Power Grid and Communications Interdependencies

Key Challenges for Reliable, Resilient Operations

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Part of a series of white papers on
electric grid communications.

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Introduction

Because the electricity grid and communications networks support critical national functions,[1] these systems are critical infrastructure. The interdependence between these two sectors—communications networks require power, and the power grid relies on communications networks—is important and has been the subject of several studies by entities such as the National Security Telecommunications Advisory Committee (NSTAC) and the Federal Communications Commission (FCC) dating back to 1987. These studies have covered everything from day-to-day operations to long term outages. An NSTAC report from 2006[2] states, "collaboration between the two sectors is most important at the regional and local levels to ensure the rapid recovery of both sectors." Interdependence affects not only the electric power and communications sectors, but all critical infrastructure sectors including transportation, water, and natural gas. Previous papers in this series have touched on the evolving grid edge and its implications for communications and electric power. This paper focuses on the interdependencies between electric power and communications systems, highlighting three opportunities—service prioritization, load shedding, and direct transfer trip protocols—to improve grid reliability and resilience via collaboration between the sectors and with regulators.

Secure Communications

A secure communications system protects the end-to-end physical pathway that transports data from origin to destination. That pathway may: involve different transmission methods, such as optical fiber, copper wire, and microwave; transport diverse data including grid state information and control messaging; and use a variety of analog and digital formats. Securing this end-to-end communications pathway—which is essential for reliable grid operations—involves preventing unauthorized access and monitoring traffic to identify anomalous activity without compromising the confidentiality, integrity, or availability of the data. Communications security methods complement cybersecurity approaches used to protect data at origin and destination.

What are the implications of increasing dependence on third-party communications on reliable electric grid operations?

Traditionally, the grid involved power flowing unidirectionally from synchronous generation to loads, and communications networks for grid operation were largely maintained and operated by the electric industry. Today, the grid incorporates bidirectional power flows between asynchronous generators and controllable loads supported by a variety of digital technology (Figure 1), and grid communications requirements to support this more complex and information-rich architecture have increased. The current and evolving environment requires a high-speed, bidirectional pathway for digital, packetized communications supporting power system monitoring and control functions, includes energy management, substation alarms, video monitoring, distribution automation, protection, and fault recording for both on- and off-network installations. Grid communications now rely on a mixture of private, utility-owned infrastructure and commercial leased infrastructure to meet this demand, as reported by NSTAC in 2006[3] and by the Utilities Technology Council in 2019.[4]

[1] https://www.cisa.gov/topics/risk-management/national-critical-functions

[2] NSTAC Telecommunications and Electric Power Interdependency Task Force (TEPITF), January 31, 2006.

[3] NSTAC Telecommunications and Electric Power Interdependency Task Force (TEPITF), January 31, 2006.

[4] Utilities Technology Council "Utility Network Baseline – April 2019", https://utc.org/wp-content/uploads/2019/04/UTC-Utility-Network-Baseline-Final.0419.pdf

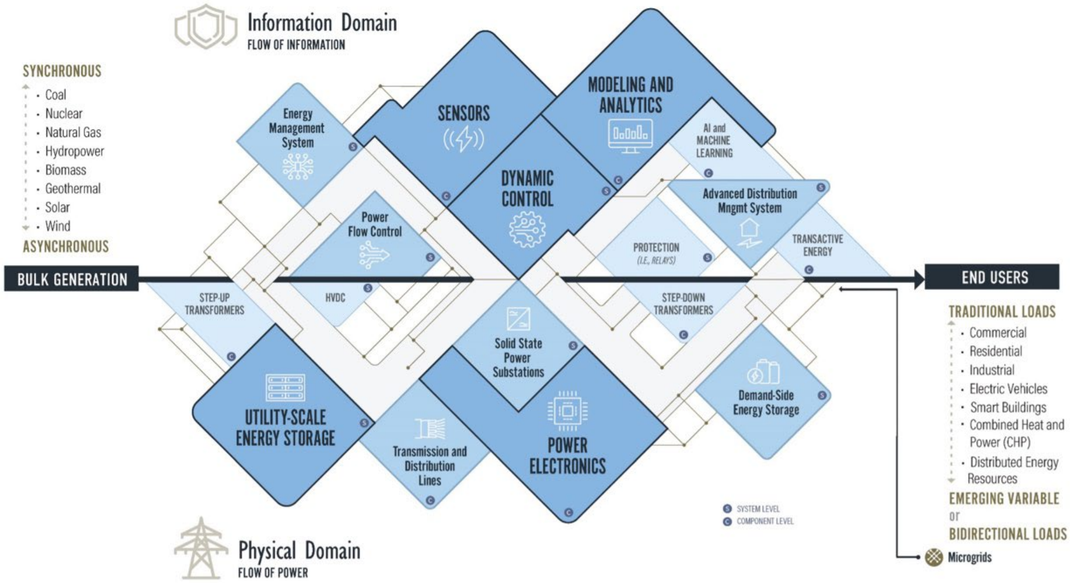

Figure 1: Increasing information loads on the evolving electric grid.

The increasing importance of commercial communications systems for grid stability was exemplified in April 2022, when the California Independent System Operator (CAISO) reported that for about fifteen minutes the state's energy requirements were completely met by renewables.[5] Much renewable generation, being distributed and not on utility communications networks, was controlled and monitored remotely using IP over commercial communications links. Commercial links are often the best or the only viable option for interconnecting and communicating with distributed energy resources (DERs). System operators are working through architectures, processes, and requirements for using these links.[6,7] Furthermore, the use of DER aggregators will continue to expand the use of communications networks out of the utilities' control,[8] increasing the electric power industry's dependence on the communications sector and causing a fundamental shift in how the electric utilities will have to think about communications security. While the full impact of the blending of utility and commercial communications assets on the reliable, secure operation of the power grid is currently unknown, the opportunity for and importance of collaboration between the two sectors is clear.

One issue to be addressed by collaboration is the prioritization by communications providers of power grid traffic in times of network congestion. The need to prioritize electric utility traffic is not new. In the middle of the 20th century, communications providers maintained priority services for electric utilities via a mechanism called "hotline service," which connected a call to a pre-designated number by simply lifting the handset.[9] In

[5] "For the first time in history, California's demand was 100% matched by renewable energy generation," PV Magazine, May 2, 2022. https://pv-magazine-usa.com/2022/05/02/for-the-first-time-in-history-california-was-100-powered-by-renewable-energy

[6] "Enabling Technologies for Distributed Energy Resources," NYISO, https://www.nyiso.com/documents/20142/1391862/Enabling-Technologies-for-DER-Study-Report.pdf/0cf5cee1-8849-6b4d-0195-bc9441e177db

[7] "New Remote Intelligent Gateway and Secure Socket Layer Validation Procedure" California ISO, https://www.caiso.com/Documents/RIG_DPGValidationProcedure.pdf

[8] "Metering and Telemetry Requirements" PJM https://www.pjm.com/-/media/committees-groups/subcommittees/dirs/2021/20210303/20210303-item-06a-metering-and-telemetry.ashx

[9] The most famous of these "hotline" connections is the one between the Whitehouse and the Kremlin. Electric utilities used the same mechanism to maintain connectivity between two locations to communicate during emergencies.

the 1980s, the FCC instituted the Telecommunications Service Priority program (TSP), [10] which gives *voice* communications for certain users priority treatment under a five-tier program. Electric utilities fall under Level 3, as communications services are necessary for public health, safety, and maintenance of law and order.

Until 2022, the TSP program provided no prioritization of data or packetized voice. The FCC updated the language for TSP in May of 2022 to clarify that common carriers must offer restoration and provisioning of circuit-switched voice communications services and can *voluntarily* offer prioritized provisioning and restoration of data, video, and IP-based voice services.[11] The TSP program does not include mandatory prioritized data transport services for critical infrastructure. The potential for grid telemetry data to be adversely affected by sharing bandwidth with ordinary user traffic is concerning to utilities and speaks to the need for a clear prioritization mechanism supporting critical infrastructure.

What are the implications of electricity-communications system interdependence on resilience and recovery?

This increasing reliance on communications industry infrastructure by the electric power industry can create interdependencies on both sectors for system resilience and recovery. Consider the following example, in which load shedding[12] and direct transfer trip (DTT)[13] protocols interact with and amplify each other to exacerbate a capacity shortfall. On a hot summer afternoon, high demand creates a regional power shortage. The grid operators must take action to shed load (consumption) to ensure that supply can meet demand and prevent a system collapse. During this load-shed action, power is cut to communications infrastructure linked to a DER facility's control system, causing loss of telemetry from the distributed energy resource management system (DERMS) to the power utility control center. Due to the loss of situational awareness from the DERMS, the utility control system then automatically performs a DTT, cutting the DER output to the grid, worsening the power shortage, and potentially creating additional load-shed events and cascading impacts. Had the utility fully mapped the dependencies of electric infrastructure on communications networks, the load-shed plan could have prioritized the communications provider as critical infrastructure, maintained a link to the DERMS, and perhaps averted the DTT and the loss of additional generation on the system.

Agility in grid control increasingly relies on commercial communications providers and a variety of technologies, from wireless (e.g., 5G, microwave, Wi-Fi) to wireline (fiber, copper) to radio communications (P25, other repeater-based systems); all these communications systems rely on electric power. The complexity of this dependence and associated event consequences is often underestimated. For example, even if the central office of the communications provider is still powered, the electric utility's local communications devices can be nonfunctional if any node in the communications path is left unpowered by an outage. For critical customers such as military installations, this interdependence must be considered by the utilities and the communications companies.

Just as electric utilities must account for communications dependences when operating the grid resiliently,

[10] https://www.fcc.gov/general/telecommunications-service-priority

[11] Federal Communications Commission, Review of Rules and Requirements for Priority Services Report and Order FCC 22-36, May 19, 2022.

[12] Load-shedding is when utility providers purposefully reduce demand on their electrical grids by temporarily powering down certain areas. For more detail see: https://blog.ecoflow.com/us/what-is-load-shedding

[13] The main function of DTT is to remove the distributed generation site during faults on the grid. If the communication is interrupted, the DTT system will operate in a fail-safe mode and disconnect the distributed generation site. For additional information see: https://www.tdworld.com/smart-utility/article/20972708/improving-the-reliability-and-security-of-distribution-automation-networks

efficient post-event recovery also requires inclusion of communications facilities in restoration planning. Communications and power infrastructure should be restored in tandem so that critical communications nodes have power, and critical power infrastructure has the communications links required to operate it.

Conclusions

Coordination between the electricity and communications sectors is critical for a reliable, resilient, and secure electric grid. The goal of this paper is to motivate discussions on collaboration between these two sectors—in addition to regulators, standards bodies, and other stakeholders—to explore secure communications concerns and develop potential solutions. This white paper is part of an effort by the Department of Energy Office of Electricity to bring stakeholders together to discover gaps, identify needs, and explore how secure communications can enable new capabilities for the electricity system of the 21st century.

Please consider participating in a series of Department of Energy-sponsored webinars, workshops, and conferences in 2024 and beyond to drive consensus toward an innovative, cost-effective, and secure solution for grid communications.