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*Expanding the Adoption of IEC 61850*

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## Foreword

This white paper was developed by the National Electrical Manufacturers Association's Distribution Automation Section and explores issues of IEC 61850 adoption. It offers suggestions to promote the use of 61850 in North America.

NEMA appreciates input from these utilities in the development of this white paper: Duke Energy, National Grid, Southern Company, and Tennessee Valley Authority.

## Background

The electrical grid is evolving. There is a transition to digital networks from traditionally analog systems. The electric delivery infrastructure is moving to a more decentralized system from a centralized one. Renewable energy is being integrated on a faster scale than traditional generation. There are significantly more renewable energy interconnection requests in the utility generation queue. While not all may move forward in the queue, for the ones that do, there is still a need to be integrated into the protection schemes designed to ensure the safe and reliable operation of the electrical power grid.

The IEC 61850 standard offers reliability, resiliency, flexibility, and interoperability needed in the transition to the digital grid. The main parts of the standard were first published from 2002 to 2005. The initial scope of IEC 61850 was standardization of communication in substation automation systems. The first edition of the standard was primarily related to protection, control, and monitoring. From 2009 onward, the original parts of the IEC 61850 series have been updated and extended to cover measurement (including statistical and historical data handling) and power quality.<sup>1</sup>

Nearly 100% of European utilities use IEC 61850, but very few do so in North America. In the U.S., lack of adoption generally centers on the perceived risks of moving to the standard and a limited view of the technology's benefits.

Other protocols will remain in use in the future and can provide workable alternatives for substation modernization and the digital substation as well. DNP3, for example, is in use in over 75% of North American utilities and is designed to focus on inexpensive endpoints and low-bandwidth communication channels while 61850 is designed for high-bandwidth communication channels with a wider range of features. Both protocols must adapt to the flexibility of electric delivery systems.

*IEC 61850 is not just a communications protocol. It is a comprehensive standard for the design of substation automation systems and applications. It contains a collection of multiple protocols, concepts, and component standards and is a platform for designing, implementing, and operating utility automation systems.*

## Comparison of IEC 61850 and DNP3

IEC 61850 will help to simplify relays to be connected digitally and talk to each other and enable functionality like simplified islanding schemes. Legacy protocols such as Modbus and DNP3 mostly focus on the data transfer portion of the automation system. IEC 61850 expands beyond the data, which lets the user design automation systems based on what should be done as opposed to how the data should be transferred. The table below provides a high-level overview of the comparison of IEC 61850 and DNP3.<sup>2</sup>

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<sup>1</sup> IEC/TR 61850-1 Edition 2.0 2013-03 Technical Report.

<sup>2</sup> EnerNex, Features and Benefits of IEC 61850.

<b>Issue</b>	<b>IEC 61850</b>	<b>DNP3 (IEEE 1815)</b>
Recognized in NIST Interoperability Framework	Yes	Yes
Distribution Feeder Automation	No profile currently exists for low-bandwidth networks	Designed for it
Substation Automation	Yes	Yes
Substation to Control Center	Yes	Yes
High Speed Peer-to-Peer	Yes	No
Structured Data and Naming	Yes	Limited; numbered points
Self-Description	Yes	Limited
XML Configuration File	Yes	Yes

### Major Features of the IEC 61850 Standard

- a. Use of extensible markup language or XML-based substation configuration description language (SCL). SCL formally describes the configuration of intelligent electronic devices (IEDs) in terms of functionality (e.g., circuit breaker control, measurements, and status values), communication addresses, and services (e.g., reporting). It also describes the switchyard layout and its relation to the functions implemented in the IEDs.<sup>3</sup>
- b. IEC 61850 communications can be point-to-point or point-to-multipoint. Point to multi-type is used for the flow of data between two pre-defined devices. When a single piece of information needs to be conveyed simultaneously, typically at very high speeds to multiple recipients, then point-to-multipoint communication is used.
- c. Standard data names for common device functions, e.g., energy meter, capacitor bank controller, transformer tap changer.

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[https://library.e.abb.com/public/a56430e1e7c06fdcf12577a00043ab8b/3BSE063756\\_en\\_ABB\\_Review\\_Special\\_Report\\_IEC\\_61850.pdf](https://library.e.abb.com/public/a56430e1e7c06fdcf12577a00043ab8b/3BSE063756_en_ABB_Review_Special_Report_IEC_61850.pdf). Accessed March 18, 2021.

## Advantages of 61850 over Legacy Protocols

61850 contains an extensive toolkit of best practices for substation automation and other application domains. It's the only non-proprietary international standard that specifically addresses substation control at protection speeds.<sup>4</sup> It also improves data transfer from the grid edge, where many sensors and other devices reside.

IEC 61850 attempts to create an instruction guide for the construction of automation systems. It contains well-defined parameters, such as standard measurements and well-defined activities. Without these details, you couldn't integrate the standard appropriately. That's one of the main advantages IEC 61850 offers—it is a comprehensive resource of well-defined automation parameters, activities, and terminologies.

A digital substation enabled by IEC 61850 will have more proactive condition-based maintenance procedures, where systems are monitored continually, data is collected, and maintenance can be conducted in a more prescribed manner. This is different from the traditional approach where potential issues can be hard to find and all devices must be inspected on a frequent basis to determine when maintenance is required.

It is fully compatible with previous equipment versions, which is helpful to protect prior investments in automation. Legacy products can accommodate protection functions that were defined after the release of the older product. This backward compatibility allows vendors to offer functionality beyond what is written in the standard.

IEC 61850 uses Generic Object-Oriented System Event (GOOSE) messaging, which is designed to be vendor independent, and allows most pieces of equipment to use only a single power connection and an Ethernet port without device-to-device wiring. It replaces hard-wired blocking signal paths to enable sophisticated logic schemes for substation protection and automation. It dramatically reduces necessary wiring. Examples of protection schemes include interlocking busbar protection, circuit breaker failure protection, and power quality controls of parallel power transformers.

## Motivations for Adopting 61850

### Flexibility

- Utilities want to be on the leading edge and not bleeding edge of technology integration; adopting a platform that industry is heading toward helps achieve that vision.
- 61850 facilitates interoperability of devices from multiple manufacturers.
- Minimal investment and less time needed to add new equipment; it can be implemented via network connection and configuration change.

### Cost

- Reduced O&M—maintenance is performed less frequently, based on events rather than time intervals.
- Improved space utilization—30-50% reduced footprint of control house allows more to be packed in or reduce overall size; hundreds of copper cables are replaced with a few fiber optic cables. Digital control replaces control switches, saving panel space.
- Testing can be done remotely and automatically logged instead of being done in-person.

### Workforce

- Increased personnel and property safety since test switches are removed from the panel and replaced with digital signals, making the panel safer.
- Reduced human performance errors.

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<sup>4</sup> *EET&D Magazine*, Bruce Milschiltz, "IEC 61850 What Are You Waiting For?" September/October 2018, Issue 5, Volume 22.

## Summary of Challenges for Implementing 61850

- a. The standard is very large and can be difficult to read. The current version contains over 40 parts with more than 1,500 pages. It should be noted that the content of the standard is meant for exchanges among computer applications; there are tools that can convert this language into a form that is more digestible for technicians.
- b. Compliance and new products/devices add costs to company. New products and devices added to inventory add O&M costs.
- c. Explaining to auditors what utilities have done about these routable protocols.
- d. Change management—making people familiar with a new way of thinking. It is important to have leadership in the organization that can take ownership and drive the transition.
- e. There are some vendor nuances, and some utilities have had to develop their own standards to accommodate vendors.
- f. Workforce issues and lack of knowledge in the industry can be an issue. 61850 takes out manual wiring and goes to integrated chips and networks. Some utilities have had to bring in outside resources, which may not be easy to find given the niche skill set to work on relays, for instance. Working with local colleges and trade associations to find resources could help.
- g. Fear of not being NERC CIP compliant.

## Recommendations for Utilities

- a. Walk before running. There isn't a need to convert from copper to Ethernet overnight. An implementation roadmap can be useful when helping to plan out this transition. A long view of the project is needed.
- b. Taking a piecemeal approach to upgrading equipment may not realize benefits quickly or become fully realized for customers. Embracing the development cost of a fully digital substation can result in reduced transition time and total cost.
- c. Engage stakeholders in the utility and map out a change management plan to get organizational commitment. It will take time. Don't leave execution to a legacy operations team—decisions are delayed or made with only the immediate cost and benefit in mind, slowing the transition.
- d. Don't outsource implementation of 61850 entirely; internal staff won't understand it enough to be able to manage it. Instead, partner with a trusted advisor and future-proof through collaboration.
- e. Join an inter-utility working group. These groups may have a facility to test/use equipment and provide education. Showing vendors and utilities these testing laboratories creates a great avenue for knowledge sharing. Some utilities are interested in adopting 61850 and have developed a laboratory for testing. In some cases, the pandemic has delayed this testing of the equipment.
- f. As a key part of its long-term strategy, National Grid is creating a completely new set of engineering, commissioning, and testing standards for P&C systems at digital substations. In the past, P&C designs were done using a bottom-up approach, where the design was dictated by the equipment available at the time. This approach did not maximize the full capability of new systems and, ultimately, would impair the advancement of National Grid's IEC 61850 strategy.
- g. The new National Grid IEC 61850-based standard is being developed using a top-down design that examines system requirements holistically rather than in individual sections. This way,

efficiencies can be gained by meeting several requirements at once, while benefiting customers through accelerated cost savings as well as reduced design and construction time. The top-down approach enables a long-term view and optimization of the full complement of digital substation functionality, usability, and security.

- h. The utility's top-down design also includes a comprehensive view of cybersecurity risks throughout its electricity networks and mitigating those risks head on. Movement toward digital substations does not mean the utility will compromise the security of its networks. As such, given the importance of these hazards, from day one, the future system has been designed with cybersecurity and usability in mind.<sup>5</sup>

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<sup>5</sup> <https://energycentral.com/news/national-grid-advances-digital-substations-0>. Accessed March 18, 2021.