TELVENT

International Standards: The Challenges for an Interoperable Smart Grid

Standardization supports efficiency, security, innovation

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The power grids prevalent today represent the technology available when energy production and delivery costs and environmental impact were not a priority. Today, the world wants smart electric grids that can reduce outages and faults, improve responsiveness, increase efficiency, and manage costs.

However, the power grid can become smart only if the utility has the realistic means to harness the flood of data generated by its high technology network and make that information available as real-time and accurate business intelligence across the entire enterprise. The Smart Grid links the various devices, applications, and systems across its processes to create such a single, unified information network.

This paper discusses the concept of an integrated electric grid and the industry standards, particularly the overarching IEC standards accepted worldwide, that make a unified, interoperable Smart Grid possible.

The elements of a Smart Grid

The International Electrotechnical Commission (IEC) and the U.S. National Institute of Standards and Technology (NIST) have adopted a similar concept of the Smart Grid – one divided into several domains as shown in Figure 1. Each domain is comprised of actors that perform applications and are connected with each other by associations:

- Actors – are the devices, computer systems, or software programs, such as smart meters, solar generators, and control systems, and/or the organizations that own them. Actors make decisions and exchange information with other actors through interfaces.
- Applications – are the tasks performed by the actors within the domains; for example: home automation, solar energy generation and energy storage, and energy management. Some applications are performed by a single actor, others by several actors working together.
- Domains – are the groups of actors with similar objectives, characteristics, or requirements. Domains might contain other domains. Note: domains are not organizations; for example, an ISO or RTO might have actors in both the Markets and Operations domains. Similarly, a distribution utility is likely to contain actors not only in the Distribution domain but also in the Operations domain, such as a Distribution Management System actor, and in the Customer domain, such as meter actors.
- Associations – are the logical connections between actors that establish bilateral relationships. In Figure 1, electrical associations between domains are shown as dashed lines, and communications associations are shown as solid lines.

- Interfaces – are the access points – either electrical or communications connections – at each end of the communication associations where information enters and exits a domain; interfaces are logical and can be bi-directional.

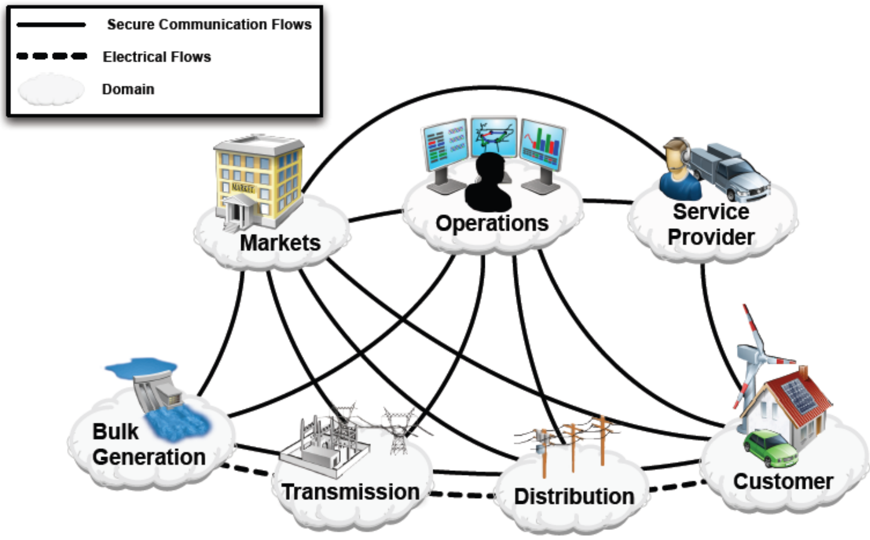

Figure 1. Smart Grid domains interface with each other through electrical and communications connections (source: NIST).

Table 1 provides description of the seven present and near-term logical domains of a Smart Grid system. In the future, some of the domains (such as transmission and distribution) might combine. Others might diminish in importance; for example, bulk generation might become less significant as micro-generators become more prevalent.

Domain	Description
Customers	The end users of electricity; might also generate, store, and manage the use of energy. Traditionally, three customer types are discussed, each with its own domain: home, commercial/building, and industrial.
Markets	The operators and participants in electricity markets.
Service Providers	The organizations providing services to electrical customers and utilities.
Operations	The managers of the movement of electricity.
Bulk Generation	The generators of electricity in bulk quantities; might also store energy for later distribution.
Transmission	The carriers of bulk electricity over long distances; might also store and generate electricity.
Distribution	The distributors of electricity to and from customers; might also store and generate electricity.

Table 1. Domains of the Smart Grid

Figure 2 provides a conceptual reference diagram of the Smart Grid. This conceptual model assumes that a Smart Grid includes a wide variety of use cases and applications, data management, and application integration. It also suggests how the interaction of actors and applications, sourced by many different vendors, becomes highly complex. Adherence to universal standards allows integration and interoperability between and among actors and applications: NIST identified 75 existing standards that are likely to be applicable to the development of a complex Smart Grid.

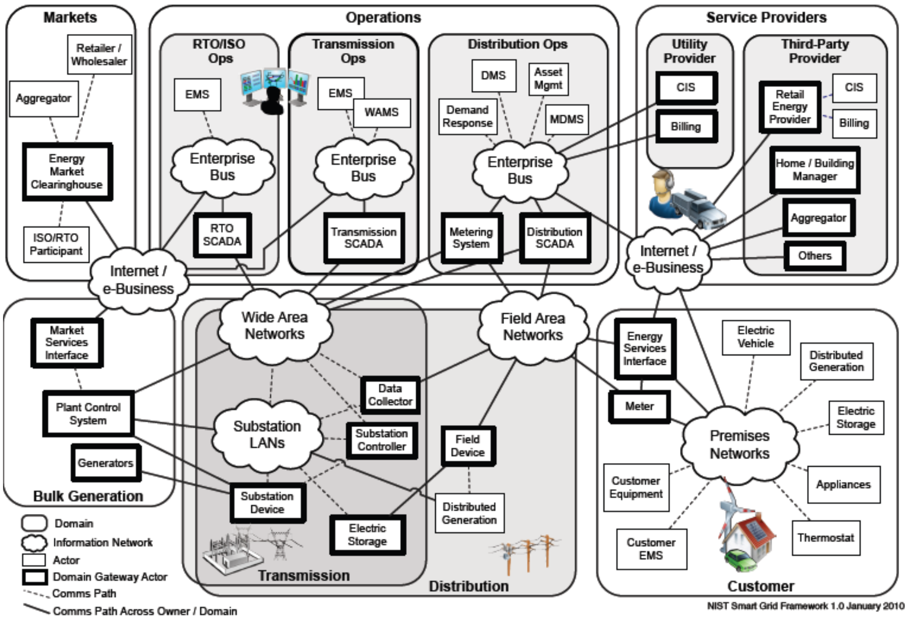

Figure 2. Conceptual reference diagram for the Smart Grid (source: NIST).

Interoperability put to work

Utilities are faced with the need to increase energy delivery capabilities to meet rising demand, while still controlling costs and satisfying regulatory direction. Here are examples of how a Smart Grid uses real-time information characterizing the operating state of the network to increase energy availability:

More efficient network operations. A utility can reduce load by improving the efficiency of delivered power. For example, by improving volt/var control, including flattening the voltage profile along many feeders, some utilities have been able to use distribution system demand response (DSDR) to anticipate peak demand reductions of 5 to 7 percent.

Enhanced system reliability. Improved switching and sectionalizing can significantly benefit some utilities, especially those faced with poor or deteriorating performance and regulatory pressures. Interoperability enables automated switching sequences that make it possible for portions of the distribution system to 'heal' themselves.

Integration of distributed renewable and non-renewable sources. These resources have the potential to improve delivery efficiency and enable peak shaving if reliable interconnection standards meet utility-grade operating requirements.

Demand response/management through customer choice. Demand response (DR) programs including time-of-use (TOU) or critical-peak-pricing (CPP) rate structures give customers the ability to reduce demand at certain times. These programs are most successful when implemented through a meter data management (MDM) system integrating meter information with business processes.

Standards and certification key to smart grid success

Simpler deployment. Those who choose solutions based on proprietary standards will find it difficult or even impossible to fully integrate with various systems found across the grid.

Seamless communication. Interoperability enables the different components of a grid to exchange, analyze, and utilize information and to mutually understand the information exchanged.

Future-proofed investments. The 'standardized' smart grid can consider nearly any of the millions of similarly-standardized components expected to be available for the future Smart Grid.

Practical innovation. Standards enable innovation that can be realistically developed and deployed.

Simpler support. Standardized systems allow consistency in systems management and maintenance over the life cycles of components.

To assure standards compliance, conformance testing and certification are essential. NIST, in consultation with industry, government, and other stakeholders, has started work to develop an overall framework for conformance testing and certification for 2010 implementation.

IEC standards relating to interoperability and security

The IEC is the leading global organization that prepares and publishes international standards for all electrical, electronic, and related technologies. Its charter embraces electronics, magnetics and electromagnetics, electroacoustics, multimedia, telecommunication, and energy production and distribution, as well as associated general disciplines such as terminology and symbols, electromagnetic compatibility, measurement and performance, dependability, design and development, safety, and the environment. IEC Standards were significant in the development of the NIST roadmap, which includes approximately 10 IEC standards at this time.

Standardization protects investments

The evidence of the essential role of standards is growing. A recent U.S. Congressional Research Service report cited the need of widely accepted standards to successfully deploy smart meters. The U.S. investment in smart meters is predicted to be at least $40 billion to $50 billion over the next several years. Globally, 100 million new smart meters are predicted to be installed over the next five years. Sound interoperability standards are needed to ensure that sizable public and private sector technology investments are not stranded.

The IEC Standardization Management Board (SMB) is responsible for the management of the IEC's standards work, including the creation, dissolution, and approval of scopes of the IEC technical committees (TC), the timeliness of standards production, and liaisons with other international organizations. It has established a Strategic Group, SG 3, which provides advice on fast-moving ideas and technologies likely to form the basis for new International Standards or IEC TCs in the area of Smart Grid technologies. Following are some of the standards chosen by the IEC SG3 in the Framework 1, relating to interoperability and security.

IEC 61970, Common Information Model (CIM)

This is an abstract model that represents all the major power system objects in an electric utility enterprise, focusing on power system connectivity. The IEC 61970 series targets integration of applications developed by different suppliers in the control center environment – for the exchange of real-time information across legacy and new systems and to systems external to the control center environment.

IEC 60870, Inter Control Center Protocol (ICCP)

The six-part 60870 standard supports exchange of real-time and historical power system monitoring and control data – including measured values, scheduling data, energy accounting data, and operator messages – over Wide Area Networks (WANs) between a utility control centre's Supervisory Control And Data Acquisition/Energy Management System/Distribution Management System (SCADA/EMS/DMS) host and:

- other control centres
- other utilities
- power pools
- regional control centres
- Non-Utility Generators

IEC 62351, Utility communications security

While reliability and security of electric grid assets have always been important in the design and operation of power systems, information security becomes critical as operation of these assets increasingly relies on an information infrastructure. The IEC 62351 series provides standards to ensure:

- authenticated access to sensitive power system equipment
- authorized access to sensitive market data
- reliable and timely information on equipment functioning and failures
- backup of critical systems
- audit capabilities that permit detection and reconstruction of crucial events

IEC 62443, Control systems

This standard identifies specifications to support security of industrial automation and control systems (IACS). It targets the prevention of illegal or unwanted penetration, intentional or unintentional

SG 3 interoperability and security standards

SG 3's first task at an April, 2009, meeting was to finish laying down the road map for the development of the Framework 1 to achieve interoperability of Smart Grid systems. Since then, it submitted a 160-page report that covers the 24 TCs that have published International Standards relating to the Smart Grid and agreed on a basic set of standards covering the technical specifications that appear here. The new Framework 2 being developed by the SG 3 is a progressive release of Framework 1.

interference with the proper and intended operation, or inappropriate access to confidential information in the IACS. In particular, it focuses on the security of computers, networks, operating systems, applications, and other programmable configurable components of the system.

IEC 61968, CIM for business-to-business exchange of information

The IEC 61968 series is intended to facilitate integration of the various distributed software application systems that need to exchange data on an event driven basis through middleware services; see Figure 3. This series of standards defines interfaces among the components of Distribution Management Systems (DMS):

- monitoring and control of equipment for power delivery
- management processes to ensure system reliability
- voltage management
- demand-side management
- outage management
- work management
- automated mapping
- facilities management

IEC 61968 defines interfaces only, allows interoperability among different computer systems, platforms, and languages. The methods and technologies used to implement a functionality conforming to these interfaces are outside of the scope of the IEC 61968 series.

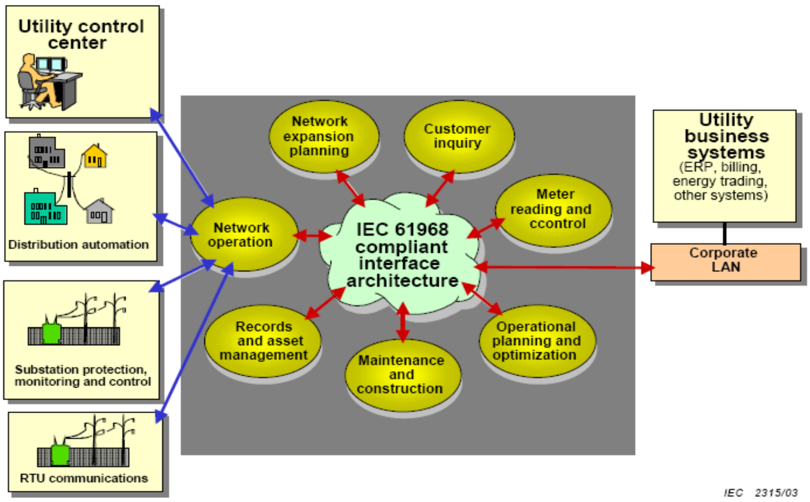

Figure 3. IEC 61968 defines the interoperability of the Distribution Management System (DMS).

IEC 62056, Electricity metering – data exchange for meter reading and tariff and load control

The integrated commercial process that starts with the measurement of the delivered product (energy) and ends with the revenue collection requires meter interoperability. IEC 62056 defines data exchange for the purposes of meter reading, tariff and load control, and consumer

Testing certifies "Smart Grid Ready"

In 2010, the Telvent Responder Smart Grid Outage Management System (OMS) passed the industry's first smart grid interoperability testing to the IEC/CIM 61968 standard, Part 9 profile for meter data interchange. The test, conducted by the Electrical Power Research Institute (EPRI), demonstrates the Telvent solution integrates with other industry providers' smart grid technology – a key feature of successful Smart Grid technology components.

information, using various alternative communication media, with reference to ISO and ITU standards.

IEC 61850, Substation equipment monitoring, operation, and control

IEC 61850 defines the various communication requirements for substation and feeder equipment. This standard also defines conformance testing. Discussions are underway to look at defining 61850 for the Substation-to-Master communication protocol currently in service in several installations.

- Uses the strengths of the OSI 7 layer communication model
- Standardized data models for electrical applications
- Defines Data Types and Communication Services
- Models devices, functions, processes and architectures
- Describes Engineering and Configuration Process
- Provides examples of typical applications in electrical substations

Work yet to do

In the U.S., the Energy Independence and Security Act of 2007 (EISA 2007) designated development of a Smart Grid as a national policy goal. It gave the Department of Energy (DOE) the overall lead of the Smart Grid program and assigned to NIST the job of developing a framework of standards and protocols to ensure interoperability and security. EISA specifies that the interoperability framework should be flexible, uniform, and technology-neutral. The Federal Energy Regulatory Commission (FERC), which has regulatory authority over the interstate energy industry, must approve the final standards.

While the first release of the NIST framework identified 75 existing standards that are likely to be applicable to the development of the Smart Grid, it also specified 15 high-priority gaps or areas for which new or revised standards are needed. Without standards, the report explained, there is the potential for technologies becoming obsolete prematurely or implemented without necessary security measures.

"The Smart Grid will ultimately require hundreds of standards, specifications and requirements," the document reported. "Some are needed more urgently than others." The framework identified eight priorities for standards development:

- Demand response and consumer energy efficiency
- Wide-area situational awareness
- Energy storage
- Electric transportation
- Advanced metering infrastructure
- Distribution grid management
- Cyber security
- Network communications

The second phase of the process began in November 2009 with the launch of a Smart Grid Interoperability Panel to help NIST develop

Telvent's subCAT certification

subCAT is a member of Telvent's family of Remote Terminal Units (RTU) for electric power automation. This family of RTUs has been certified by KEMA Consulting as complying with the IEC 61850 standard, both as client (Figure 4) and as server (Figure 5).

Certification of the subCAT to this standard assures interoperability between Intelligent Electronic Devices (IED) from different manufacturers and supports Telvent's Smart Network Solution, part of its Smart Grid Solution Suite for distributing electricity more efficiently, economically, reliably and securely.

IEC 61850 Certificate Level A[1]

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Issued to:
Telvent Energia, S.A.
Valgrande, 6 Alcobendas
28108 – Madrid
Spain

For the client system:
Telvent subCAT
firmware version 1.409

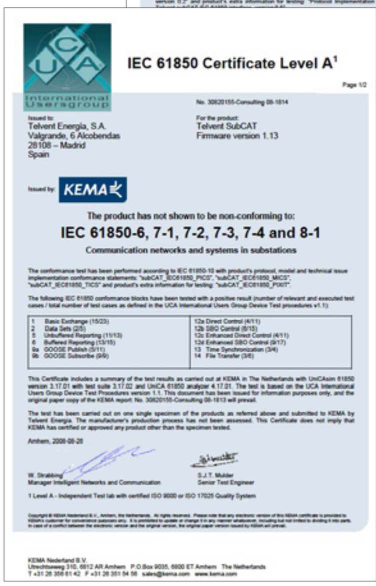
Issued by: KEMA

The product has not shown to be non-conforming to:

IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations

Figure 4



IEC 61850 Certificate Level A[1]

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Issued to:
Telvent Energia, S.A.
Valgrande, 6 Alcobendas
28108 – Madrid
Spain

For the product:
Telvent SubCAT
Firmware version 1.13

Issued by: KEMA

The product has not shown to be non-conforming to:

IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations

1 Basic Exchange (15/23)	12a Direct Control (4/11)
2 Data Sets (2/5)	12b SBO Control (6/15)
5 Unbuffered Reporting (11/13)	12c Enhanced Direct Control (4/11)
6 Buffered Reporting (13/15)	12d Enhanced SBO Control (9/17)
9a GOOSE Publish (5/11)	13 Time Synchronization (3/4)
9b GOOSE Subscribe (9/9)	14 File Transfer (3/6)

Arnhem, 2008-08-26

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Senior Test Engineer

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Figure 5

KEMA Nederland B.V. has certified the Telvent subCAT RTU (as client, Figure 4; as server, Figure 5) to IEC 61850-6, 7-1,7-2,7-3, 7-4, and 8-1 regulation for communication networks and systems in substations.

needed standards. The panel now includes nearly 500 organizations and 1,350 individuals. The final step is to develop a program for testing and certification to ensure that Smart Grid equipment and systems comply with standards.

Generation and Transmission

Mature standards and regulations are in place for equipment and communications involved in the power generation. Similarly, standards, specifications, and technologies are in place for transmission equipment and communications; see Table 2 for representative standards categorized by transmission application domain. It is inevitable that new standards will continue to be developed as technology evolves.

Domain	Standard/Specification/Technology
Control Centers	• IEC 61970 Common Information Model (CIM) • IEC 60870-6 Inter-Control Center Protocol (ICCP) • NRECA MultiSpeak
Substations	• IEEE C37.1 SCADA and Automation Systems • IEEE C37.2 Device Function Numbers • IEC 61850 Protocols, Configuration, Information Models • IEEE 1646 Communications Performance • Distributed Network Protocol (DNP3) • Modbus • IEEE C37.111-1999 – COMTRADE • IEEE 1159.3 PQDIF
Outside the Substation	• IEEE C37.118 Phasor Measurement • IEC 61850-90 (in development) • IEEE 1588 Precision Time Protocol • Network Time Protocol
Security	• IEEE 1686 IED Security • IEC 62351 Utility Communications Security • NERC Critical Infrastructure Protection (CIP) Standards
Hardening / Codes	• IEEE 1613 Substation Hardening for Gateways • IEC 61000-4 Electromagnetic Compatibility • IEC 60870-2 Telecontrol Operating Conditions • IEC 61850-3 General Requirements

Table 2. Transmission Standards and Technologies

Distribution
Mature standards and regulations are defined for transmission operations with a typical central generation supply and typical substation designs and their legacy communications. However, distributed resources – both their generation and their storage – are expected to be connected to the distribution portion of the grid in increasing numbers, requiring further standards development for this domain.

Customer
For the consumer, equipment standards are generally driven by product safety codes and regulations, especially for electricity-consuming products. Most consumer devices are tested and certified to accept any incoming interfering signals and continue operations, and to not generate any interfering signals in a certain frequency band. Communications standards and specifications, in general, have not yet been developed due to the variety of products involved.

Cyber security
"Ensuring cyber security of the Smart Grid is a critical priority," according to NIST's framework report, "and achieving it requires incorporating security at the architectural level." A Cyber Security Coordination Task Group led by NIST and consisting of almost 300 participants from the private and public sectors is developing a cyber security strategy for the Smart Grid.

Summary
The complexity of the regulatory environment, existing network context, and emerging technologies make defining and implementing a Smart Grid a significant project for any utility. The utility planning to transform a disjointed power network into an automated, integrated grid for the next generation must not only address business drivers and technology needs but also integration framework and architecture.

The strategic frameworks created by the IEC and NIST that identify applicable standards for network interoperability are key in helping utilities build a smart grid infrastructure that will support the operations and business decisions that can:

- reduce costs
- cut energy loss along the grid
- improve maintenance
- enhance reliability
- drive conservation through expanded rate offerings
- support more green energy options.

The interoperable Smart Grid also will adapt easily with currently available standardized technology, as needs change, and grow as innovation provides new standardized technology.

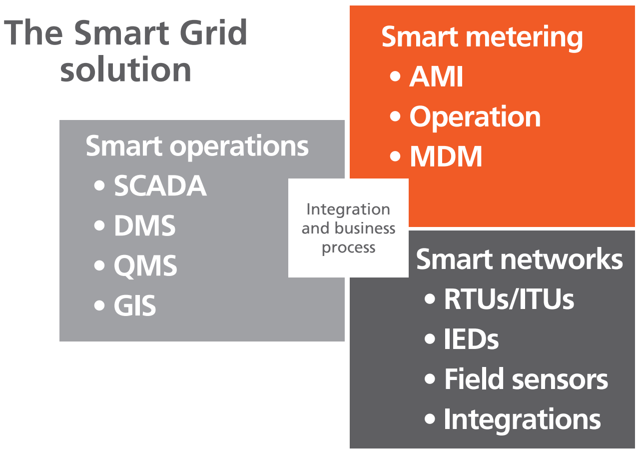
Learn more about Telvent's leadership in Smart Grid initiatives

Telvent is the leading provider of smart electric grid solutions, offering more proven, real-time information management tools and practical utility experience than any other Smart Grid partner. Our Smart Grid Solution suite is:

Uniquely complete, with all components based on a single data model available across the enterprise to provide a 'single version of the truth' regarding network operations status.

Scalable, for a sustainable solution benefiting customers and the environment, today and tomorrow.

Interoperable, complying with industry standards to assure secure operation and leverage legacy assets, third-party software, and future technology.



Contact us, by phone or e-mail, to request a copy of white papers discussing the definition and development of your smarter grid, or for more information about Smart Grid Solutions for interoperability.

References

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2. Activities in Smart Grid Standardization, ITU, Repository, Version 1.0, April 2010.
3. NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, January 2010.
4. Smart Grid Standards Assessment and Recommendations for Adoption and Development, EnerNex Corporation, 2009.

Telvent (NASDAQ: TLVT) is a global IT solutions and business information services provider that improves the efficiency, safety and security of the world's premier organizations. The company serves markets critical to the sustainability of the planet, including the energy, transportation, agriculture, and environmental sectors. (www.telvent.com)