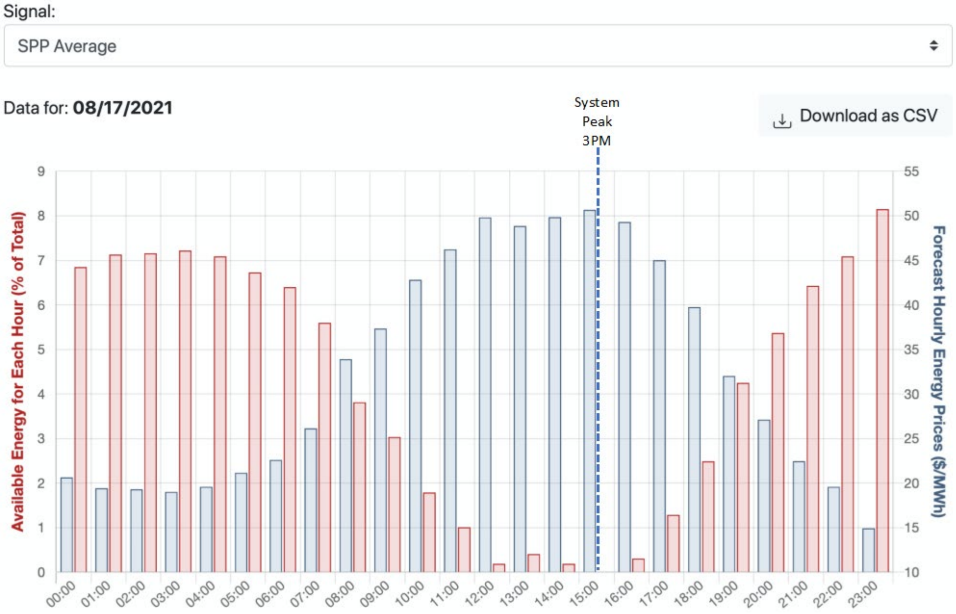


Figure 4 - Example Cost-Optimized Load Shape Based on Hourly Pricing

In Figure 4, the red bars (with the scale at left) denote an example of one possible cost-optimized load shape and blue bars (with scale at right) denote the same hourly wholesale electricity price in the Southwest Power Pool shown in Figure 2. *In* Figure 4*, note the minimization of load during peak hours, which reduces electricity costs.*

Figure 2, Figure 3, and Figure 4 provide insights as to how broadband providers can orchestrate demand to follow the lowest cost supply. To rapidly reduce the cost of electricity for all stakeholders in the energy value chain, a programmable infrastructure was created to harvest ISO data and convert it to an Optimum Load Shape (OLS) signal that complies with the U.S. National Standard ANSI SCTE 267 2021.[xi] For the cost-optimized use case in Figure 4, the newly created OLS server uses ISO day-ahead pricing forecasts to produce a signal that orchestrates demand to follow the lowest cost supply. To simplify and accelerate cross-industry adoption of OLS technology, wholesale pricing and cost-optimized load shapes for nearly 22,000 grid transmission interconnection points covering the vast majority of the U.S. are now available at a single IP Address via an OLS Signal interactive viewer and application programming interface (API).[xii]

For example, broadband providers may use any number of OLS clients that interface with the OLS API, to retrieve forecast optimum load shapes and then autonomously shape their load to reduce their electricity bills and carbon footprint—while also reducing their utilities' electricity production costs and extending the life expectancy of the generation, transmission, and distribution infrastructure.

OLS signals will be increasingly important in the charging of broadband's emerging fleet of electric vehicles (EVs).[xiii] An example of OLS-enabled savings in charging EVs shown in Table 1.

Table 1 - OLS-Enabled Savings

	EV Optimum Load Shape	→	Shaped EV Load	Unshaped EV Load	Retail ¢/kWh	Shaped ¢/h	Unshaped ¢/h
Midnight	7.3%		0.73	-	15.1	11.1	0.0
1	7.3%		0.73	-	14.4	10.5	0.0
2	7.2%		0.72	-	14.2	10.2	0.0
3	7.1%		0.71	-	14.4	10.2	0.0
4	7.0%		0.70	-	15.2	10.7	0.0
5	7.5%		0.75	-	15.4	11.5	0.0
6	7.1%		0.71	-	16.8	11.9	0.0
7	The vehicle is in use and unavailable for charging from 0700 - 1800 hours. The charger takes unavailability into consideration and autonomously adjusts the Optimum Load Shape that it received from the supply-side.				19.8	0.0	0.0
8					19.4	0.0	0.0
9					19.6	0.0	0.0
10					18.2	0.0	0.0
11					17.9	0.0	0.0
Noon					16.5	0.0	0.0
13					16.7	0.0	0.0
14					17.5	0.0	0.0
15					18.4	0.0	0.0
16					19.9	0.0	0.0
17					20.1	0.0	0.0
18	8.3%		0.83	7.00	22.2	18.5	155.3
19	9.2%		0.92	3.00	19.1	17.7	57.4
20	8.9%		0.89	-	18.7	16.7	0.0
21	8.3%		0.83	-	18.0	15.0	0.0
22	7.4%		0.74	-	18.4	13.5	0.0
23	7.3%		0.73	-	16.8	12.3	0.0
Totals →	100%		10.00	10.00	**Cost→**	**$ 1.70**	**$ 2.13**
			kWh	kWh	**Savings→**	**$ 0.43**	**$ 157.03**
					20%	**per/day**	**per/year**

In Table 1, the EV requires a total of 10 kilowatt-hours (kWh) per charge. Starting at the left of Table 1, using an OLS signal (in purple), the charge controller modulates the rate of charge during all the hours that the vehicle is plugged in and available for charging. Multiplying the rate of charge for shaped load (in blue) and unshaped load (in black) by the hourly retail electricity price results in costs at right. An estimated per vehicle charging savings of 20% is shown at bottom right. Table 1 savings are based on the OLS example in Figure 2 of ANSI SCTE 267 2021.[xi]

3. A New Lucrative Triple Play: Optimization of Load Shaping, Sensing, and Forecasting

Looking beyond broadband operations to new business models, the importance of OLS is that its cost-saving benefits dramatically increase with scale. Soon, most companies and homes will have EV charging stations, and broadband is a logical choice to ensure OLS signals are delivered to these and other electrical devices. In traditional cable TV parlance, think of broadcasting: Time, temperature, and OLS. Table 2 provides a sense of the far-reaching applications of OLS in grid and microgrid use cases.

Table 2 - OLS Use Cases in the Utility Ecosystem

Use Case	Min Gen Cost	Max Asset Utilization	Max RES	Min Energy Charges	Min Demand Charges
1. Generation	●	●	●		
2. Transmission		●			
3. Wholesale Purchaser			●	●	●
4. Distributor		●			
5. End User				●	●
6. Utility-tied Microgrid	●	●	●	●	●

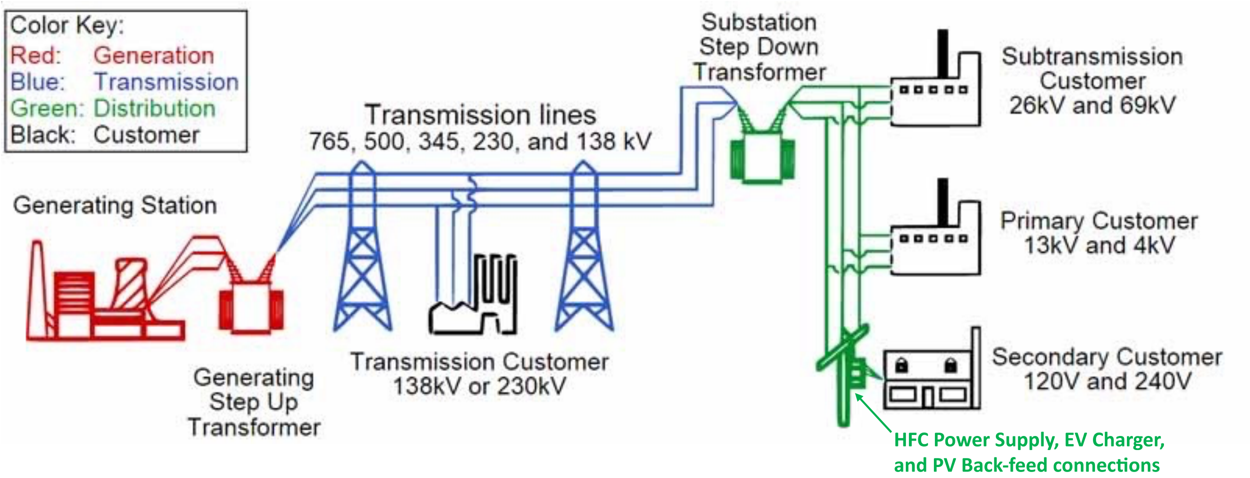
In Table 2, green dots denote the many objectives of OLS such as: minimizing cost and/or carbon emissions; maximizing utilization of generation, transmission and distribution assets; maximizing the use of renewables; and minimizing energy and demand charges. In all use cases, a primary benefit is that OLS client devices can achieve the objectives of any OLS use case, as each client device operates independently of the OLS source.

3.1. Business Model 1: Sell Delivery of Load Shaping Signals

In a new service offering that extends the reach of OLS, broadband operators can distribute the ISO cost-optimized OLS signals (the same signals that are used in broadband operations) across broad geographic areas to commercial and residential consumers, so they can reduce their cost of electricity. Without adding new software or special logic, broadband operators can leverage their existing processes to use managed Wi-Fi routers to confirm that shapes are delivered to connected devices such as batteries, vehicle chargers, water heaters, air conditioners, and commercial refrigeration systems. Like managing DERs in broadband operations, OLS signals modulate the charge and discharge of batteries and other forms of energy storage. In addition, widely distributed OLS signals will allow for new applications, such as OLS-managed battery-backed EV chargers that ensure vehicles are always charged with renewable energy. The “Extending OLS” business model reduces energy costs throughout the energy value chain, and broadband operators can get a portion of savings from utilities.

3.2. Business Model 2: Sell Sensing for Distribution Grid Segments

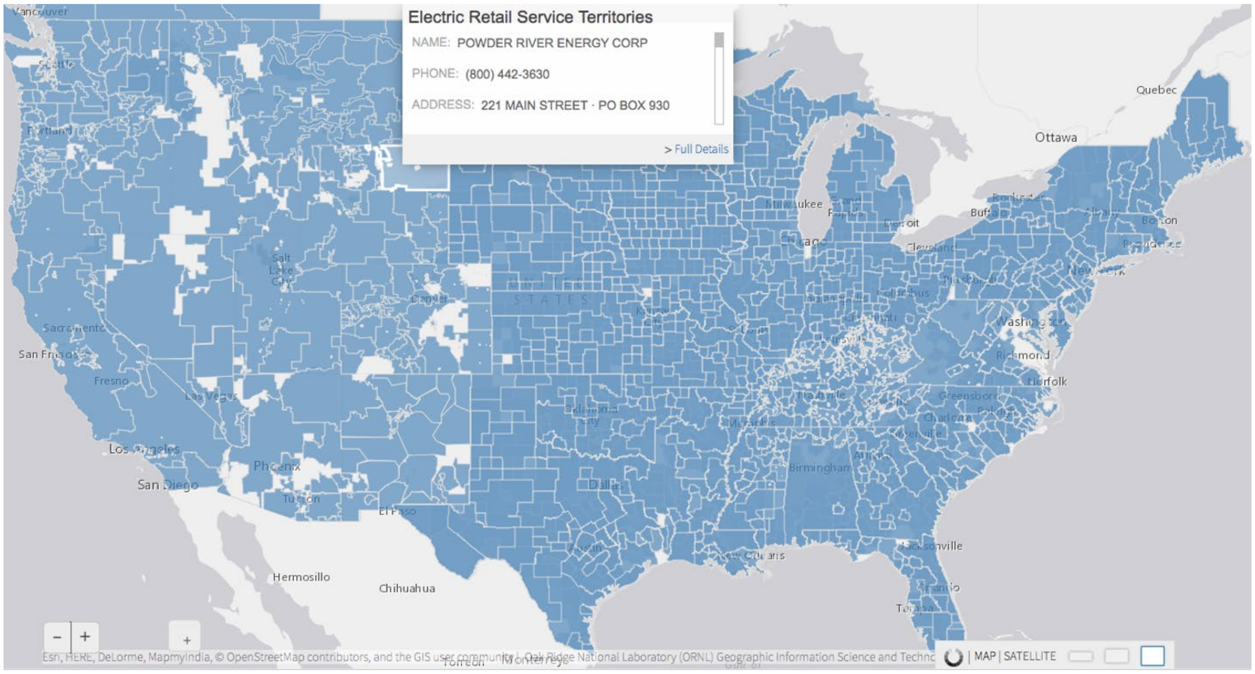
The distribution portion of the global power grid is sensor-starved and ill-equipped to monitor changes in load that result in grid congestion, overheating, outages, and costly hardware upgrades. What is needed for coordination and control are robust and secure communications which rapidly propagate changes in load to provide utilities with real-time data that quantify grid congestion. Distribution networks are vastly distributed infrastructures; their place in the overall grid is shown in Figure 5, which does not reflect their enormity.



HFC Power Supply, EV Charger, and PV Back-feed connections

Figure 5 - Grid Pictorial[xiv]

In Figure 5, red depicts generation, blue depicts transmission networks that make up 3.5 % of the grid, and green depicts distribution networks that make up 96.5% of the grid—and require continuous load monitoring as DERs are added. Fortunately, broadband providers have relationships with thousands of utilities each of which maintains distribution networks. In the U.S. alone there are nearly 3,200 distribution networks spanning 5 million miles. Figure 6 provides a sense of the relative shapes and sizes of distribution networks.



Electric Retail Service Territories

NAME: POWDER RIVER ENERGY CORP

PHONE: (800) 442-3630

ADDRESS: 221 MAIN STREET · PO BOX 930

Figure 6 - U.S. Distribution System Operator Territories[xv]

Broadband's capability to provide real-time notification of voltage changes is a perfect complement to the wireless mesh and other network technologies that utilities use to monitor and manage the grid. For example, in the face of increasing cyberattacks designed to cause voltage fluctuations that destabilize and bring down the grid, broadband is the highest-performance out-of-band alternative to assist utilities in monitoring the grid in real-time.

Like canaries accompanying coal miners, the broadband network follows the grid's secondary distribution network everywhere it goes—and already provides early warning signs of some grid issues. Today, all broadband network elements are plugged in to the grid and battery backed, and many act as grid power quality sensors. For example, there are already nearly a million HFC power supply voltage and inverter sensors in the Americas and another million or so throughout the world. A new commercially available innovative grid monitoring application based on existing broadband sensors is already providing tremendous value and is drawing attention from multiple industries and government entities.[xvi]

3.3. Business Model 3: Sell Forecasts of Loads, Flexibility, and Congestion

To efficiently manage grid infrastructure capital expenditures, utilities will increasingly need comprehensive spatiotemporal forecasts of load, flexibility, and congestion at millions of points throughout the distribution network. Broadband operators can leverage the data from sensors to create hyper-local forecasts to sell to DSOs, for example, identifying where EV chargers will be causing dangerous grid overloads and brownouts. Using machine learning—in hierarchical edge and cloud-based signal processing of sensor readings—broadband operators can identify the impact of weather, local habits, and myriad other factors. Forecast errors can be reduced over time, year over year to create Optimal Load Forecasts.

4. Conclusion

The broadband industry faces increasing energy costs and decreasing grid reliability—and can seize the opportunity to implement load shaping to improve network reliability and technical operations. In addition, the broadband industry can build lucrative businesses in load sensing and forecasting that redefine energy management on a global scale. Moreover, as more residences and businesses produce as well as consume electricity (i.e., become prosumers), the connectivity and sensing capabilities of broadband will enable seamless management of efficient energy transactions and uses—thereby supporting current trends in connected communities and customer-side energy management.

The development of new business models will allow for more onsite energy production, distribution, and use of renewable energy sources like wind, solar, hydro, and geothermal power. New business models provide direct tangible economic value in a) load shaping (selling virtual energy and capacity as well as the delivery of OLS signals to the masses), b) hyper-local load sensing (selling data to DSOs), and c) hyper-local load forecasting (selling forecasts to DSOs). New business models also allow utilities to avoid capital upgrades and extend the life of the grid, thereby improving the reliability of broadband and energy services.

It's now or never. New broadband standards and innovations are paving the way for lucrative opportunities in both operations and business development. First, load shaping creates clean and mighty virtual power plants that create economic value by mitigating congestion, favoring renewables, and raising the efficiency of generation to achieve 20% savings in charging EV and facility batteries. Second, sensing of power quality in the grid and HFC networks aids in outage prediction and coordination between utilities and broadband providers—and improves the customer experience and network reliability by streamlining troubleshooting and restoration efforts. Third, forecasting predicts load, flexibility, and voltage sags due to congested power flows. With the right investments and Federal and State grants, standards-based broadband innovations can reduce broadband and other industries' operational and capital expenditures. Indeed, broadband can outperform proprietary solutions in modernizing the grid.

5. Abbreviations and Definitions

5.1. Abbreviations

API	application programming interface
CAISO	California Independent System Operator
DER	distributed energy resource
DSO	distribution system operators
ERCOT	Electric Reliability Council of Texas
EV	electric vehicle
HFC	hybrid fiber-coax
ISO	independent system operator

ISO-NE	Independent System Operator – New England
kWh	kilowatt-hour
MISO	Midcontinent Independent System Operator
NYISO	New York Independent System Operator
OLS	Optimum Load Shape
PJM	Pennsylvania, Jersey, Maryland Independent System Operator
MWh	megawatt-hour
RTO	regional transmission operator
SCTE	Society of Cable Telecommunications Engineers
SPP	Southwest Power Pool
TOU	time-of-use

5.2. Definitions

Optimum Load Shape	A set of numbers that specify the percent of total energy to be used in each time period
time-of-use	A rate for electricity with cost that varies, e.g., by hour of day

6. References

---

[i] International Energy Agency, World Energy Outlook, 2019, Stated Policies Scenario, https://www.iea.org/reports/world-energy-outlook-2019/electricity

[ii] Getting the Rates Right for a Public EV Charging Build-Out, https://www.greentechmedia.com/articles/read/getting-the-rates-right-for-a-public-electric-vehicle-charging-buildout

[iii] The Paradox of Declining Renewable Costs and Rising Electricity Prices, https://www.forbes.com/sites/brianmurray1/2019/06/17/the-paradox-of-declining-renewable-costs-and-rising-electricity-prices/?sh=7866599861d5

[iv] Why Aren’t Falling Renewables Costs Cutting European Energy Market Prices? https://www.greentechmedia.com/articles/read/why-arent-lower-renewable-costs-cutting-european-energy-market-prices

[v] Residential electricity price growth US 2022, https://www.statista.com/statistics/201714/growth-in-us-residential-electricity-prices-since-2000/

[vi] Fix Texas electricity — and hurry! https://www.utilitydive.com/news/fix-texas-electricity-and-hurry/603159/

[vii] Global EV Outlook 2020 – Analysis, https://www.iea.org/reports/global-ev-outlook-2020

[viii] Summary Report on EVs at Scale and the US Electric Power System, https://www.energy.gov/sites/prod/files/2019/12/f69/GITT%20ISATT%20EVs%20at%20Scale%20Grid%20Summary%20Report%20FINAL%20Nov2019.pdf

---

[ix] Propelling the transition: The battle for control of virtual power plants is just beginning, https://www.utilitydive.com/news/propelling-the-transition-the-battle-for-control-of-virtual-power-plants-i/581875/?%3A+2020-+12-+30+Top+Utility+Trends+%5Bissue%3A31552%5D=

[x] Electric Cars Would Save America Huge Amounts of Energy, https://www.bloomberg.com/graphics/2021-opinion-renewables-will-power-future-of-us-energy/

[xi] Optimum Load Shaping for Electric Vehicle and Battery Charging, https://www.scte.org/standards-development/library/standards-catalog/optimum-load-shaping-for-electric-vehicle-and-battery-charging/

[xii] OLS Blog, https://optimumloadshape.com/

[xiii] Summary Report on EVs at Scale and the US Electric Power System, https://www.energy.gov/sites/prod/files/2019/12/f69/GITT%20ISATT%20EVs%20at%20Scale%20Grid%20Summary%20Report%20FINAL%20Nov2019.pdf

[xiv] Adapted from https://www.researchgate.net/figure/Overview-of-the-traditional-electric-power-system_fig1_321722658

[xv] Cable TV Opportunities in Electric Grid Modernization, Robert Cruickshank, Anthony Florita, Bri-Mathias Hodge., U.S. Department of Energy, National Renewable Energy Laboratory, 2017

[xvi] Gridmetrics Inc., https://gridmetrics.io/

SCTE STANDARDS JOURNAL

SCTE
a subsidiary of CableLabs®

140 Philips Road | Exton, PA 19341-1318 | 800.542.5040 | scte.org