NIST Technical Note 2042

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https://doi.org/10.6028/NIST.TN.2042

National Institute of Standards and Technology
U.S. Department of Commerce

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April 2019

U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Institute of Standards and Technology
Walter Copan, NIST Director and Undersecretary of Commerce for Standards and Technology

National Institute of Standards and Technology Technical Note 2042
Natl. Inst. Stand. Technol. Tech. Note 2042, 71 pages (April 2019)
CODEN: NTNOEF

This publication is available free of charge from:
https://doi.org/10.6028/NIST.TN.2042

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Abstract

The National Institute of Standards and Technology (NIST) Smart Grid Program seeks to accelerate the development of conformity assessment or testing and certification (T&C) programs for smart grid interoperability standards to ensure that the implementations conform to the standards' requirements and therefore enhance interoperability of smart grid devices and systems. This document presents a review of the current state of T&C for smart grid standards using a set of metrics developed from functional aspects of the standards. These functional metrics include information model and model mapping, communication protocol and protocol mapping, device physical performance, test methodologies, guidelines and best practices, and cybersecurity. These metrics are used to analyze smart grid standards and the T&C availability of these standards was also evaluated. The 240 smart grid standards analyzed were drawn primarily from three resources: the Smart Electric Power Alliance (SEPA) Catalog of Standards (CoS), the 2014 release of NIST's Framework and Roadmap for Smart Grid Interoperability Standards Release 3.0, and the Union of the Electricity Industry (EURELECTRIC) and European Distribution System Operator (EDSO) priorities for smart grid standardization position paper. The results of the smart grid standards T&C landscape analysis are provided in the report. These results indicate that only a small percentage of smart grid standards have available T&C programs.

Key words

Conformity assessment; interoperability; metrics; smart grid; standards; testing and certification (T&C).

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1. Introduction

Smart grid standards play a key role in the deployment of new technologies for the power grid. Standards can encourage innovation, boost productivity, and enhance economic efficiency by reducing or eliminating technical barriers for new technologies [1], and those standards that advance interoperability help maximize operational benefits while minimizing deployment costs for new equipment [2]. Testing and certification (T&C) programs provide a mechanism for all stakeholders to gain confidence that equipment function conforms to standards and will operate as intended, and are important to realize the benefits of a strong standards ecosystem [3].

The National Institute of Standards and Technology (NIST) previously conducted a landscape analysis study in 2010 to review the availability of T&C for smart grid standards [4]. The study found a limited number of existing smart grid test programs. To gain an understanding of the evolving T&C landscape for smart grid interoperability since the initial study, NIST compiled a representative list of smart grid standards and reviewed the status of associated T&C programs in this report. Because the complexity of smart grid standards and their applications have increased commensurately with that of the electrical grid, NIST assessed the T&C landscape for interoperability impact that each standard—and any associated T&C program—might have from a functional perspective.

2. Review Methodology

Applications for smart grid standards may span numerous dimensions of the grid. For example, the International Electrotechnical Commission (IEC) 61850 standard [5] shown in **Figure 1** has applications in each of the NIST Smart Grid Conceptual Model domains [2], including generation, transmission, distribution, customer, market, operations, and service provider. It also has diverse functionality or capabilities requirements, such as for the structure of an information model, communication protocols and specifications, performance requirements, testing methods, and so on. **Figure 1** also shows the IEC 61850 device structures (upper left) [7], object model (upper middle) [8], communication protocols (upper right) [9], and IEC 61850 applications and interface specifications across the grid domains (red circles in lower graphic) [6]. Compounding the complexity inherent to this breadth of application is the fact that smart grid standards—IEC 61850 included—will likely have different use cases in each domain or subdomain.

To identify those standards that might impact smart grid interoperability, NIST employed a functional classification system to complement the traditional architectural view of standards applications. Standards were functionally categorized as relating to information model and model mapping, communication protocol and protocol mapping, physical performance specification, test methodology, guideline and best practice, and cybersecurity; standards could be assigned multiple categories. Those standards associated with the following three function classes were deemed relevant to smart grid interoperability:

1) Information model and model mapping;
2) Communication protocol and protocol mapping; and
3) Physical performance specification.

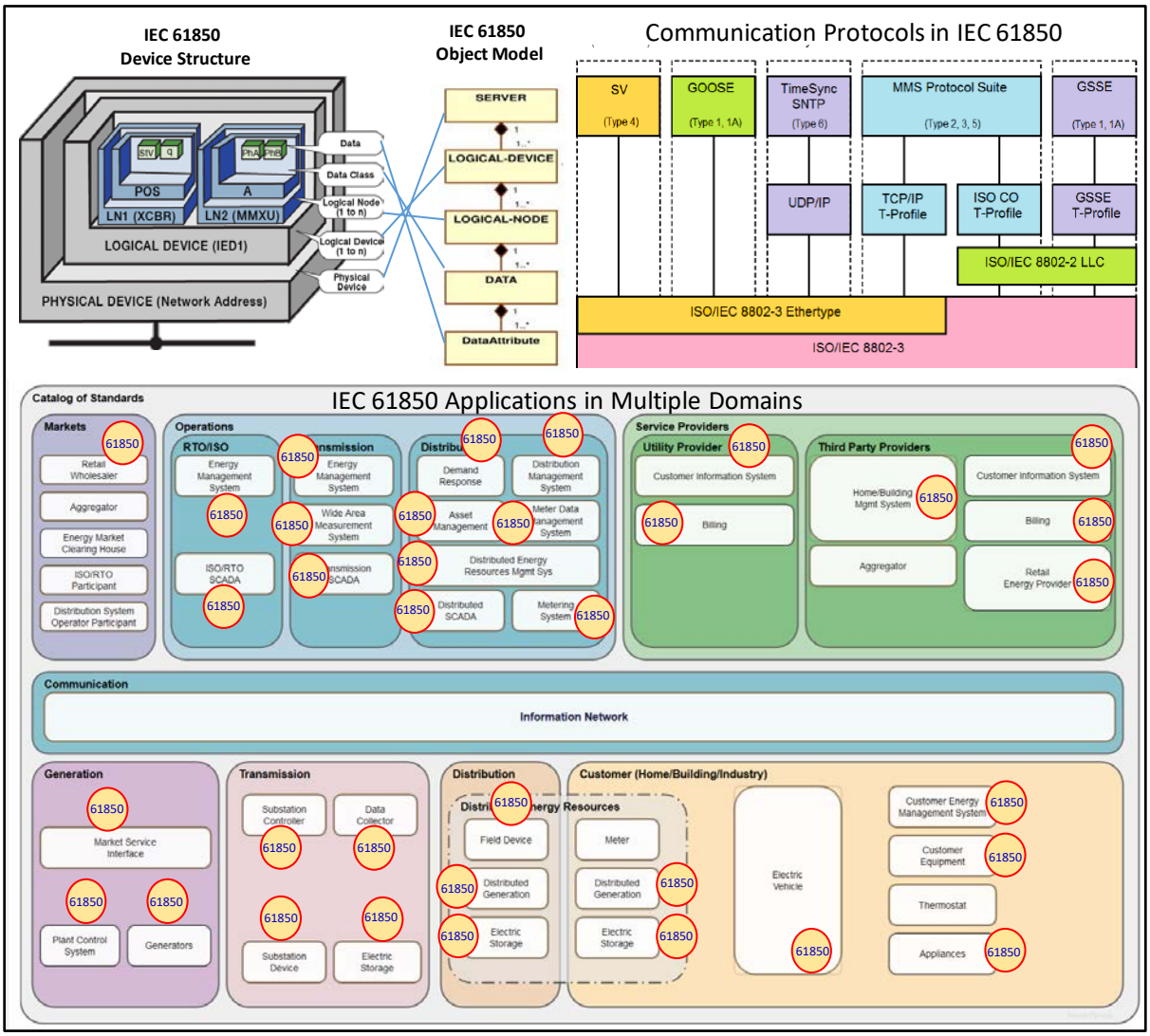

Figure 1. IEC 61850 functionality and applications in multiple domains[1].

Each standard was reviewed to determine if an associated T&C program is currently available or planned to for the future. The review covered different types of testing, including first party (self-certification), second party (user certification), and third party (independent certification) testing. NIST's determination of T&C program availability (or planned availability) was based on publicly available documentation on testing services associated with each standard, T&C program operators, test labs, and certification bodies. NIST did not assess the quality or effectiveness of T&C programs in this review and makes no claim regarding the relevance or importance of any T&C program.

[1] http://www.gridstandardsmap.com/. Multiple domains image used with permission from SEPA.

3. Identified Smart Grid Standards for Review

This review included 240 individual standards from twenty-two standards development organizations covering more than thirty-four families of standards. Drawn from numerous sources including those described below, NIST makes no claim regarding the importance of any standard included in these lists, or the relevance or importance of any standard not included in these lists. Sources included:

> ***Smart Electric Power Alliance (SEPA) Catalog of Standards (CoS)***
> SEPA produces and maintains the CoS as a reference to the electric grid community. With 81 smart grid standards, the catalog is a compendium of standards and practices considered to be relevant for the development and deployment of a robust, interoperable, and secure grid [6].
>
> ***NIST Framework and Roadmap for Smart Grid Interoperability Standards, R3.0***
> The 2014 version of the NIST Interoperability Framework identifies 72 smart grid-relevant standards. Guiding principles for identifying standards for implementation and including them on this list are provided on pages 55-56 of this report [2].
>
> ***European Distribution System Operator Priority List***
> The European Commission has identified broad priorities for smart grid standardization in Europe. Based on these recommendations, utility members of the Union of the Electricity Industry (EURELECTRIC) and European Distribution System Operator (EDSO) for smart grids have developed a list of priority standards and related activities for implementation in the smart grid [5] and the IEC smart grid standards map [10].

Most, but not all, of the standards used for this review were drawn from the above three sources. Yet because standards evolve in concert with technology, some standards have been updated or modified since these lists were published and so the newer versions were also reviewed. For example, the American National Standards Institute (ANSI) C12.20-2010 [11] is included in both the SEPA CoS and the NIST Framework R3.0, but a major update with significant new performance criteria in ANSI C12.20-2015 [12] has since been released and was included in this review.

A preliminary analysis was presented at the NIST Testing & Certification Workshop on July 9, 2018 [13], and stakeholder feedback was incorporated in this report. The full list of smart grid standards and associated reviews are provided in **Appendix B**. Only standards published before March 2019 were included in this analysis.

4. Results

Of the 240 standards reviewed, 169 standards were found to be functionally related to interoperability, and of those only a small percentage were found to have T&C programs of any form—either existing or planned. **Table 1** provides an overview of the total number of standards determined to be in each functional interoperability category (rows), as well as the number and implementation structure for any associated T&C programs; standards that

address multiple interoperability functional categories were identified and grouped accordingly. Certification type is broken into three: independent third party certification authorities (ITCA), first party (vendor self-certification), and second party (user certification). Because there were only two well-known second party T&C programs, these were grouped with first party programs in **Table 1**. The "Planned" column indicates when a T&C program is planned but not yet available for these smart grid standards.

Table 1. Standard Category and Number of Standards Evaluated.

Standard Category	**Number of Standards Evaluated**			
	Total No. of Standards	*with T&C Programs of type:*		
		ITCA[2]	1st Party	Planned
Information Model	34	5	0	2
Information Model & Communication Protocol	28	7	4	1
Communication Protocol	77	21	2	1
Communication Protocol & Physical Performance	7	0	1	2
Physical Performance	22	3	8	0
Information Model + Communication Protocol + Physical Performance	1	0	0	0
Total	*169*	*36*	*15*	*6*

A complete list of smart grid standards reviewed for T&C availability and functional categorization is available in **Appendix B**. The results of this analysis are described in **Table 1** and shown in **Figure 2.** These information model, communication protocol, and physical performance standards in **Figure 2** are presented in blue, orange, and green colors, respectively. The total 240 smart grid standards are presented in the black circle. In the legend of **Figure 2**, independent T&C, 1st party T&C, and planed T&C programs are represented in hatches, dots, and lines, respectively. The review results reveal several important trends about the standards evaluated for this study:

- Only 21% of 169 interoperability standards have independent T&C programs.
- When including 1st and 2nd party activities, only 30% of 169 interoperability standards have T&C programs.
- Physical performance standards are most likely to have T&C programs, but the substantial majority of those are not independent.
- There is no existing or planned path to device certification for the substantial majority of interoperability relevant smart grid standards.

The challenge of assuring interoperability is made more complex by the fact that interoperability for the smart grid demands more than the mere exchange of original or unprocessed data—sometimes called syntactic interoperability—and instead requires a semantic model [14] that utilizes elements from each of the above functional categories. Looked at another way, the limited extent of T&C programs within each functional grouping

[2] Independent third party certification authorities (ITCAs): https://www.iassc.org/question/why-is-an-independent-third-party-certification-important/

means the likely availability of certification-based assurance programs becomes vanishingly small once one realizes that achieving a full measure of device or systems interoperability requires a combined set of capabilities built from standards across multiple functional groupings.

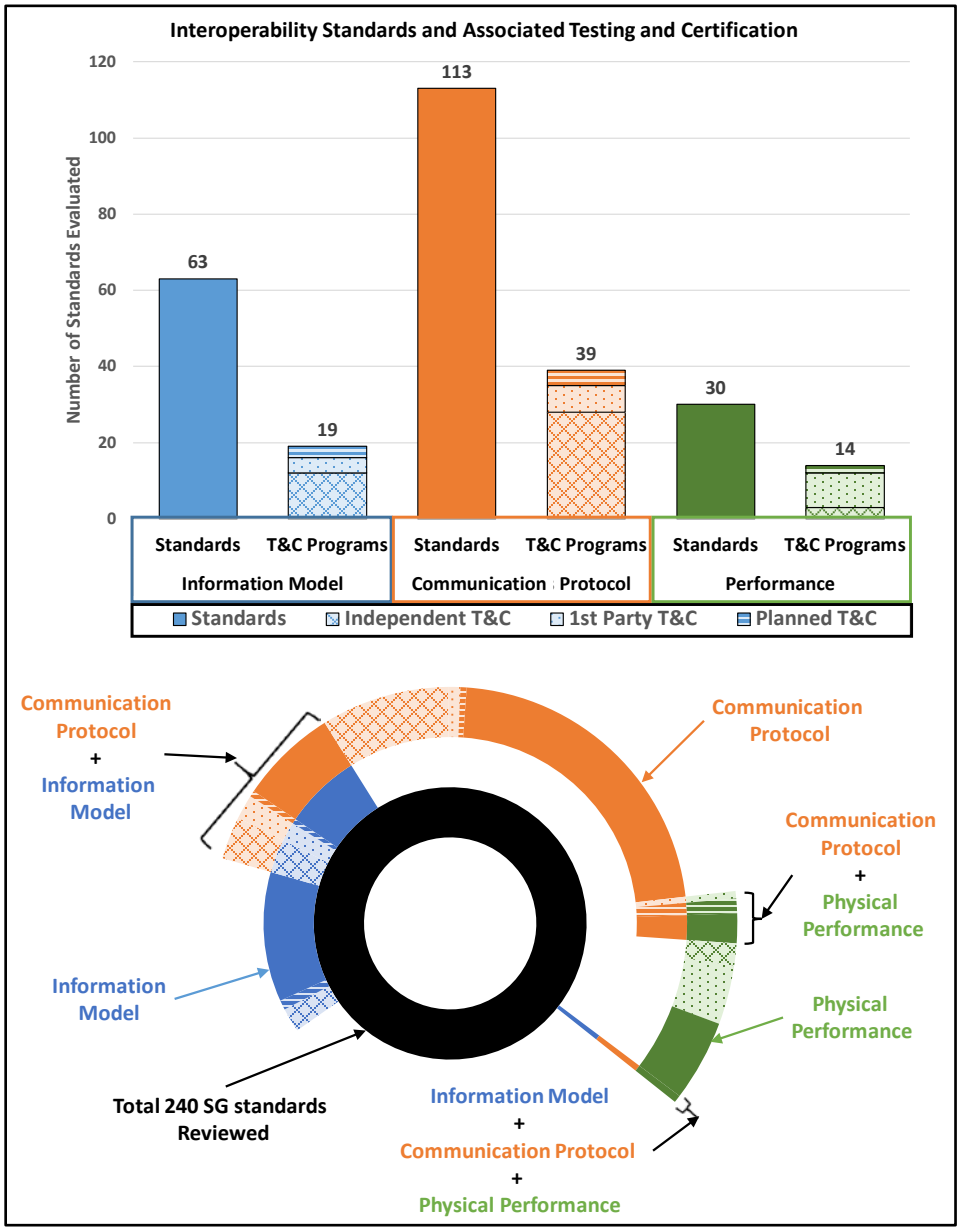

Figure 2. Review results of smart grid standards for T&C landscape.

Acknowledgments

The authors wish to thank all those who contributed ideas and suggestions for this report. They include Dr. David Wollman and Dr. Marty Burns of EL's Smart Grid and Cyber-Physical Systems Program Office, Steve Bushby of EL's Energy and Environment Division, Dr. Gerald Fitzpatrick and Thomas Nelson of PML's Quantum Measurement Division.

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[2] NIST Special Publication 1108r3, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1108r3.pdf.

[3] Public Utilities Commission of the State of California Resolution E-4527 (2012), http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M029/K624/29624509.PDF.

[4] Existing Conformity Assessment Program Landscape (2010), http://collaborate.nist.gov/twiki-sggrid/pub/SmartGrid/SGIPDocumentsAndReferencesSGTCC/D11a-ConformityLandscape_delivered.doc

[5] IEC 61850 Communication networks and systems for power utility automation, https://webstore.iec.ch/searchform&q=61850.

[6] SEPA Smart Grid Catalog of Standards, https://sepapower.org/knowledge/catalog-of-standards/catalog-of-standards-complete-list-of-entries/.

[7] Juan Gers, A PRIMER on IEC 61850 grid data communications, https://blogs.dnvgl.com/energy/a-primer-on-iec-61850-grid-data-communications.

[8] Drew Baigent, Mark Adamiak, Ralph Mackiewicz, IEC 61850 Communication Networks and Systems In Substations: An Overview for Users, https://www.slideserve.com/tate-olson/iec-61850-communication-networks-and-systems-in-substations-an-overview-for-users.

[9] IEC 61850 Protocol Libraries, http://www.xelasenergy.com/products/61850_protocols.php

[10] IEC Smart Grid Standards Map, http://smartgridstandardsmap.com/.

[11] ANSI C12.20-2010, American National Standard for Electricity Meters— 0.2 and 0.5 Accuracy Classes, https://webstore.ansi.org/Previews/PREVIEW_ANSI+C12.20-2010.pdf.

[12] ANSI C12.20-2015: American National Standard for Electricity Meters —0.1, 0.2, and 0.5 Accuracy Classes, https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI+C12.20-2015.

[13] NIST Testing & Certification Workshop on July 9, 2018, https://www.nist.gov/sites/default/files/documents/2018/06/25/draft_tc_landscape_evaluation_final.pdf

[14] Papaioannou I., Tarantola S., Lucas A., Kotsakis E., Marinopoulos A., Ginocchi M., Olariaga Guardiola M., Masera M., *Smart grid interoperability testing methodology*, EUR 29416 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-96855-6, doi:10.2760/08049, JRC110455, http://publications.jrc.ec.europa.eu/repository/bitstream/JRC110455/kjna29416enn_final.pdf

Appendix A: List of Acronyms and Abbreviations

ACSI	Abstract Communication Service Interface
AES	Advanced Encryption Standard
AC	Alternating Current
AMI	Advanced Metering Infrastructure
AMR	Automated Meter Reading
ANSI	American National Standards Institute
API	Application Programming Interface
ASDU	Application Service Data Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BACnet	Building Automation and Control Networks
BEV	Battery EV
BPL	Broadband over Power Line
CDC	Common Data Classes
CEA	Carcinoembryonic Antigen
CIM	Common Information Model
CIP	Critical Infrastructure Protection
CIS	Customer Information System
CNP	Control Network Protocol
COMFEDE	Common Format for Event Data Exchange
COMTRADE	Common Format for Transient Data Exchange
CoS	Catalog of Standards
COSEM	Companion Specification for Energy Metering
CPS	Cyber-Physical System
CRC	Circuit Reconfiguration Controller
CTA	Consumer Technology Association
DA	Distribution Access
DC	Direct Current
DER	Distributed Energy Resources
DG	Distributed Generation
DHS	Department of Homeland Security
DLL	Data Link Layer
DLMS/COSEM	Device Language Message Specification/Companion Specification for Energy Metering
DMS	Distributed Management System
DNP	Distributed Network Protocol
DR	Demand Response
D-SCADA	Distribution SCADA
DSO	Distribution System Operators
DSU	Distribution Substation Units
ED	End Device
EDSO	European Distribution System Operator
EIA	Enzyme Immunoassay
EMC	Electromagnetic Compatibility
EMS	Energy Management System

ES	Energy System
ESA	Electronic Sub Assembly
ESB	Enterprise Service Bus
ESP	Energy Service Provider
ESPI	ESP Interface
ESS	Energy Storage Systems
EUI	Energy Usage Information
EV	Electric Vehicle
EVSE	EV Supply Equipment
FP	Functional Profile
FPI	Fault Passage Indicators
FSGIM	Facility Smart Grid Information Model
GOOSE	Generic Object-Oriented Substation Event
HAN	Home Area Network
HES	Home Electronic System
HLDL	High-Level Data Link
HTTP	Hyper Text Transfer Protocol
HVAC	Heating, Ventilating, Air Conditioning
HVAC&R	Heating, Ventilating, Air Conditioning and Refrigerating
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IoT	Internet of Things
IP	Internet Protocol
IPv6	Internet Protocol Version 6
ISO	International Organization for Standardization
IT	Information Technology
ITU-T	International Telecommunication Union - Telecommunication
LAN	Local Area Network
LD	Logical Device
LN	Logical Node
LPIT	Low Power Instrument Transformers
MAC	Media Access Control
MCI	Modular Communications Interface
MDM	Meter Data Management
MDMS	Meter Data Management System
MEMS	Microgrid Energy Management System
MIB	Management Information Base
MIC	Monitoring, Information exchange, and Control
MMS	Manufacturing Message Specification
MPC	Monitoring, Protection and Control
MSVCB	Multicast Sampled Value Control Block

NAESB	North American Energy Standards Board
NB-PLC	Narrowband PLC
NCAP	Network Capable Applications Processor
NEMA	National Electrical Manufacturers Association
NERC	North American Electric Reliability Corporation
NIST	National Institute of Standards and Technology
NN	Neighborhood Network
NSM	Network and System Management
OASIS	Organization for the Advancement of Structured Information Standards
OASIS	Organization for the Advancement of Structured Information Standards
OBIS	Object Identification System
OFDM	Orthogonal Frequency Division Multiplexing
OGC	Open Geospatial Consortium
OGC-GML	Open Geospatial Consortium - Geography Markup Language
OLE	Object Linking and Embedding
OMS	Outage Management System
OPC	OLE for Process Control
OPC UA	OPC Unified Architecture
OpenADR	Open Automated Demand Response
OpenFMB	Open Field Message Bus
OpenHAN	Open Home Area Network
OSI	Open Systems Interconnection
PAN	Personal Area Network
PDC	Phasor Data Concentrator
PEFC	Polymer Electrolyte Fuel Cell
PHEV	Plug-in Hybrid Road Vehicles
PHY	Physical Layer
PICS	Protocol Implementation Conformance Statement
PLC	Power Line Communication
PMU	Phasor Measurement Unit
PSD	Power Spectral Density
PSTN	Public Switched Telephone Network
PTP	Precision Time Protocol
PV	Photovoltaic
RBA	Role Bases Access
RESS	Rechargeable Energy Storage Systems
REST	Representational State Transfer
ROCOF	Rate of Change of Frequency
RTO	Regional Transmission Organization
RTP	Real Time Price
RTU	Remote Terminal Unit
SAE	Society of Automotive Engineers
SAS	System/Substation Automation System
SCADA	Supervisory Control and Data Acquisition

SCL	System/Substation Configuration Language
SCSM	Specific Communication Service Mapping
SEP	Smart Energy Profile
SEPA	Smart Electric Power Alliance
SGIP	Smart Grid Interoperability Panel
SGIRM	Smart Grid Interoperability Reference Model
SM	Smart Meter
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol
SOA	Service-oriented Architecture
SOAP	Simple Object Access Protocol
SPS	Special Protection Systems
SV	Sampled Value
T&C	Testing and Certification
TASE	Telecontrol Application Service Elements
TCP	Transmission Control Protocol
TEDS	Transducer Electronic Data Sheet
TIM	Transducer Interface Module
TR	Technical Report
TS	Technical Specification
TSO	Transmission System Operator
UAS	Utility Automation System
UCA	Utility Communications Architecture
UCAIug	UCA International Users Group
UDP	User Datagram Protocol
UML	Unified Model Language
URI	Uniform Resource Identifier
USVCB	Unicast Sampled Value Control Block
Volt/VAR	Voltage/Volt-Ampere Reactive
W3C	World Wide Web Consortium
WAMPAC	Wide Area Monitoring, Protection, and Control
WAMS	Wide Area Management Systems
WAN	Wide Area Network
WS	Web Service
WSDL	Web Service Description Language
WTIM	Wireless Transducer Interface Module
XML	Extensible Markup Language
XMPP	Extensible Messaging and Presence Protocol

Appendix B: A List of Reviewed Smart Grid Standards

T&C Programs in Table 2 are categorized as follows: x – an independent T&C authority (ITCA) exists for this standard; y – the ITCA program for this standard derives from requirements established in a different standard; z – 1st or 2nd party T&C programs exist for this standard; and p – a T&C program is planned for this standard. This table will be separately published as a dataset and will be available in the link: https://doi.org/10.18434/M32061.

Table 2. A List of Reviewed Smart Grid Standards.

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
ANSI C12	ANSI C12.1-2008	ANSI C12.1-2008:American National Standard for Electric Meters Code for Electricity Metering. https://webstore.ansi.org/Standards/NEMA/ANSIC122008?gclid=EAIaIQobChMIquWPtN3D4QIVRCaGCh0uVAgREAAYASAAEgJo_fD_BwE			x	x					This standard establishes acceptable performance criteria for new types of ac watthour meters, demand meters, demand registers, pulse devices, and auxiliary devices. It also describes acceptable in-service performance levels for meters and devices used in revenue metering.	This standard also includes information on related subjects, such as recommended measurement standards, installation requirements, test methods, and test schedules. This Code for Electricity Metering is designed as a reference for those concerned with the art of electricity metering, such as utilities, manufacturers, and regulatory bodies.	• Operations/Distribution operations/Metering system • Transmission/Substation devices • DERs / (Field device, Meter) • Customers/Meter	• Meter remote connect & disconnect: This use case addresses the messages exchanged between customer information system (CIS) and smart meter (SM) through the Advanced Metering Infrastructure (AMI) head-end and AMI network when a meter connect/disconnect request is issued by CIS. • Outage Management System (OMS) poll multicast: it is an OMS poll of certain SMs that will enable operations personnel to determine if an outage is still valid. The OMS Poll is a multicast which can be initiated manually or automatically. • OMS poll unicast • Outage notification: This use case addresses the Outage Notification message generated by the SM and how this message gets generated into a trouble ticket. • Outage restoration notification: Utility implements integrated management of DERs • Performing real time price option: This use case addresses the process of computing the Real Time Price (RTP) signals for the Smart Grid Dispatch. • Remote programming SM: Meter remote connect & disconnect: This use case addresses the messages exchanged between CIS and SM through the AMI head-end and AMI network when a meter	z
	ANSI C12.1-2014	ANSI C12.1-2014: Electric Meters - Code for Electricity Metering https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%20C12.1-2014			x	x					This standard establishes acceptable performance criteria for new types of AC watthour meters, demand meters, demand registers, pulse devices, and auxiliary devices. It also describes acceptable in-service performance levels for meters and devices used in revenue metering. There are two versions of this standard because manufacturers are producing and testing meters to both versions.	This standard also includes information on related subjects, such as recommended measurement standards, installation requirements, test methods, and test schedules. This Code for Electricity Metering is designed as a reference for those concerned with the art of electricity metering, such as utilities, manufacturers, and regulatory bodies.			z
	ANSI C12.18-2006	ANSI C12.18-2006: American National Standard for Protocol Specification for ANSI Type 2 Optical Port. https://www.smartgrid.gov/document/ansi_c1218_2006ieee_p1701mc1218_protocol_specification_ansi_type_2_optical_port https://webstore.ansi.org/standards/nema/ansic12182006r2016	x	x	x						This standard describes the criteria required for communications between a C12.18 Device and a C12.18 Client via an optical port. The C12.18 Client may be a handheld reader, a portable computer, a master station system or some other electronic communication device. This Standard provides details for a complete implementation of an OSI 7-layer model. The protocol specified in this document was designed to transport data in Table format. The Table definitions are in ANSI C12.19 Utility Industry End Device Data Tables.	The C12.18 Client may be a handheld reader, a portable computer, a master station system or some other electronic communication device. The C12.18 Device is An electronic communication apparatus that implements an ANSI Type 2 Optical Port for communication according to the protocol specification of this Standard. Point-to-point communications is defined as communication between C12.18 Client (reader or master) and C12.18 Device (server or apparatus) through a single optical interface.			
	ANSI C12.19-2008	ANSI C12.19-2008: American National Standard for Utility Industry End Device Data Tables. https://www.smartgrid.gov/document/ansi_c1219_2008ieee_p1377mc1219_american_national_standard_utility_industry_end_device_data https://webstore.ansi.org/standards/nema/ansic12192008	x								This standard provides a common data structure for use in transferring data to and from utility EDs, typically meters. The standard data structure is defined as sets of tables. The tables are grouped together into sections called decades. Each decade pertains to a feature- set and related function such as Time-of-use, Load Profile, etc. Table data is transferred from or to the ED by reading from or writing to a table or portion of a table.	This Standard defines a Table structure for utility application data to be passed between an End Device and any other device.			

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
ANSI C12	ANSI C12.19-2012	ANSI C12.19-2012: American National Standard for Utility Industry End Device Data Tables. https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI+C12.19-2012 https://global.ihs.com/doc_detail.cfm?&csf=ECIA&item_s_key=00286183&item_key_date=871231&input_doc_number=&input_doc_title=&doc_numb=ANSI%20C12%2E9	x								This standard defines a table structure for utility application data to be passed between an end device and any other device. It neither defines device design criteria nor specifies the language or protocol used to transport that data. The tables defined in this standard represent a data structure that shall be used to transport the data, not necessarily the data storage format used inside the end device. It provides a common data structure and descriptors for use in transferring data to and from utility EDs, typically meters and head-ends. There are two versions of this standard because manufacturers are producing and testing meters to both versions.	This standard is to provide a uniform, structured, and adaptive data model, such that utility EDs and ancillary devices (e.g., home appliances and communication technology) can operate in a "plug-and-play" and multisource enterprise AMI environment. It defines a table structure for utility application data to be passed between an ED and any other device.		connect/disconnect request is issued by CIS	
	ANSI C12.20-2015	ANSI/NEMA C12.20-2015: American National Standard for Electricity Meters —0.1, 0.2, and 0.5 Accuracy Classes. https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI+C12.20-2015			x						This standard establishes the physical aspects and acceptable performance criteria for 0.1, 0.2, and 0.5 accuracy class electricity meters meeting Blondel's Theorem.	The 0.1, 0.2, and 0.5 accuracy class electricity meters established within ANSI C12.20-2015 are accurate to within +/-0.1%, +/-0.2%, and +/-0.5% of true value at a full load, respectively. Beyond the designations of these three meter types, the standard covers voltage and frequency ratings, test current values, service connection arrangements, pertinent dimensions, form and display designations, environmental tests, and acceptable performance of the meters and associated equipment.			z
	ANSI C12.21-2006	ANSI C12.21-2006: Protocol Specification for Telephone Modem Communication. https://webstore.ansi.org/standards/nema/ansic12212006r2016 https://www.smartgrid.gov/document/ansi_c1221_2006ieee_p1702mc1221_protocol_specification_telephone_modem_communication	x	x							This standard detail the criteria required for communications between a C12.21 Device and a C12.21 Client via a modem connected to the switched telephone network.	The protocol specified in this Standard was designed to transport data in Table format. The Table definitions are in ANSI C12.19, and Annex D of this document. The C12.21 Client could be a laptop or portable computer, a master station system or some other electronic communication device.			
	ANSI C12.22-2012	ANSI C12.22-2012: American National Standard Protocol Specification for Interfacing to Data Communication Networks. https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI+C12.22-2012	x	x						x	This standard describes the process of transporting C12.19 table data over a variety of networks, with the intention of advancing interoperability among communication modules and meters. Uses AES encryption to enable strong, secure Smart Grid communications, including confidentiality and data integrity, and is also fully extensible to support additional security mechanisms the industry may require in the future. It defines network Application Services for the exchange of Table data and control elements. These services must be implemented by all C12.22 Nodes, including "back-office" or "head-end" systems.	This standard extends the concepts of ANSI C12.18/MC12.18/IEEE 1701, ANSI C12.21/MC12.18/IEEE 1702, and ANSI C12.19/MC12.19/ IEEE 1377 standards to allow transport of Table data over any reliable networking communication system. This standard describes an optionally exposed point-to-point interface between a C12.22 Device and a C12.22 Communication Module designed to attach to "any" network.			

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
ANSI/ASHRAE	ANSI/ASHRAE 135-2016 (ISO 16484-5:2017)	ANSI/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 135-2016: BACnet— A Data Communication Protocol for Building Automation and Control Networks. (This standard supersede ANSI/ASHRAE 135-212) https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2FASHRAE+Standard+135-2016 ISO 16484-5:2017: https://www.iso.org/standard/71935.html	x	x							This standard defines data communication services and protocols for computer equipment used for monitoring and control of HVAC&R and other building systems and to define, in addition, an abstract, object-oriented representation of information communicated between such equipment, thereby facilitating the application and use of digital control technology in buildings. It contains significant new functionality that will be implemented in products over the next few years. Building automation and control systems for applications such as HVAC, lighting control, access control, and fire detection systems and their associated equipment. T&C for this standard is done in conformance to ANSI/ASHRAE 135.1-2013	Here are a few highlights. • There are new standard object types for elevators, lighting control, and network management. • A specification for how BACnet devices can directly communicate on IPv6 networks has been added. • Web services for integration between enterprise systems and building automation systems have been completely redesigned, with greatly improved functionality. The new web services are based on RESTful principles. • Semantic tags can be attached to any BACnet object, allowing an object's purpose to be described in a machine-interpretable way. The BACnet committee and Project Haystack are developing standard tag sets. • Consulting engineers will benefit from several new BACnet device profiles, which will make it easier to specify BACnet functionality in building control products.	• Service providers/Third party providers/ (Aggregator, home/Building management system) • DER/Meter • Customers / (Meter, Customer EMS, Customer equipment, Thermostat, and Appliance)	Building automation and control systems for applications such as heating, ventilating, and of heating, ventilating, air conditioning (HVAC), lighting control, access control, and fire detection systems and their associated equipment.	y
	ANSI/ASHRAE 135.1-2013 (ISO 16484-6:2014)	ASHRAE 135.1-2013 Standard 135.1-2013 -- Method of Test for Conformance to BACnet https://webstore.ansi.org/standards/ashrae/ansiashraestandard1352013 https://www.techstreet.com/standards/ashrae-135-1-2013?product_id=1873280 ISO 16484-6:2014: https://www.iso.org/obp/ui/#iso:std:iso:16484:-6:ed-3:v1:en				x					This standard provides a comprehensive set of procedures for verifying the conformance of each capability claimed on a BACnet implementation. An addendum to this standard was approved in May 2018 to cover the additional requirements in the ANSI/ASHRAE 135-2016 standard.	Protocol Implementation Conformance Statement (PICS) including: (a) support of each claimed BACnet service, either as an initiator, executor, or both, (b) support of each claimed BACnet object-type, including both required properties and each claimed optional property, (c) support of the BACnet network layer protocol, (d) support of each claimed data link option, and (e) support of all claimed special functionality. The ITCA for this standard is BACnet International.	Distribution, Customer, Building		x
	ANSI/ASHRAE/NEMA 201-2016 International Organization for Standardization (ISO) 17800:2017	ANSI/ASHRAE/National Electrical Manufacturing Association (NEMA) 201-2016 FSGIM (Facility Smart Grid Information Model) https://webstore.ansi.org/standards/ashrae/ansiashraenemastandard2012016 https://www.techstreet.com/ashrae/standards/ashrae-201-2016?product_id=1915946 ISO 17800:2017: https://www.iso.org/standard/71547.html	x								This ANSI/ASHRAE/NEMA standard defines an abstract, object-oriented information model to enable appliances and control systems in homes, buildings, and industrial facilities to manage electrical loads and generation sources in response to communication with a "smart" electrical grid and to communicate information about those electrical loads to utility and other electrical service providers.	This standard provides a common basis for electrical energy consumers to describe, manage and communicate about electrical energy consumptions and forecasts. This standard provides a way to model real building systems as a combination of four abstract components: loads, generators, meters and energy managers. The building system can be a family house, a commercial or institutional building, a manufacturing or industrial facility or multiple buildings such as a college campus.	• Customers / (Electric vehicle (EV) and Customer energy management system (EMS), Customer equipment, Thermostat, and Appliance) • Customer/Distributed energy resources (DERs)/ (meter, distributed generation (DG), energy system (ES))	• See FSGIM user guide. *Note that purchase of this standard includes a copy of a user's guide that illustrates application of the standard to several use cases.	

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
ANSI/CEA 709	ANSI/CEA 709.1-D-2014 (ISO/IEC 14908-1:2012)	ANSI/CEA 709.1-D-2014: Control Network Protocol Specification Consumer Electronics Association (CEA®) https://webstore.ansi.org/RecordDetail.aspx?sku=CEA+709.1-D-2014+(ANSI) ISO/IEC 14908-1:2012: https://webstore.iec.ch/preview/info_isoiec14908-1%7Bed1.0%7Den.pdf		x							This specification applies to a communication protocol for networked control systems. The protocol provides peer-to-peer communication for networked control and is suitable for implementing both peer-to-peer and master-slave control strategies. This specification applies to a communication protocol for networked control systems. The protocol provides peer-to-peer communication for networked control and is suitable for implementing both peer-to-peer and master-slave control strategies. This specification describes services in layers 2-7. In the layer 2 (data link layer) specification, it also describes the MAC sub-layer interface to the physical layer. The physical layer provides a choice of transmission media. The interface described in this specification supports multiple transmission media at the physical layer. In the layer 7 specification, it includes a description of the types of messages used by applications to exchange application and network management data.	This specification describes services in layers 2-7. In the layer 2 (data link layer) specification, it also describes the MAC sub-layer interface to the physical layer. The physical layer provides a choice of transmission media. The interface described in this specification supports multiple transmission media at the physical layer. In the layer 7 specification, it includes a description of the types of messages used by applications to exchange application and network management data.	• Service providers/Third party providers / (Home/Building management system) • Customers / (Meter, Customer EMS, Thermostat, Appliance)	• This standard is used in thermostats, appliances, controllers, lighting, and other small devices within the home or commercial facilities. • Used in substation monitoring and automation, and electricity metering. • Used in transportation (locomotive, light rail, subway, bus, automotive) for controls and monitoring. • Used for commercial demand response and building automation. • Used in PV and Wind farms for monitoring and gen-set interfacing. • Used in backup generator monitoring and control. Used for medium-voltage monitoring and distribution-transformer monitoring	
	ANSI/CEA 709.2-A-2006 (ISO/IEC 14908-2:2012)	ANSI/CEA 709.2-A-2006 Control Network Power Line Channel Specification https://webstore.ansi.org/standards/cea/ansicea7092006 https://www.smartgrid.gov/document/ansicea_7092_a_2006_control_network_power_line_pl_channel_specification ISO/IEC 14908-2:2012: https://www.iso.org/standard/60204.html		x							This document specifies the Control Network PL Channel and serves as a companion document to the EIA-709.1 Control Network Protocol Specification. Its purpose is to present the information necessary for the development of a PL physical network and nodes to communicate the share information over the network. This is one of a series of documents covering the various media that comprise the EIA-709 Standard.	This document covers the complete physical layer (OSI Layer 1), including the interface to the Media Access control (MAC) layer and the interface to the medium. Parameters that are controlled by other layers but control the operation of the physical layer are also specified.			
	ANSI/CEA 709.3-R2004 (ISO/IEC 14908-3:2012)	ANSI/CEA-709.3-R2004 - Free-Topology Twisted-Pair Channel Specification https://webstore.ansi.org/standards/cea/ansicea709r2004 https://webstore.ansi.org/RecordDetail.aspx?sku=CEA+709.2-A-2000+(R2012)+(ANSI) ISO/IEC 14908-3:2012: https://www.iso.org/standard/60205.html		x							This document specifies the Control Network Power Line (PL) Channel and serves as a companion document to the EIA-709.1 Control Network Protocol Specification. Its purpose is to present the information necessary for the development of a PL physical network and nodes to communicate the share information over the network. This is one of a series of documents covering the various media that comprise the EIA-709 Standard.				
	ANSI/CEA 709.4-2013 (ISO/IEC 14908.4)	ANSI/CEA 709.4-2013 Fiber-Optic Channel Specification https://webstore.ansi.org/Standards/CEA/CEA7092013ANSI		x	x						This document specifies the physical layer (OSI Layer 1) requirements for the EIA -709.4 fiber-optic channel which encompasses the interface to the Media Access Control (MAC) layer and the interface to the medium. Parameters that are controlled by other layers but control the operation of the physical layer are also specified.				

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ANSI/CEA 852	ANSI/CEA 852-C-2014	ANSI/CEA 852-C-2014: Tunneling Device Area Network Protocols Over Internet Protocol Channels https://webstore.ansi.org/Standards/CEA/CEA8522014ANSI		x							This standard specifies a communications method that allows networked data acquisition and control devices to communicate with each other over the internet. The purpose of such devices are widely varying and include functions such as appliance monitoring, meter reading, and HVAC and lighting control to name a few. CEA-852 does not replace existing device communications protocols, but instead allows those protocols to use the internet as a communications medium. to revise ANSI/CEA 852-B.		• Service providers/Third party providers / (Home/Building management system) • Customers / (Meter, Customer EMS, Customer equipment, Thermostat, Appliance)		
	ANSI/CEA 852.1-A-2014	ANSI/CEA 852.1-A-2014: Enhanced Protocol for Tunneling Component Network Protocols over Internet Protocol Channels https://webstore.ansi.org/RecordDetail.aspx?sku=CEA+852.1-A-2014+(ANSI) https://standards.cta.tech/kwspub/published_docs/ANSI-CEA-852.1-A-Preview.pdf		x							This standard specifies a communications method that allows networked data acquisition and control devices to communicate with each other over the internet. The purpose of such devices are widely varying and include functions such as appliance monitoring, meter reading, and HVAC and lighting control to name a few. CEA-852.1 does not replace existing device communications protocols, but instead allows those protocols to use the internet as a communications medium.		• Service providers/Third party providers / (Home/Building management system) • Customers / (Meter, Customer EMS, Customer equipment, Thermostat, Appliance)		
	ANSI/NEMA SG-IPRM 1-2016	ANSI/NEMA SG-IPRM 1-2016 Smart Grid Interoperability Process Reference Manual https://webstore.ansi.org/standards/nema/ansinemasgiprm2016 https://www.techstreet.com/standards/ansi-nema-sg-iprm-1-2016?product_id=1915475 https://www.nema.org/Standards/ComplimentaryDocuments/ANSINEMA%20SG-IPRM%201-2016-CONTENTS-AND-SCOPE.pdf							x		Smart Grid Interoperability Process Reference Manual. It defines a process by which industry stakeholders may procure, test, and assert interoperability between disparate vendors of smart grid products to identified standards. This is accomplished by defining the relationships between smart grid stakeholders invested in this goal. This standard defines requirements and recommendations for general test policies, test suite specifications, test profiles, interoperability testing and certification authority technical programs, governance, laboratory qualifications, and (process) improvements. Finally, this standard describes an implementation approach.		Generation, Transmission, Distribution, Operation, Service Provider, Customer		
	CEA CEDIA-CEB29	CEA CEDIA-CEB29 Recommended Practice for the Installation of Smart Grid Devices https://webstore.ansi.org/standards/cea/ceacediaceb292012							x		This standard describes installation and wiring of residential smart grid devices. To give attention relationships of low and residential line voltage mediums, surge arresting or electrical networks and devices, proximity of transmitters of like frequency ranges, grounding and shielding practices and other elements that concern creating an acceptable installation environment for smart grid devices and systems.		• Customers / (Meter, Customer equipment, Thermostat, Appliance)		

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	CTA 2045	Consumer Technology Association (CTA) 2045: Modular Communications Interface for Energy Management https://www.techstreet.com/standards/cta-2045?product_id=1850054		x							This CTA standard defines a modular communications interface (MCI) to facilitate communications with residential devices for applications such as energy management. It provides a standard interface for energy management signals and messages to reach devices. Such devices may include an energy management hub, an energy management controller, an energy management agent, a residential gateway, an energy services interface, a sensor, a thermostat, an appliance, or other consumer products.	The MCI enables any product to connect to any type of demand response system, such as advanced meter reading, Smart Energy Profile (SEP), Open Automated Demand Response (OpenADR), and/or home or building network. It also includes physical interface. Note: There is a new version of this standard. CTA 2045-A could be found in the web link: https://www.techstreet.com/standards/cta-2045-a?product_id=2002822	• DER/ Meter • Customers / (Meter, EV, Customer EMS, Customer equipment, Costumer thermostat, and Appliance)	• This standard interface is used for energy management hub, an energy management controller, an energy management agent, a residential gateway, an energy services interface, a sensor, a thermostat, an appliance, or other consumer products.	
	Department of Homeland Security: Cyber Security Procurement Language for Control Systems	Department of Homeland Security (DHS): Cyber Security Procurement Language for Control Systems https://ics-cert.us-cert.gov/sites/default/files/documents/Procurement_Language_Rev4_100809_S508C.pdf								x	This document summarizes security principles that should be considered when designing and procuring control systems products and services (software, systems, maintenance, and networks), and provides example language to incorporate into procurement specifications. The guidance is offered as a resource for informative use. It is not intended to be a policy or standard		Generation, Transmission, Distribution, Operation, Service Provider, Customer		
	DHS NCS Catalog of control systems security: recommendation for standard developers	DHS National Communications System (NCS) Catalog of control systems security: recommendation for standard developers. https://ics-cert.us-cert.gov/sites/default/files/documents/CatalogofRecommendationsVer7.pdf								x	This catalog presents a compilation of practices that various industry bodies have recommended to increase the security of control systems from both physical and cyberattacks. The recommendations in this catalog are grouped into 19 families, or categories, that have similar emphasis. The recommendations within each family are displayed with a summary statement of the recommendation, supplemental guidance or clarification, and a requirement enhancements statement providing augmentation for the recommendation under special situations.	This catalog is not limited for use by a specific industry sector. All sectors can use it to develop a framework needed to produce a sound cybersecurity program. The number of new and updated published Cyber Security Standards and guidelines has increased significantly this past year. An attempt has been made to reference and include the best practices introduced by these new and updated documents to interested users for consideration as input into individual industrial cybersecurity plans under development and review. This catalog should be viewed as a collection of guidelines and recommendations to be considered and judiciously employed, as appropriate, when reviewing and developing cybersecurity standards for control systems. The recommendations in this catalog are intended to be broad enough to provide any industry using control systems the flexibility needed to develop sound cybersecurity standards specific to their individual security needs. These recommendations are subservient to existing legal rules and regulations pertaining to specific industry sectors, and the user is urged to consult and follow those applicable regulations.	Generation, Transmission, Distribution, Operation, Service Provider, Customer		
	Framework for Improving Critical Infrastructure Cybersecurity	Framework for Improving Critical Infrastructure Cybersecurity V1.1 April,16, 2018 https://nvlpubs.nist.gov/nistpubs/CSWP/NIST.CSWP.04162018.pdf							x	x	The Framework focuses on using business drivers to guide cybersecurity activities and considering cyber Security risks as part of the organization's risk management processes. The Framework consists of three parts: the Framework Core, the Framework Profile, and the Framework Implementation Tiers. The Framework Core is a set of cybersecurity activities, outcomes, and informative references that are common across sectors and critical infrastructure. Elements of the Core provide detailed guidance for developing individual organizational Profiles. Through use of Profiles, the Framework will help an organization to align and prioritize its cybersecurity activities with its business requirements, risk tolerances, and resources. The Tiers provide a mechanism for organizations to view and understand the characteristics of their approach to managing cybersecurity risk, which will help in prioritizing and achieving cybersecurity objectives.		Generation, Transmission, Distribution, Operation, Service Provider, Customer		

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IEC 60255	IEC 60255	IEC 60255: Measuring relays and protection equipment			x						This family standard specifies common rules and requirements applicable to measuring relays and protection equipment including any combination of devices to form schemes for power system protection such as control, monitoring and process interface equipment in order to obtain uniformity of requirements and test		• Generic substation • Distribution automation • Power plant • Electric system operation • Enterprise	Operation Meter: • Meter remote connect disconnect • Outage management system poll multicast • Outage management system poll unicast • Outage notification • Outage restoration notification • Performing RTP option • Programming SM Station Controller: • Integrated Volt/VAR • Adaptive transmission protection • Advanced distribution automation with DER function • Circuit reconfiguration • Integrated Volt/VAR decentralized • AGC frequency control • Fault isolation • Field control request • Volt/VAR on substation basis • Advanced DA functions •System engineer retrofits a substation	
	IEC 60255-1:2009	IEC 60255-1:2009 Measuring relays and protection equipment - Part 1: Common requirements https://webstore.iec.ch/publication/1160			x						This standard specifies common rules and requirements applicable to measuring relays and protection equipment including any combination of devices to form schemes for power system protection such as control, monitoring and process interface equipment in order to obtain uniformity of requirements and tests. Covers all measuring relays and protection equipment used for protection within the power system environment.				
	IEC 60255-24:2013	IEC 60255-24:2013 Measuring relays and protection equipment - Part 24: Common format for transient data exchange (COMTRADE) for power systems https://webstore.iec.ch/publication/1170		x							This standard defines a format for files containing transient waveform and event data collected from power systems or power system models. The format is intended to provide an easily interpretable form for use in exchanging data. The standard is for files stored on currently used physical media such as portable external hard drives, USB drives, flash drives, CD, and DVD. This standard defines a common format for the data files and exchange medium needed for the interchange of various types of fault, test, and simulation data.	The ITCA for this standard is ICAP.			x
	IEC 60255-26:2013	IEC 60255-26:2013 Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements https://webstore.iec.ch/publication/1171			x						This standard is applicable to measuring relays and protection equipment, taking into account combinations of devices to form schemes for power system protection including the control, monitoring, communication and process interface equipment used with those systems. This standard specifies the requirements for electromagnetic compatibility for measuring relays and protection equipment. The requirements specified in this standard are applicable to measuring relays and protection equipment in a new condition and all tests specified are type tests only.	This new edition includes the following significant technical changes with respect to the previous edition: - definition of test specifications, test procedures and acceptance criteria per phenomena and port under test in one document; - extension of radiated emission measurement for frequencies above 1 GHz; - limitation of radiated emission measurement at 3 m distance for small equipment only; - addition of zone A and zone B test level on surge test; - extension of tests on the auxiliary power supply port by a.c. and d.c. voltage dips, a.c. component in d.c. (ripple) and gradual shut-down/start-up; - harmonization of acceptance criteria for immunity tests.	Transmission, Distribution		
	IEC 60255-27:2013	IEC 60255-27:2013 Measuring relays and protection equipment - Part 27: Product safety requirements https://webstore.iec.ch/publication/1172							x		This standard describes the product safety requirements for measuring relays and protection equipment having a rated a.c. voltage up to 1 000 V with a rated frequency up to 65 Hz, or a rated d.c. voltage up to 1 500 V. Above these limits, IEC 60664-1 is applicable for the determination of clearance, creepage distance and withstand test voltage. This standard details essential safety requirements to minimize the risk of fire and hazards caused by electric shock or injury to the user.	This new edition includes the following significant technical changes with respect to the previous edition: - the removal of tables and diagrams which are from other standards and referring instead directly to the source standard; - all aspects of IEC 60255-5 have been covered and this standard will be withdrawn.	Transmission, Distribution		

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IEC 60870-5	IEC 60870-5-101:2003	IEC 60870-5-101:2003 IEC 60870-5-101:2003 Transmission Protocols - companion standards for basic tele-control tasks https://webstore.ansi.org/Standards/IEC/IEC60870101Eden2003?gclid=EAIaIQobChMIqvqPwvOM3wIVGY_ICh23sQ2yEAAYASAAEgIKT_D_BwE		x							This standard is primarily used with relatively slow transmission media on the asynchronous V.24 interface. The standard promises baud rates of up to 9600 bit/s, with much higher baud rates (<115200 bit/s) actually being used. X.24/X.27 interfaces with baud rates up to 64000 bit/s, also part of the standard's description, could not establish themselves and are rarely used.	The ITCA for this standard is DNV GL.	• Among EMS, supervisory control and data acquisition (SCADA), EMS, wide area management systems (WAMS)		x
	IEC 60870-5-102:1996	IEC 60870-5-102:1996 Transmission Protocols - Companion standard for the transmission of integrated totals in electric power systems (this standard is not widely used) https://webstore.iec.ch/publication/3744		x							This standard is a companion standard for the transmission of integrated totals in electric power systems. It standardizes the transmission of integrated totals representing the amount of electrical energy transferred between power utilities, or between a power utility and independent producers on a high voltage or medium voltage network.	IEC 60870-5-102 is primarily used with relatively slow transmission media on the asynchronous V.24 interface. The standard promises baud rates of up to 9600 bit/s. X.24/X.27 interfaces with baud rates up to 64000 bit/s, also defined by the standard, could not establish themselves and are rarely used.	• Among EMS, SCADA, EMS, WAMS systems	• The transmission of integrated totals in EPS	
	IEC 60870-5-103:1997	IEC 60870-5-103:1997: Transmission Protocols - Companion standard for the informative interface of protection equipment https://webstore.iec.ch/publication/3745		x							This standard applies to protection equipment with coded bit serial data transmission for exchanging information with control systems. Defines a companion standard that enables interoperability between protection equipment and devices of a control system in a substation		• Among EMS, SCADA, EMS, WAMS systems	• The informative interface of protection equipment. • It is mainly used for relatively slow transmission media on asynchronous V.24 (RS232) and RS485 interfaces.	
	IEC 60870-5-104 Ed. 2.1 b:2016	IEC 60870-5-104 Ed. 2.1 b: 2016: Transmission Protocols - Network access for IEC 60870-5-101 using standard transport profiles. https://webstore.ansi.org/Standards/IEC/IEC60870104Ed2016		x							This standard defines a telecontrol companion standard that enables interoperability among compatible telecontrol equipment. Applies to telecontrol equipment and systems with coded bit serial data transmission for monitoring and controlling geographically widespread processes.	It does not support short time stamps (3-byte format), the length of the various address elements is set to defined maximum values. The ITCA for this standard is DNV GL.	• Among EMS, SCADA, EMS, WAMS systems	It enables communication between control station and substation via a standard Transmission Control Protocol (TCP) and the Internet Protocol (IP) (TCP/IP) network. The TCP protocol is used for connection-oriented secure data transmission.	x

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IEC 60870-6	IEC 60870-6-503:2014	IEC 60870-6-503:2014 Telecontrol equipment and systems - Part 6-503: Telecontrol protocols compatible with ISO standards and ITU-T tecommendations - TASE.2 Services and protocol https://webstore.iec.ch/publication/3760		x							This standard specifies a method of exchanging time-critical control center data through wide-area and local-area networks using a full ISO compliant protocol stack. It contains provisions for supporting both centralized and distributed architectures. This standard includes the exchange of real-time data indications, control operations, time-series data, scheduling and accounting information, remote program control and event notification.	This new edition includes the following significant technical changes with respect to the previous edition: • certain objects were made informative; • services associated with the informative objects were made informative; • certain tele-control application service elements (TASE).2 conformance blocks were made out-of-scope. The ITCA for this standard is DNV GL.	• Operations / (Regional transmission organization (RTO)/ISO operations and Transmission operations)	• Used for tele-control (SCADA) in electrical engineering and power system automation applications.	x
	IEC 60870-6-702:2014	IEC 60870-6-702:2014 Telecontrol equipment and systems - Part 6-702: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Functional profile for providing the TASE.2 application service in end systems https://webstore.iec.ch/publication/3768		x							Part 6-702: Functional profile for providing the TASE.2 application service in end systems. This standard is a functional profile (FP) and defines the provision of the TASE.2 communications services between two control center end systems. It is supported by the transport services implemented in accordance with transport-profiles defined for the type of network that interconnects the control center end systems.	• Certain objects were moved from being normative to informative. • Certain TASE.2 conformance blocks have been made out-of-scope. These changes were made in order to remove TASE.2 blocks that were seldom used and whose capabilities are typically implemented by some other means besides TASE.2. This was done to promote interoperability of implementations from an application perspective. • The ITCA for this standard is DNV GL.	• Operations / (RTO/ISO operations and Transmission operations)	• Used for tele-control (SCADA) in electrical engineering and power system automation applications.	x
	IEC 60870-6-802:2014	IEC 60870-6-802:2014 Telecontrol equipment and systems - Part 6-802: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.2 Object models https://webstore.iec.ch/publication/3769	x								TASE.2 Object models. This standard specifies a method of exchanging time-critical control center data through wide-area and local-area networks using a full ISO compliant protocol stack. It contains provisions for supporting both centralized and distributed architectures.	The standard includes the exchange of real-time data indications, control operations, time series data, scheduling and accounting information, remote program control and event notification. This new edition includes the following significant technical changes with respect to the previous edition: - certain objects have been changed from informative to normative; - certain TASE.2 conformance blocks have been made out of scope.	• Operations / (RTO/ISO operations and Transmission operations)	• Used for tele-control (SCADA) in electrical engineering and power system automation applications.	x

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
IEC 61000	IEC 61000-2-2:2002+AMD 1:2017+AMD 2:2018	IEC 61000-2-2:2002+AMD1:2017+AMD2: 2018 CSV Consolidated version Electromagnetic compatibility (EMC) - Environment - Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems. https://webstore.iec.ch/publication/63116			x						IEC 61000-2-2:2002+A1:2017+A2:2018 is concerned with conducted disturbances in the frequency range from 0 kHz to 9 kHz, with an extension up to 148,5 kHz specifically for mains signaling systems. It gives compatibility levels for public low voltage a.c. distribution systems having a nominal voltage up to 420 V, single-phase or 690 V, three-phase and a nominal frequency of 50 Hz or 60 Hz. Compatibility levels are specified for electromagnetic disturbances of the types which can be expected in public low voltage power supply systems, for guidance in: - the limits to be set for disturbance emission into public power supply systems; - the immunity limits to be set by product committees and others for the equipment exposed to the conducted disturbances present in public power supply systems. This consolidated version consists of the second edition (2002), its amendment 1 (2017) and its amendment 2 (2018). Therefore, no need to order amendment in addition to this publication.		Electric system operation • Distribution automation • DER integration • AMI • Home & Building automation • Retail energy market	•DER control: •Utility implements integrated •management of distributed energy resources •Utility and or customer provides •Energy storage in conjunction with photovoltaic •DER for voltage regulation •Voltage security •DER management •DER islanding •DER equipment interfaces •Earth fault localization •ISO uses energy storage	
	IEC 61000-3-2:2018	IEC 61000-3-2:2018 Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase) https://webstore.iec.ch/publication/28164			x						This standard deals with the limitation of harmonic currents injected into the public supply system. It specifies limits of harmonic components of the input current which can be produced by equipment tested under specified conditions. It is applicable to electrical and electronic equipment having a rated input current up to and including 16 A per phase, and intended to be connected to public low-voltage distribution systems. Arc welding equipment which is not professional equipment, with a rated input current up to and including 16 A per phase, is included in this document. Arc welding equipment intended for professional use, as specified in IEC 60974-1, is excluded from this document and can be subject to installation restrictions as indicated in IEC 61000-3-12. The tests according to this document are type tests. For systems with nominal voltages less than but not equal to 220 V (line-to-neutral), the limits have not yet been considered.	This fifth edition cancels and replaces the fourth edition published in 2014. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition: a) an update of the emission limits for lighting equipment with a rated power ≤ 25 W to take into account new types of lighting equipment; b) the addition of a threshold of 5 W under which no emission limits apply to all lighting equipment; c) the modification of the requirements applying to the dimmers when operating non-incandescent lamps; d) the addition of test conditions for digital load side transmission control devices; e) the removal of the use of reference lamps and reference ballasts for the tests of lighting equipment; f) the simplification and clarification of the terminology used for lighting equipment; g) the classification of professional luminaires for stage lighting and studios under Class A; h) a clarification about the classification of emergency lighting equipment; i) a clarification for lighting equipment including one control module with an active input power ≤ 2 W; j) an update of the test conditions for television receivers; k) an update of the test conditions for induction hobs, taking also into account the other types of cooking appliances; l) for consistency with IEC 61000-3-12, a change of the scope of IEC 61000-3-2 from equipment with an input current ≤ 16 A to equipment with a rated input current ≤ 16 A.	Transmission, Distribution, DER	• BEMS control of DER & HVAC power system control by battery aggregation • Microgrid power quality • Microgrid energy management • Microgrid autonomous control • DMS control of microgrids • Microgrid connected • Microgrid islanded operation • Energy storage & DER •RTP- DER device management RTU: • Advanced distribution automation with DER function • Circuit reconfiguration • Integrated Volt/VAR decentralized • AGC frequency control • Fault isolation • Field control request • Volt/VAR on substation basis •System engineer retrofits a • Substation •volt /Var dispatch • Volt /Var optimization	
	IEC 61000-4-1:2016	IEC TR 61000-4-1:2016 Electromagnetic compatibility (EMC) - Part 4-1: Testing and measurement techniques - Overview of IEC 61000-4 series https://webstore.iec.ch/publication/24660				x					This standard gives information and guidance on the EMC basic standards and other basic EMC documents published in the IEC 61000-4 series. Those basic standards describe mainly immunity tests to be considered and applied for electric and electronic equipment, including systems. It has the status of a basic EMC publication in accordance with IEC Guide 107. This first edition as a Technical Report cancels and replaces the third edition of the International Standard published in 2006. This edition constitutes a technical revision.		Transmission, Distribution, DER		

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IEC 61000	IEC 61000-4-30:2015	IEC 61000-4-30:2015 Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods https://webstore.iec.ch/publication/21844			x						This standard defines the methods for measurement and interpretation of results for power quality parameters in a.c. power supply systems with a declared fundamental frequency of 50 Hz or 60 Hz. Measurement methods are described for each relevant parameter in terms that give reliable and repeatable results, regardless of the method's implementation. This standard addresses measurement methods for in-situ measurements. Measurement of parameters covered by this standard is limited to conducted phenomena in power systems. The power quality parameters considered in this standard are power frequency, magnitude of the supply voltage, flicker, supply voltage dips and swells, voltage interruptions, transient voltages, supply voltage unbalance, voltage harmonics and interharmonics, mains signaling on the supply voltage, rapid voltage changes, and current measurements. Emissions in the 2 kHz to 150 kHz range are considered in Annex C (informative), and over- and underdeviations are considered in Annex D (informative). Depending on the purpose of the measurement, all or a subset of the phenomena on this list may be measured. This third edition cancels and replaces the second edition published in 2008.	This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition: - the measurement method for current, previously informative, is now normative with some changes; - the measurement method for RVC (rapid voltage change) has been added; - the measurement method for conducted emissions in the 2 kHz to 150 kHz range has been added in informative Annex C; - underdeviation and overdeviation parameters are moved to informative Annex D; - Class A and Class S measurement methods are defined and clarified, while Class B is moved to informative Annex E and considered for future removal; - measurement methods continue in this standard, but responsibility for influence quantities, performance, and test procedures are transferred to IEC 62586-2. The contents of the corrigendum of December 2016 have been included in this copy	Transmission, Distribution, DER		
IEC 61334	IEC 61334-4-32:1996	IEC 61334-4-32:1996 Distribution automation using distribution line carrier systems - Part 4: Data communication protocols - Section 32: Data link layer - Logical link control (LLC) https://webstore.iec.ch/publication/5301		x							This standard covers the services required of, or by, the DCP Logical Link Control (LLC) sublayer entity at the logical interfaces with the application layer and the MAC sublayer.	•DER/station controller •consumption/home & building automation •consumption/elec-mobility •consumption/industrial automation	Distribution, DER, EV	DER/Station controller: • Integrated Volt/VAR • Adaptive transmission protection • Advanced distribution automation with DER function • Circuit reconfiguration • Integrated Volt/VAR decentralized • AGC frequency control • Fault isolation • Field control request • Volt/VAR on substation basis • Advanced DA functions •System engineer retrofits a substation Operation meter: Revenue meter: • Meter remote connect disconnect • Outage management system poll multicast • Outage management system poll unicast • Outage notification • Outage restoration notification • Performing real time price option • Programming SM Consumption/industrial automation/load controller: • Direct load control event • Demand response load profile • DR- Load management with dynamic tariffs	
	IEC 61334-4-41:1996	IEC 61334-4-41:1996 Distribution automation using distribution line carrier systems - Part 4: Data communication protocols - Section 41: Application protocol - Distribution line message specification https://webstore.iec.ch/publication/5303		x							This standard defines the distribution line message specification (DLMS) within the OSI application layer.				
	IEC 61334-4-511:2000	IEC 61334-4-511:2000 Distribution automation using distribution line carrier systems - Part 4-511: Data communication protocols - Systems management - CIASE protocol. https://webstore.iec.ch/publication/5305		x							This standard specifies the data communication protocol (DCP) management requirements. Describes the management services in an abstract way as well as the underlying protocol.		Distribution, Service Provider, Customer		

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IEC 61334	IEC 61334-4-512:2001	IEC 61334-4-512:2001 Distribution automation using distribution line carrier systems - Part 4-512: Data communication protocols - System management using profile 61334-5-1 - Management Information Base (MIB) https://webstore.iec.ch/publication/5306		x							This standard specifies the data communication protocols - System management using profile 61334-5-1 - Management Information Base (MIB)			• Customer implements demand response • Demand response utility • Commanded load control • Load shedding (by order)	
	IEC 61334-5-1:2001	IEC 61334-5-1:2001 Distribution automation using distribution line carrier systems - Part 5-1: Lower layer profiles - The spread frequency shift keying (S-FSK) profile https://webstore.iec.ch/publication/5308		x							This standard describes the requirements of S-FSK (frequency shift keying modulation) in conjunction with the services provided by the physical layer entity and the MAC sublayer. The transmission medium is assumed to be the distribution network on both MV and LV level. To be used in conjunction with IEC 61334-4-32.				
IEC 61850	IEC 61850-1: 2013	IEC 61850-1: 2013 Communication networks and systems for power utility automation - Part 1: Introduction and overview. https://webstore.iec.ch/publication/6007							x		Part 1: Introduction and overview. This standard is applicable to power utility automation systems and defines the communication between intelligent electronic devices in such a system, and the related system requirements. This part gives an introduction and overview of the IEC 61850 standard series	This edition includes the following significant technical changes with respect to the previous edition: - extended application scope of the IEC 61850 standard: - power quality domain; - statistical and historical data; - distributed generation monitoring and automation purpose; - for substation to substation communication; - smart grid considerations.	• Operation/RTO/ISO operation / (EMS and SCADA) • Operation /Transmission operation / (EMS, WAMS, SCADA) • Operation/Distribution operations / (Distributed management system (DMS), Asset management, Distributed SCADA, and DER Management System) • Transmission / (Substation controller, Data collector, Electric storage, Substation devices) • Distribution / (Field device, Distribution generation, Electric storage) • DERs / (Energy Storage, Distribution generation, Field device) • Customers / (Distribution generation, Electric storage) • Consumption: • AMI • Elect-Mobility • Home Building Automation • Electric system operation • Enterprise • Retail Energy Market INCL VPP • Wholesale Energy Market	Monitoring, protection and control (MPC) for generation, transmission and distribution, DER, consumption, enterprise, retail energy market, wholesale energy market. • Adaptive transmission protection: Changes in the state of any of the parallel lines or the system around them may affect differently the operation of the line protection relays for faults on the protected line or even on some of the parallel lines. Then, based on the state of the switching devices received through IEC 61850 locally and switching and grounding of transmission lines or other changes in the system configuration received from the system level, the adaptive protection system will change settings or setting groups in one or more relays to adapt to the system or substation changes. • Advanced distribution automation with DER Function: The objective of this use case is to enhance the reliability of power system service, power quality, and power system efficiency, by automating the following three processes of distribution operation control: data preparation in near- real-time; optimal decision-making; and the control of distribution operations in coordination with transmission and generation systems operations. • Protection testing	
	IEC 61850-2:2003	IEC TS 61850-2:2003 Communication networks and systems in substations - Part 2: Glossary https://webstore.iec.ch/publication/6009							x		Part 2: Glossary. This standard contains the glossary of specific terms and definitions used in the context of Substation Automation Systems which are standardized in the various parts of the IEC 61850 series.				
	IEC 61850-3:2013	IEC 61850-3:2013 Communication networks and systems for power utility automation - Part 3: General requirements. https://webstore.iec.ch/publication/6010							x		Part 3: General requirements. This standard defines the general requirements, mainly regarding construction, design and environmental conditions for utility communication and automation IEDs (intelligent electronic devices) and systems in power plant and substation environments.	These general requirements are in line with requirements for IEDs used in similar environments, for example measuring relays and protection equipment. This new edition includes the following significant technical changes with respect to the previous edition: - requirements are in line with those of other equipment used in the same environment (e.g. protection relays); - product safety added based on IEC 60255-27; - EMC requirements completed and in line with IEC 60255 series and IEC 61000-6-5.			
	IEC 61850-4-2011	IEC 61850-4-2011: Communication networks and systems for power utility automation - Part 4: System and project management. https://webstore.iec.ch/publication/6011							x		Part 4: System and project management. This standard applies to projects associated with process near automation systems of power utilities (UAS, utility automation system), like e.g. substation automation systems (SAS). It defines the system and project management for UAS systems with communication between intelligent electronic devices (IEDs) in the substation respective plant and the related system requirements.	This second edition constitutes a technical revision to align the document more closely with the other parts of the IEC 61850 series, in addition to enlarging the scope from substation automation systems to all utility automation systems.			

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
IEC 61850	IEC 61850-5:2013	IEC 61850-5:2013 Communication networks and systems for power utility automation - Part 5: Communication requirements for functions and device models https://webstore.iec.ch/publication/6012			x						Part 5: Communication requirements for functions and device models. This standard applies to power utility automation systems with the core part of substation automation systems (SAS); it standardizes the communication between intelligent electronic devices (IEDs) and defines the related system requirements to be supported.	The major technical changes with regard to the previous edition are as follows: - extension from substation automation systems to utility automation systems; - inclusion of interfaces for communication between substations; - requirements from communication beyond the boundary of the substation		• Load shedding (by Frequency Relay): This use case provides under-frequency protection at the main distribution substation. As system frequency decreases, load is disconnected in discrete steps according to frequency thresholds. Protective relays are used for automatic gradually under-frequency load shedding. Under and over-frequency relays are specified by frequency settings and delays. The frequency must remain above/below the specified frequency for the specified delay for the relay to operate. Zero delays are permitted. • Post fault analysis: • Relay settings over network: The utility decides to implement a new operating or protection philosophy, and this requires the change of the settings of a specific set of functions throughout the network. The change is entered into the engineering tool(s) at the network level. At the network level the setting change is initiated, and the specific functions are instructed through the communication network to update their settings. Automatically the configuration files at IED, substation and system level are updated to reflect the change. • Wide area protection schemes: Special protection systems (SPS) or remedial action schemes play a very important role in the prevention of wide spread power system disturbances. Different phases of their engineering, configuration and maintenance are based on the availability of a common information model (CIM) system model. It is used to run dynamic system simulations, change the action	
	IEC 61850-6:2009+AMD1:2018	IEC 61850-6:2009+AMD1:2018 CSV Consolidated version Communication networks and systems for power utility automation - Part 6: Configuration description language for communication in power utility automation systems related to IEDs https://webstore.iec.ch/publication/63319		x							IEC 61850-6:2009+A1:2018 specifies a file format for describing communication-related IED (Intelligent Electronic Device) configurations and IED parameters, communication system configurations, switch yard (function) structures, and the relations between them. The main purpose of this format is to exchange IED capability descriptions, and SA system descriptions between IED engineering tools and the system engineering tool(s) of different manufacturers in a compatible way. The main changes with respect to the previous edition are as follows: - functional extensions added based on changes in other Parts of IEC 61850, especially in IEC 61850-7-2 and IEC 61850-7-3; - functional extensions concerning the engineering process, especially for configuration data exchange between system configuration tools, added; - clarifications and corrections. This consolidated version consists of the second edition (2009) and its amendment 1 (2018). Therefore, no need to order amendment in addition to this publication. This publication is of core relevance for Smart Grid.	T&C for this standard is done in conformance with IEC 61850-10:2012.			y
	IEC 61850-7-1:2011	IEC 61850-7-1:2011: Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models. https://webstore.iec.ch/publication/6014	x	x							Part 7-1: Basic communication structure - Principles and models. This standard introduces the modelling methods, communication principles, and information models that are used in the various parts of the IEC 61850-7 series. The purpose is to provide - from a conceptual point of view - assistance to understand the basic modelling concepts and description methods for: - substation-specific information models for power utility automation systems, - device functions used for power utility automation purposes, and - communication systems to provide interoperability within power utility facilities.	Compared to the first edition, this second edition introduces: - the model for statistical and historical statistical data, - the concepts of proxies, gateways, LD hierarchy and LN inputs, - the model for time synchronization, - the concepts behind different testing facilities, - the extended logging function. It also clarifies certain items.			y

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
IEC 61850	IEC 61850-7-2:2010	IEC 61850-7-2:2010 Communication networks and systems for power utility automation - Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI). https://webstore.iec.ch/publication/6015	x	x							Part 7-2: Basic communication structure - Abstract communication service interface (ACSI). This standard applies to the ACSI communication for utility automation. The ACSI provides the following abstract communication service interfaces: - abstract interface describing communications between a client and a remote server; - and abstract interface for fast and reliable system-wide event distribution between an application in one device and many remote applications in different devices (publisher/sub-scriber) and for transmission of sampled measured values (publisher/subscriber).	Major technical changes with regard to the previous edition are as follows: - data types not required have been removed, - service tracking for control blocks have been added, - security issues are solved by the IEC 62351 series, - service tracking for control blocks have been added, - the view concept will be according to the new work on role bases access (RBA), - security issues are solved by the IEC 62351 series.		of the SPS to adapt to changing system conditions or analyze the operation in case of a system event. At the same time SPS needs to receive real-time power flow, frequency, load, generation and other measurements and status information from multiple locations in the system. It will also send signals for breaker tripping or load/generation shedding to substations included in the SPS. SPS will also need to be modeled in IEC 61850 (no such model exists today). • • Bus protection: The zone of protection of a bus differential function is dependent on the knowledge of the substation bus configuration, location of current transformers and status of switching devices. The bus differential configuration tool needs to read the CIM model of the substation to capture the bus configuration. • Protection model verification: The application reads back the configuration from an implemented 61850 substation and reverse engineers the protection schemes including overlapping protection zones. This enables the protection engineer to verify whether the implementation is what it should be. • Short circuit localization: • System engineer retrofits a substation: • Adaptive transmission protection: The utility needs to configure the protection of a transmission line that is mutually coupled with one or more other transmission lines on the same or different voltage levels, on the same or different towers as the protected line. It is important to also keep in mind that usually these lines are not transposed and may have unsymmetrical configuration. Parallel transmission lines have been extensively utilized in modern power systems to enhance the reliability and security for the transmission of electrical energy. The different possible configurations of parallel	y
	IEC 61850-7-3:2010	IEC 61850-7-3:2010 Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes. https://webstore.iec.ch/publication/6016	x								Part 7-3: communication structure - Common Data Classes. This standard is applicable to the description of device models and functions of substations and feeder equipment. It specifies constructed attribute classes and common data classes related to substation applications. It specifies common data classes for status information, common data classes for measured information, common data classes for control, common data classes for status settings, common data classes for analogue settings and attribute types used in these common data classes.	This second edition defines new common data classes used for new standards defining object models for other domains based on IEC 61850 and for the representation of statistical and historical data. T&C for this standard is done in conformance with IEC 61850-10:2012.			y
	IEC 61850-7-4:2010(E)	IEC 61850-7-4: 2010(E) Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes. https://webstore.iec.ch/publication/6017	x								Part 7-4: Basic communication structure - Compatible logical node classes and data classes. This standard specifies the information model of devices and functions generally related to common use regarding applications in systems for power utility automation. It also contains the information model of devices and function-related applications in substations. In particular, it specifies the compatible logical node names and data object names for communication between intelligent electronic devices (IED). This includes the relationship between logical nodes and data objects	. Major technical changes with regard to the previous edition are as follows: - corrections and clarifications according to technical issues raised by the users' community; extensions for new logical nodes for the power quality domain; - extensions for the model for statistical and historical statistical data; - extensions regarding IEC 61850-90-1; - extensions for new logical nodes for monitoring functions according to IEC 62271; - new logical nodes from IEC 61850-7-410 and IEC 61850-7-420 of general interest.	Transmission/Distribution, Substation		y
	IEC 61850-7-410:2012+AMD1:2015	IEC 61850-7-410:2012+AMD1:2015CSVC onsolidated version. Communication networks and systems for power utility automation - Part 7-410: Basic communication structure - Hydroelectric power plants - Communication for monitoring and control. https://webstore.iec.ch/publication/23693	x								Part 7-410: Basic communication structure - Hydroelectric power plants - Communication for monitoring and control This standard specifies the additional common data classes, logical nodes and data objects required for the use of IEC 61850 in a hydropower plant. The main changes with respect to the previous edition are as follows: - the logical nodes in IEC 61850-7-410:2007 that were not specific to hydropower plants have been transferred to IEC 61850-7-4:2010; - the definitions of logical nodes in this edition of IEC 61850-7-410 have been updated; - most of the modelling examples and background information included in IEC 61850-7-410:2007 have been transferred to IEC/TR 61850-7-510.	This new edition of IEC 61850-7-410 includes additional general-purpose logical nodes that were not included in IEC 61850-7-4:2010, but are required in order to represent the complete control and monitoring system of a hydropower plant. This consolidated version consists of the second edition (2012) and its amendment 1 (2015). Therefore, no need to order amendment in addition to this publication. Communication protocol for monitoring and control is for Hydroelectric power plants.	Generation: Hydroelectric power plants		

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
IEC 61850	IEC 61850-7-420:2009	IEC 61850-7-420:2009 Communication networks and systems for power utility automation - Part 7-420: Basic communication structure - Distributed energy resources logical nodes. https://webstore.iec.ch/publication/6019	x								Part 7-420: Communications systems for Distributed Energy Resources (DER) - Logical nodes. This standard defines IEC 61850 information models to be used in the exchange of information with distributed energy resources (DER), which comprise dispersed generation devices and dispersed storage devices, including reciprocating engines, fuel cells, microturbines, photovoltaics, combined heat and power, and energy storage.	Utilizes existing IEC 61850-7-4 logical nodes where possible, but also defines DER-specific logical nodes where needed. Data model is for DER/Microgrids.	DERs/Microgrid		
	IEC 61850-7-500:2017	IEC TR 61850-7-500:2017 Communication networks and systems for power utility automation - Part 7-500: Basic information and communication structure - Use of logical nodes for modeling application functions and related concepts and guidelines for substations. https://webstore.iec.ch/publication/59703	x								Part 7-500: Basic information and communication structure - Use of logical nodes for modeling application functions and related concepts and guidelines for substations. This standard describes the use of the information model for devices and functions of IEC 61850 in applications in substation automation systems, but it may also be used as informative input for the modeling of any other application domain. In particular, it describes the use of compatible logical node names and data objects names for communication between Intelligent Electronic Devices (IED) for use cases.	This includes the relationship between Logical Nodes and Data Objects for the given use cases. If needed for the understanding of the use cases, the application of services is also described informatively. If different options cannot be excluded they are also mentioned.	Transmission/Distribution, Substation		
	IEC 61850-7-510:2012	IEC TR 61850-7-510:2012 Communication networks and systems for power utility automation - Part 7-510: Basic communication structure - Hydroelectric power plants - Modelling concepts and guidelines. https://webstore.iec.ch/publication/6020	x								Part 7-510: Basic communication structure - Hydroelectric power plants - Modelling concepts and guidelines. This standard provides explanations on how to use the Logical Nodes defined in IEC 61850-7-410 as well as other documents in the IEC 61850 series to model complex control functions in power plants, including variable speed pumped storage power plants. This is data model for hydro power plant.	This publication is to be used in conjunction with IEC 61850-7-410 which introduced the general modelling concepts of IEC 61850 to hydroelectric power plants. Keywords: power utility, automation, communication, hydroelectric.	Generation, Hydro power plant		
	IEC 61850-8-1:2011	IEC 61850-8-1:2011 Communication networks and systems for power utility automation - Part 8-1: Specific communication service mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3. https://webstore.iec.ch/publication/6021		x			x				This standard specifies a method of exchanging time-critical and non-time-critical data through local-area networks by mapping ACSI to MMS and ISO/IEC 8802-3 frames. Defines a standardized method of using the ISO 9506 services to implement the exchange of data. For those ACSI services defined in IEC 61850-7-2 that are not mapped to MMS, this part defines additional protocols. It describes real utility devices with respect to their external visible data and behavior using an object-oriented approach. The objects are abstract in nature and may be used to a wide variety of applications. The use of this mapping goes far beyond the application in the utility communications. MMS and GOOSE communication protocols over Ethernet for MPC are in substation bus.	The main changes with respect to the previous edition are listed below: - the support of gigabit Ethernet, - the link layer redundancy, - the extension of the length of the object reference, - the extension of the reason for inclusion type for comprehensive logging, - the mapping of the tracking services, - a second mapping of the objectReference when used in the tracking services, or as linking, - the extension of the AdditionalCause enumeration, - the simulation of GOOSE telegram, - the so-called fixed-length encoded GOOSE, - the removal of the SCL Control Block.)	Transmission/Distribution, Substation		y

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
IEC 61850	IEC 61850-8-2:2018	IEC 61850-8-2:2018 Communication networks and systems for power utility automation - Part 8-2: Specific communication service mapping (SCSM) - Mapping to Extensible Messaging Presence Protocol (XMPP) https://webstore.iec.ch/publication/34345		x			x				This part of IEC 61850 specifies a method of exchanging data through any kinds of network, including public networks. Among the various kinds of services specified in the IEC 61850-7-2 only the client/server and time synchronization services are considered so far. For the client/server services, the principle is to map the objects and services of the ACSI (Abstract Communication Service Interface defined in IEC 61850-7-2) to XML messages transported over XMPP. The mapping description includes mainly three aspects: • The usage of the XMPP protocol itself, describing in details which features are really used and how they are used by the mapping (see chapter 6). • How to achieve end-to-end secured communications (see chapter 8). • The description of the XML payloads corresponding to each ACSI service thanks in particular to the XML Schema and XML message examples (starting at chapter 10).	The purpose of IEC 61850-8-2 is to provide detailed instructions/specifications as to the mechanisms and rules required to implement the core ACSI services specified in IEC 61850-7-2, while making use of XMPP, as well as the usage of SNTP for time synchronization.	Transmission/Distribution, Substation		
	IEC 61850-90-1: 2010	IEC 61850-90-1: 2010 Communication networks and systems for power utility automation - Part 90-1: Use of IEC 61850 for the communication between substations. https://webstore.iec.ch/publication/6024		x							This standard provides a comprehensive overview on the different aspects that need to be considered while using IEC 61850 for information exchange between substations.	In particular, this technical report defines use cases that: - require an information exchange between substations; - describes the communication requirements; - gives guidelines for the communication services and communication architecture to be used; - defines data as a prerequisite for interoperable applications; -describes the usage and enhancements of the configuration language SCL	Transmission/Distribution, Substation		
	IEC 61850-90-10:2017	IEC TR 61850-90-10:2017 Communication networks and systems for power utility automation - Part 90-10: Models for scheduling. https://webstore.iec.ch/publication/33426	x								This standard describes scheduling for devices using IEC 61850.		Transmission/Distribution, Substation		
	IEC 61850-90-8:2016	IEC TR 61850-90-8:2016 Communication networks and systems for power utility automation - Part 90-8: Object model for E-mobility. https://webstore.iec.ch/publication/24475						x			This standard shows how IEC 61850-7-420 can be used to model the essential parts of the E-Mobility standards related to Electric Vehicles and Electric Vehicle Supply Equipment (IEC 62196, IEC 61851, IEC 15118) and the Power system (IEC 61850-7-420), in order to secure a high level of safety and interoperability.		Distribution, EV		

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IEC 61850	IEC 61850-9-2:2004	IEC 61850-9-2: Communication networks and systems for power utility automation - Part 9-2: Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3. https://webstore.iec.ch/publication/20084		x			x				This standard defines the specific communication service mapping for the transmission of sampled values according to the abstract specification in IEC 61850-7-2. The mapping is that of the abstract model on a mixed stack using direct access to an ISO/IEC 8802-3 link for the transmission of the samples in combination with IEC 61850-8-1.	Main changes with respect to the first edition are: - addition of an optional link redundancy layer; - redefinition of "reserved" fields in link layer; - evolution of USVCB and MSVCB components; - evolution of encoding for the transmission of the sampled value buffer. T&C for this standard is done in conformance with IEC 61850-10:2012.	• Transmission/Distribution, Substation	• SV communication protocol over Ethernet for MPC in process bus	y
	IEC 61850-9-2:2004 LE	Implementation guideline for digital interface to instrument transformer using IEC 61850-9-2 http://iec61850.ucaiug.org/Implementation%20Guidelines/DigIF_spec_9-2LE_R2-1_040707-CB.pdf		x			x				This document gives additional information on how to implement a digital communication interface to non-conventional instrument transformers according to IEC 61850-9-2 and IEC 60044-7/8.This document define the subset of IEC 61850-9-2 only supports the service SendMSVMessage. The communication is unidirectional from the merging unit to the bay level devices and does not need to support the MMS stack. This document defines a logical device merging unit and a dataset used for the transmission of the sampled values.		• Transmission/Distribution, Substation	• SV communication protocol over Ethernet for MPC in process bus	y
	IEC 61850-9-2:2011	IEC 61850-9-2:2011 Communication networks and systems for power utility automation - Part 9-2: Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3 https://webstore.iec.ch/publication/6023		x							IEC 61850-9-2:2011 defines the specific communication service mapping for the transmission of sampled values according to the abstract specification in IEC 61850-7-2. The mapping is that of the abstract model on a mixed stack using direct access to an ISO/IEC 8802-3 link for the transmission of the samples in combination with IEC 61850-8-1.	Main changes with respect to the first edition are: - addition of an optional link redundancy layer; - redefinition of "reserved" fields in link layer; - evolution of USVCB and MSVCB components; - evolution of encoding for the transmission of the sampled value buffer.	• Transmission/Distribution, Substation	• SV communication protocol over Ethernet for MPC in process bus	y
	IEC 61850-9-3:2016	IEC 61850-9-3:2016 Communication networks and systems for power utility automation – Part 9-3: Precision time protocol profile for power utility automation https://webstore.iec.ch/publication/24998		x	x						This standard specifies a precision time protocol (PTP) profile of IEC 61588:2009 ¦ IEEE Std 1588-2008 applicable to power utility automation, which allows compliance with the highest synchronization classes of IEC 61850-5 and IEC 61869-9.	Precision time protocol profile for PUA	• Transmission/Distribution, Substation	• power utility automation	p
	IEC 61850-10:2012	IEC 61850-10:2012 Communication networks and systems for power utility automation - Part 10: Conformance testing https://webstore.iec.ch/publication/6008				x					Part 10: Conformance testing. This standard specifies standard techniques for testing of conformance of client, server and sampled value devices and engineering tools, as well as specific measurement techniques to be applied when declaring performance parameters. The use of these techniques will enhance the ability of the system integrator to integrate IEDs easily, operate IEDs correctly, and support the applications as intended.	The major technical changes with regard to the previous edition are as follows: - updates to server device conformance test procedures; - additions of certain test procedures (client device conformance, sampled values device conformance, (engineering) tool related conformance, GOOSE performance). - The ITCA for this standard is UCAIug.			x

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IEC 61850	IEC 61850-80-1:2016	IEC TS 61850-80-1:2016 Communication networks and systems for power utility automation - Part 80-1: Guideline to exchanging information from a Common Data Classes (CDC)-based data model using IEC 60870-5-101 or IEC 60870-5-104. https://webstore.iec.ch/publication/25511	x					x	x		This standard gives a guideline on how to exchange information from a Common Data Classes (CDC)-based data model (for example IEC 61850) using IEC 60870-5-101 or IEC 60870-5-104 between substation(s) and control center(s). Mostly guidelines for functions needed in a substation gateway device are given. The goal of this technical specification is to describe standardized mapping of device-oriented data models (for example IEC 61850) with already defined attributes of CDCs and services (for example IEC 61850-7) onto the already defined ASDUs and services of IEC 60870-5-104 or IEC 60870-5-101.	This second edition includes the following significant technical changes with respect to the previous edition: it makes reference to Edition 2 standards of the IEC 61850 series, more particularly to IEC 61850-7-3:2010, which introduces new Common Data Classes (CDCs).	Transmission/Distribution, Substation		
	IEC 61850-80-3:2015	IEC TR 61850-80-3:2015 Communication networks and systems for power utility automation - Part 80-3: Mapping to web protocols - Requirements and technical choices. https://webstore.iec.ch/publication/23695		x			x				This standard describes the requirements and gives an overview of the technical solution for using web protocols as a new communication mapping (SCSM) for the IEC 61850 standard. The structure of this part of IEC 61850 illustrates a two-step approach: Collection of the use cases and requirements based upon emerging smart grid architectural considerations, considering the new extended scope of IEC 61850. Evaluation and selection of technologies to build a consistent SCSM.		Transmission/Distribution, Substation		
	IEC 61850-80-4:2016	IEC TS 61850-80-4:2016 Communication networks and systems for power utility automation - Part 80-4: Translation from the COSEM object model (IEC 62056) to the IEC 61850 data model. https://webstore.iec.ch/publication/24355	x					x			This standard defines the one-to-one relationship of IEC 62056 OBIS codes to IEC 61850 Logical Nodes. The purpose is to increase the availability of revenue meter information to other applications defined within the IEC 61850 framework. This increased visibility will contribute to information available for smart grid applications.		Distribution, AMI		
	IEC 61850-90-2:2016	IEC TR 61850-90-2:2016 Communication networks and systems for power utility automation - Part 90-2: Using IEC 61850 for communication between substations and control centers. https://webstore.iec.ch/publication/24249		x			x				This standard provides a comprehensive overview of the different aspects that need to be considered while using IEC 61850 for information exchange between substations and control or maintenance centers or other system level applications	In particular, this technical report: - defines use cases and communication requirements that require an information exchange between substations and control or maintenance centers; - describes the usage of the configuration language of IEC 61850-6; - gives guidelines for the selection of communication services and architectures compatible with IEC 61850; - describes the engineering workflow; introduces the use of a Proxy/Gateway concept; - describes the links regarding the Specific Communication Service Mapping.	Transmission/Distribution, Substation and Control center		
	IEC 61850-90-3:2016	IEC TR 61850-90-3:2016 Communication networks and systems for power utility automation - Part 90-3: Using IEC 61850 for condition monitoring diagnosis and analysis. https://webstore.iec.ch/publication/24777		x							This standard addresses communication aspects related to specific sensor networks that are widely used as well as information exchange towards asset management systems. Since the outcome of this work will affect several parts of IEC 61850, in a first step, this technical report has been prepared to address the topic from an application specific viewpoint across all affected parts of IEC 61850. Once this technical report has been approved, the affected parts of the standard will be amended with the results from the report.	This approach is similar to what is done as an example with IEC 61850-90-1 for the communication between substations.	Transmission/Distribution, Substation		

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IEC 61850	IEC 61850-90-4:2013	IEC TR 61850-90-4:2013 Communication networks and systems for power utility automation - Part 90-4: Network engineering guidelines. https://webstore.iec.ch/publication/6025							x		This standard is intended for an audience familiar with network communication and/or IEC 61850-based systems and particularly for substation protection and control equipment vendors, network equipment vendors and system integrators. This Technical Report focuses on engineering a local area network limited to the requirements of IEC 61850-based substation automation. It outlines the advantages and disadvantages of different approaches to network topology, redundancy, clock synchronization, etc. so that the network designer can make educated decisions. In addition, this report outlines possible improvements to both substation automation and networking equipment.	This TR addresses the most critical aspects of IEC 61850, such as protection related to tripping over the network. This Technical Report addresses in particular the multicast data transfer of large volumes of sampled values from merging units. It also considers the high precision clock synchronization and "seamless" guaranteed transport of data across the network under failure conditions that is central to the process bus concept.	Transmission/Distribution, Substation		
	IEC 61850-90-5:2012	IEC 61850-90-5:2012 Communication networks and systems for power utility automation - Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118 https://webstore.iec.ch/publication/6026	x	x			x	x			This standard provides a way of exchanging synchrophasor data between PMUs, PDCs WAMPAC (Wide Area Monitoring, Protection, and Control), and between control center applications. The data, to the extent covered in IEEE C37.118-2005, are transported in a way that is compliant to the concepts of IEC 61850. However, given the primary scope and use cases, this document also provides routable profiles for IEC 61850-8-1 GOOSE and IEC 61850-9-2 SV packets.	These routable packets can be utilized to transport general IEC 61850 data as well as synchrophasor data. Keywords: communication network, power utility, synchrophasor.	Transmission/Distribution, Substation	• MMS, GOOSE, SV, C37.118.2 communication protocol over Ethernet for monitoring, protection and control in process bus	
	IEC 61850-90-7:2013	IEC TR 61850-90-7:2013 Communication networks and systems for power utility automation - Part 90-7: Object models for power converters in distributed energy resources (DER) systems. https://webstore.iec.ch/publication/6027	x								This standard describes the functions for power converter-based distributed energy resources (DER) systems, focused on DC-to-AC and AC-to-AC conversions and including photovoltaic systems (PV), battery storage systems, electric vehicle (EV) charging systems, and any other DER systems with a controllable power converter.	This standard defines the IEC 61850 information models to be used in the exchange of information between these powers converter-based DER systems and the utilities, energy service providers (ESPs), or other entities which are tasked with managing the volt, volt-ampere reactive (VAR), and watt capabilities of these power converter-based systems. These power converter-based DER systems can range from very small grid-connected systems at residential customer sites, to medium-sized systems configured as microgrids on campuses or communities, to very large systems in utility-operated power plants, and to many other configurations and ownership models..	Transmission, Distribution, DER	• Modeling for DER	
	IEC 61850-90-12:2015	IEC TR 61850-90-12:2015 Communication networks and systems for power utility automation - Part 90-12: Wide area network engineering guidelines. https://webstore.iec.ch/publication/22942							x		This standard provides definitions, guidelines, and recommendations for the engineering of WANs, in particular for protection, control and monitoring based on IEC 61850 and related standards. It addresses substation-to-substation communication, substation-to-control center and control center-to-control center communication. In particular, this Technical Report addresses the most critical aspects of IEC 61850 such as protection related data transmission via GOOSE and SMVs, and the multicast transfer of large volumes of synchrophasor data. The Technical Report addresses issues such as topology, redundancy, traffic latency and quality of service, traffic management, clock synchronization, security and maintenance of the network.	This TR contains use cases that show how utilities tackle their WAN engineering. This Technical Report is intended for an audience familiar with electrical power automation based on IEC 61850 and particularly for data network engineers and system integrators. It is intended to help them to understand the technologies, configure a wide area network, define requirements, write specifications, select components and conduct tests.	Transmission/Distribution, Substation		

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IEC 61850	IEC 61850-90-17:2017	IEC TR 61850-90-17:2017 Communication networks and systems for power utility automation - Part 90-17: Using IEC 61850 to transmit power quality data. https://webstore.iec.ch/publication/33747		x							This standard provides a way of exchanging power quality data between instruments whose functions include measuring, recording and possibly monitoring power quality phenomena in power supply systems, and clients using them in a way that is compliant to the concepts of IEC 61850.	The main goal is the interoperability of power quality instruments. This document provides: - Guidelines for using of IEC 61850 for power quality domain; - Name space extensions based on power quality function assessment; - Profile for using IEC 61850 in the specific context of IEC 61000-4-30.	Transmission/Distribution, Substation		
IEC 61851	IEC 61851-1:2017	IEC 61851-1:2017 Electric vehicle conductive charging system - Part 1: General requirements https://webstore.iec.ch/publication/33644			x						This standard applies to EV supply equipment for charging electric road vehicles, with a rated supply voltage up to 1 000 V AC or up to 1 500 V DC and a rated output voltage up to 1 000 V AC or up to 1 500 V DC. Electric road vehicles (EV) cover all road vehicles, including plug-in hybrid road vehicles (PHEV), that derive all or part of their energy from on-board rechargeable energy storage systems (RESS). The requirements for electrical safety for the EV supply equipment.	The aspects covered in this standard include: - the characteristics and operating conditions of the EV supply equipment; - the specification of the connection between the EV supply equipment and the EV;	• Customer/EV	PEV charging at premise • Consumer portal - EV management • PV output forecasting • Customer attributes • EV load management • EV network testing & diagnostics • Impact of EVs on distribution operations • EV as storage • EV charge mode • EV participates in utility events • EV diagnostics • Substation protocol conversion • EV home connection • EV another customers home connection • EV connections outside of home territory • EV connections at public location • EV charging • EV supply equipment (EVSE) connection • Premise EVSE • Premise EVSE & charger • EV conductive charging system	
	IEC 61851-21-1:2017	IEC 61851-21-1:2017 Electric vehicle conductive charging system - Part 21-1 Electric vehicle on-board charger EMC requirements for conductive connection to AC/DC supply. https://webstore.iec.ch/publication/32045				x					This standard defines requirements for conductive connection of an electric vehicle (EV) to an AC or DC supply. It applies only to on-board charging units either tested on the complete vehicle or tested on the charging system component level (ESA - electronic sub assembly). This document covers the electromagnetic compatibility (EMC) requirements for electrically propelled vehicles in any charging mode while connected to the mains supply. This first edition, together with IEC 61851-21-2, cancels and replaces IEC 61851-21:2001.	It constitutes a technical revision. This edition includes the following significant technical changes with respect to IEC 61851-21:2001: a) this document addresses now only EMC tests instead of other electrical tests; b) test setups are defined more precisely; c) Annex A "Artificial networks, asymmetric artificial networks and integration of charging stations into the test setup" was added.			z
	IEC 61851-23:2014	EC 61851-23:2014 Electric vehicle conductive charging system - Part 23: DC electric vehicle charging station. https://webstore.iec.ch/publication/6032			x						This standard gives the requirements for d.c. electric vehicle (EV) charging stations, herein also referred to as "DC charger", for conductive connection to the vehicle, with an a.c. or d.c. input voltage up to 1 000 V a.c. and up to 1 500 V d.c. according to IEC 60038..	It provides the general requirements for the control communication between a d.c. EV charging station and an EV. The requirements for digital communication between d.c. EV charging station and electric vehicle for control of d.c. charging are defined in IEC 61851-24			y
	IEC 61851-24:2014	IEC 61851-24:2014 Electric vehicle conductive charging system - Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging https://webstore.iec.ch/publication/6033	x	x							This standard applies to digital communication between a d.c. EV charging station and an electric road vehicle (EV) for control of d.c. charging, with an a.c. or d.c. input voltage up to 1 000 V a.c. and up to 1 500 V d.c. for the conductive charging procedure. The EV charging mode is mode 4, according to IEC 61851-23. Annexes A, B, and C give descriptions of digital communications for control of d.c. charging specific to d.c. EV charging systems A, B and C as defined in Part 23. The contents of the corrigendum of June 2015 have been included in this copy.				
	IEC 61869-9:2016	IEC 61869-9:2016 Instrument transformers - Part 9: Digital interface for instrument transformers. https://webstore.iec.ch/publication/24663		x							This standard is based on the IEC 61850 series, UCA international users group document Implementation guideline for digital interface to instrument transformers using IEC 61850-9-2, and the relevant parts of IEC 60044-8 that are replaced by this standard. It includes additional improvements including the IEC 61588 network based time synchronization. This first edition replaces the corresponding specific requirements previously contained in IEC 60044-8, published in 2002	This International Standard contains specific requirements for electronic low power instrument transformers (LPIT) having a digital output. However, the reader is encouraged to use its most recent edition. This publication contains an attached file in the form of a .xml file. This file is intended to be used as a complement and does not form an integral part of the publication.	• Transmission/Distribution, Substation (the same as 61850-9-2 SV, 61850-8-1 MMS and GOOSE)	• MMS, GOOSE, SV communication protocol over Ethernet for monitoring, protection and control in process bus and station bus	z

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IEC 61968	IEC 61968-4:2007	IEC 61968-4:2007 Application integration at electric utilities - System interfaces for distribution management - Part 4: Interfaces for records and asset management. https://webstore.iec.ch/publication/6203		x							This standard specifies the information content of a set of message types that can be used to support many of the business functions related to records and asset management. Typical uses of the message types include network extension planning, copying feeder or other network data between systems, network or diagram edits and asset inspection.		Distribution		z
	IEC 61968-8:2015	IEC 61968-8:2015 Application integration at electric utilities - System interfaces for distribution management - Part 8: Interfaces for customer operations. https://webstore.iec.ch/publication/22537		x							This standard specifies the information content of a set of message types that can be used to support many of the business functions related to customer support. Typical uses of the message types include service request, customer agreement, and trouble management. The purpose is to define a standard for the integration of customer support (CS), which would include customer service, trouble management and point of sale related components integrated with other systems and business functions within the scope of IEC 61968.	The scope of this standard is the exchange of information between a customer support system and other systems within the utility enterprise.	Distribution, Service Provider, Customer, AMI		
	IEC 61968-9:2013	IEC 61968-9:2013 Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control. https://webstore.iec.ch/publication/6204		x							This standard specifies the information content of a set of message types that can be used to support many of the business functions related to meter reading and control. Typical uses of the message types include meter reading, controls, events, customer data synchronization and customer switching. The purpose of IEC 61968-9 is to define a standard for the integration of metering systems (MS), which includes traditional manual systems, and (one or two-way) automated meter reading (AMR) systems, and meter data management (MDM) systems with other enterprise systems and business functions within the scope of IEC 61968.	The scope of IEC 61968-9 is the exchange of information between metering systems, MDM systems and other systems within the utility enterprise. This new edition includes the following significant technical changes with respect to the previous edition: - changes to and addition of new profiles to support PAN and UsagePoints; - extensions to support PAN devices generically as EndDevices; - extensions to the MeterReading model and profiles to support richer descriptions of metered quantities and to accommodate coincident readings. Typical uses of the message types include meter reading, controls, events, customer data synchronization and customer switching.			
	IEC 61968-11: 2013	IEC 61968-11: 2013 Application integration at electric utilities - System interfaces for distribution management - Part 11: Common information model (CIM) extensions for distribution. https://webstore.iec.ch/publication/6199	x								Part 11: Common Information Model (CIM) Extensions for Distribution. It specifies the distribution extensions of the CIM specified in IEC 61970-301. It defines a standard set of extensions of CIM, which support message definitions in IEC 61968-3 to IEC 61968-9, IEC 61968-13 and IEC 61968-14. The scope of this standard is the information model that extends the base CIM for the needs of distribution networks, as well as for integration with enterprise-wide information systems typically used within electrical utilities.	Major changes with respect to the first edition are summarized below: - Introduction of new classes to support flexible naming of identified objects. - Introduction of new classes to support single line diagrams exchange. - Consolidated transmission and distribution models for lines, transformers, switching, sensing and other auxiliary equipment. - The planned ITCA for this standard is UCAIug.			p
	IEC 61968-13:2008	IEC 61968-13:2008 Application integration at electric utilities - System interfaces for distribution management - Part 13: CIM RDF Model exchange format for distribution. https://webstore.iec.ch/publication/6200		x							This standard specifies the format and rules for exchanging modelling information based upon the CIM and related to distribution network data. Allows the exchange of instance data in bulk. Thus, the imported network model data should be sufficient to allow performing network connectivity analysis, including network tracing, outage analysis, load flow calculations, etc.	This standard could be used for synchronizing geographical information system databases with remote control system databases. The planned ITCA for this standard is UCAIug.			p

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IEC 61968	IEC 61968-100:2013	IEC 61968-100:2013 Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles https://webstore.iec.ch/publication/6198		x							This standard specifies an implementation profile for the application of the other parts of IEC 61968 using common integration technologies, including JMS and web services. This International Standard also provides guidance with respect to the use of Enterprise Service Bus (ESB) technologies. This provides a means to derive interoperable implementations of IEC 61968-3 to IEC 61968-9. At the same time, this International Standard can be leveraged beyond information exchanges defined by IEC 61968, such as for the integration of market systems or general enterprise integration.				
IEC 61970	IEC 61970-1:2005	IEC 61970-1:2005 Energy management system application program interface (EMS-API) - Part 1: Guidelines and general requirements. https://webstore.iec.ch/publication/6208							x		This standard provides a set of guidelines and general infrastructure capabilities required for the application of the EMS-API interface standards. Describes typical integration scenarios where these standards are to be applied and the types of applications to be integrated. Defines a reference model and provides a framework for the application of the other parts of these EMS-API standards.		Customer, EMS	•DMS control of microgrids • Microgrid connected • Microgrid islanded operation • Interaction between EMSs • Network coloring • Network equivalents between EMS & planning • Network extension • Network modifications • Power quality contracts • Power event notifications • Process contingency definition • Process dynamic rating • Network model management • Model change request • Model manage data • Post fault analysis • Real time topology processor • SCADA data update • Intentional islanding • Study mode topology processor • New transmission line with IEC 61850 • CIM model from IEC 61850 • System engineer retrofits a substation • System operator identifies, locates, isolates and restores service • System operator switches feeders based on contingency analysis • Telemetry definition in CIM database • Transport contingency specifications • Utility implements integrated management of DERs • Utility and or customer provides electrical energy storage in conjunction with photovoltaic • DER for voltage regulation • Voltage security • WAMAC emergency operations baseline • Wide area control system for the self- healing grid • Wide-area control system advanced auto-restoration	
	IEC 61970-2:2004	IEC TS 61970-2:2004 Energy management system application program interface (EMS-API) - Part 2: Glossary. https://webstore.iec.ch/publication/6209							x		This standard Provides a glossary for the volume of work produced as part of the IEC 61970 series of publications. Supplies terms and abbreviations that are either specific to the series, or that require explanation because of the way that they are used.				
	IEC 61970-301:2016	IEC 61970-301:2016 Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base. https://webstore.iec.ch/publication/31356	x								This standard lays down the common information model (CIM), which is an abstract model that represents all the major objects in an electric utility enterprise typically involved in utility operations. By providing a standard way of representing power system resources as object classes and attributes, along with their relationships, the CIM facilitates the integration of network applications developed independently by different vendors, between entire systems running network applications developed independently, or between a system running network applications and other systems concerned with different aspects of power system operations, such as generation or distribution management. SCADA is modeled to the extent necessary to support power system simulation and inter-control center communication.	The CIM facilitates integration by defining a common language (i.e. semantics) based on the CIM to enable these applications or systems to access public data and exchange information independent of how such information is represented internally. This new edition includes the following significant technical changes with respect to the previous edition: - new model for grounding including Petersen coils; - models for HVDC; addition of Static Var Compensation models; - phase shift transformer updates; - short circuit calculations based on IEC 60909; - addition of non-linear shunt compensator; - addition of model for steady state calculation inputs, Steady State Hypothesis; - addition of base frequency model; - Annex A with custom extensions added.			p

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IEC 61970	IEC 61970-401:2005	IEC TS 61970-401:2005 Energy management system application program interface (EMS-API) - Part 401: Component interface specification (CIS) framework. https://webstore.iec.ch/publication/6211		x							This standard specifies the framework for the specification of Component Interface Specifications (CIS) for Energy Management System Application Program Interfaces. A CIS specifies the interfaces that a component (or application) should implement to be able to exchange information with other components (or applications) and/or to access publicly available data in a standard way.			• Wide-area monitoring and control û automated control functions • Wide-area wind generation forecasting • Market operations - day ahead market operations • Market operations - long term planning • Market operations - medium & short-term planning • Market operations - overview • Market operations - post dispatch • Load forecast data between ems & planning • Load shedding by order • Maintain SCADA database • Alarm management • Direct load control event • AGC frequency control • Alarm management • Load/capacity balancing • EMS data transfer operation to planning • EMS data transfer planning to • operations • EMS data transfer planning to planning • Contingency analysis - baseline • Contingency analysis future (advanced) • Controlled islanding • Transmission outage schedules • Demand response utility commanded • Load control • DER management • DER islanding • DER forecasting • DER equipment interfaces • Earth fault localization • Power export • Field control request • Import operational model to planning • Automated demand response for network operators • Inter-area oscillation damping • ISO uses synchrophasor data • Load forecast data between ems & planning • Load shedding (by order) • EMS contingency coordination • Virtual Microgrid • PV output forecasting	
	IEC 61970-501:2006	IEC 61970-501:2006 Energy management system application program interface (EMS-API) - Part 501: Common Information Model Resource Description Framework (CIM RDF) schema. https://webstore.iec.ch/publication/6215	x								This standard specifies the format and rules for producing a machine readable form of the Common Information Model (CIM) as specified in the IEC 61970-301 standard. Describes a CIM vocabulary to support the data access facility and associated CIM				

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IEC 62052	IEC 62052-11:2003	IEC 62052-11:2003 Electricity metering equipment (AC) – General requirements, test s and test conditions – Part 11: Metering equipment https://webstore.iec.ch/preview/info_iec62052-11%7Bed1.0%7Den_d.pdf				x					This standard covers type tests for electricity metering equipment for indoor and outdoor application and applies to newly manufactured equipment designed to measure the electrical energy on 50 Hz or 60 Hz networks, with a voltage up to 600 V	This standard applies to electromechanical or static meters for indoor and outdoor application consisting of a measuring element and register(s) enclosed together in a meter case. It also applies to operation indicator(s) and test output(s). If the meter has a measuring element for more than one type of energy (multi-energy meters), or when other functional elements, such as maximum demand indicators, electronic tariff registers, time switches, ripple control receivers, data communication interfaces, etc. These are enclosed in the meter case, then the relevant standards for these elements apply. It does not apply to: a) portable meters; b) data interfaces to the register of the meter; c) reference meters.	Distribution, Customer, AMI		z
	IEC 62052-21:2004	IEC 62052-21:2004 Electricity metering equipment (a.c.) – General requirements, tests and test conditions –Part 21: Tariff and load control equipment. https://webstore.iec.ch/preview/info_iec62052-21%7Bed1.0%7Den.pdf							x		This standard specifies general requirements for the type test of newly manufactured indoor tariff and load control equipment, like electronic ripple control receivers and time switches that are used to control electrical loads, multi-tariff registers and maximum demand indicator devices.	This standard gives no requirements for constructional details internal to the tariff and load control equipment. In the case where tariff and load control functionality is integrated into multifunction electricity metering equipment, the relevant parts of this standard apply. This standard does not cover the acceptance tests and the conformity tests. Nevertheless, an example of what could be an acceptance test is given in Annex F.	Distribution, Customer, AMI		z
IEC 62053	IEC 62053-21:2003+AMD1:2016	IEC 62053-21:2003+AMD1:2016 CSV Consolidated version Electricity metering equipment (a.c.) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2) https://webstore.iec.ch/publication/26236			x						IEC 62053-21:2003+A1:2016 Applies only to newly manufactured static watt-hour meters of accuracy classes 1 and 2, for the measurement of alternating current electrical active energy in 50 Hz or 60 Hz networks and it applies to their type tests only. It applies only to static watt-hour meters for indoor and outdoor application consisting of a measuring element and register(s) enclosed together in a meter case. This publication is of high relevance for Smart Grid. This consolidated version consists of the first edition (2003) and its amendment 1 (2016). Therefore, no need to order amendment in addition to this publication. The contents of the corrigendum of March 2018 have been included in this copy.		Distribution, Customer, AMI		z
	IEC 62053-22:2016	IEC 62053-22:2016 Electricity metering equipment (AC) – Particular requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S) https://webstore.ansi.org/Standards/IEC/IEC6205322Ed2016?gclid=EAIaIQobChMIsNXuxYCN3wIVEYzICh3D6QQxEAAYASAAEgLDtvD_BwE			x						This standard applies only to newly manufactured static watt-hour meters of accuracy classes 0,2 S and 0,5 S, for the measurement of alternating current electrical active energy in 50 Hz or 60 Hz networks and it applies to their type tests only.	This standard applies only to transformer-operated static watt-hour meters for indoor application consisting of a measuring element and register(s) enclosed together in a meter case. It also applies to operation indicator(s) and test output(s). If the meter has a measuring element for more than one type of energy (multi-energy meters), or when other functional elements, like maximum demand indicators, electronic tariff registers, time switches, ripple control receivers, data communication interfaces, etc. are enclosed in the meter case, then the relevant standards for these elements also apply.	Distribution, Customer, AMI		z

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IEC 62053	IEC 62053-23	IEC 62053-23 Electricity metering equipment (a.c.) - Particular requirements - Part 23: Static meters for reactive energy (classes 2 and 3) https://webstore.iec.ch/publication/6384			x						This standard applies only to newly manufactured static var-hour meters of accuracy classes 2 and 3, for the measurement of alternating current electrical reactive energy in 50 Hz or 60 Hz networks and it applies to their type tests only. For practical reasons, this standard is based on a conventional definition of reactive energy for sinusoidal currents and voltages containing the fundamental frequency only.		Distribution, Customer, AMI		z
IEC 62054	IEC 62054-21	IEC 62054-21: Electricity metering (a.c.) – Tariff and load control – Part 21: Particular requirements for time switches https://webstore.iec.ch/preview/info_iec62054-21%7Bed1.0%7Den.pdf			x						This standard specifies particular requirements for the type test of newly manufactured indoor time switches with operation reserve that are used to control electrical loads, multi-tariff registers and maximum demand devices of electricity metering equipment.		Distribution, Customer, AMI		z
IEC 62056	IEC 62056-1-0:2014	IEC 62056-1-0:2014 Electricity metering data exchange - The DLMS/COSEM suite - Part 1-0: Smart metering standardization framework https://webstore.iec.ch/publication/6397							x		This standard provides information on the smart metering use cases and on architectures supported by the IEC 62056 DLMS/COSEM series of standards specifying electricity meter data exchange. It describes the standardization framework including: - the principles on which the standards shall be developed; - the ways the existing standards shall be extended to support new use cases and to accommodate new communication technologies, while maintaining coherency; - the aspects of interoperability and information security. It also provides guidance for selecting the suitable standards for a specific interface within the smart metering system.		• Consumption/AMI/meter • Consumption/Electric mobility • Consumption/Home & Building automation •DER	Revenue meter: • Meter remote connect disconnect • Outage management system poll multicast • Outage management system poll unicast • Outage notification • Outage restoration notification • Performing real time price option • Programming SM • Integrated Volt/VAR • Adaptive transmission protection • Advanced distribution automation with DER function • Circuit reconfiguration • Integrated Volt/VAR decentralized AGC frequency control • Fault isolation • Field control request • Volt/VAR on substation basis • Advanced DA functions •System engineer retrofits a substation Operation meter: • Meter remote connect disconnect • Outage management system poll multicast • Outage management system poll unicast • Outage notification • Outage restoration notification • Performing real time price option • Programming SM	
	IEC 62056-3-1:2013	IEC 62056-3-1:2013 Electricity metering data exchange - The DLMS/COSEM suite - Part 3-1: Use of local area networks on twisted pair with carrier signaling https://webstore.iec.ch/publication/6399		x							This standard describes three profiles for local bus data exchange with stations either energized or not. For non-energized stations, the bus supplies energy for data exchange. Three different profiles are supported: - base profile; - profile with DLMS; - profile with DLMS/COSEM. The three profiles use the same physical layer and they are fully compatible, meaning that devices implementing any of these profiles can be operated on the same bus. The transmission medium is twisted pair using carrier signaling and it is known as the Eurid is Bus. This first edition cancels and replaces the first edition of IEC 62056-31, issued in 1999, and constitutes a technical revision.	The main technical changes are: - addition of a profile which makes use of the IEC 62056 DLMS/COSEM Application layer and COSEM object model, - review of the data link layer which is split into two parts: a pure Data Link layer; a "Support Manager" entity managing the communication media; - ability to negotiate the communication speed, bringing baud rate up to 9 600 bauds.			

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IEC 62056	IEC 62056-4-7:2015	IEC 62056-4-7:2015 Electricity metering data exchange - The DLMS/COSEM suite - Part 4-7: DLMS/COSEM transport layer for IP networks https://webstore.iec.ch/publication/22487		x							This standard specifies a connection-less and a connection oriented transport layer (TL) for DLMS/COSEM communication profiles used on IP networks. These TLs provide OSI-style services to the service user DLMS/COSEM AL. The connection-less TL is based on the Internet Standard User Datagram Protocol (UDP). The connection-oriented TL is based on the Internet Standard Transmission Control Protocol (TCP). This first edition cancels and replaces the IEC 62056-47 published in 2006 and constitutes a technical revision. It includes the following changes: - This standard is applicable now both for IP4 and IPv6 networks; - Latest editions of the IEC 62056 suite are referenced. DLMS/COSEM IANA-registered port numbers added.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-5-3:2017	IEC 62056-5-3:2017 Electricity metering data exchange - The DLMS/COSEM suite - Part 5-3: DLMS/COSEM application layer https://webstore.iec.ch/publication/27065		x							This standard specifies the DLMS/COSEM application layer in terms of structure, services and protocols for DLMS/COSEM clients and servers, and defines rules to specify the DLMS/COSEM communication profiles. It defines services for establishing and releasing application associations, and data communication services for accessing the methods and attributes of COSEM interface objects, defined in IEC 62056-6-2 using either logical name (LN) or short name (SN) referencing. This third edition cancels and replaces the second edition of IEC 62056-5-3, published in 2016. It constitutes a technical revision. The significant technical changes with respect to the previous edition are listed in Annex K (Informative).	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-6-1:2017	IEC 62056-6-1:2017 Electricity metering data exchange - The DLMS/COSEM suite - Part 6-1: Object Identification System (OBIS) https://webstore.iec.ch/publication/32782	x								This standard specifies the overall structure of the OBject Identification System (OBIS) and the mapping of all commonly used data items in metering equipment to their identification codes. This third edition cancels and replaces the second edition of IEC 62056-6-1, published in 2015. It constitutes a technical revision. The main technical changes with respect to the previous edition are listed in Annex B (informative).	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-6-2:2017	IEC 62056-6-2:2017 Electricity metering data exchange - The DLMS/COSEM suite - Part 6-2: COSEM interface classes. https://webstore.iec.ch/publication/34317	x	x							IEC 62056-6-2:2017 specifies a model of a meter as it is seen through its communication interface(s). Generic building blocks are defined using object-oriented methods, in the form of interface classes to model meters from simple up to very complex functionality. Annexes A to F (informative) provide additional information related to some interface classes. This third edition cancels and replaces the second edition of IEC 62056-6-2 published in 2016. It constitutes a technical revision. The significant technical changes with respect to the previous edition are listed in Annex F(Informative).	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x

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IEC 62056	IEC 62056-6-9:2016	IEC TS 62056-6-9:2016 Electricity metering data exchange - The DLMS/COSEM suite - Part 6-9: Mapping between the Common Information Model message profiles (IEC 61968-9) and DLMS/COSEM (IEC 62056) data models and protocols https://webstore.iec.ch/publication/24736	x					x			This standard describes how in the utility environment an ERP system or a third party system can exchange information with a metering system. In particular, this Technical Specification covers the mapping between information interchange messages of a CIM-based ERP or third party system and a DLMS/COSEM-based metering system	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-7-3:2017	IEC 62056-7-3:2017 Electricity metering data exchange - The DLMS/COSEM suite - Part 7-3: Wired and wireless M-Bus communication profiles for local and neighborhood networks https://webstore.iec.ch/publication/26774		x							This standard specifies DLMS/COSEM wired and wireless M-Bus communication profiles for local and neighborhood networks. It is restricted to aspects concerning the use of communication protocols in conjunction with the COSEM data model and the DLMS/COSEM application layer.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-7-5:2016	IEC 62056-7-5:2016 Electricity metering data exchange - The DLMS/COSEM suite - Part 7-5: Local data transmission profiles for Local Networks (LN) https://webstore.iec.ch/publication/24779		x							This standard specifies DLMS/COSEM communication profiles for transmitting metering data modelled by COSEM interface objects through a Local Data Transmission Interface (LDTI). The LDTI may be part of a meter or of a Local Network Access Point (LNAP) hosting a DLMS/COSEM server.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-7-6:2013	IEC 62056-7-6:2013 Electricity metering data exchange - The DLMS/COSEM suite - Part 7-6: The 3-layer, connection-oriented HDLC based communication profile: https://webstore.iec.ch/publication/6411		x							It specifies the DLMS/COSEM 3-layer, connection-oriented HDLC based communication profile.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-8-20:2016	IEC TS 62056-8-20:2016 Electricity metering data exchange - The DLMS/COSEM suite - Part 8-20: Mesh communication profile for neighborhood networks https://webstore.iec.ch/publication/26175		x							This standard specifies a DLMS/COSEM communication profile that can be used in a smart metering system in which the Neighborhood Networks (NN) are mesh networks. This profile may be considered as an adaptation and extension of the UDP/IP communication profile specified in IEC 62056-9-7:2013. It specifies a number of features essential to the efficient operation of a large scale AMI using mesh NNs.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x

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IEC 62056	IEC 62056-8-3:2013	IEC 62056-8-3:2013 Electricity metering data exchange - The DLMS/COSEM suite - Part 8-3: Communication profile for PLC S-FSK neighborhood networks. https://webstore.iec.ch/publication/6412		x							This standard specifies the DLMS/COSEM PLC S-SFK communication profile for neighborhood networks. It uses standards established by IEC TC 57 in the IEC 61334 series.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-8-5:2017	IEC 62056-8-5:2017 Electricity metering data exchange - The DLMS/COSEM suite - Part 8-5: Narrow-band OFDM G3-PLC communication profile for neighborhood networks https://webstore.iec.ch/publication/30874		x							This standard specifies the IEC 62056 DLMS/COSEM communication profile for metering purposes based on the Recommendations ITU-T G.9901: Narrowband orthogonal frequency division multiplexing power line communication transceivers - Power spectral density specification and ITU-T G.9903:2014, Narrowband orthogonal frequency division multiplexing power line communication transceivers for G3-PLC networks, an Orthogonal Frequency Division Multiplexing (OFDM) Power Line Communications (PLC) protocol.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-8-6:2017	EC 62056-8-6:2017 Electricity metering data exchange - The DLMS/COSEM suite - Part 8-6: High speed PLC ISO/IEC 12139-1 profile for neighborhood networks https://webstore.iec.ch/publication/26615		x							This standard specifies the DLMS/COSEM communication profile for ISO/IEC 12139-1. High speed PLC (HS-PLC) neighborhood networks. It uses the standard ISO/IEC 12139-1 established by ISO/IEC JTC1 SC06.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-9-1:2016	IEC TS 62056-9-1:2016 Communication profile using web-services to access a DLMS/COSEM server via a COSEM Access Service (CAS) https://webstore.iec.ch/publication/24737		x							This standard defines how DLMS/COSEM servers can be accessed from a COSEM Access Client via an intermediate COSEM Access Service (CAS) providing Web services.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.			x
	IEC 62056-9-7:2013	IEC 62056-9-7:2013 Communication profile for TCP-UDP/IP networks https://webstore.iec.ch/publication/6413		x							IEC 62056-9-7:2013 specifies the DLMS/COSEM communication profile for TCP-UDP/IP networks.	The ITCA for this standard is the DLMS/COSEM User Association. This T&C program is only available in Europe.	Distribution, Customer, AMI		
	IEC 62056-42:2002	IEC 62056-42:2002 Electricity metering - Data exchange for meter reading, tariff and load control - Part 42: Physical layer services and procedures for connection-oriented asynchronous data exchange https://webstore.iec.ch/publication/6401		x							This standard specifies the physical layer services and protocols within the Companion Specification for Energy Metering (COSEM) three-layer connection oriented profile for asynchronous data communication. In annex A, an example of how this physical layer can be used for data exchange through the Public Switched Telephone Network (PSTN) using intelligent Hayes modems is given. Annex B gives an explanation of the role of data models and protocols in electricity meter data exchange. This bilingual version (2013-05) corresponds to the monolingual English version, published in 2002-02.				

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IEC 62056	IEC 62056-46:2002	IEC 62056-46:2002 Electricity metering - Data exchange for meter reading, tariff and load control - Part 46: Data link layer using HDLC protocol https://webstore.iec.ch/publication/6403		x							This standard Specifies the data link layer for connection-oriented, HDLC-based, asynchronous communication profile.		Distribution, Customer, AMI		
IEC 62282	IEC 62282-1:2013	IEC TS 62282-1:2013 Fuel cell technologies - Part 1: Terminology https://webstore.iec.ch/publication/6751							x		This standard provides uniform terminology in the forms of diagrams, definitions and equations related to fuel cell technologies in all applications including but not limited to stationary power, transportation, portable power and micro power applications. The main changes with respect to the previous edition consist of: - four new terms added; - editorial changes to thirty terms; - one term removed.		• DER/Energy storage	• Community energy storage • ISO uses energy storage • Power system control by battery aggregation • Energy storage & DER • Utility and/or customer provides • Electrical energy storage in conjunction with photovoltaic	
	IEC 62282-2:2012	IEC 62282-2:2012 Fuel cell technologies - Part 2: Fuel cell modules https://webstore.iec.ch/publication/6752			x						This standard provides the minimum requirements for safety and performance of fuel cell modules; it applies to fuel cell modules with or without an enclosure which can be operated at significant pressurization levels or close to ambient pressure. Deals with conditions that can yield hazards to persons and cause damage outside the fuel cell modules. This edition includes the following significant technical changes with respect to the previous edition: - inclusion of definitions for hazards and hazardous locations based on the IEC 60079 series; - modification of the general safety strategy and of the electrical components clause to reflect the needs for different application standards. Key word: fuel cell				
	IEC 62282-3-100:2012	IEC 62282-3-100:2012 Fuel cell technologies - Part 3-100: Stationary fuel cell power systems - Safety https://webstore.iec.ch/publication/6753							x		This standard is applicable to stationary fuel cell power systems intended for indoor and outdoor commercial, industrial and residential use in non-hazardous (unclassified) areas. It contemplates all significant hazards, hazardous situations and events, with the exception of those associated with environmental compatibility (installation conditions), relevant to fuel cell power systems, when they are used as intended and under the conditions foreseen by the manufacturer.				

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IEC 62282	IEC 62282-3-200:2015	IEC 62282-3-200:2015 Fuel cell technologies - Part 3-200: Stationary fuel cell power systems - Performance test methods https://webstore.iec.ch/publication/23736				x					This standard covers operational and environmental aspects of the stationary fuel cell power systems performance. The test methods apply as follows: - power output under specified operating and transient conditions; - electrical and heat recovery efficiency under specified operating conditions; - environmental characteristics; - for example, exhaust gas emissions, noise, etc. under specified operating and transient conditions. This new edition includes the following significant technical changes with respect to the previous edition: a stabilization zone of +- 10 % for thermal output of 100 % response time is provided instead of the tests for thermal output of 90 % response time, while the tests for electric output of 90 % response time remain as an option; the calculations for the ramp rate in kW/s are deleted and only the calculations for the response time (s) remain.		DER		
	IEC 62282-3-201:2017	IEC 62282-3-201:2017 Fuel cell technologies - Part 3-201: Stationary fuel cell power systems - Performance test methods for small fuel cell power systems https://webstore.iec.ch/publication/33617				x					This standard provides test methods for the electrical, thermal and environmental performance of small stationary fuel cell power systems that meet the following criteria: - rated electric power output of less than 10 kW; - grid-connected/independent operation or stand-alone operation with single-phase AC output or 3-phase AC output not exceeding 1 000 V, or DC output not exceeding 1 500 V; - maximum allowable working pressure of less than 0,1 MPa (gauge) for the fuel and oxidant passages; - gaseous fuel (natural gas, liquefied petroleum gas, propane, butane, hydrogen, etc.) or liquid fuel (kerosene, methanol, etc.); - air as oxidant.	This document describes type tests and their test methods only. This document covers fuel cell power systems whose primary purpose is the production of electric power. This new edition includes the following significant technical changes with respect to the previous edition: revision of test set-up, revision of measurement instruments, introduction of ramp-up test, introduction of rated operation cycle efficiency, introduction of electromagnetic compatibility (EMC) test, revision of exhaust gas test, introduction of typical durations of operation cycles.			
	IEC 62282-3-400:2016	IEC 62282-3-400:2016 Fuel cell technologies - Part 3-400: Stationary fuel cell power systems - Small stationary fuel cell power system with combined heat and power output https://webstore.iec.ch/publication/26208							x		This standard specifies the requirements for construction, safety, installation, fitness for purpose, rational use of energy, marking, and performance measurement of these appliances. This standard also provides regional and country specific requirements to facilitate the worldwide application of this IEC standard.	This standard applies to small stationary fuel cell power systems serving as a heating appliance providing both electric power and useful heat with or without a supplementary heat generator providing peak load function. This standard applies to fuel cell power systems that are intended to be permanently connected to the electrical system of the customer (end user). Direct connection to the mains (parallel operation) is also within the scope of this standard. This standard is limited to gas and liquid fueled fuel cell CHP appliances that have a heat input based on lower heating value of less than or equal to 70 kW.			
	IEC 62282-4-101:2014	IEC 62282-4-101:2014 Fuel cell technologies - Part 4-101: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) - Safety of electrically powered industrial trucks https://webstore.iec.ch/publication/6757							x		This standard covers safety requirements for fuel cell power systems intended to be used in electrically powered industrial trucks. This standard is limited to electrically powered industrial trucks and is applicable to material-handling equipment, e.g. forklifts. It applies to gaseous hydrogen-fueled fuel cell power systems and direct methanol fuel cell power systems for electrically powered industrial trucks.				

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IEC 62282	IEC 62282-4-102:2017	IEC 62282-4-102:2017 Fuel cell technologies - Part 4-102: Fuel cell power systems for industrial electric trucks - Performance test methods https://webstore.iec.ch/publication/28730				x					This standard covers performance test methods of fuel cell power systems intended to be used for electrically powered industrial trucks. The scope of this document is limited to electrically powered industrial trucks. This document applies to gaseous hydrogen-fueled fuel cell power systems and direct methanol fuel cell power systems for electrically powered industrial trucks. This document covers fuel cell power systems whose fuel source container is permanently attached to either the industrial truck or the fuel cell power system. This document applies to DC type fuel cell power systems, with a rated output voltage not exceeding 150 V DC for indoor and outdoor use.				
	IEC 62282-7-1:2017	IEC TS 62282-7-1:2017 Fuel cell technologies - Part 7-1: Test methods - Single cell performance tests for polymer electrolyte fuel cells (PEFC) https://webstore.iec.ch/publication/31478				x				x	This standard covers cell assemblies, test station setup, measuring instruments and measuring methods, performance test methods, and test reports for PEFC single cells. This document is used for evaluating: - the performance of membrane electrode assemblies (MEAs) for PEFCs in a single cell configuration; - materials or structures of PEFCs in a single cell configuration; or - the influence of impurities in fuel and/or in air on the fuel cell performance.		DER		
IEC 62325	IEC 62325-301:2014	IEC 62325-301:2014 Framework for energy market communications - Part 301: Common information model (CIM) extensions for markets https://webstore.iec.ch/publication/6839	x								This standard specifies the common information model for energy market communications. The common information model (CIM) is an abstract model that represents all the major objects in an electric utility enterprise typically involved in utility operations and electricity market management. By providing a standard way of representing power system resources as object classes and attributes, along with their relationships, the CIM facilitates the integration of market management system (MMS) applications developed independently by different vendors, between entire MMS systems developed independently, or between an MMS system and other systems concerned with different aspects of market management, such as capacity allocation, day-ahead management, balancing, settlement, etc.		• Retail Energy Market INCL VPP • Wholesale energy market • Enterprise • Electric system operation • Power Plant • Generic substation • Home & Building Automation	AEP AMI network bulk meter reads • On demand meter reading from CIS • Outage management system poll multicast • Outage management system poll unicast • Outage notification • Outage restoration • Notification performing real Time price option • Post real time price auction processing • RTP billing • RTP HAN device provisioning •RTP HAN messaging • Meter firmware update • Programming SM TOU Program • Real time pricing program • Critical peak pricing program • RTP Base • RTP calculation function • RTP customer building • Automation system optimization •RTP- DER device management • Energy service provider • Energy and ancillary services aggregation •RTP - ESP customer specific •RTP calculator • RTP load forecasting	
	IEC 62325-351:2016	IEC 62325-351:2016 Framework for energy market communications - Part 351: CIM European market model exchange profile https://webstore.iec.ch/publication/25128	x								This standard is applicable to European style electricity markets and specifies a UML package which provides a logical view of the functional aspects of European style market management within an electricity markets. This package is based on the common information model (CIM). The use of the CIM goes far beyond its application in a market management system. This new edition of IEC 62325-351 contains new classes and associations required to comply with new business development for European style market, and in particular the implementation of recent European regulations.				

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
IEC 62325	IEC 62325-451-1:2017	IEC 62325-451-1:2017 Framework for energy market communications - Part 451-1: Acknowledgement business process and contextual model for CIM European market https://webstore.iec.ch/publication/31307	x								This standard specifies a UML package for the acknowledgment business process and its associated document contextual model, assembly model and XML schema for use within the European style electricity markets. The relevant aggregate core components (ACCs) defined in IEC 62325-351 have been contextualized into aggregated business information entities (ABIEs) to satisfy the requirements of the European style market acknowledgment business process. The contextualized ABIEs have been assembled into the acknowledgment document contextual model. This new edition includes the following significant technical changes with respect to the previous edition: - addition of an optional attribute ProcessType to the acknowledgement document to ease routing of incoming acknowledgement document instances to the appropriate application; - clarification of the activity diagram for the acknowledgement process; - addition of the list of constraints on datatypes.			• RTP market operations ancillary Services • RTP market operations energy services • RTP baseline	
	IEC 62325-503:2014	IEC TS 62325-503:2014 Framework for energy market communications - Part 503: Market data exchanges guidelines for the IEC 62325-351 profile https://webstore.iec.ch/publication/6848		x					x		This standard is a technical specification intended for European electricity markets, and specifies a communication platform which every Transmission System Operator (TSO) in Europe may use to reliably and securely exchange documents for the energy market. Consequently a European market participant (trader, distribution utilities, etc.) could benefit from a single, common, harmonized and secure platform for message exchange with the different TSOs; thus reducing the cost of building different IT platforms to interface with all the parties involved. This also represents an important step in facilitating parties entering into markets other than their national ones. Keyword: deregulation of energy market				
IEC 62351	IEC 62351-1:2007	IEC 62351-1:2007 Power systems management and associated information exchange - Data and communications security - Part 1: Communication network and system security - Introduction to security issues https://webstore.iec.ch/publication/6903								x	This standard provides an introduction to the remaining parts of the IEC 62351 series, primarily to introduce the reader to various aspects of information security as applied to power system operations.	The scope of the IEC 62351 series is information security for power system control operations. Its primary objective is to undertake the development of standards for security of the communication protocols defined by IEC TC 57, specifically the IEC 60870-5 series, the IEC 60870-6 series, the IEC 61850 series, the IEC 61970 series, and the IEC 61968 series. The ITCA for this standard is UL.	• Operations/RTO/ISO operations / (EMS, ISO/RTO SCADA) • Operations/Transmission operations / (EMS, WAMS, Transmission SCADA) • Operations/Distribution operations / (Demand response, DMS, Asset Management, Distributed SCADA, metering system, DER management systems) • Service providers/Third party providers/Retail energy provider • Generation/ (Market service interface, Plant control system) • Distribution/ (Distribution generation, Electric storage) • DERs/ (Electric storage, Distribution, Field device) • Customers / (Distribution generation, Electric storage)		x

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IEC 62351	IEC 62351-2:2008	IEC 62351-2:2008 Glossary of terms https://webstore.iec.ch/publication/6905							x		This standard covers the key terms used in the IEC 62351 series, and is not meant to be a definitive list. Most terms used for cyber security are formally defined by other standards organizations, and so are included here with references to where they were originally defined.				
	IEC 62351-3:2014+AMD1:2018	IEC 62351-3:2014+AMD1:2018 CSV Consolidated version Power systems management and associated information exchange - Data and communications security - Part 3: Communication network and system security - Profiles including TCP/IP https://webstore.iec.ch/publication/63235								x	IEC 62351-3:2014+A1:2018 specifies how to provide confidentiality, integrity protection, and message level authentication for SCADA and telecontrol protocols that make use of TCP/IP as a message transport layer when cyber-security is required. Although there are many possible solutions to secure TCP/IP, the particular scope of this part is to provide security between communicating entities at either end of a TCP/IP connection within the end communicating entities. This part of IEC 62351 reflects the security requirements of the IEC power systems management protocols. This consolidated version consists of the first edition (2014) and its amendment 1 (2018). Therefore, no need to order amendment in addition to this publication.	The ITCA for this standard is UL.			x
	IEC 62351-4:2007	IEC 62351-4:2007 Part 4: Security for any profiles including MMS (e.g., ICCP-based IEC 60870-6, IEC 61850, etc.). https://webstore.iec.ch/publication/6907								x	This standard specifies procedures, protocol extensions, and algorithms to facilitate securing ISO 9506 - Manufacturing Message Specification (MMS) based applications. It is intended that this technical specification be referenced as a normative part of other IEC TC 57 standards that have the need for using MMS in a secure manner.	The ITCA for this standard is UL.			x
	IEC 62351-5:2013	IEC 62351-5:2013 Part 5: Security for any profiles including IEC 60870-5 (e.g., DNP3 derivative) https://webstore.iec.ch/publication/6908								x	This standard specifies messages, procedures and algorithms for securing the operation of all protocols based on or derived from IEC 60870-5: Telecontrol equipment and systems - Transmission protocols. This Technical Specification applies to at least those protocols listed in IEC 60870-5-101, 5-102, 5-103, 5-104	This new edition includes the following main changes with respect to the previous edition: - adds the capability to change Update Keys remotely; - adds security statistics to aid in detecting attacks; - adds measures to avoid being forced to change session keys too often; - discards unexpected messages more often as possible attacks; - adds to the list of permitted security algorithms; - adds new rules for calculating challenge sequence numbers. The ITCA for this standard is UL.			x
	IEC 62351-6:2007	IEC 62351-6:2007 Security for IEC 61850 profiles Part 6: Security for IEC 61850 profiles https://webstore.iec.ch/publication/6909								x	This standard specifies messages, procedures, and algorithms for securing the operation of all protocols based on or derived from the standard IEC 61850. Applies to at least those protocols of IEC 61850-8-1, IEC 61850-9-2 and IEC 61850-6.	The ITCA for this standard is UL.			x

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IEC 62351	IEC 62351-7:2017	IEC 62351-7:2017 Security through network and system management Part 7: Security through network and system management https://webstore.iec.ch/publication/30593								x	This standard defines network and system management (NSM) data object models that are specific to power system operations. These NSM data objects will be used to monitor the health of networks and systems, to detect possible security intrusions, and to manage the performance and reliability of the information infrastructure. The goal is to define a set of abstract objects that will allow the remote monitoring of the health and condition of IEDs (Intelligent Electronic Devices), RTUs (Remote Terminal Units), DERs (Distributed Energy Resources) systems and other systems that are important to power system operations	This new edition constitutes a technical revision and includes the following significant technical changes with respect to IEC TS 62351-7 (2010): NSM object data model reviewed and enriched; UML model adopted for NSM objects description; SNMP protocol MIBs translation included as Code Components. The ITCA for this standard is UL.			x
	IEC 62351-8:2011	IEC 62351-8:2011 Power systems management and associated information exchange - Data and communications security - Part 8: Role-based access control https://webstore.iec.ch/publication/6911								x	This standard covers the access control of users and automated agents to data objects in power systems by means of role-based access control. The scope of this specification covers everything that is needed for interoperability between systems from different vendors.	The ITCA for this standard is UL.			x
	IEC 62351-9:2017	IEC 62351-9:2017 Power systems management and associated information exchange - Data and communications security - Part 9: Cyber security key management for power system equipment. https://webstore.iec.ch/publication/30287								x	This standard specifies cryptographic key management, namely how to generate, distribute, revoke, and handle public-key certificates and cryptographic keys to protect digital data and its communication. Included in the scope is the handling of asymmetric keys (e.g. private keys and public-key certificates), as well as symmetric keys for groups (GDOI). This document assumes that other standards have already chosen the type of keys and cryptography that will be utilized, since the cryptography algorithms and key materials chosen will be typically mandated by an organization's own local security policies and by the need to be compliant with other international standards.	This document therefore specifies only the management techniques for these selected key and cryptography infrastructures. The objective is to define requirements and technologies to achieve interoperability of key management. The purpose of this document is to guarantee interoperability among different vendors by specifying or limiting key management options to be used. This document assumes that the reader understands cryptography and PKI principles.			
	IEC 62351-10:2012	IEC TR 62351-10:2012 Power systems management and associated information exchange - Data and communications security - Part 10: Security architecture guidelines. https://webstore.iec.ch/publication/6904							x	x	This standard targets the description of security architecture guidelines for power systems based on essential security controls, i.e. on security-related components and functions and their interaction. Furthermore, the relation and mapping of these security controls to the general system architecture of power systems is provided as a guideline to support system integrators to securely deploy power generation, transmission, and distribution systems applying available standards.				
	IEC 62351-11:2016	IEC 62351-11:2016 Power systems management and associated information exchange - Data and communications security - Part 11: Security for XML documents. https://webstore.iec.ch/publication/25948								x	This standard specifies schema, procedures, and algorithms for securing XML documents that are used within the scope of the IEC as well as documents in other domains. This part is intended to be referenced by standards if secure exchanges are required, unless there is an agreement between parties to use other recognized secure exchange mechanisms.	This part of IEC 62351 utilizes well-known W3C standards for XML document security and provides profiling of these standards and additional extensions.			

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IEC 62351	IEC 62351-12:2016	IEC TR 62351-12:2016 Power systems management and associated information exchange - Data and communications security - Part 12: Resilience and security recommendations for power systems with distributed energy resources (DER) cyber-physical systems. https://webstore.iec.ch/publication/24474								x	This standard discusses cyber security recommendations and engineering/operational strategies for improving the resilience of power systems with interconnected Distributed Energy Resources (DER) systems. It covers the resilience requirements for the many different stakeholders of these dispersed cyber-physical generation and storage devices, with the goal of enhancing the safety, reliability, power quality, and other operational aspects of power systems, particularly those with high penetrations of DER systems.	It addresses the resilience issues for cyber-physical DER systems interconnected with the power grid, building on the concepts and the hierarchical architecture described in the Smart Grid Interoperability Panel (SGIP) draft DRGS Subgroup B White Paper - Categorizing Use Cases in Hierarchical DER Systems. (https://sepapower.org/resource/distributed-energy-resources-der-hierarchical-classification-use-cases-process-developing-information-exchange-requirements-object-models/)		• Security for DER	
	IEC 62351-13:2016	IEC TR 62351-13:2016 Power systems management and associated information exchange - Data and communications security - Part 13: Guidelines on security topics to be covered in standards and specifications. https://webstore.iec.ch/publication/25621								x	This standard provides guidelines on what security topics could or should be covered in standards and specifications (IEC or otherwise) that are to be used in the power industry, and the audience is therefore the developers of standards and specifications.	These guidelines cannot be prescriptive for every standard, since individual standards and specifications may legitimately have very different focuses, but it should be expected that the combination of such standards and specifications used in any implementation should cover these security topics. These guidelines are therefore to be used as a checklist for the combination of standards and specifications used in implementations of systems.			
IEC 62357	IEC 62357-1:2016	IEC TR 62357-1:2016 Power systems management and associated information exchange - Part 1: Reference architecture https://webstore.iec.ch/publication/26251							x		This standard provides a clear and comprehensive map of all standards which are contributing to support interactions, in an open and interoperable way, between actors, components and systems in the field of electricity grids from generation to consumers, including transmission and distribution. The document also brings the vision of the path which will be followed by the concerned IEC technical committees and working groups in the coming years, to improve the global efficiency, market relevancy and coverage of this series of standards. This second edition includes the following significant technical changes with respect to the previous edition:	This standard provides updates and defines layered Reference Architecture to help direct longer term goals and activities, specifically to ensure compatibility of all new standards developed in the IEC by benefitting from lessons learned during development of the current standards and their application to actual utility projects as well as through application of other internationally recognized architecture standards. It reflects the most recent editions of the IEC standards relating to power systems management and associated information exchange, including the IEC 61850 series and the IEC 61968, IEC 61970 and IEC 62325 Common Information Model (CIM) standards.	Transmission and Distribution		

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IEC 62357	IEC 62357-200:2015	IEC TR 62357-200:2015 Power systems management and associated information exchange - Part 200: Guidelines for migration from Internet Protocol version 4 (IPv4) to Internet Protocol version 6 (IPv6) https://webstore.iec.ch/publication/22943	x	x							This standard applies to information exchange in power systems including, but not restricted to, substations, control center, maintenance center, energy management systems, synchrophasor-based grid stability systems, bulk energy generation, distributed energy generation (renewables), energy storage, and load management. It addresses the issues encountered when migrating from Internet Protocol version 4 (IPv4) to Internet Protocol version 6 (IPv6). It describes migration strategies, covering impact on applications, communication stack, network nodes, configuration, address allocation, cyber security and the related management. This Technical Report considers backward compatibility and show concepts as well as necessary migration paths to IPv6 from IPv4 where necessary, for a number of protocols in the IEC 61850 framework.		Transmission, Distribution, Service Provider, Customer, DER		
IEC 62541	IEC 62541-1:2016	IEC 62541-1:2016 OPC unified architecture - Part 1: Overview and concepts https://webstore.iec.ch/publication/25997							x		Part 1: Overview and Concepts. It presents the concepts and overview of the OPC Unified Architecture (OPC UA). Reading this document is helpful to understand the remaining parts of this multi-part document set. Each of the other parts is briefly explained along with a suggested reading order.	This second edition cancels and replaces the first edition of IEC TR 62541-1, published in 2010. This edition includes no technical changes with respect to the previous edition but includes updates to reflect changes or additions in normative parts of IEC 62541.	• Operations/Distribution • Operations/ (Asset management, DER management systems) • Service providers/Third party providers / (Aggregator, home/Management system) • Generation / (Plant control system, Generators) • Distribution / (Distribution generation, Electric storage) • DERs / (Electric storage, Distribution generation, Field device) • Customers/ (Distribution generation, Electric storage, Customer EMS, Appliance)		
	IEC 62541-2:2016	IEC 62541-2:2016 OPC unified architecture - Part 2: Security Model. https://webstore.iec.ch/publication/25996							x	x	Part 2: Security Model. It provides suggestions or best practice guidelines on implementing security. Any seeming ambiguity between this part of IEC 62541 and one of the normative parts of IEC 62541 does not remove or reduce the requirement specified in the normative part. This second edition cancels and replaces the first edition of IEC TR 62541-2, published in 2010. This second edition includes no technical changes with respect to the first edition but a number of clarifications and additional text for completeness. It describes the OPC unified architecture (OPC UA) security model. It describes the security threats of the physical, hardware, and software environments in which OPC UA is expected to run. It describes how OPC UA relies upon other standards for security. It provides definition of common security terms that are used in this and other parts of the OPC UA specification. It gives an overview of the security features that are specified in other parts of the OPC UA specification. It references services, mappings, and Profiles that are specified normatively in other parts of this multi-part specification.	It provides suggestions or best practice guidelines on implementing security. Any seeming ambiguity between this part of IEC 62541 and one of the normative parts of IEC 62541 does not remove or reduce the requirement specified in the normative part. This second edition cancels and replaces the first edition of IEC TR 62541-2, published in 2010. This second edition includes no technical changes with respect to the first edition but a number of clarifications and additional text for completeness.			

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IEC 62541	IEC 62541-3:2015	IEC 62541-3:2015 OPC unified architecture - Part 3: Address Space Model. https://webstore.iec.ch/publication/21996	x								Part 3: Address Space Model. It describes the OPC Unified Architecture (OPC UA) AddressSpace and its Objects. It is the OPC UA meta model on which OPC UA information models are based. This second edition cancels and replaces the first edition published in 2010 and constitutes a technical revision.	It includes the following changes: - Added rules for subtyping enumerations; - Added Property EnumValues; - Added Property ValueAsText; - Added EventType SystemStatusChangeEventType; - Added Properties MaxArrayLength and MaxStringLength; - Removed the concept of ModelParent; - Added EventType ProgressEventType; - Stated that it is allowed to use TAI in all places where UTC time is used; - Added Property EngineeringUnits; - Added ModellingRules OptionalPlaceholder and MandatoryPlaceholder.	Transmission, Distribution		
	IEC 62541-4:2015	IEC 62541-4:2015 OPC Unified Architecture - Part 4: Services. https://webstore.iec.ch/publication/21995		x							Part 4: Services It defines the OPC Unified Architecture (OPC UA) Services. The Services described are the collection of abstract Remote Procedure Calls (RPC) that are implemented by OPC UA Servers and called by OPC UA Clients. This second edition cancels and replaces the first edition published in 2011. It constitutes a technical revision.	It includes the following changes: - Update for 6.4 Redundancy. - Clarifications for Publish and Reconnect scenarios. - Handling of MonitoredItem changes in short network interruption scenarios. - Update for 6.1.3 Determining if a Certificate is Trusted. - Revised definition of parameters semaphoreFile and isOnline in Service RegisterServer. - Services ModifySubscription and ModifyMonitoredItems			
	IEC 62541-5:2015	IEC 62541-5:2015 OPC Unified Architecture - Part 5: Information Model. https://webstore.iec.ch/publication/21994	x								Part 5: Information Model It defines the Information Model of the OPC Unified Architecture. The Information Model describes standardized Nodes of a Server's AddressSpace. These Nodes are standardized types as well as standardized instances used for diagnostics or as entry points to server-specific Nodes. This second edition cancels and replaces the first edition published in 2011 and constitutes a technical revision.	This edition includes the following changes: - Defined ProgressEventType; - Defined DataType called BitFieldMaskDataType; - Delete Property SamplingRateCount in ServerDiagnosticSummaryDataType; - Added the Property "EffectiveTransitionTime" to TransitionVariableType; - Introduced VariableType OptionSetType; - Added a new EventType called SystemStatusChangeEventType; - Added properties to ServerCapabilitiesType. Added an object for operation limits. Added type OperationLimitsType containing that information; - Added SecureChannelId to AuditActivateSessionEventType; - Added normative Annex C defining FileType and Methods; - Added a Method GetMonitoredItems on ServerType; - Removed the concept of ModelParent. Added meta data for namespaces in ServerType and created types for managing that. Added representations for ModellingRules OptionalPlaceholder and MandatoryPlaceholder; - Added new types NonTransparentNetworkRedundancyType, NetworkGroupDataType and EndpointUrlListDataType.			
	IEC 62541-6:2015	IEC 62541-6:2015 OPC unified architecture - Part 6: Mappings. https://webstore.iec.ch/publication/21993						x		x	Part 6: Mappings. It specifies the OPC Unified Architecture (OPC UA) mapping between the security model described in IEC TR 62541-2, the abstract service definitions, described in IEC 62541-4, the data structures defined in IEC 62541-5 and the physical network protocols that can be used to implement the OPC UA specification. This second edition cancels and replaces the first edition published in 2011 and constitutes a technical revision.	This edition includes the following changes: - A new HTTPS transport has been defined; - Added an additional padding byte to handle asymmetric key sizes larger than 2048 bits. Fixed errors in SOAP action URIs; - Needed a standard way to serialize nodes in an address space. Added the UANodeSet schema defined in Annex F.			

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IEC 62541	IEC 62541-7:2015	IEC 62541-7 :2015 OPC unified architecture - Part 7: Profiles https://webstore.iec.ch/publication/21992				x					Part 7: Profiles. It describes the OPC Unified Architecture (OPC UA) Profiles. The Profiles in this document are used to segregate features with regard to testing of OPC UA products and the nature of the testing (tool based or lab based). This includes the testing performed by the OPC Foundation provided OPC UA CTT (a self-test tool) and by the OPC Foundation provided Independent certification test labs. It is also defining functionality that can only be tested in an a lab and defining the grouping of functionality that is to be used when testing OPC UA products either in a lab or using automated tools.	This second edition cancels and replaces the first edition published in 2012 and constitutes a technical revision. It includes the following changes: - Added a large number of new Facets to cover additional functional areas of OPC UA. Most significantly: - Facets for Historical Access; - Facets for Aggregates; - Facets for HTTPs; - New Security Facets; - New User Token Facet that supports anonymous access; - Best Practice Facets as well as New Security Policy for asymmetric key length > 2048.			
	IEC 62541-8:2015	IEC 62541-8:2015 OPC Unified Architecture - Part 8: Data Access. https://webstore.iec.ch/publication/21991	x	x							Part 8: Data Access. It defines the information model associated with Data Access (DA). It particularly includes additional VariablecTypes and complementary descriptions of the NodeClasses and Attributes needed for Data Access, additional Properties, and other information and behaviour. This second edition cancels and replaces the first edition published in 2011 and constitutes a technical revision.	This edition includes the following changes: - Clarified that deadband has to be between 0.0 and 100.0. Violations result in error Bad_DeadbandFilterInvalid; - Added VariableTypes handling ArrayItems and DataTypes supporting this, including complex number types.			
	IEC 62541-9:2015	IEC 62541-9:2015 OPC Unified Architecture - Part 9: Alarms and conditions. https://webstore.iec.ch/publication/21990	x	x							Part 9: Alarms and Conditions. This standard specifies the representation of Alarms and Conditions in the OPC Unified Architecture. Included is the Information Model representation of Alarms and Conditions in the OPC UA address space. This second edition cancels and replaces the first edition published in 2012 and constitutes a technical revision.	This edition includes the following changes: - added section to describe expect behaviour for A&C servers and the associated information model in the case of redundancy or communication faults; - changed the DialogConditionType to be not abstract since it is expect that instance of this type will exist in the system; - updated ConditionRefresh Method to allow the use of the well know NodeIds associated with the types for the MethodId and ConditionId instead of requiring the call to use only the MethodId and ConditionId that is part of an instance; - Fixed ExclusiveLimitStateMachineType and ShelvedStatemachineType to be sub-types of FinitStateMachineType not StateMachineType.			
	IEC 62541-10:2015	IEC 62541-10:2015 OPC Unified Architecture - Part 10: Programs. https://webstore.iec.ch/publication/21923	x								Part 10: Programs. It defines the information model associated with Programs. This includes the description of the NodeClasses, standard Properties, Methods and Events and associated behavior and information for Programs.	This second edition cancels and replaces the first edition published in 2012 and constitutes a technical revision. It includes the following technical changes: - Based on NIST review, security considerations have been included as 4.2.2; - Fixed the definition of the Program Diagnostic Type into a data type (5.2.8) and added missing data type for the Program Diagnostic Variable in the ProgramType in Table 5;			
	IEC 62541-13:2015	IEC 62541-13:2015 OPC Unified Architecture - Part 13: Aggregates. https://webstore.iec.ch/publication/21988	x								This second edition cancels and replaces the first edition published in 2012 and constitutes a technical revision. It includes the following technical changes: - Based on NIST review, security considerations have been included as 4.2.2; - Fixed the definition of the Program Diagnostic Type into a data type (5.2.8) and added missing data type for the Program Diagnostic Variable in the ProgramType in Table 5;				

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
IEC 62541	IEC 62541-100:2015	IEC 62541-100:2015 OPC Unified Architecture - Part 100: Device Interface. https://webstore.iec.ch/publication/21987	x	x							Part 100: Device Interface an extension of the overall OPC Unified Architecture standard series and defines the information model associated with Devices.	This part of IEC 62541 describes three models which build upon each other: - the (base) Device Model intended to provide a unified view of devices; - the Device Communication Model which adds Network and Connection information elements so that communication topologies can be created; - the Device Integration Host Model finally which adds additional elements and rules required for host systems to manage integration for a complete system. It allows reflecting the topology of the automation system with the devices as well as the connecting communication networks.			
IEC 62689	IEC 62689-1:2016	IEC 62689-1:2016 Current and voltage sensors or detectors, to be used for fault passage indication purposes - Part 1: General principles and requirements https://webstore.iec.ch/publication/24791							x		This standard defines the minimum requirements (therefore performances) and consequent classification and tests (with the exception of functional and communication ones) for fault passage indicators (FPIs) and distribution substation units (DSUs) (including their current and/or voltage sensors), which are, respectively, a device or a device/combination of devices and/or functions able to detect faults and provide indications about their localization.		Transmission, Distribution		
	IEC 62689-2:2016	IEC 62689-2:2016 Current and voltage sensors or detectors, to be used for fault passage indication purposes - Part 2: System aspects https://webstore.iec.ch/publication/24809			x						This standard describes electric phenomena and electric system behavior during faults, according to the most widely diffused distribution system architecture and to fault typologies, to define the functional requirements for fault passage indicators (FPI) and distribution substation units (DSU) (including their current and/or voltage sensors), which are, respectively, a device or a device/combination of devices and/or of functions able to detect faults and provide indications about their localization. By localization of the fault is meant the fault position with respect to the FPI/DSU installation point on the network (upstream or downstream from the FPI/DSU's location) or the direction of the fault current flowing through the FPI itself. The fault localization may be obtained - directly from the FPI/DSU, or - from a central system using information from more FPIs or DSUs, considering the features and the operating conditions of the electric system where the FPIs/DSUs are installed.	This part of IEC 62689 is therefore aimed at helping users in the appropriate choice of FPIs/DSUs (or of a system based on FPI/DSU information) properly operating in their networks, considering adopted solutions and operation rules (defined by tradition and/or depending on possible constraints concerning continuity and quality of voltage supply defined by a national regulator), and also taking into account complexity of the apparatus and consequent cost. This part of IEC 62689 is mainly focused on system behavior during faults, which is the "core" of FPI/DSU fault detection capability classes described in IEC 62689-1, where all requirements are specified in detail.	Transmission, Distribution		
	IEC 62689-100:2016	IEC TR 62689-100:2016 Current and voltage sensors or detectors, to be used for fault passage indication purposes – Part 100: Requirements and proposals for the IEC 61850 series data model extensions to support fault passage indicators applications. https://webstore.iec.ch/publication/26114	x					x			This Technical Report was prepared jointly with TC 57 with the scope to prepare requirements and proposals for the IEC 61850 series data model extensions to support fault passage indicators (all classes and extended functions) applications to be introduced in the future IEC 61850-90-6 and that, in turn, will be needed for the preparation of the future IEC 62689-3.		Transmission, Distribution		

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
	IEC 62786:2017	IEC TS 62786:2017 Distributed energy resources connection with the grid https://webstore.iec.ch/publication/30385							x		This standard provides principles and technical requirements for distributed energy resources (DERs) connected to the distribution network. It applies to the planning, design, operation and connection of DERs to distribution networks. It includes general requirements, connection scheme, choice of switchgear, normal operating range, immunity to disturbances, active power response to frequency deviation, reactive power response to voltage variations and voltage changes, EMC and power quality, interface protection, connection and start to generate electrical power, active power management, monitoring, control and communication, and conformance tests.	This document specifies interface requirements for connection of generating plants with the distribution network operating at a nominal frequency of 50 Hz or 60 Hz. DERs include distributed generation and permanently connected electrical energy storage in the form of synchronous generators, asynchronous generators, converters, etc., connected to the medium voltage (MV) or low voltage (LV) distribution network.	DERs/Microgrid		
	IEEE 1377-2012 (ANSI C12.19)	IEEE 1377-2012: Utility Industry Metering Communication Protocol Application Layer (End Device Data Tables): https://standards.ieee.org/findstds/standard/1377-2012.html	x								Utility Industry Metering Communication Protocol Application Layer (End Device Data Tables): Common structures are provided in this standard for encoding data in communication between End Devices (meters, home appliances, IEEE 1703 Nodes) and Utility enterprise collection and control systems using binary codes and Extensible Markup Language (XML) content. The Advanced Metering Infrastructure (AMI) and Smart Grid requirements are addressed as identified by the Office of Electricity Delivery and Energy Reliability of the U.S. Department of Energy and by the Smart Metering Initiative of the Ontario Ministry of Energy (Canada) and of Measurement Canada. Sets of tables are exposed that are grouped together into sections that pertain to a particular feature-set and related function such as Time-of-use, Load Profile, Security, Power Quality, and more.	Tables are provided in support of Gas, Water, and Electric sensors and related appliances. Tables are also provided for network configuration and management by referencing its companion standard IEEE Std 1703TM-2012.	• Operations/Distribution operations/ (Metering system, Meter data management system) • Distribution/Field device • DERs/Field device • Customers/Meter	• Data model for gas, water, and electric sensors and related appliances	
IEEE 1451	IEEE 1451.0-2007	IEEE 1451.0-2007 - IEEE Standard for a Smart Transducer Interface for Sensors and Actuators - Common Functions, Communication Protocols, and Transducer Electronic Data Sheet (TEDS) Formats. https://standards.ieee.org/standard/1451_0-2007.html	x	x							This standard provides a common basis for members of the IEEE 1451 family of standards to be interoperable. It defines the functions that are to be performed by a transducer interface module (TIM) and the common characteristics for all devices that implement the TIM. It specifies the formats for Transducer Electronic Data sheets (TEDS). It defines a set of commands to facilitate the setup and control of the TIM as well as reading and writing the data used by the system. Application programming interfaces (APIs) are defined to facilitate communications with the TIM and with applications.	This standard working group is working on new version. P1451.0 defines a set of common functionality for the family of IEEE 1451 smart transducer interface standards. This functionality is independent of the physical communications media. It includes the common transducer services required to control and manage smart transducers and Transducer Electronic Data Sheet (TEDS) formats. It defines a set of implementation-independent application programming interfaces (API). This project does not specify signal conditioning and conversion, physical media, or how the TEDS data are used in applications. The details of P1451.0 could be found in the link: https://standards.ieee.org/project/1451_0.html	Transmission, Distribution, Generation, Customer, DER		
	IEEE 1451.1-1999	IEEE 1451.1-1999 - IEEE Standard for a Smart Transducer Interface for Sensors and Actuators - Network Capable Application Processor Information Model. https://standards.ieee.org/standard/1451_1-1999.html		x							This standard defines an object model with a network-neutral interface for connecting processors to communication networks, sensors, and actuators. The object model containing blocks, services, and components specifies interactions with sensors and actuators and forms the basis for implementing application code executing in the processor.	This standard working group is working on new version. P1451.1 defines a set of common network services for communication with IEEE 1451 smart transducers invoking IEEE 1451.0 transducer services. The details of P1451.1 could be found in the link: https://standards.ieee.org/project/1451_1.html			

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IEEE 1451	IEEE 1451.4-2004	IEEE 1451.4-2004 - IEEE Standard for A Smart Transducer Interface for Sensors and Actuators--Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats https://standards.ieee.org/standard/1451_4-2004.html		x							This standard defines the protocol and interface that allows analog transducers to communicate digital information with an IEEE 1451 object. It also defines the format of the Transducer TEDS. The Transducer TEDS is based on the IEEE 1451.2(TM) TEDS. The standard does not specify the transducer design, signal conditioning, or the specific use of the TEDS.	This standard working group is working on new version of this standard. P1451.4 defines a protocol and interface. It also defines a format of the Transducer Electronics Data Sheets (TEDS). The TEDS is based on the IEEE 1451.2 TEDS. The standard does not specify the transducer design, signal conditioning, or the specific use of the TEDS. The details of P1451.4 could be found in the link: https://standards.ieee.org/project/1451_4.html			
	IEEE 1451.5-2007	IEEE 1451.5-2007 - IEEE Standard for a Smart Transducer Interface for Sensors and Actuator -- Wireless Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats. https://standards.ieee.org/findstds/standard/1451.5-2007.html		x							This standard defines a wireless interface for sensors. It specifies radio-specific protocols for this wireless interface. It defines communication modules that connect the wireless transducer interface module (WTIM) and the network capable applications processor (NCAP) using the radio-specific protocols. It also defines the transducer electronic data sheets (TEDS) for the radio-specific protocols.	This standard working group is working on new version of this standard. P1451.5 defines a TEDS based on the IEEE 1451 concept and protocols to access TEDS and transducer data. It adopts necessary wireless interfaces and protocols to facilitate the use of technically differentiated, existing wireless technology solutions. It does not specify transducer design, signal conditioning, wireless system physical design or use, or use of TEDS. The details of P1451.5 could be found in the link: https://standards.ieee.org/project/1451_5.html			
IEEE 1547	IEEE 1547-2018	IEEE 1547-2018: Standard for Interconnection and Interoperability of DERs with Associated EPS Interfaces https://standards.ieee.org/standard/1547-2018.html			x						This standard provides interconnection and interoperability technical and test specifications and requirements for distributed energy resources (DER). Additionally, several annexes are included in this standard that provide additional material for informative purposes, but are not required to be used in conjunction with this standard. This document provides a uniform standard for the interconnection and interoperability of distributed energy resources with electric power systems. It provides requirements relevant to the interconnection and interoperability performance, operation and testing, and, to safety, maintenance and security considerations.	This standard establishes criteria and requirements for interconnection of distributed energy resources with electric power systems (EPSs) and associated interfaces. The stated technical specifications and requirements are universally needed for interconnection and interoperability of distributed energy resources (DERs2) and will be sufficient for most installations. The specified performance requirements apply at the time of interconnection and as long as the DER remains in service. T&C conformance for this standard derives from IEEE 1547.1, and UL1741 which are in the process of being updated.	Transmission, Distribution, Customer, DER		y
	IEEE 1547.1-2005	IEEE 1547.1-2005 Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems https://standards.ieee.org/findstds/standard/1547.1-2005.html http://grouper.ieee.org/groups/scc21/1547.1/1547.1_index.html				x					This is a standard conformance test procedure for equipment interconnecting distributed resources with electric power systems. This standard specifies the type, production, and commissioning tests that shall be performed to demonstrate that the interconnection functions and equipment of the DR conform to IEEE Std. 1547. This standard is in the process of being updated along with the companion UL1741 testing standard.	The planned ITCA for this standard is ICAP.	Transmission, Distribution, Customer, DER		p

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IEEE 1547	IEEE 1547.2-2008	IEEE 1547.2-2008: Application Guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems https://standards.ieee.org/findstds/standard/1547.2-2008.html http://grouper.ieee.org/groups/scc21/1547.2/1547.2_index.html							x		This is an application guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems. Technical background and application details to support understanding of IEEE Std 1547-2003 are provided. The guide facilitates the use of IEEE Std 1547-2003 by characterizing various forms of distributed resource (DR) technologies and their associated interconnection issues. It provides background and rationale of the technical requirements of IEEE Std 1547-2003. It also provides tips, techniques, and rules of thumb, and it addresses topics related to DR project implementation to enhance the user's understanding of how IEEE Std 1547-2003 may relate to those topics.	This guide is intended for use by engineers, engineering consultants, and knowledgeable individuals in the field of DR. The IEEE 1547 series of standards is cited in the Federal Energy Policy Act of 2005, and this guide is one document in the IEEE 1547 series.	Transmission, Distribution, Customer, DER		
	IEEE 1547.3-2007	IEEE Std 1547.3-2007 - IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems https://standards.ieee.org/findstds/standard/1547.3-2007.html http://grouper.ieee.org/groups/scc21/1547.3/1547.3_index.html	x	x							This guide is intended to facilitate the interoperability of distributed resources (DR) and help DR project stakeholders implement monitoring, information exchange, and control (MIC) to support the technical and business operations of DR and transactions among the stakeholders. The focus is on MIC between DR controllers and stakeholder entities with direct communication interactions.	This guide incorporates information modeling, use case approaches, and a preform information exchange template and introduces the concept of an information exchange interface. The concepts and approaches are compatible with historical approaches to establishing and satisfying MIC needs. The IEEE 1547™ series of standards is cited in the U.S. Federal Energy Policy Act of 2005, and this guide is one document in the IEEE 1547 series.	Transmission, Distribution, Customer, DER		
	IEEE 1547.4-2011	IEEE 1547.4-2011 - IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems http://ieeexplore.ieee.org/document/5960751/ http://grouper.ieee.org/groups/scc21/1547.4/1547.4_index.html							x		This guide is used for design, operation, and integration of distributed resource island systems with EPS. Alternative approaches and good practices for the design, operation, and integration of DR island systems with EPS are provided. This includes the ability to separate from and reconnect to part of the area EPS while providing power to the islanded EPS. This guide includes the DRs, interconnection systems, and participating EPS.	This standard provides technical information and guidance to all parties involved in the interconnection of dispatchable electric power sources to a transmission grid about the various considerations needed to be evaluated for establishing acceptable parameters such that the interconnection is technically correct	Transmission, Distribution, Customer, DER		
	IEEE 1547.6:2011	IEEE 1547.6:2011 IEEE Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks https://standards.ieee.org/findstds/standard/1547.6-2011.html http://grouper.ieee.org/groups/scc21/1547.6/1547.6_index.html							x		This guide is used for recommendations and guidance for DR interconnected on the distribution secondary networks, including both spot networks and grid networks, are provided. This document gives an overview of distribution secondary network systems design, components, and operation; describes considerations for interconnecting DR with networks; and provides potential solutions for the interconnection of DR on network distribution systems	IEEE Std 1547.6-2011 is part of the IEEE 1547(TM) series of standards. IEEE Std 1547-2003 provides mandatory requirements for the interconnection of DR with EPSs and focuses primarily on radial distribution circuit interconnections. For DR interconnected on networks, all of IEEE Std 1547-2003 needs to be satisfied. IEEE Std 1547.6-2011 was specifically developed to provide additional information in regard to interconnecting DR with distribution secondary networks.	Transmission, Distribution, Customer, DER		

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IEEE 1547	IEEE 1547.7-2013:	IEEE 1547.7-2013: IEEE Guide for Conducting Distribution Impact Studies for Distributed Resource Interconnection https://standards.ieee.org/findstds/standard/1547.7-2013.html http://grouper.ieee.org/groups/scc21/1547.7/1547.7_index.html							x		IEEE Std 1547.7(TM) is part of the IEEE 1547(TM) series of standards. Whereas IEEE Std 1547(TM)-2003 provides mandatory requirements for the interconnection of distributed resources (DR) with electric power systems (EPS), this guide does not presume the interconnection is IEEE 1547(TM) compliant. Further, this guide does not interpret IEEE Std 1547(TM) or other standards in the IEEE 1547(TM) series, and this guide does not provide additional requirements or recommended practices related to the other IEEE 1547(TM) documents. However, DR interconnection may contribute to resultant conditions that could exceed what was normally planned for and built into the distribution system. This guide provides alternative approaches and good practices for engineering studies of the potential impacts of a DR or aggregate DR interconnected to the electric power distribution system. This guide describes criteria, scope, and extent for those engineering studies. Study scope and extent are described as functions of identifiable characteristics of the DR, the EPS, and the interconnection. The intent includes promoting impact study consistency while helping identify only those studies that should be performed based on technically transparent criteria for the DR interconnection.		Transmission, Distribution, Customer, DER		
	IEEE 1588-2008	IEEE 1588-2008: Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems https://standards.ieee.org/findstds/standard/1588-2008.html		x	x						This standard defines a protocol enabling precise synchronization of clocks in measurement and control systems implemented with technologies such as network communication, local computing and distributed objects. The protocol is applicable to systems communicating by local area networks supporting multicast messaging including but not limited to Ethernet.	The protocol enables heterogeneous systems that include clocks of various inherent precision, resolution, and stability to synchronize to a grandmaster clock. The protocol supports system-wide synchronization accuracy in the sub-microsecond range with minimal network and local clock computing resources. The default behavior of the protocol allows simple systems to be installed and operated without requiring the administrative attention of users.	Transmission, Distribution, Substation		z
	IEEE 1686-2013	IEEE 1686-2013: Standard for Intelligent Electronic Devices Cyber Security Capabilities https://standards.ieee.org/findstds/standard/1686-2013.html								x	This is an updated standard for IED Cyber Security Capabilities. The functions and features to be provided in IEDs to accommodate CIP programs are defined in this standard.	Security regarding the access, operation, configuration, firmware revision and data retrieval from an IED are addressed. Communications for the purpose of power system protection (teleprotection) are not addressed in this standard.	• Operations/Distribution operations/ Metering system • Distribution/ Field device • DERs/Field device • Customers/Meter		

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	IEEE 1701-2011 (ANSI C12.18)	IEEE 1701-2011: Standard for Optical Port Communication Protocol to Complement the Utility Industry End Device Data Tables https://standards.ieee.org/findstds/standard/1701-2011.html	x	x						x	This is a standard for Optical Port Communication Protocol to Complement the Utility Industry ED Data Tables. It provides multi-source and "plug and play" environment for the millions of metering devices in the field now and the future using the ANSI Type 2 optical port interface.	This standard solves the problems associated with single source systems and with multi-source systems based upon proprietary communications protocols.	• Operations/Distribution operations/ Metering system • Distribution/ Field device • DERs/Field device • Customers/Meter	• Electric, water, and gas utilities and corresponding vendors can realize cost savings which ultimately shall benefit the client consumers of the utilities.	
	IEEE 1702-2011 (ANSI C12.21)	IEEE 1702-2011: Standard for Telephone Modem Communication Protocol to Complement the Utility Industry End Device Data Tables https://standards.ieee.org/findstds/standard/1702-2011.html	x	x						x	This is a standard for telephone modem communication protocol to complement the utility industry ED data tables. It provides multisource and "plug and play" environment for the millions of metering devices in the field now and in the future using the telephone modem communication interface.	It solves the problems associated with single-source systems and with multisource systems based upon proprietary communications protocols.	• Operations/Distribution operations/ Metering system • Distribution/ Field device • DERs/Field device • Customers/Meter	• Electric, water, and gas utilities and corresponding vendors can realize cost savings which ultimately shall benefit the client consumers of the utilities.	
IEEE 1815	IEEE 1815-2010	IEEE Std 1815-2010 - IEEE Standard for Electric Power Systems Communications -- Distributed Network Protocol (DNP3). https://standards.ieee.org/findstds/standard/1815-2010.html	x	x							The DNP3 protocol structure, functions, and application alternatives and the corresponding conformance test procedures are specified. In addition to defining the structure and operation of DNP3, three application levels that are interoperable are defined. The simplest application is for low-cost distribution feeder devices, and the most complex is for full-featured master stations. The intermediate application level is for substation and other intermediate devices. The protocol is suitable for operation on a variety of communication media consistent with the makeup of most electric power communication systems.		• Operation/RTO/ISO operation / (EMS and SCAD) • Operation /Transmission operation / (EMS, WAMS, SCADA) • Operation/Distribution operations / (DMS, Asset management, distributed SCADA, and DER Management System) • Transmission / (Substation controller, Data collector, Electric storage, Substation devices) • Distribution / (field device,	• IEEE 1815 (DNP3) continues to be implemented by a majority of North America electric utilities for transmission and distribution automation and SCADA/EMS/DMS applications. • Its main use is in utilities such as electric and water companies. Usage in other industries is not common.	z
	IEEE 1815-2012	IEEE 1815-2012: Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3). https://standards.ieee.org/findstds/standard/1815-2012.html	x	x						x	Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3): The DNP3 protocol structure, functions, and interoperable application options (subset levels) are specified.	The simplest application level is intended for low-cost distribution feeder devices, and the most complex for full-featured systems. The appropriate level is selected to suit the functionality required in each device. The protocol is suitable for operation on a variety of communication media consistent with the makeup of most electric power communication systems. It also define device models.			z
	IEEE 1815.1-2015/Cor1-2016	IEEE 1815.1-2015/Cor1-2016: Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815 https://standards.ieee.org/findstds/standard/1815.1-2015.html	x	x			x	x			Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815(TM) [Distributed Network Protocol (DNP3)] This standard specifies the standard approach for mapping between IEEE Std 1815™ [Distributed Network Protocol (DNP3)] and IEC 61850 (Communications Networks and Systems for Power Utility Automation). Two primary use cases are addressed: a) mapping between an IEEE 1815-based master and an IEC 61850-based remote site and b) mapping between an IEC 61850-based master and an IEEE 1815-based remote site.	This standard addresses a selection of features, data classes, and services of the two standards. Mapping aspects included in the standard are: conceptual architecture; general mapping requirements; the mapping of Common Data Classes, Constructed Attribute Classes and Abstract Communication Service Interface (ACSI); cyber security requirements, the architecture of a gateway used for translation and requirements for embedding mapping configuration information into IEC 61850 System Configuration Description Language (SCL) and DNP3 Device Profile.			

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IEEE 1901	IEEE 1901-2010	IEEE 1901-2010: Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications https://standards.ieee.org/findstds/standard/1901-2010.html		x							Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications A standard for high-speed communication devices via electric power lines, so called broadband over power line (BPL) devices, is defined. Transmission frequencies below 100 MHz are used. All classes of BPL devices can use this standard, including BPL devices used for the first-mile/last-mile connection to broadband services as well as BPL devices used in buildings for local area networks (LANs), Smart Energy applications, transportation platforms (vehicle) applications, and other data distribution.	The balanced and efficient use of the power line communications channel by all classes of BPL devices is the main focus of this standard, defining detailed mechanisms for coexistence and interoperability between different BPL devices, and ensuring that desired bandwidth and quality of service may be delivered. The necessary security questions are addressed to ensure the privacy of communications between users and to allow the use of BPL for security sensitive services.	Distribution, Customer		
	IEEE 1901.2-2013/IEEE Std 1901.2a-2015 (Amendment to IEEE Std 1901.2-2013)	IEEE 1901.2-2013/IEEE Std 1901.2a-2015 (Amendment to IEEE Std 1901.2-2013) Standard for Low-Frequency (less than 500 kHz) Narrowband Power Line Communications for Smart Grid Applications https://standards.ieee.org/findstds/standard/1901.2-2013.html https://standards.ieee.org/findstds/standard/1901.2a-2015.html		x							Standard for narrowband power line communications (PLC) via alternating current, direct current, and non-energized electric power lines using frequencies below 500 kHz. Data rates of up to 500 kb/s are supported.	The field of use includes Smart Grid applications. Coexistence mechanisms that can be used by other PLC technologies operating below 500 kHz are also included. These coexistence mechanisms may be used separately from the rest of the standard.	• Operations/Distribution/ (Demand response, DMS, Asset management, D-SCADA, Metering system, Meter data management system, DER management systems) • Service providers/Third party providers/ (Home/Building management system) • Distribution/Field device, distribution generation, and electric storage) • DERs/ (Electric storage, Distribution generation, Field device) • Customers/ (Meter, Distribution generation, Electric storage, EV, Customer EMS, Customer equipment, Thermostat, and Appliance)		

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IEEE 2030	IEEE 2030-2011	IEEE Std 2030-2011 - IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads https://standards.ieee.org/findstds/standard/2030-2011.html		x					x		IEEE Std 2030 provides alternative approaches and best practices for achieving smart grid interoperability. It is the first all-encompassing IEEE standard on smart grid interoperability providing a roadmap directed at establishing the framework in developing an IEEE national and international body of standards based on cross-cutting technical disciplines in power applications and information exchange and control through communications.	IEEE Std 2030 establishes the smart grid interoperability reference model (SGIRM) and provides a knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end-use applications and loads. A system of systems approach to smart grid interoperability lays the foundation on which IEEE Std 2030 establishes the SGIRM as a design tool that inherently allows for extensibility, scalability, and upgradeability.	Transmission, Distribution, Service Provider, Customer		
	IEEE 2030.1	IEEE P2030.1 Draft Guide for Electric-Sourced Transportation Infrastructure http://grouper.ieee.org/groups/scc21/2030.1/2030.1_index.html							x		This document provides guidelines that can be used by utilities, manufacturers, transportation providers, infrastructure developers and end users of electric-sourced vehicles and related support infrastructure in addressing applications for road-based personal and mass transportation. This guide provides a knowledge base addressing terminology, methods, equipment, and planning requirements for such transportation and its impacts on commercial and industrial systems including, for example, generation, transmission, and distribution systems of electrical power. This guide provides a roadmap for users to plan for short, medium, and long-term systems	This guideline provides methods that can be utilized by utilities, manufacturers, transportation providers, infrastructure developers and end users of electric-sourced vehicles and related infrastructure to develop and support systems that allow increased utilization of electric sourced transportation. The transition to alternative-fuel vehicles, including those that use electricity, is inevitable. Servicing of the limited number of electric vehicles operating today can be absorbed by current generation and distribution capacity. The existence of a few hundred thousand of these vehicles, however, is just the first step in a long-term trend. Preparing for rapid growth in electric vehicle use is necessary since new and upgraded supporting infrastructure, whether charging stations, generating capacity or enhanced transmission systems, requires time for deployment. To reduce the amount of new generation required and better utilize the existing generation, energy efficiency methods for electric sourced transportation based on an end-to-end systems approach are outlined in this document. Standards that exist and research that is being performed are pointed out in this document. Where new standards are needed, they are pointed out in this document. This document supports utilities in planning for the most economic method of production to support increasing transportation loads. This document allows manufacturers to understand the standardization requirements and bring products to fruition as the supporting systems and methods are developed and standardized. This document allows end users to understand technologies that can be implemented for their transportation energy needs. A phased implementation is suggested in this document and is based on economic considerations for technologies available today and technologies being developed. While regional political and regulatory issues may alter these methods, this document does not consider the wide range of regional differences available. It is incumbent on the user of the guide to understand the financial differences that these factors may have on their specific planning requirements. This document does not consider non-road forms of transportation.	Customer, EV		

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IEEE 2030	IEEE 2030.1.1-2015	IEEE Std 2030.1.1-2015 - IEEE Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles https://standards.ieee.org/findstds/standard/2030.1.1-2015.html							x		Direct-current (dc) charging is a method of charging that facilitates rapid energy transfer from the electric grid to plug-in vehicles. This method of charging allows significantly more current to be drawn by the vehicle versus lower rated alternating-current (ac) systems. A combination of vehicles that can accept high-current dc charge and the dc supply equipment that provides it has led to the use of terminology such as "fast charging," "fast charger," "dc charger," "quick charger," etc. DC charging and ac charging vary by the location at which ac current is converted to dc current. For typical dc charging, the current is converted at the off-board charger, which is separate from the vehicle. For ac charging, the current is converted inside the vehicle, by means of an on-board charger. The location of the ac to dc conversion equipment, or converter, shapes the complexity of the equipment design. Regarding ac charging, as previously mentioned, the conversion is on board the vehicle. This allows the original equipment maker (OEM) designed systems to control the charging operation in its entirety. The on-board charger (converter) and battery controller solution is under direct control of the vehicle manufacturer. For dc charging, an entirely new challenge exists for OEMs. The dc charger is now external to the vehicle and requires the vehicle engineers to control an external power device. For the reason of necessary interoperability, standards such as IEEE Std 2030.1.1 are provided to assist developers.		Customer, EV		
	IEEE 2030.2-2015	IEEE Std 2030.2-2015 - IEEE Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure https://standards.ieee.org/findstds/standard/2030.2-2015.html							x		This guide applies the smart grid interoperability reference model (SGIRM) process (IEEE Std 2030™-2011) to energy storage by highlighting the information relevant to energy storage system (ESS) interoperability with the energy power system (EPS). The process can be applied to ESS applications located on customer premises, at the distribution level, and on the transmission level (i.e., bulk storage). This guide provides useful industry-derived definitions for ESS characteristics, applications, and terminology that, in turn, simplify the task of defining system information and communications technology (ICT) requirements. As a result. these requirements can be communicated more clearly and consistently in project specifications.	This guide also presents a methodology that can be used for most common ESS projects to describe the power system, communications, and information technology (IT) perspectives based on the IEEE 2030™ definitions. From this framework, a seemingly complex system can be more clearly understood by all project stakeholders. Emerging cybersecurity requirements can also be incorporated into the framework as appropriate. Additionally, this guide provides the templates that can be used to develop requirements for an ESS project and goes through several real-world ESS project examples step by step.	Transmission, Distribution, Customer, DER		
	IEEE 2030.3-2016	IEEE Std 2030.3-2016 - IEEE Standard Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications https://standards.ieee.org/findstds/standard/2030.3-2016.html				x					Applications of electric energy storage equipment and systems (ESS) for electric power systems (EPSs) are covered. Testing items and procedures, including type test, production test, installation evaluation, commissioning test at site, and periodic test, are provided in order to verify whether ESS applied in EPSs meet the safety and reliability requirements of the EPS. Grid operators, ESS manufactures, and ESS operators are for whom this standard is established.		Transmission, Distribution, Customer, DER		

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IEEE 2030	IEEE 2030.5-2013	IEEE 2030.5 (SEP 2)-2013: IEEE Adoption of Smart Energy Profile 2.0 Application Protocol Standard https://standards.ieee.org/findstds/standard/2030.5-2013.html	x	x						x	IEEE Adoption of Smart Energy Profile 2.0 Application Protocol Standard. It defines the mechanisms for exchanging application messages, the exact messages exchanged including error messages, and the security features used to protect the application messages. With respect to the OSI network model, this standard is built using the four-layer Internet stack model.	The defined application protocol is an IEC 61968 common information model [CIM] profile, mapping directly where possible, and using subsets and extensions where needed, and follows an IETF RESTful architecture [REST]. The 'APPLICATION' layer with TCP/IP providing functions in the 'TRANSPORT' and 'INTERNET' layers is defined in this standard. Depending on the physical layer in use (e.g., IEEE 802.15.4(TM), IEEE 802.11(TM), IEEE 1901(TM)), a variety of lower layer protocols may be involved in providing a complete solution.	• Operations/Distribution operations/Demand response) • Service providers/Third party providers/ (Aggregator, home/Building management system) • Distribution/Field device • DERs/Field device • Customers/ (Meter, EV, Customer EMS, Customer equipment, Thermostat, and Appliance)		z
	IEEE 2030.6/D03, Mar 2016	IEEE P2030.6/D03, Mar 2016 - IEEE Approved Draft Guide for the Benefit Evaluation of Electric Power Grid Customer Demand Response http://grouper.ieee.org/groups/2030/6/status.html							x		This draft guide proposed a framework for monitoring the effects and evaluating comprehensive benefits of demand response programs. From perspectives of ex ante and ex post evaluation, the draft guide introduces the contents including the evaluation processes on demand response effects with its comprehensive benefits, and implemented calculation methods in detail. This guide could be applied in various electricity market structures to provide utilities the references for the planning, design, implementation and post-evaluation of demand response programs.		Distribution, Service Provider, Customer		
	IEEE 2030.7-2017	IEEE 2030.7-2017 - IEEE Standard for the Specification of Microgrid Controllers https://standards.ieee.org/standard/2030_7-2017.html		x	x						A key element of microgrid operation is the microgrid energy management system (MEMS). It includes the control functions that define the microgrid as a system that can manage itself, operate autonomously or grid connected, and seamlessly connect to and disconnect from the main distribution grid for the exchange of power and the supply of ancillary services. The scope of this standard is to address the functions above the component control level associated with the proper operation of the MEMS that are common to all microgrids, regardless of topology, configuration, or jurisdiction. Testing procedures are addressed.	The standardization focuses on defining functions and interface configurations that allow modularity and interoperability. It deals with the Microgrid Controller operation and defines those aspects that need to be standardized and those can remain proprietary, while enabling the interoperability with various DERs interfaces and facilitating the wide adoption by vendors and utilities. The standard is functionality-driven and focuses on a modular approach that enables potential future expansion and features.	Transmission, Distribution, Customer, DER		

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IEEE 2030	IEEE 2030.8-2018	IEEE 2030.8-2018 - IEEE Standard for the Testing of Microgrid Controllers https://standards.ieee.org/standard/2030_8-2018.html				x					A key element of microgrid operation is the microgrid controller and more specifically the energy management system. It includes the control functions that define the microgrid as a system that can manage itself, and operate autonomously or grid connected, and seamlessly connect to and disconnect from the main distribution grid for the exchange of power and the supply of ancillary services, including for the distribution system to which it is connected. It is recognized that microgrid components and operational solutions exist in different configurations with different implementations. The scope of this standard is to develop a set of testing procedures allowing the verification, the quantification of the performance and a comparison of the performance with expected minimum requirements of the different functions of the microgrid controller that are common to the control of all microgrids, regardless of topology, configuration or jurisdiction. It aims to present metrics for a comparison of the control functions required from both the microgrid operator and the distribution system operator.	The reason for establishing a standard for testing microgrid controllers, in the context of enabling interoperability of the different controllers and components needed to operate the controller through cohesive and platform-independent interfaces, is to establish standardized testing criteria leading to procedures. This approach allows for flexibility and customization of components and control algorithms to be 16 deployed without limiting potential functionality, while ensuring minimum requirements are met. The standardization focuses on testing functional requirements, while recognizing that there are many possible hardware and software implementations of the same microgrid controller generic functions. The interoperability with various Distributed Energy Resource (DER) interfaces, and other electrical system interfaces within the microgrid should be considered. A standardized set of testing criteria/procedures should facilitate the wide adoption standard microgrid controller functional and performance requirements by vendors and utilities, including the Distribution System Operator, for ease of interfacing with the Distribution Management System. The standard is functionality-driven and focuses on a modular approach to the implementation of the functional requirements	Transmission, Distribution, Customer, DER		
IEEE C37.118	IEEE C37.118.1-2011	IEEE C37.118.1-2011: Standard for Synchrophasor Measurements for Power Systems https://standards.ieee.org/findstds/standard/C37.118.1-2011.html			x						This is a standard for Synchrophasor Measurements for Power Systems. This standard defines synchrophasors, frequency, and rate of change of frequency (ROCOF) measurement under all operating conditions. It specifies methods for evaluating these measurements and requirements for compliance with the standard under both steady-state and dynamic conditions. Time tag and synchronization requirements are included. Performance requirements are confirmed with a reference model, provided in detail.	This document defines a phasor measurement unit (PMU), which can be a stand-alone physical unit or a functional unit within another physical unit. This standard does not specify hardware, software, or a method for computing phasors, frequency, or ROCOF.	Transmission and distribution substation		
	IEEE C37.118.1a-2014	IEEE C37.118.1a-2014 Standard for Synchrophasor Measurements for Power Systems -- Amendment 1 (C37.118.1-2011): Modification of Selected Performance Requirements https://standards.ieee.org/findstds/standard/C37.118.1a-2014.html			x						This is a standard for Synchrophasor Measurements for Power Systems -- Amendment 1 (C37.118.1-2011): Modification of Selected Performance Requirements. Modifications in this amendment include some performance requirements with related text updates to correct inconsistencies and remove limitations introduced by IEEE Std C37.118.1(TM)-2011. It was discovered that a few requirements were not achievable with the published models as was intended and others were extremely difficult to meet with available hardware.	This amendment modifies requirements in Table 4 through Table 10. Text was modified to support the requirement modification. Testing described in 5.5.9 was clarified, and Table 11 (formerly Table 12) was modified to match. Annex C was modified to keep it consistent with the rest of the document.	Transmission and distribution substation		x
	IEEE C37.118.2-2011	IEEE C37.118.2-2011 Standard for Synchrophasor Data Transfer for Power Systems. https://standards.ieee.org/findstds/standard/C37.118.2-2011.html		x							This is a standard for Synchrophasor Data Transfer for Power Systems. A method for real-time exchange of synchronized phasor measurement data between power system equipment is defined. This standard specifies messaging that can be used with any suitable communication protocol for real-time communication between phasor measurement units (PMU), phasor data concentrators (PDC), and other applications.	It defines message types, contents, and use. Data types and formats are specified.	Transmission and distribution substation		

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IEEE C37.238	IEEE C37.238-2011	IEEE C37.238-2011: Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications. https://standards.ieee.org/findstds/standard/C37.238-2011.html		x	x						This is a standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications. A common profile for the use of Precision Time Protocol (PTP) of IEEE Std 1588-2008 in power system protection, control, automation, and data communication applications utilizing an Ethernet communications architecture is specified.		• Operations/RTO/ISO operations / (EMS, ISO/RTO SCADA) • Operations/Transmission operations / (EMS, WAMS, Transmission SCADA) • Operations/Distribution operations / (Demand response, DMS, Asset Management, Distributed SCADA, Metering system, Meter data management system, DER management systems) • Service providers/Third party providers/ (Aggregator, Retail energy provider) • Generation/ (Market service interface, Plant control system, Generator) • Transmission/ (Substation controller, Data collector, Electric storage, and Substation device) • Distribution/ (Field device, Distribution generation, Electric storage) • DER/ (Electric storage, Distribution generation, Field device) • Customers / (Distribution generation, Electric storage)		
	IEEE C37.238-2017	IEEE C37.238-2017 - IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications https://standards.ieee.org/standard/C37_238-2017.html		x	x						An extended profile is specified for the use of Precision Time Protocol of IEEE Std 1588-2008 in power system protection, control, automation, and data communication applications utilizing an Ethernet communications architecture. There are two versions of this standard because manufacturers are still supporting the 2011 version as an optional profile for the devices.	The planned ITCA for this standard is ICAP.			p
	IEEE C37.239-2010	IEEE C37.239-2010: Standard for Common Format for Event Data Exchange (COMFEDE) for Power Systems https://standards.ieee.org/findstds/standard/C37.239-2010.html		x							This is a standard for Common Format for Event Data Exchange (COMFEDE) for Power Systems. A common format for data files used for the interchange of various types of event data collected from electrical power systems or power system models is defined. Extensibility, extension mechanisms, and compatibility of future versions of the format are discussed. An XML schema is defined. A sample file is given.		• Operations/RTO/ISO operations / (EMS, ISO/RTO SCADA) • Operations/Transmission operations / (EMS, WAMS, Transmission SCADA) • Operations/Distribution operations / (Demand response, DMS, Asset Management, Distributed SCADA, metering system, Meter data management system, DER management systems) • Service providers/Third party providers/ (Aggregator, Retail energy provider) • Generation/ (Market service interface, Plant control system, Generator) • Transmission/ (Substation controller, Data collector, Electric storage, and Substation device) • Distribution/ (Field device, distribution generation, Electric storage) • DERs/ (Electric storage, Distribution generation) • Customers / (Distribution generation, Electric storage)		

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	IETF RFC-6272-2011	Internet Engineering Task Force (IETF) RFC-6272-2011: Internet Protocols for the Smart Grid https://www.rfc-editor.org/rfc/rfc6272.txt		x							This standard identifies the key infrastructure protocols of the Internet Protocol Suite for use in the smart grid	This standard provides an overview of the IPS and the key infrastructure protocols that are critical in integrating smart grid devices into an IP-based infrastructure	• Market / (Retail wholesaler, Aggregator, Energy market clearing house, ISO/RTO participant, Distribution system operator participant) • Operations/RTO/ISO operations/ (EMS, ISO/RTO SCADA) • Operations/Transmission operations/ (EMS, WAMS, transmission SCADA) • Operations/Distributions/ (Demand response, DMS, Asset management, Distributed SCADA, Metering system, Meter data management system, DER management systems) • Service providers/Utility provider/ (Customer information system, Billing) • Service providers/Third party providers/ (Aggregator, home/Building management system, Retail energy provider) • Generation / (Market service interface, Plant control system, Generators) • Transmission / (Substation controller, Data collector, Electric storage, Substation device) • Distribution/ (Field device, Distribution generation, and Electric storage) • DERS/ (Electric storage, Distribution generation, Field device, Meter) • Customers/ (Meter, Distribution generation, Electric storage, EV, Customer EMS, customer		
ISO 15118	ISO 15118-1:2013	ISO 15118-1:2013 Road vehicles -- Vehicle to grid communication interface -- Part 1: General information and use-case definition https://www.iso.org/standard/55365.html							x		This standard specifies terms and definitions, general requirements and use cases as the basis for the other parts of ISO 15118. It provides a general overview and a common understanding of aspects influencing the charge process, payment and load levelling. ISO 15118 does not specify the vehicle internal communication between battery and charging equipment and the communication of the SECC to other actors and equipment (beside some dedicated message elements related to the charging). All connections beyond the SECC, and the method of message exchanging are considered to be out of the scope as specific use cases.		Consumption/Elec-mobility	Plugin EV: • Consumer portal - EV management • Customer attributes • EV load management • EV network testing & diagnostics • Impact of EVs on distribution operations • EV as storage •EV charge mode • EV participates in utility events •EV diagnostics • Substation protocol conversion	

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ISO 15118	ISO 15118-2:2014	ISO 15118-2:2014 Road vehicles -- Vehicle-to-Grid Communication Interface -- Part 2: Network and application protocol requirements https://www.iso.org/standard/55366.html		x							This standard specifies the communication between battery electric vehicles (BEV) or plug-in hybrid electric vehicles (PHEV) and the Electric Vehicle Supply Equipment. The application layer message set defined in ISO 15118-2:2014 is designed to support the energy transfer from an EVSE to an EV. ISO 15118-1 contains additional use case elements describing the bidirectional energy transfer. The implementation of these use cases requires enhancements of the application layer message set defined herein.	The purpose of ISO 15118-2:2014 is to detail the communication between an EV (BEV or a PHEV) and an EVSE. Aspects are specified to detect a vehicle in a communication network and enable an Internet Protocol (IP) based communication between EVCC and SECC. ISO 15118-2:2014 defines messages, data model, XML/EXI based data representation format, usage of V2GTP, TLS, TCP and IPv6. In addition, it describes how data link layer services can be accessed from a layer 3 perspective. The Data Link Layer and Physical Layer functionality is described in ISO 15118-3.		•EV home connection • EV another customers home connection • EV connections outside of home territory • EV connections at public location •EV charging • EVSE connection Charging station: • PEV charging at premise • Consumer portal – EV management •PV output forecasting • Customer attributes • EV load management • EV network testing & diagnostics • Impact of EVs on distribution operations • EV as storage •EV charge mode • EV participates in utility events •EV diagnostics • Substation protocol conversion •EV home connection • EV another customers home connection • EV connections outside of home territory • EV connections at public location EVSE connection •Premise EVSE • Premise EVSE & charger	
	ISO 15118-3:2015	ISO 15118-3:2015 Road vehicles -- Vehicle to grid communication interface -- Part 3: Physical and data link layer requirements https://www.iso.org/standard/59675.html		x							This standard specifies the requirements of the physical and data link layer for a high-level communication, directly between battery electric vehicles (BEV) or plug-in hybrid electric vehicles (PHEV), termed as EV (electric vehicle) [ISO-1], based on a wired communication technology and the fixed electrical charging installation [Electric Vehicle Supply Equipment (EVSE)] used in addition to the basic signaling, as defined in [IEC-1].	It covers the overall information exchange between all actors involved in the electrical energy exchange. ISO 15118 (all parts) is applicable for manually connected conductive charging.			
	ISO 15118-6	ISO/IEC 15118-6:-Road Vehicles : Vehicle to grid communication interface-Part6: General information and use-case definition for wireless communication. https://joinup.ec.europa.eu/solution/isoiec-15118-6-road-vehicles-vehicle-grid-communication-interface-part-6-general		x							This standard specifies a wireless communication link as an alternative to the existing conductive communication link included in ISO/IEC 15118-3 standard. Although wireless link shall comply with any applicable requirements and use cases of ISO/IEC 15118 standards, additional requirements and use cases derived from the use of wireless communication link are described. This standard defines general information and use case definition for wireless communication, including extensions to existing use cases described in ISO/IEC 15118-1 and additional specific use cases for wireless applications. This standard is applicable to conductive power transfer technologies and wireless power transfer technologies	A particular attention has been paid to the EV-EVSE communication interface association process to ensure that the EV is correctly associated with the unique EVSE which the EV is currently, or is willing to be, attached to for the power transfer process. This standard is based on existing standardized wireless communication technologies, suitable to vehicle to grid communication.	Distribution, Customer, EV		
	ISO 15118-8:2018	ISO 15118-8:2018 Road vehicles — Vehicle to grid communication interface — Part 8: Physical layer and data link layer requirements for wireless communication https://www.iso.org/standard/62984.html		x							This standard specifies the requirements of the physical and data link layer of a wireless High Level Communication (HLC) between Electric Vehicles (EV) and the Electric Vehicle Supply Equipment (EVSE). The wireless communication technology is used as an alternative to the wired communication technology as defined in ISO 15118-3. It covers the overall information exchange between all actors involved in the electrical energy exchange. ISO 15118 (all parts) are applicable for conductive charging as well as Wireless Power Transfer (WPT).		Distribution, Customer, EV		

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ISO/IEC 14908	ISO/IEC 14908-1:2012	ISO/IEC 14908-1:2012 Information technology -- Control network protocol -- Part 1: Protocol stack https://www.iso.org/standard/60203.html		x							This standard specifies a communication protocol for local area control networks. The protocol provides peer-to-peer communication for networked control and is suitable for implementing both peer-to-peer and master-slave control strategies. ISO/IEC 14908-1:2012 describes services in layers 2 to 7. In the layer 2 (data link layer) specification, it also describes the Medium Access Control (MAC) sublayer interface to the physical layer. The physical layer provides a choice of transmission media.	The interface described in ISO/IEC 14908-1:2012 supports multiple transmission media at the physical layer. In the layer 7 specification, it includes a description of the types of messages used by applications to exchange application and network management data.	• DERs/Microgrid/Station controller • Generation/Power Plant • Transmission/Generic substation/Router • Distribution/Distribution automation/Router • DER/Router • Electric system operation/ Router • Enterprise/Router • Wholesale energy market/Router • Retail energy market INCL vector packet processing (VPP)/router • Consumption/Home & Building automation, Elec-mobility, AMI	DER/Station controller: • Integrated Volt/VAR • Adaptive transmission protection • Advanced distribution automation with DER function • Circuit reconfiguration • Integrated Volt/VAR decentralized • AGC frequency control • Fault isolation • Field control request • Volt/VAR on substation basis • Advanced DA functions •System engineer retrofits a substation • Transmission/generic substation router • Power plant router • Distribution/distribution automation/router • DER/router • Electric system operation/ router • enterprise/router • wholesale energy market/router • retail energy market INCL VPP/router • Consumption/Home & building automation, exec-mobility, AMI routers • Communication Network Management	
	ISO/IEC 14908-2:2012	ISO/IEC 14908-2:2012 Information technology -- Control network protocol -- Part 2: Twisted pair communication https://www.iso.org/standard/60204.html		x							This standard specifies the control network protocol (CNP) free-topology twisted-pair channel for networked control systems in local area control networks and is used in conjunction with ISO/IEC 14908-1. The channel supports communication at 78,125 kbit/s between multiple nodes, each of which consists of a transceiver, a protocol processor, an application processor, a power supply and application electronics.	This standard overs the complete physical layer (OSI Layer 1), including the interface to the Media Access Control (MAC) sublayer and the interface to the medium. Parameters that are controlled by other layers but control the operation of the physical layer are also specified.			
	ISO/IEC 14908-3:2012	ISO/IEC 14908-3:2012 Information technology -- Control network protocol -- Part 3: Power line channel specification https://www.iso.org/standard/60205.html							x		This standard specifies the control network Power Line (PL) channel and serves as a companion document to ISO/IEC 14908-1. It presents the information necessary for the development of a PL physical network and nodes to communicate and share information over that network.	This standard covers the complete physical layer (OSI layer 1) including the interface to the Medium Access Control (MAC) sublayer and the interface to the medium. It includes parameters specific to the PL channel type, even though the parameters may be controlled at an OSI layer other than layer 1. ISO/IEC 14908-3:2011 also provides a set of guideline physical and electrical specifications for the power line environment as an aid in developing products for that environment.			
	ISO/IEC 14908-4:2012	ISO/IEC 14908-4:2012 Information technology -- Control network protocol -- Part 4: IP communication https://www.iso.org/standard/60206.html		x							This standard specifies the transporting of the Control Network Protocol (CNP) packets for commercial local area control networks over Internet Protocol (IP) networks using a tunneling mechanism wherein the CNP packets are encapsulated within IP packets. It applies to both CNP nodes and CNP routers.	The purpose of ISO/IEC 14908-4:2011 is to ensure interoperability between various CNP devices that wish to use IP networks to communicate using the CNP.			
ISO/IEC 15067	ISO/IEC 15067.3:2012	ISO/IEC 15067-3:2012 Information technology -- Home Electronic System (HES) application model -- Part 3: Model of a demand-response energy management system for HES. https://www.iso.org/standard/55596.html	x	x							This standard specifies an energy management model for programs that manage the consumer demand for electricity using a method known as "demand response". Three types of demand response are specified in this standard: direct control, local control and distributed control. It replaces ISO/IEC TR 15067-3, first edition, published in 2000, and constitutes a technical revision.	This standard includes the following significant technical changes with respect to the previous edition: - the demand response options have been expanded; - distributed energy resources such as local generation and storage have been included; - the terminology for demand response has been aligned with smart grid.	• Customers / (Meter, EV, Customer EMS, Customer equipment, Thermostat, Appliance)		
	ISO/IEC 15067-3-2:2016	ISO/IEC TR 15067-3-2: 2016: Information technology -- Home Electronic System (HES) application model -- Part 3-2: GridWise interoperability context-setting framework https://www.iso.org/standard/69385.html							x		This standard describes a framework for identifying and discussing interoperability issues to facilitate the integration of entities that interact with electric power systems.		• Customers / (Meter, EV, Customer EMS, Customer equipment, Thermostat, Appliance)		

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	ITU T-G.9903	ITU T-G.9903: Narrowband orthogonal frequency division multiplexing power line communication transceivers for G3-PLC networks http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=11823		x							This Recommendation ITU-T G.9903 contains the physical and data link layer (DLL) specification for the G3- PLC narrowband orthogonal frequency division multiplexing (OFDM) power line communication transceivers for communications via alternating current and DC electric power lines over frequencies below 500 kHz.	This Recommendation uses material from Recommendations ITU-T G.9955 and ITU T G.9956; specifically, from Annexes A and D of ITU-T G.9955 and Annex A of ITU-T G.9956. New technical material has not been introduced in this version. The control parameters that determine spectral content, power spectral density (PSD) mask requirements and the set of tools to support the reduction of the transmit PSD can be found in Recommendation ITU-T G.9901.	• Operations/Distribution Operations/ (Demand response, DMS, Asset management, distributed SCADA, Metering system, meter data management system, DER management systems) • Distribution/ (Field device, Electric storage) • DERs/ (Electric storage, field device) • Customers/ (Meter, Electric storage, EV, EMS, Customer equipment, thermostat, Appliance)		
	ITU T-G.9960-2011	ITU T-G.9960-2011 Unified high-speed wireline-based home networking transceivers – system architecture and physical layer specification http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=11403		x							This Recommendation ITU-T G.9960 specifies the system architecture and physical layer for wireline-based home networking transceivers capable of operating over premises wiring including inside telephone wiring, coaxial cable, and power-line wiring. It complements the DLL specification in Recommendation ITU-T G.9961.	Besides the inclusion of minor enhancements and error fixes, this version of the Recommendation removes the control parameters that determine spectral content, power spectral density (PSD) mask requirements, and the set of tools to support reduction of the transmit PSD, all of which have been moved to Recommendation ITU-T G.9964	Distribution, Customer		
	ITU T-G.9972:2010	ITU T-G.9972:2010 Coexistence mechanism for wireline home networking transceivers https://www.itu.int/rec/T-REC-G.9972-201006-I/en		x							This standard specifies a coexistence mechanism for home networking transceivers capable of operating over power line wiring. The coexistence mechanism allows ITU-T G.996x devices to coexist with other coexisting systems, as defined in this Recommendation, operating on the same power line wiring.	It also defines Generic management message including State indication messages and Resynchronization messages	Distribution, Customer		
	MultiSpeak Security-V1.0	MultiSpeak Security-V1.0 https://www.multispeak.org/security-considerations/		x			x			x	A specification for application software integration within the utility operations domain; a candidate for use in an Enterprise Service Bus.	An open, mature specification developed and maintained by a consortium of electric utilities and industry vendors, with an interoperability testing program. It is part of PAP08's task for harmonization of IEC 61850/CIM and MultiSpeak (PAP08: CIM/61850 for Distribution Grid Management. The ITCA for this standard is NRECA.	• Operations/Distribution Operations/ (Demand response, DMS, Asset management, Distributed SCADA, metering system, Meter data management system, DER management systems) • Service providers/Third party providers /Aggregator • Distribution/ (Field device, Distribution generation, Electric storage) • DERs/ (Electric storage, Distribution generation, Field device) • Customers/ (Meter, Distribution generation, Electric storage, EV, EMS, Customer equipment, Thermostat, Appliance)		x

Standard Family	Standard No.	Name and URL	Information Model	Communication	Physical Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Cybersecurity	Description	Characteristics	Domain, Subdomain, and Components	Use Cases	T&C
	MultiSpeak V3.0:2015	MultiSpeak V3.0 http://www.multispeak.org/multispeak-specification/	x	x							The MultiSpeak Specification consists of: • UML class models and XML schemas that document the MultiSpeak data model • web service description language (WSDL) files that define the messages used to implement interoperable web services • a specification document • use case documentation • a security standard • endpoint schemas	• ML schemas • WSDLs for 23 web services endpoints comprised of 300+ defined messages • Specification document outlining the proper implementation of this version of the specification • The only specification of its type to be adopted by the Smart Grid Interoperability Panel (SGIP) in its Catalog of Standards	Distribution		x
	NAESB REQ.19	North American Energy Standards Board (NAESB) REQ 19 Measurement & Verification (M&V) of Energy Efficiency Programs Model Business Practices (MBPs) https://www.naesb.org/member_login_form.asp?doc=retail_bk19_071417.pdf							x		The standards specify two-way flows of energy usage information based on a standardized information model.		Distribution, Service Provider, Customer		
	NAESB REQ.21	NAESB REQ.21 Energy Services Provider Interface Model Business Practices (MBPs) https://www.naesb.org/member_login_form.asp?doc=retail_bk21_071417.pdf	x	x						x	NAESB REQ.21 Energy Services Provider Interface (ESPI) builds on the NAESB EUI (EUI) Model and, subject to the governing documents and any requirements of the applicable regulatory authority, will help enable retail customers to share energy usage information with third parties who have acquired the right to act in this role.	This standard provides a consistent method for retail customers to authorize a third party to gain access to EUI. Doing so will help enable retail customers to choose third party products to assist them to better understand their energy usage and to make more economical decisions about their usage. ESPI will contribute to the development of an open and interoperable method for third party authorization and machine-to-machine exchange of retail customer EUI. The ITCA for this standard is the Green Button Alliance.	Distribution, Service Provider, Customer		x
	NAESB REQ.22	NAESB REQ.22 Third Party Access to Smart Meter-based Information Model Business Practices (MBPs) https://www.naesb.org/member_login_form.asp?doc=retail_bk22_071417.pdfrds.asp							x		The NAESB REQ.22 document "establishes voluntary Model Business Practices for Third Party access to Smart Meter-based information." These business practices are intended only to serve as flexible guidelines rather than requirements, with the onus on regulatory authorities or similar bodies to establish the actual requirements. They are also not intended for any billing or collection activities.	This standard provides guidelines for the privacy business practices for Distribution Companies and Third Parties when managing private customer Smart Meter information. ESPI applies to customer interaction systems of utilities, third party service providers, and customers and their devices such as handheld and desktop computers, thermostats, electricity meters, etc. SGIP PAP 20, Green Button EPSI Evolution, is building on this work. Additionally, open source implementations for ESPI and related testing tools are being developed.	Distribution, Service Provider, Customer		

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	NAESB RMQ.18	NAESB RMQ.18 https://www.naesb.org//member_login_form.asp?doc=weq_rat10220910_weq_2010_ap_6d_rec.doc.	x								This document establishes the Business Practice Standards for end-use energy usage information communication. Specifically, these Business Practice Standards establish an information model for energy usage information. The Business Practice Standard does not limit the form or function of the information model and is exemplary, but not exclusive, of the information that may be communicated in a consistent format among a variety of Entities, including but not limited to Distribution Companies, energy service providers, meter-reading entities, and end-use customers. Such communication may occur via multiple systems and devices. Establishment of this energy usage information model will standardize a common data format which may be used when information is communicated between Distribution Companies, third parties and energy end-use customers which may aid end-use customers in tracking and managing their energy use.		Distribution, Service Provider, Customer		
	NAESB RMQ.26	NAESB RMQ.26 OpenFMB https://www.naesb.org/member_login_form.asp?doc=retail_bk26_071417.pdf	x	x					x	x	The OpenFMB™ framework provides a specification for power systems field devices to leverage a non-proprietary and standards-based reference architecture, which consists of internet protocol (IP) networking and Internet of Things (IoT) messaging protocols. The framework supports Distributed Energy Resources that communicate based on a common schematic definition and then can process the data locally for action (control, reporting).	OpenFMB™ supports field-based applications that enable: • Scalable peer-to-peer publish/subscribe architecture • Data-centric, rather than device-centric, communication including support for harmonized system and device data • Distributed operations augmenting centralized control	Distribution, DER		p
	NAESB WEQ.19:2010	NAESB WEQ.19:2010 https://www.naesb.org//member_login_form.asp?doc=weq_rat10220910_weq_2010_ap_6d_rec.doc.	x								This Model Business Practice establishes the Model Business Practices for Retail Customer energy usage information communication. Specifically, these Model Business Practices establish an information model for energy usage information. The Model Business Practice does not limit the form or function of the information model and is exemplary, but not exclusive, of the information that may be communicated in a consistent format among a variety of Entities, including, but not limited to, Distribution Companies, energy service providers, meter-reading entities, and Retail Customers. Such communication may occur via multiple systems and devices. Establishment of this energy usage information model will standardize a common data format which may be used when information is communicated between Distribution Companies, third parties and energy use customers which may aid Retail Customers in tracking and managing their energy use		Distribution, Service Provider, Customer		

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	NEMA SG-AMI 1-2009 (R2015)	NEMA SG-AMI 1-2009 (R2015) Requirements for Smart Meter Upgradeability https://www.techstreet.com/nema/standards/nema-sg-ami-1-2009-r2015?gateway_code=nema&product_id=1645246 https://webstore.ansi.org/RecordDetail.aspx?sku=NEMA+SG-AMI+1-2009+(R2015)			x				x	x	This standard will be used by smart meter suppliers, utility customers, and key constituents, such as regulators, to guide both development and decision making as related to smart meter upgradeability. This standard serves as a key set of requirements for smart meter upgradeability. These requirements should be used by smart meter suppliers, utility customers, and key constituents, such as regulators, to guide both development and decision making as related to smart meter upgradeability.	The purpose of this document is to define requirements for smart meter firmware upgradeability in the context of an AMI system for industry stakeholders such as regulators, utilities, and vendors. This standard was coordinated by PAP00 Meter Upgradeability Standard - http://collaborate.nist.gov/twikisggrid/bin/view/SmartGrid/PAP00MeterUpgradability and has been recommended by the SGIP Governing Board and approved by the SGIP Plenary for the CoS.	Distribution, Customer		z
	NERC Critical Infrastructure Protection (CIP) 002-009	NERC Critical Infrastructure Protection (CIP) 002-009 https://www.nerc.com/pa/Stand/Pages/CIPStandards.aspx								x	These standards cover organizational, processes, physical, and cybersecurity standards for the bulk power system. Mandatory standards for the bulk electric system. Currently being revised by the North American Electric Reliability Corporation (NERC).		Generation, Transmission		
	NIST SP 800-53-Rev 5-2017	NIST SP 800-53-Rev 5-2017 Security and Privacy Controls for Information Systems and Organizations. https://csrc.nist.gov/publications/detail/sp/800-53/rev-5/draft								x	This publication provides a catalog of security and privacy controls for federal information systems and organizations to protect organizational operations and assets, individuals, other organizations, and the Nation from a diverse set of threats including hostile attacks, natural disasters, structural failures, human errors, and privacy risks. The controls are flexible and customizable and implemented as part of an organization-wide process to manage risk. The controls address diverse requirements derived from mission and business needs, laws, Executive Orders, directives, regulations, policies, standards, and guidelines.	The publication describes how to develop specialized sets of controls, or overlays, tailored for specific types of missions and business functions, technologies, environments of operation, and sector-specific applications. Finally, the consolidated catalog of controls addresses security and privacy from a functionality perspective (i.e., the strength of functions and mechanisms) and an assurance perspective (i.e., the measure of confidence in the security or privacy capability). Addressing both functionality and assurance ensures that information technology products and the information systems that rely on those products are sufficiently trustworthy.	Generation, Transmission, Distribution, Operation, Service Provider, Customer		

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NISTIR	NISTIR 7628	NISTIR 7628 Guidelines for Smart Grid Cyber Security: Vol. 1, Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements https://csrc.nist.gov/publications/detail/nistir/7628/archive/2010-08-31 https://nvlpubs.nist.gov/nistpubs/ir/2010/NIST.IR.7628.pdf							x	x	Smart Grid technologies will introduce millions of new intelligent components to the electric grid that communicate in much more advanced ways (e.g., two-way communications, and wired and wireless communications) than in the past. This report is for individuals and organizations who will be addressing cyber security for Smart Grid systems. The privacy recommendations, the security requirements, and the supporting analyses that are included in this report may be used by strategists, designers, implementers, and operators of the Smart Grid, e.g., utilities, equipment manufacturers, regulators, as input to their risk assessment process and other tasks in the security lifecycle of a Smart Grid information system. This report focuses on specifying an analytical framework that may be useful to an organization. It is a baseline, and each organization must develop its own cyber security strategy for the Smart Grid. The information in this report serves as guidance to various organizations for assessing risk and selecting appropriate security requirements and privacy recommendations.		• Market/ (Retail wholesaler, Aggregator, Energy market clearing house, ISO/RTO participant, Distribution system operator participant) • Operations/RTO/ISO operations/ (EMS, ISO/RTO SCADA) • Operations/Transmission operations/ (EMS, WAMS, transmission SCADA) • Operations/Distributions/ (Demand response, DMS, Asset management, Distributed SCADA, Metering system, Meter data management system, DER management systems) • Service providers/Utility provider/ (Customer information system, Billing) • Service providers/Third party providers/ (Aggregator, home/Building management system, Retail energy provider) • Generation/ (Market service interface, Plant control system, Generators) • Transmission/ (Substation controller, Data collector, Electric storage, Substation device) • Distribution/ (Field device, Distribution generation, and electric storage) • DERS/ (Electric storage, Distribution generation, Field device, Meter) • Customers/ (Meter, Distribution generation, Electric storage, Electric vehicle, Customer EMS, Customer		
	NISTIR 7761-2011	NISTIR 7761-2011: Guidelines for Assessing Wireless Standards for Smart Grid Applications https://www.nist.gov/publications/nist-sgip-priority-action-plan-2-guidelines-assessing-wireless-standards-smart-grid		x					x		This report is a draft of key tools and methods to assist smart grid system designers in making informed decisions about existing and emerging wireless technologies. An initial set of quantified requirements have been brought together for advanced metering infrastructure (AMI) and initial distribution automation (DA) communications.	These two areas present technological challenges due to their scope and scale. These systems will span widely diverse geographic areas and operating environments and population densities ranging from urban to rural.	• Operations/Distributions/ (Demand response, DMS, Asset management, Distributed SCADA, Metering system, Meter data management system, DER management systems) • Distribution/ (Field device, Distribution generation, and electric storage) • DERS/ (Electric storage, Distribution generation, Field device, Meter) • Customers/ (Meter, Distribution generation, Electric storage, EV, Customer EMS)		

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NISTIR	NISTIR 7862-2012	NISTIR 7862-2012: Guideline for the Implementation of Coexistence for Broadband Power Line Communication Standards https://www.nist.gov/publications/guideline-implementation-coexistence-broadband-power-line-communication-standards		x					x		This guideline is used for the implementation of coexistence for broadband power line communication standards PLC systems provide a bi- directional communication platform capable of delivering data for a variety of smart grid applications such as home energy management and intelligent meter reading and control. One benefit of applying power line communication on power grid is that it provides an infrastructure that is much more comprehensive and widespread than other wired/wireless alternatives.	Power line cables are a shared medium, therefore multiple PLC devices operate on the same frequency over the same power line may interfere with each other, thus reducing the effectiveness of these devices. This publication introduces the coexistence mechanism for the IEEE and ITU-T BB-PLC standards, and provides implementation guidelines for PLC devices to be used for smart grid applications	Distribution, Customer		
	NISTIR 7943-2013	NISTIR 7943-2013 Guideline for the Implementation of Coexistence for Low Frequency Narrowband Power Line Communication Standards in the Smart Grid https://www.nist.gov/publications/guideline-implementation-coexistence-low-frequency-narrowband-power-line-communication		x			x				This report addresses the harmonization of new power line communications (PLC) standards and their coexistence specifications. This NISTIR presents PAP15's recommendation to the SGIP on the implementation of coexistence mechanisms for narrowband PLC (NB-PLC) standards. This document also provides an introduction of NB-PLC standards and their coexistence mechanisms.	NB-PLC standards define communication protocols operating below 500 kHz frequency with a bandwidth from tens to hundreds of kbps. The coexistence mechanism allows multiple devices of different technologies to coexist over the shared power lines.	Distribution, Customer		
	OASIS EMIX V1.0:2012	OASIS (Organization for the Advancement of Structured Information Standards) EMIX (Energy Market Information eXchange) V1.0: http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html	x								This specification defines an information model and XML vocabulary for the interoperable and standard exchange of prices and product definitions in transactive energy markets: • Price information • Bid information • Time for use or availability • Units and quantity to be traded • Characteristics of what is traded	This specification defines an information model to exchange Price and Product information for power and energy markets. Product definition includes quantity and quality of supply as well as attributes of interest to consumers distinguishing between power and energy sources. It is anticipated to be used for information exchange in a variety of market-oriented interactions.	Distribution, Service Provider, Market		
	OASIS EI-2014 V1.0	OASIS Energy-Interop (EI)-2014 http://docs.oasis-open.org/energyinterop/ei/v1.0/energyinterop-v1.0.pdf	x	x							Energy interoperation describes an information model and a communication model to enable collaborative and transactive use of energy, service definitions consistent with the OASIS SOA Reference Model, and XML vocabularies for the interoperable and standard exchange of: • Dynamic price signals • Reliability signals • Emergency signals • Communication of market participation information such as bids • Load predictability and generation information	The work facilitates enterprise interaction with energy markets, which: • Allows effective response to emergency and reliability events Allows taking advantage of lower energy costs by deferring or accelerating usage, • Enables trading of curtailment and generation, • Supports symmetry of interaction between providers and consumers of energy, • Provides for aggregation of provision, curtailment, and use,	Distribution, Service Provider, Market		
	OASIS WS Calendar V1.0	OASIS WS Calendar-Common- Schedule 2011 V1.0 http://docs.oasis-open.org/ws-calendar/ws-calendar/v1.0/ws-calendar-1.0-spec.pdf	x								WS-Calendar describes • A semantic (or information) model for exchange of calendar information to coordinate activities • A means of synchronizing and maintaining calendars The specification includes XML vocabularies for the interoperable and standard exchange of: • Schedules, including sequences of schedules • Intervals, including sequences of Intervals • Other calendar information consistent with the IETF iCalendar standards	These vocabularies describe schedules and Intervals future, present, or past (historical). The specification is divided into three parts. 1) The information model and XML vocabularies for exchanging schedule information 2) RESTful Services for calendar update and synchronization 3) Web services for calendar update and synchronization	Distribution, Service Provider, Market		

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	OPC-UA	Object Linking and Embedding (OLE) for Process Control Unified Architecture (OPC-UA): https://opcfoundation.org/developer-tools/specifications-unified-architecture/part-1-overview-and-concepts/	x	x			x	x			A platform-independent specification for a secure, reliable, high-speed data exchange based on a publish/subscribe mechanism. Modern service-oriented architecture (SOA) designed to expose complex data and metadata defined by other information model specifications (e.g. IEC 61850, BACnet, OpenADR).	Works with existing binary and widely supported open standard, with compliance testing program.	Transmission, Distribution, Service Provider, Market, Customer		z
	OGC-GML	Open Geospatial Consortium - Geography Markup Language (OGC-GML) Geography Markup Language http://www.opengeospatial.org/standards/gml	x	x					x		This is a standard for exchange of location-based information addressing geographic data requirements for many Smart Grid applications. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet. A GML document is described using a GML Schema.	An open standard, GML encoding is in compliance with International Organization for Standardization (ISO) 19118 for the transport and storage of geographic information modeled according to the conceptual modeling framework used in the ISO 19100 series of International Standards and is in wide use with supporting open source software. Also used in Emergency Management, building, facility, and equipment location information bases (http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=32554).	Transmission, Distribution		
	OpenHAN	Open Home Area Network (OpenHAN) http://osgug.ucaiug.org/sgsystems/openhan/Shared%20Documents/OpenHAN%202.0/UCAIug%20HAN%20SRS%20-%20v2.0.pdf							x		A specification developed by users group, Utility Communications Architecture International Users Group (UCAIug), that contains a "checklist" of requirements that enables utilities to compare the many available HANs.	The OpenHAN standards for home networks (sometimes called home grids) was promoted by groups such as openAMI[1] and UtilityAMI.[2] Both efforts aim to standardize powerline networking interoperation from a utility point of view and ensure reliable communications co-extant with AC power outlets.	Distribution, Customer		
	OpenADR 2.0 Profile A OpenADR 2.0 Profile B	OpenADR 2.0 Profile A OpenADR 2.0 Profile B https://www.openadr.org/specification	x	x							This standard defines a communications data model designed to facilitate sending and receiving DR signals from a utility or independent system operator to electric customers. The intention of the data model is to interact with building and industrial control systems that are pre-programmed to take action based on a DR signal, enabling a demand response event to be fully automated, with no manual intervention. The OpenADR specification is a highly flexible infrastructure design to facilitate common information exchange between a utility or Independent System Operator (ISO) and their end-use participants. The concept of an open specification is intended to allow anyone to implement the signaling systems, providing the automation server or the automation clients." The Open Automated Demand Response Communications Specification defines the interface to the functions and features of a Demand Response Automation Server (DRAS) that is used to facilitate the automation of customer response to various Demand Response programs and dynamic pricing through a communicating client. This specification, referred to as OpenADR, also addresses how third parties such as utilities, ISOs, energy and facility managers, aggregators, and hardware and software manufacturers will interface to and utilize the functions of the DRAS in order to automate various aspects of demand response (DR) programs and dynamic pricing."	The Organization for the OASIS is the SDO that created and published the OpenADR 2.0 Profile as a subset of the Energy Interoperation (EI) standard. The OpenADR Alliance maintains the standard and is recognized as the ITCA by SEPA.	Distribution, Service Provider, Market		x

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	SAE J1772-2017	Society of Automotive Engineers (SAE) J1772-2017 https://global.ihs.com/doc_detail.cfm?rid=Z56&mid=SAE&document_name=SAE%20J1772&item_s_key=00255427&utm_source=google&utm_medium=cpc&utm_campaign=sae&utm_content=SAE_J1772&gclid=EAIaIQobChMIgJmcsMyu3wIVBVSGCh3qIQujEAAYASAAEgKG4vD_BwE		x	x				x		This SAE Standard covers the general physical, electrical, functional and performance requirements to facilitate conductive charging of EV/PHEV vehicles in North America. This document defines a common EV/PHEV and supply equipment vehicle conductive charging method including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector.		Distribution, Service Provider, Customer, EV		
	SAE J2836-Use-Cases-(1-3) SAE J2836/1	SAE J2836-Use-Cases-(1-3) SAE J2836/1: Use Cases for Communication Between Plug-in Vehicles and the Utility Grid https://www.sae.org/standards/content/j2836/1_201004/		x					x		This document responds to a need by system designers for documentation of use cases as inputs to creation of end-to-end system solutions between EVs and utilities. After review by PAP11 (PAP11: Common Object Models for Electric Transportation - http://collaborate.nist.gov/twikisggrid/bin/view/SmartGrid/PAP11PEV), CSWG and SGAC, it has been recommended to and approved by the SGIPGB for inclusion in the SGIP Catalog of Standards.		Distribution, Service Provider, Customer, EV		
	SAE J2847/1	SAE J2847/1:2010 Communication between Plug-in Vehicles and the Utility Grid. http://standards.sae.org/j2847/1_201006		x							This SAE recommended practice establishes requirements and specifications for communication between plug-in electric vehicles and the electric power grid, for energy transfer and other applications. Where relevant, this document notes, but does formally specify, interactions between the vehicle and vehicle operator.		Distribution, Service Provider, Customer, EV		
	Security Profile for Advanced Metering Infrastructure, v 1.0	Security Profile for Advanced Metering Infrastructure, v 1.0, December 10, 2009 http://osgug.ucaiug.org/utilisec/amisec/Shared%20Documents/AMI%20Security%20Profile%20(ASAP-SG)/AMI%20Security%20Profile%20-%20v1_0.pdf								x	The scope of this work extends from the meter data management system (MDMS) up to and including the home area network (HAN) interface of the smart meter. Informative security guidance may be provided for systems and components relevant but beyond the explicitly designated scope. In developing this guidance, the task force examined community-established AMI use cases, evaluated risk for AMI, and utilized a security service domain analysis.	The task force then modified and enhanced controls from the Department of Homeland Security to produce the recommended cyber security controls for AMI. The actionable portion of this document is the resulting catalog of controls applicable to AMI systems and components.	Distribution, Customer		
	SGIP 2011-0008-1 PAP 18 Transition from SEP 1 to SEP 2.0	Smart Grid Interoperability Panel (SGIP) 2011-0008-1 PAP 18 Transition from SEP 1 to SEP 2.0							x		The SGIP Priority Action Plan 18: SEP 1.x to SEP 2.0 Transition and Coexistence was created to specifically address SEP 1.x to SEP 2.0 migration and coexistence. SEP 1.0 provides a set of functionality for HANs designed to meet the requirements established in the OpenHAN System Requirements		Distribution, Customer		