NARUC
National Association of Regulatory Utility Commissioners

Regulator's Financial Toolbox Brief: Operational Communications Networks for Grid Edge Technology Integration

The National Association of Regulatory Utility Commissioners (NARUC) Center for Partnership and Innovation (CPI) Financial Toolbox series explores the types of financial tools utility regulators can use to support integration of electricity system technologies that benefit the public interest. This brief was prepared by Chris Villarreal (Plugged In Strategies) and Kerry Worthington (NARUC CPI) under DOE Cooperative Agreement # DOE-OE0000818[1] *between NARUC and the U.S. Department of Energy.*

On August 10, 2021, NARUC CPI hosted a webinar on Communications Networks, featuring opening remarks from moderator, Chair Gladys Brown-Dutrieuille (Pennsylvania Public Utility Commission), and presentations from Anterix, Xcel Energy, Taconic Advisory Services, and Newport Consulting Group. The speakers' biographies and presentations and August 10, 2021, recording are located at www.naruc.org/cpi-1/electricity-system-transition/valuation-and-ratemaking/.

The webinar and this accompanying brief address:

- Background on communications networks
- Visualizing the communications network on the electricity system
- Benefits of modern communication networks
- Considerations for utility regulators
- Status of adoption and barriers
- Resources for more detailed information

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Background on Communications Networks

Electricity system operators view communication networks as a vital component of understanding what is occurring on their systems because the information transmitted provides essential business and operational data about the systems and resources.[2] Without a communication network, it would be challenging for system operators to ensure that the electric system is operating safely and reliably.

Traditionally, wired and wireless communication networks have been used by centralized generating plants and substations for ensuring that power is flowing and during emergencies. For example, voice communications were an early technology for operators to monitor, control, protect, and balance the system and was especially used during restoration activities.[3] Communication technologies have strengthened operator response and aid in matching the predicted behavior of the grid with its actual status. Most of the grid is not automated and continues to require a human response and reaction to disturbances; however, newer devices have computational capacity and improved communications so that some automation is possible.

Today, for a variety of reasons beyond the scope of this brief, customers, the utility, third parties, and system operators may access more information to monitor and control the system and specific resources through sophisticated communication devices. Communication is necessary throughout the system, but this brief focuses on a distribution utility communicating with grid edge devices and programs such as customer meters, demand response, storage, solar PV, and other distributed energy resources (DERs). To connect the communications of grid edge devices, typically at the meter, the communication network is an important grid architecture layer that allows devices to transmit data.

The information contained on the grid edge communications network is vital for every phase of the power supply chain to be as aware as possible of system conditions. Being able to communicate with grid edge devices helps operators reliably and cost effectively integrate resources. Without this information, the utility is operating the system with only partial information (visibility of voltage swings, for example) and it may cause unusual conditions such as tripping feeders, reverse power flows, DERs pushing electricity onto the system at the same time as the operating utility, harmed DER inverters, or other unstable conditions that risk impacting reliability and safety. As such, connecting substations to communication networks allows for operational information to be shared with operators who can monitor power flows and communicate with resources (and other technologies and sensors), which becomes increasingly important as electric vehicles and rooftop solar, for example, proliferate across the system.

Case Study: Communications Benefits to Customer-Sited Solar

In 2013, the Western Electricity Industry Leaders (WEIL), in-part inspired by a costly retrofit program in Germany, issued a call for the standardization of advanced, “smart,” inverter functionalities and communication protocols, specifically for customer-sited solar installations. By defining the operations of functions and enabling new functions, an advanced inverter may avoid additional investment by utilities and customers and minimize impacts from otherwise unmonitored solar installations.

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[2] Modern Distribution Grid, Volume 2, Version 1.1 at 50. https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-II_v1_1.pdf.

[3] For more details on communications technologies, please visit the NARUC Interoperability Learning Module on Introduction to Communications Networks at: https://www.youtube.com/watch?v=mbOoKyZyLec

Unmonitored solar could negatively affect itself, the surrounding grid, and neighboring devices unintentionally; and in normal conditions, make the grid unpredictable to an operator due to intermittent power flow.

The WEIL call provided significant momentum for the updating of the IEEE 1547 standard, which addresses interconnection of distributed solar and storage. Updates to 1547, cataloged under IEEE 1547-2018, have been adopted by the electric industry to ensure that a customer resource is online and not affecting neighboring devices. Advanced inverters assist with grid-balancing by sensing voltage changes, frequency disruptions, preventing other power quality problems, preventing power safety issues such as the solar PV feeding power to a de-energized line, and allowing "low-voltage ride-through." These functionalities strengthen grid reliability, prevent local power outages, and foster adoption of distributed technologies, and are enabled with two-way communication.[4]

Visualizing the Communication Network on the Electricity Network

Information may traverse the customer, the substation, the back office of the utility, and back to the customer. The communications network may be used for customer metering, grid operations, and the use of DERs and tele-protection systems. Modern networks may be leveraged for multiple uses, referred to as converged networks in telecommunications.[5] Considering the communications network as a part of a holistic and integrated system is a new way to view the electricity system and communications. For example, with increased rooftop solar PV and the need for protection, differential relays are replacing impedance relays, which requires a different way to communicate.

The Smart Grid Conceptual Model developed by the National Institute for Standards and Technology (NIST), shown below in ***Figure 1***, provides a visual of the paths of a communications network for the entire electricity system.[6] Here, communications are represented by solid blue lines, while electricity flows are represented by dashed lines. Communications touches every part of the grid and its domains, even if electricity flow is not present, such as between the operator and service provider. As shown in the NIST Framework Version 4.0, the electricity system is undergoing an evolution where distribution is taking on greater importance, which is illustrated by the distribution domain shifting to the center of the diagram. Ensuring that the existing electricity system is prepared for the changes occurring on the distribution system, and adding a communications network to respond to those changes, requires organization and consideration of a new architecture to understand the relationships and hierarchies between and inside domains and the impacts of those relationships on electricity and communications systems.

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[4] https://www.greentechmedia.com/articles/read/western-utilities-call-for-smart-solar-inverters

[5] "Regulators' Financial Toolbox: Communications Networks," NARUC Center for Partnerships and Innovation, Presentation by Paul De Martini at slide 10 (August 10, 2021) ("Regulators' Financial Toolbox Communications Networks for DER Integration"). Available at: https://pubs.naruc.org/pub/E6208D86-1866-DAAC-99FB-9F3D47BA95F2

[6] Framework and Roadmap for Smart Grid Interoperability Standards, Release 4.0, National Institute on Standards and Technology at 13 (February 2021). https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1108r4.pdf.

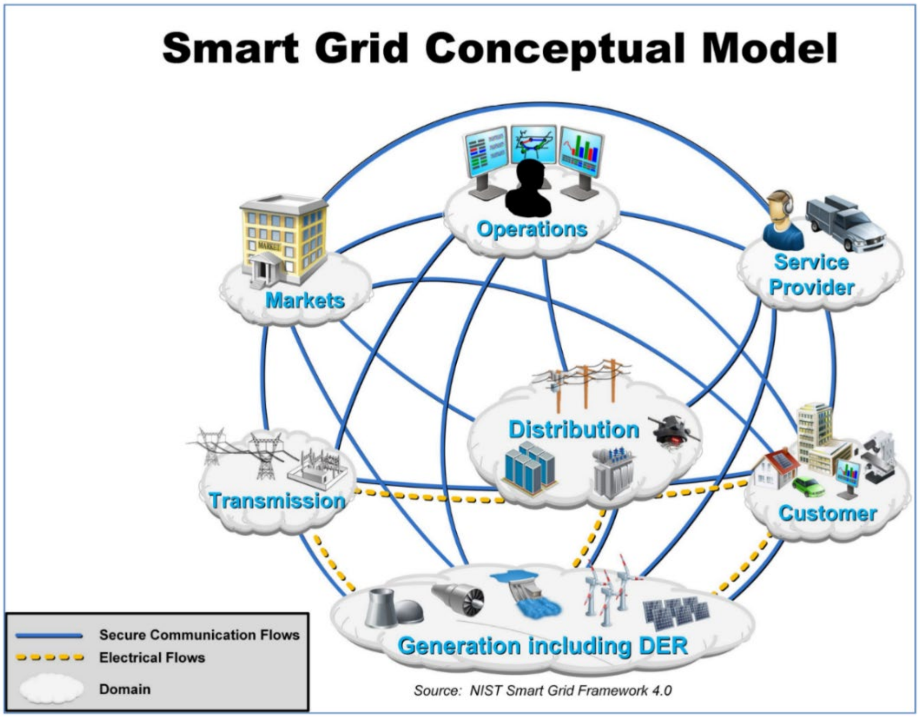

Figure 1 – NIST Smart Grid Conceptual Model, Release 4.0 (2021)[6]

In the architecture shown in ***Figure 2*****,** the communication network is organized into three components: the Neighborhood Area Network (NAN), Field Area Network (FAN), and the Wide Area Network (WAN). Inside each cloud is a set of technologies, controls, standards, and systems responsible for ensuring that devices inside the cloud can communicate and, at certain points, can interact with the Field Area Network. The FAN sits at a critical point as the network responsible for organizing communications within its own cloud, but also to ensure that messages, signals, and information is shared with both the WAN – which is more organizationally situated – and the NAN – which is situated on the grid edge. (See box for definitions.)

These communications can be enabled over entirely wired, or fully wireless, or a combination of wired and wireless communication networks. Although fiber has traditionally been rolled out to generating plants, wireless is graining traction for distributed energy resources due to the number of endpoints.[7]

This communications architecture is a way to logically organize both the physical assets and resources across the utility system, but also the communications networks of the utility. In other words, by organizing its systems and networks into these sets, the NAN, FAN, and WAN, utility divisions can operate independently of each other for certain tasks, but also share information necessary for the operations of the other. If a neighborhood loses power, for example, then the NAN would transmit that information to the FAN, which would then be able to respond and support the NAN, but also share that information with the WAN, which could then bring on additional resources from beyond the immediate

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[7] NARUC CPI Regulators' Toolbox: Communications Networks, Andrew Bordine, Anterix, https://www.youtube.com/watch?v=HMRDJH1WOZU

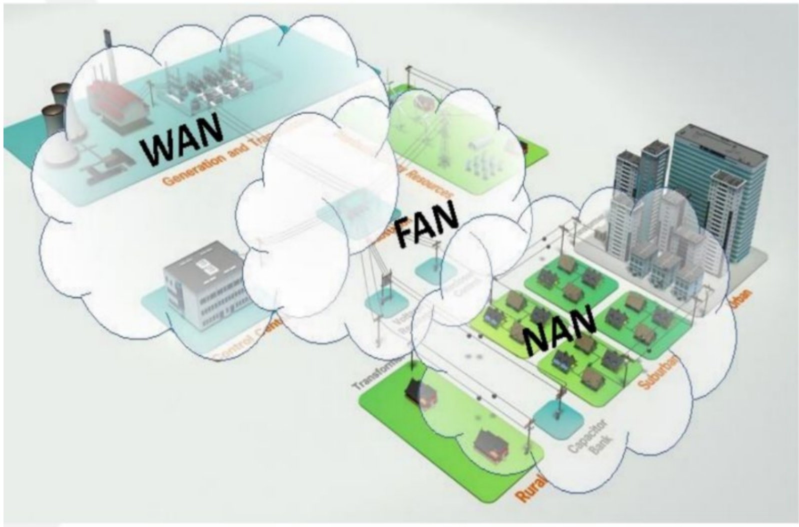

Figure 2 – Example of communications network architecture (Di Martini, Slide 11, Regulators' Financial Toolbox: Communications Networks.)

Terminology[8,9]

Wide Area Network (WAN) - Transmits organization information and voice communications as well as grid operations, which primarily involves grid operational information, and controls and protection signals. The WAN covers an entire service area, linking substations, and operating or control centers and may also provide the two-way network needed for SCADA, and points of presence for interconnection of FANs and specific high bandwidth and/or low latency applications.

Field Area Network (FAN) - Connects the NAN with the WAN by providing a link to transmit data, signals and other (backhaul services) from NAN concentrators or access points to WAN points of presence. Interconnection between substations is provided by the WAN. Substations may provide the physical location of a WAN point of presence used by the FAN. FAN services also include low latency and peer-to-peer (P2P) communications for protection and control.

Neighborhood Area Network (NAN) - Supports information flow for grid edge devices (e.g., smart meters or DA devices) and the FAN. It enables data collection from customers in a neighborhood for transmission to a control center. NAN enables a range of smart grid applications, such as smart metering, service disconnect switches, and power outage notification messages.

Node - A point on the system that communicates information.

Public Carrier - A public entity that provides communications services to multiple entities under an existing license.

Private Carrier - An entity that provides its own communications services.

Broadband - Highspeed data transmission with high bandwidth; WAN and FAN are two examples of broadband networks.

Roam - The ability to use a communication device with a network outside of the utility territory.

Auto-sectionalizing - The ability for the system to sense a disturbance on the system and reroute electricity to maintain power.

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[8] Modern Distribution Grid (DSPx) Volume II: Advanced Technology Maturity Assessment. Available at: https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_II_v2_0.pdf

[9] NARUC Interoperability Learning Module on Introduction to Communications Networks. Available at: https://www.youtube.com/watch?v=mbOoKyZyLec.

area. This architecture then creates efficiencies in the operations of the physical electricity system through an organized communications architecture.

Case Study: Distribution Communication Network at Xcel Energy

Utilities use a combination of wireless and wired communications networks for monitoring and control. ***Figure 3*** is an example of such a combination, illustrating Xcel Energy's operational technology (OT) network structure for residential service. Xcel considers their OT network to be their fourth grid, following their distribution grid, transmission grid, and natural gas grid. Xcel has seen benefits from separating the OT network from their IT network for cybersecurity protection.

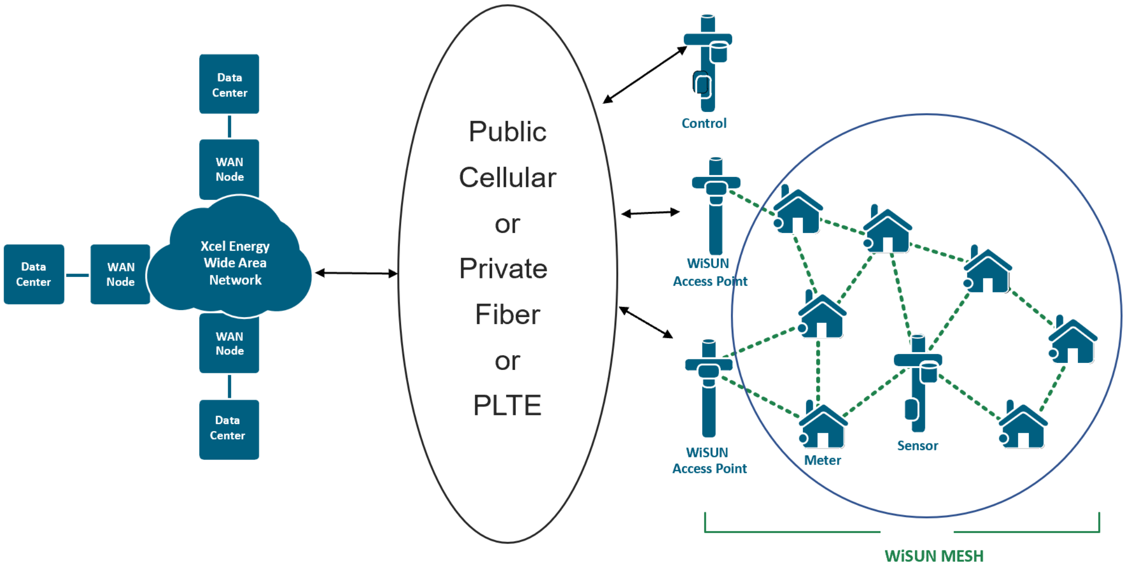

Figure 3. Xcel Energy's advanced metering infrastructure and integration with other utilities services, such as an Advanced Distribution Management System.[10] *(Xcel Energy, Slide 28, "Regulators' Financial Toolbox: Communications Networks.)*

Figure 3 shows a network architecture associated with Xcel's advanced metering infrastructure and identifies the several types of communication technologies that the utility can consider for its distribution system.

In this example, Xcel's Advanced Metering Infrastructure (AMI) system uses a wireless mesh network, where each meter communicates with the other meters. A mesh network is used for AMI meters to enhance the communication reliability and speed of the network at that point. In essence, a mesh network ensures that if one meter's ability to communicate is halted, other meters can step in to pass along relevant messages. Then, the mesh network communicates with an Access Point to deliver usage or other information collected by the AMI system.[11]

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[10] "Regulators' Financial Toolbox: Communications Networks," NARUC Center for Partnerships and Innovation, Presentation by Xcel Energy at slide 28 (August 10, 2021) Available at: https://pubs.naruc.org/pub/E6208D86-1866-DAAC-99FB-9F3D47BA95F2

[11] For more information on capabilities of AMI, see, "Voices of Experience: Leveraging AMI Networks and Data," Department of Energy, Advanced Grid Research (March 2019). Available at: https://www.smartgrid.gov/files/documents/VOEAMI_2019.pdf

From the Access Point, a utility could use wireless communication technologies (e.g., cellular networks, Long-Term Evolution (LTE), and point-to-point networks in rural areas) or wired communication technologies (e.g., fiberoptic cables) to transmit the relevant data to the utility operator, enabling visibility into the distribution system, assets, and resources, and, potentially, control of those assets and resources. The time it takes for the message to go from the meter to the FAN, to the WAN, and back to the meter could be costly whereas the neighboring meter can respond quickly to voltage changes, for example. The ability for the network to sense and respond to disturbances lends the distribution grid to be "self-healing."[12]

Wireless and wired networks can be provided by public (e.g., Verizon, AT&T, Level3) or private (e.g., utility-owned) carriers; deciding who provides the service and what a utility's communication network architecture will be likely hinges on two factors: costs of the technology and the speed in which a message must cross the communication network to be valuable (referred to as latency). Understanding ownership tradeoffs, such as costs and access, of these communications networks may be an issue that regulators face as utilities seek to build out and recover costs for communications networks.

As shown in the Xcel example (***Figure 3***), utilities can also operate a mixed system where some networks are private and other networks are public. How to mix and match these solutions can be reviewed by commissions to ensure a cost-effective implementation of a utility's communication architecture, while ensuring that reliability of both the electric system and communications network is not infringed. Xcel has implemented both solutions for a variety of reasons including costs, cost recovery, reliability, resilience, restoration, and the net costs of building the network.[13]

The WiSun standard was selected by Xcel because it adequately connects with DERs, batteries, or anything with a medium to low bandwidth requirement and medium latency requirement (latency being the time it takes for communication to occur). Xcel has about 12-18 months of experience rolling this network out in its Colorado and Minnesota territories.

Benefits of Modern Communications Networks

Communication networks were historically used to monitor and manage fundamental components of system operations – managing supply and demand and electricity system frequency. As the Xcel example shows, modern technologies are being adopted by customers and utilities that require greater visibility and intelligence than before. As such, modern communication networks handle additional tasks beyond operation of the system. Communication networks can now:

- Support integration of added resources (e.g., rooftop solar, electric vehicles, demand response) through enhanced visibility, monitoring, and control of distribution system operations;
- Prioritize emergency communications to ensure the safe operation of the system;
- Enable market operations and contract-based economic transactions between operators and suppliers;
- Support advanced computational capabilities and applications on grid-connected devices;

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[12] "Regulators' Financial Toolbox: Communications Networks," NARUC Center for Partnerships and Innovation, Presentation by Xcel Energy at slide 28 (August 10, 2021) Available at: https://pubs.naruc.org/pub/E6208D86-1866-DAAC-99FB-9F3D47BA95F2

[13] NARUC CPI Regulators' Toolbox: Communications Networks, Wendall Reimer, Xcel Energy, https://www.youtube.com/watch?v=HMRDJH1WOZU

- Send near-real-time and real-time price or grid control signals to DERs to elicit grid services (and measure outcomes);
- Communicate in a peer-to-peer way (versus early AMI that could pass information but not communicate with other AMI meters).

Utilities often leverage both wired and wireless communications technologies to achieve their communications objectives. Sometimes, they can use both wired and wireless for a single purpose (e.g., collecting usage information from an AMI system), though specifics will depend on the cost-effectiveness of a particular combination of technologies. As an increasing number of resources come from the end of the feeder (e.g., rooftop solar and storage), having faster and more precise information about the system becomes more important for the utility, while that same network needs to communicate with other sensors and equipment as well.

In essence, modern communications networks become highways for multiple types of communications, information, data, and telemetry that may need to communicate with other devices, the utility, and non-utility equipment connected to the distribution system. One communication architecture may no longer be able to support these increasing and varied types of needs.

As noted, the network can prioritize communications during emergencies. Xcel attested to this and described that meters, distribution automation, fault detectors and other devices are on the network during blue sky days. The system can detect which of these types of communications to prioritize on the system to be able to avoid congesting the system. By prioritizing critical communications, they are better able to deploy the right resources to that network area.[14]

Leveraging Communications Networks to Better Understand its System

Not only do communications networks provide utilities with the visibility into their systems to operate them more efficiently, but networks also generate a tremendous amount of information. This information can help utilities better plan their system, manage operations, and enhance system reliability and resilience. For example, with more granular near-real-time visibility enabled by an AMI investment and associated communications network investment, a utility can get voltage information from across its system. Taking that voltage information from the AMI network and pairing with other systems, such as Geographic Information System (GIS), can provide the utility with greater insight into performance of equipment and can identify emerging areas of failure in its system before they become detrimental.[15]

Translating the data collected via communication networks into actionable information is key to ensuring that the technologies installed across the utility system and connected via the communications network provide value. As DOE's 2019 Voices of Experience paper noted when talking about AMI systems, "While reports and spreadsheets are useful, the key to extracting more value is to get the data out of the spreadsheets (or "data jail" as one participant called it) and into tools that allow operators and engineers to visualize and more easily act on the information."[16] For example, without the ability to

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[14] NARUC CPI Regulators' Toolbox: Communications Networks, Wendall Reimer, Xcel Energy, https://www.youtube.com/watch?v=HMRDJH1WOZU

[15] DOE Voices of Experience, AMI Networks and Data at 9. Available at: https://www.smartgrid.gov/files/documents/VOEAMI_2019.pdf

[16] Id.

get data to a utility's Meter Data Management System (MDMS), the MDMS will not be able to generate messages to send out to other utility systems.[17]

However, to achieve real-time management, the utility would need to undergo a series of costly updates to its network and computational capacity. Therefore, utilities are planning "data lakes" where data is aggregated and analyzed over a period of days, weeks, months, years, and the utility develops planning scenarios.

Regulatory Treatment Considerations

Understanding the communication needs for the future distribution system is a key component in reviewing utility communication proposals. As regulators review utility proposals for investments and upgrades to their communications networks, understanding the value and costs of these investments becomes even more important. The communications portion of an investment, AMI for example, may only be 10-20% of the investment proposal;[18] however, the strategy of the communications network can have long term impacts on the cost of the grid.

Commissions must consider a variety of factors when translating benefits into regulatory treatment. Utilities and regulators balance risk and uncertainty. Because modern devices and software may not have as long of a useful life as old technologies, utilities have proposed cost recovery of devices and software with varying depreciation lives. Di Martini has illustrated an example where customer meters may have a technical life of 15-years, but the functionality (some of the equipment and software) might have half of the technical life, so the utility will file for an 8-year depreciation schedule.[19]

Another relevant consideration for regulators is understanding if and how multiple utilities – the electric, gas, and water utilities – need to use communication networks and to what extent customers could save with a coordinated strategy.[20] With a coordinated strategy, there could be revenue for the owning utility, so their regulator will need to determine the most appropriate approach to that revenue, resulting in further utility action. For example, if the regulator treated the revenue as an offset to the revenue requirements, then there may not be an incentive for the utility to engage in this program. Another option is to set up a revenue sharing agreement (i.e., with customers). Revenue sharing for fiber is implemented in California.

Benefit Lag and Economic Evaluation

Upgrading a utility communications network may require significant upfront costs while the value may lag. The benefits of the network may not be realized until future years, after the network is fully deployed and the utility rolls out associated programs (e.g., alternative rate designs, data access) and technologies that provide greater visibility into grid operations to the utility. In addition, the benefits can be highly dependent on other grid modernization and data/analysis investments being made and/or the amount of DER on the grid, which is leveraging the networks. For example, ***Figure 4*** shows that the

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[17] Id. at 57. See also, DSPx, Volume 4 at 74. https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf.
[18] NARUC CPI Regulators' Toolbox: Communications Networks, Johnathan Schrag, Taconic Advisory Services LLC, https://www.youtube.com/watch?v=HMRDJH1WOZU
[19] NARUC CPI Regulators' Toolbox: Communications Networks, Di Martini Q&A, https://www.youtube.com/watch?v=HMRDJH1WOZU
[20] NARUC CPI Regulators' Toolbox: Communications Networks, Andrew Bordine at slide 23, https://www.youtube.com/watch?v=HMRDJH1WOZU

upfront costs of the communications infrastructure are greater than the value in the short-term, but, as utilization grows over time, so does the value of the network itself.[21] Another way to state this is that the value of communications networks increase as more users are connected.[22]

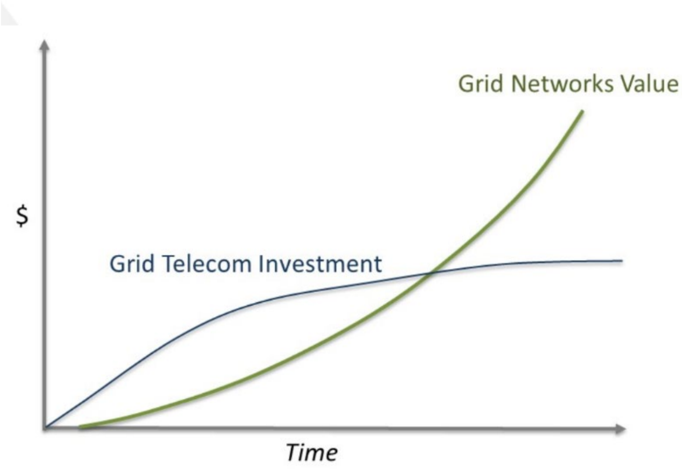

Figure 4 – Grid Telecom Network Value Creation (Di Martini, [Slide 14](), "Regulators' Financial Toolbox: Communications Networks.)

Cost-Benefit Frameworks, Best-Fit Model, and Benefit Implementation Plans

Cost-benefit frameworks, such as [DSPx Volume 4]() and the [National Standard Practice Manual for Distributed Energy Resources](), both detail evaluation methods for grid telecommunications investments. However, a communications network is considered a core investment, and one that enables other investments that drive future, joint benefits, which are interdependent and shared across multiple objectives and customers.[23] As a result, this complexity is difficult to account for in traditional cost-benefit approaches; an alternative may be better suited to determine the cost-effectiveness of such investments through the determination of a least-cost/best-fit evaluation model. Best-fit models rely upon learning and adaptation grounded around a set of metrics.[24]

One step that a regulator may consider to align their process to this best-fit model is developing a Benefit Implementation Plan (BIP). A BIP is a plan submitted by the utility that describes potential future uses and use cases from a particular investment, such as a communications network. Having a BIP submitted by a utility can be used by the regulator to ensure that the BIP itself is consistent with existing regulatory rules and policies and is forward-looking – detailing future uses and benefits of the investment, similar to a best-fit model as described in the DSPx initiative. The New York Department of Public Service and Kentucky Public Service Commission (PSC) both have BIPs. (See case study below.)

Additionally, the resources from DSPx offer a strategy to engage vendors of utilities. Along with utility plans, understanding the business plan and R&D strategy for the vendor can be a strategy to ensure continuity and understanding of priorities. Utilities' relationships with vendors is unique because vendors often supply a piece of infrastructure or a program, and also provide human resources to manage the devices. Utilities are looking for ways to better partner with vendors. Xcel's approach has been to have a commissioning phase where the contractor gets the network to a position where it is

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[21] Image from DeMartini's presentation - Regulators' Financial Toolbox: Communications Networks," NARUC Center for Partnerships and Innovation, Presentation by Paul De Martini at slide 6 (August 10, 2021) ("Regulators' Financial Toolbox Communications Networks for DER Integration"). Available at: https://pubs.naruc.org/pub/E6208D86-1866-DAAC-99FB-9F3D47BA95F2

[22] This is also known as Metcalfe's Law. *see*, "Distributed Energy Resources Rate Design and Compensation: A Manual Prepared by the NARUC Staff Subcommittee on Rate Design," NARUC at 85 (November 2016).

[23] DSPx Volume 4 at 117.

[24] Id. at 115.

working. At that time, the utility takes on the operational phase and is responsible for security and maintenance.

Another strategy that regulators could implement is to request that the utility describe their five- and ten-year plans, how they are planning for the evolution of communications systems, and how their plans are aligned with their distribution system. Bringing this type of information into a technical conference environment offers some advantages. Because utilities are customers of the vendor, the vendor has an interest in delivering a product the utility will implement. For example, the utility and vendor could be prepared for the regulator to ask, "why are you selecting this technology?" and "how are you futureproofing the architecture?"[25] The regulator can ask questions of the vendor and engage with the utility as well.

Case Study: Kentucky BIP with AMI

The Kentucky PSC outlined a BIP in an order issued on June 30, 2021.[26] Although this Order was related to approval of an AMI application from LG&E/KU, it is relevant to communications networks as well since AMI investments include a communications network to enable the meters to communicate with each other and send information back to the utility through the communications architecture described above. In the order, the Kentucky PSC conditioned approval of the AMI investment by requiring LG&E/KU to subsequently file several plans describing how they are continuing to use the approved AMI system. The Kentucky PSC required, among other items, that LG&E/KU:

- [the utility] shall file by June 30, 2022, and continuing annually, a detailed plan for customer engagement of its AMI systems before, during and after AMI deployment, and including through the system's end of useful life.
- [the utility] shall develop and file with its next base rate case detailed plans on AMI obsolescence and replacement strategies that identify, at a minimum, risks and solutions to early obsolescence, opportunities for greater cross-system compatibility, and successor technologies, including hardware and software, in order to extend the life of as many portions of the proposed AMI systems as reasonably practical.[27]

In this example, the Kentucky PSC sets requirements for future reporting by the utilities to show they are using the AMI investment for benefits beyond what was identified in the utility filing. By having a utility file subsequent reports on specific metrics or topics, a regulator (and the public) can monitor the progress of a utility towards that future where the investment elicits benefits. Requiring the utility to provide an overall plan and strategy can help commissions identify the technologies, the timing of investment in those technologies, and the means by which value will continue to be identified (and to whom).

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[25] For more details on utility plans, please visit the NARUC recording of this toolbox webinar at: https://www.youtube.com/watch?v=HMRDJH1WOZU

[26] *In the Matter of: Electronic Application of Kentucky Utilities Company for an Adjustment of its Electric Rates, a Certificate of Public Convenience and Necessity to Deploy Advanced Metering Infrastructure, Approval of Certain Regulatory and Accounting Treatments, and Establishment of a One-Year Surcredit*, Order, Kentucky Public Service Commission, Case No. 2020-00349 (June 30, 2021). http://psc.ky.gov/pscscf/2020%20Cases/2020-00349/20210630_PSC_ORDER.pdf A substantially similar Order was issued in Case No. 2020-00350, which addresses the LG&E AMI filing.

[27] Id. at 63.

Role and Value of Standards and Interoperability in Communications Networks

Interoperability is a critical component of implementing any communications network and architecture. All components of the communications network are built upon a set of standards, which ensure the communication network can communicate consistently and reliably across the utility service territory. When the communications network leverages available open standards to support communications with other devices and technologies connected to it, it can then lower overall costs to the utility to operate the system as devices can seamlessly interact with the communication network via these standards. Ensuring that a utility's communications network is built to known standards with interoperability embedded upfront will improve the likelihood that the value of the network is realized.

As the Kentucky PSC noted in its AMI order, LG&E/KU is to continually report on how its AMI system is addressing obsolescence, how it is future-proofed, and how it will work with other utility technologies.[28] Leveraging consensus, industry standards can help a utility (and vendors) more efficiently implement technologies and upgrades. While some proprietary standards may be used for discrete purposes, relying on proprietary (often patented) standards where individual vendors customize technologies or customer equipment to be able to connect to the communications network will increase costs over time. Furthermore, interoperability minimizes the risk of premature obsolescence, which results in stranded costs as the utility seeks to recover the remaining value of the obsolete equipment while also recovering the costs of new equipment.

Common Standards for Communications Networks

Many standards can be relevant to a given communications network. Some standards, however, are more widely used than others.

Standards such as **IEC 61850** and **DNP3** support the communication needs of the bulk power system and form a basic information model for transmission and distribution systems. For behind-the-meter applications, standards such as **IEEE 2030.5**, **Wi-Fi**, or **OpenADR** may also be used.

Additionally, some effort has been made to develop interoperability profiles, where a group takes pieces of several standards and turns them into one description that coalesces the technical requirements into a testable and certifiable profile. **WiSUN,** as referenced in ***Figure 3****,* is an example of an interoperability profile developed for communications networks.[29]

Status of Adoption and Barriers

As utilities and customers seek to invest in and install new equipment to modernize their systems, the communications network is a vital piece of the puzzle to ensure that those technologies can achieve their full value. If a utility is proposing substantial investments in AMI, GIS, or other data and software programs, the ability of the utility to realize the value of those investments may rely upon the utility communications network. Communications networks are not new and have been around for decades to support certain utility infrastructure. However, as the grid is aging and in need of replacement, added

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[28] Id. at 63-64.

[29] Xcel describes a variety of standards that they use on Slide 29 of the NARUC CPI Regulators' Toolbox: Communications Networks, Wendell Reimer, Xcel Energy, https://pubs.naruc.org/pub/E6208D86-1866-DAAC-99FB-9F3D47BA95F2

resources are coming online and connecting directly to the distribution system so a modern communications network is paramount.

Specifically, for utility regulators looking at grid modernization discussions, the communications network is the backbone of a modernized system. As described in DOE's Modern Distribution System initiative, the communications system is a core foundational part of the utility system.[30] Yet, for communications networks to be considered as a foundational component of the utility system, utilities must show that they are, in fact, being treated as foundational and that utility practices will maximize this investment. In other words, as shown in ***Figure 5***, core components of the utility's system, as well as new applications that can be provided by either the utility or a third party, will rely upon a communications network. As such, the communications network becomes a foundational piece of any utility system, and, looking towards the future, an investment upon which innovations will be born.

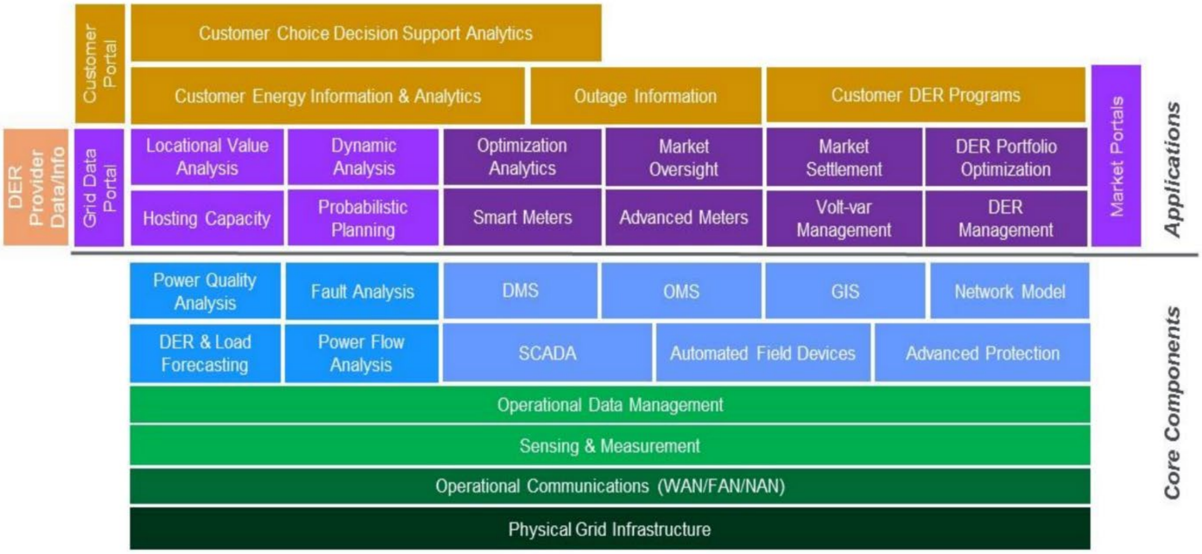

Figure 5 - Modern Distribution System Platform (Source: De Martini Presentation in the NARUC CPI webinar: Regulators' Financial Toolbox: Communication Networks

In essence, to realize the benefits of a communications network as foundational to a modern distribution system, as visualized in ***Figure 5***, any utility discussion must show how the utility is moving away from a traditional, siloed communications network architecture, to one that is more integrated with multiple components and applications. Transitioning away from these application-specific models, where a communications network is built for a specific purpose (e.g., individual networks for each application), will require the regulator to look more closely at utility plans. Utility plans may be examined in grid modernization plans or in rate cases. Because these are investments that are likely to be in place for 10 years or more, understanding the details of the utility plans, architecture, and strategy for extracting benefits into the future (and beyond what is described in an initial proposal) will help regulators manage costs and enhance benefits and value streams.

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[30] DSPx, Volume 3 at 26. https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid-Volume-III.pdf

Recognizing the value streams – for the customer and utility – that communications networks can enable can help states look broadly at these investments. Benefits, however, can only be realized if regulators look for certain components of a utility's communications architecture and investment proposal and ensure that the utility actively seeks to maximize these investments. Components to examine include:

- The architecture of the communications and network proposal;
- Alignment with the timeframes of any associated grid modernization or utility-of-the-future plans;
- Implementation timelines;
- How the utility will use the data collected from and via the communications network for existing and new purposes; and,
- How the utility plans to leverage the value of the network beyond the immediate needs of the system (e.g., identify opportunities to leverage one investment for multiple purposes[31]).

The total value of the network can only be realized if it is fully utilized and integrated with its utility operations and systems.

Resources for More Detailed Information

The Emerging Interdependence of the Electric Power Grid & Information and Communication Technology, Pacific Northwest National Laboratory (August 2015). https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24643.pdf

Framework and Roadmap for Smart Grid Interoperability Standards, Release 4.0, National Institute on Standards and Technology (February 2021). https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1108r4.pdf.

Integrated Communication Networks and the Integrated Grid, Tim Godfrey, EPRI (October 28, 2014). https://www.energy.gov/sites/prod/files/2016/12/f34/Session_4_Comms_and_Cyber_Security_Final_Master.pdf

Modern Distribution Grid, Volume 2, Version 1.1, U.S. DOE (March 2017). https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-II_v1_1.pdf

Modern Distribution Grid, Volume 3, U.S. DOE (June 2017). https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid-Volume-III.pdf

Modern Distribution Grid, Volume 4 (Draft), U.S. DOE (June 2020). https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf

National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources, National Energy Screening Project (August 2020). https://www.nationalenergyscreeningproject.org/wp-content/uploads/2020/08/NSPM-DERs_08-24-2020.pdf

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[31] DSPx, Volume 3 at 57.

"Standards for the Evolving Distributed Energy Resources (DER) Ecosystem," IEEE (November 9, 2021) ds for the Evolving. https://beyondstandards.ieee.org/ieee-standards-for-the-evolving-distributed-energy-resources-der-ecosystem/

"Voices of Experience: Leveraging AMI Networks and Data," Department of Energy, Advanced Grid Research (March 2019). https://www.smartgrid.gov/files/documents/VOEAMI_2019.pdf