

# Overview of Interoperability Standards Landscape and T&C

**Cuong Nguyen**

Engineering Laboratory  
NIST Smart Grid & Cyber-Physical Systems Office

July 9, 2018

# Sources of Standards

## SEPA/SGIP SG CoS List

Smart Electric Power Alliance CATALOG OF STANDARDS NAVIGATION TOOL

SGIP's Smart Grid Catalog of Standards  
Full List of Standards by Entry Number

SGIP Catalog of Standards	Date	SGIP Catalog of Standards	Date
1. ANSI C12.1-2008 listed Sept 5 2012	10/15/2014	43. IEC 62351-6-dated 2014-09-11	08/17/2015
2. ANSI C12.1-2008 listed Sept 5 2012	10/15/2014	44. IEC 62351-6-dated Nov 2013	10/15/2014
3. ANSI C12.19-2008 listed Sept 5 2012	10/15/2014	45. IEEE 1377-dated 2011-02-02	09/17/2015
4. ANSI C12.19-2012-dated 2014-10-17	08/17/2015	46. IEEE 1701	10/15/2014
5. ANSI C12.20-2010 listed Sept 5 2012	10/15/2014	47. IEEE 1815-2011 listed Dec 31 2011	10/16/2014
6. ANSI C12.21-2006 listed Sept 5 2012	10/15/2014	48. IEEE 1901-2010 listed Jan 31 2013	10/16/2014
7. ANSI C12.22-2008 listed Sept 5 2012	10/15/2014	49. IEEE C37.238	10/16/2014
8. ASHRAE 155-2010 listed Nov 21 2011	10/15/2014	50. IEEE C37.239-2010 listed May 4 2012	10/16/2014
9. CEA-709.1-2014-02-14rev1	10/15/2014	51. IEEE 1905-2-dated 2013-09-01	08/17/2015
10. CEA-709.2-2014-02-14rev1	10/15/2014	52. ITR RFC 6272 listed July 7 2011	10/16/2014
11. CEA-709.3-2014-02-14rev1	10/15/2014	53. ITR T G 9990	10/16/2014
12. CEA-709.4-2014-02-14rev1	10/15/2014	54. ITR T G 9972	10/16/2014
13. CEA-851.1-2014-02-14rev1	10/15/2014	55. MultiSpeak Security V1.0-dated 2013-12-05	10/16/2014
14. CEA-851.4-2014-02-14rev1	10/15/2014	56. MultiSpeak V3.0-dated 2013-12-09v1	10/16/2014
15. CEA-CD3A-CE359-dated 2013-09-01v1	10/15/2014	57. NAEBS REQ 19	10/16/2014
16. IEC 15067-3-dated 2012-11-05	08/17/2015	58. NAEBS REQ 21	10/16/2014
17. IEC 60870-6-503 listed Sept 5 2012	10/15/2014	59. NAEBS REQ 22	10/16/2014
18. IEC 60870-6-702-1998 listed Sept 5 2012	10/15/2014	60. NEMA SA-AM1	10/16/2014
19. IEC 60870-6-802	10/15/2014	61. NISTIR 7628 listed Sept 5 2012	10/16/2014
20. IEC 61850-1	10/15/2014	62. NISTIR 7761 listed July 7 2011	10/16/2014
21. IEC 61850-10	10/15/2014	63. NISTIR 7783-dated 20130928v1	10/16/2014
22. IEC 61850-2	10/15/2014	64. NISTIR 7862	10/16/2014
23. IEC 61850-3	10/15/2014	65. NISTIR 7943-dated 20140613	8/17/2015
24. IEC 61850-4	10/15/2014	66. CADP EMX listed Dec 31 2011	10/16/2014
25. IEC 61850-5	10/15/2014	67. CADP WS	10/16/2014
26. IEC 61850-6	10/15/2014	68. CADP Energy Interop	10/16/2014
27. IEC 61850-7-1	10/15/2014	69. OpenADR-2 0a-dated 2012-08-17-v1	10/16/2014
28. IEC 61850-7-2	10/15/2014	70. OpenADR-2 0b-dated 2012-08-17rev2	10/16/2014
29. IEC 61850-8	10/15/2014	71. SAE J1772-2012 listed July 7 2011	10/16/2014
30. IEC 61850-7-4	10/15/2014	72. SAE J2886 Use Cases (1-3) listed July 7 2011	10/16/2014
31. IEC 61850-7-410	10/15/2014	73. SAE J2847-1 listed Oct 14 2011	10/16/2014
32. IEC 61850-7-420	10/15/2014	74. SAE J2887-1-dated 2013-12-02 website	10/16/2014
33. IEC 61850-8-1	10/15/2014	75. SG AM1	10/16/2014
34. IEC 61850-9-0	10/15/2014	76. SSP 2011-0009-1	10/16/2014
35. IEC 61850-9-2	10/15/2014	77. ANSI/IEEE/IEA/IEEE Standard # 201p (P516M)	05/13/2017
36. IEC 62351-1	10/15/2014	78. ANSI/CTA-2045	05/13/2017
37. IEC 62351-2	10/15/2014	79. ITR T G 9903	05/13/2017
38. IEC 62351-3	10/15/2014	80. NAEBS MQG 26	05/13/2017
39. IEC 62351-4	10/15/2014	81. NEMA Standards Publication SG-IPRM 1-2014	05/13/2017
40. IEC 62351-5	10/15/2014		
41. IEC 62351-6	10/15/2014		
42. IEC 62351-7	10/15/2014		

Source: <http://www.gridstandardsmap.com/>

## Identified SG Standard List of NIST Framework R3.0

This publication is available free of charge from <http://dx.doi.org/10.6028/NIST.SP.1108r3>

NIST Special Publication 1108r3

### NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0

NIST SG Framework V3.0-2014 SG List

1. ANSI C12.1-2008	36. MultiSpeak
2. ANSI C12.18-2006	37. NAEBS REQ18, WEX19-2010
3. ANSI C12.19-2008	38. NAEBS REQ-21 Energy Services Provider Interface (ESPI)
4. ANSI C12.20-2010	39. NAEBS REQ-22
5. ANSI C12.21-2006	40. NEMA Smart Grid Standards Publication SG-AMI-1-2009
6. ANSI C12.22-2008	41. OPI-1A
7. ITR T G 9990	42. Open Automated Demand 2.0
8. ITR T G 9972	43. Open Geospatial Consortium (OGC) Geography Markup Language (GML)
9. ITR T G 9990	44. OASIS Energy Interoperation (EI)
10. ITR T G 9990	45. OASIS IMDC (Energy Market Information Exchange)
11. ITR T G 9990	46. Smart Energy Profile 2.0 Device communication and information model
12. ITR T G 9990	47. RFC 6272 IP-based SG network
13. ITR T G 9990	48. OASIS WS Calendar (Communication)
14. ITR T G 9990	49. NISTIR 7761, NIST Guidelines for Assessing Wireless Standards for SG Applications
15. ITR T G 9990	50. NISTIR 7862 - Guidelines for the Implementation of Coexistence for Broadband PLC Standards
16. ITR T G 9990	51. OpenADR
17. ITR T G 9990	52. SAE J1772: SAE Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler
18. ITR T G 9990	53. SAE J2861: Use Cases for Communication Between Plug-in Vehicles and the Utility Grid
19. ITR T G 9990	54. SAE J2847: Communication Between Plug-in Vehicles and the Utility Grid
20. ITR T G 9990	55. SGICP Interoperability Process Reference Manual (PRM) v1.0
21. ITR T G 9990	56. SGIP 2011-0009: PAR 18 Transition from SSP to SEP 2.0
22. ITR T G 9990	57. Security Profile for Advanced Metering Infrastructure, v 1.0, 2009
23. ITR T G 9990	58. DHS, NCS, Catalog of Control System Security recommendations for standards developers
24. ITR T G 9990	59. DHS Cyber Security Procurement Language for Control Systems
25. ITR T G 9990	60. IEC 61851: Electric vehicle conductive charging system - Part 1: General requirements
26. ITR T G 9990	61. IEC 62351-1
27. ITR T G 9990	62. IEC 62351-2
28. ITR T G 9990	63. IEC 62351-3 TCP/IP
29. ITR T G 9990	64. IEC 62351-4 security for AMES
30. ITR T G 9990	65. IEC 62351-5 application layer authentication and security issues
31. ITR T G 9990	66. IEC 62351-6 security for IEC 61850
32. ITR T G 9990	67. IEC 62351-7 end-to-end information security
33. ITR T G 9990	68. IEC 62351-8 specifies sub-based access control (SBAC) requirements
34. ITR T G 9990	69. IEEE 1616-2007 defines functions and formats to be provided in substation IEDs
35. ITR T G 9990	70. NERC Critical Infrastructure Protection (CIP) 002-009
36. ITR T G 9990	71. NIST Special Publication (SP) 800-53 Mandatory standards for the bulk electric system
37. ITR T G 9990	72. NISTIR 7628 Guidelines for Smart Grid Cyber Security V1.0, V2.0, V3.0

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

<https://www.nist.gov/news-events/news/2014/10/nist-releases-final-version-smart-grid-framework-update-30>

## DSO Priority List

Smart Grid Functionalities & Services

Smart Network Management	Smart Grid Functionality & Service	List of Standards
	<ul style="list-style-type: none"> <li>Electromagnetic compatibility &amp; power quality</li> <li>Advanced network operation and control (e.g. faster fault identification and self-healing capabilities, advanced network automation, volt var/watt control)</li> <li>Smart metering and power line communication</li> </ul>	<ul style="list-style-type: none"> <li>IEC 61000 series</li> <li>IEC 61968/61970/62325 (CIM)</li> <li>IEC 61850 series, IEC 60870 series</li> <li>IEC 62689 series</li> <li>IEC 62351 series</li> <li>IEC 60255 series</li> </ul>
	<ul style="list-style-type: none"> <li>Integration of distributed generation</li> <li>Integration of electric vehicles</li> <li>Integration of new uses such as storage, heating &amp; cooling, etc.</li> </ul>	<ul style="list-style-type: none"> <li>EN 50438</li> <li>IEC 61850 series</li> <li>TS 50549-1 &amp; 2</li> <li>ISO/IEC 15118</li> <li>IEC 62786</li> <li>IEC 61851</li> </ul>
	<ul style="list-style-type: none"> <li>Enable DSO to act as market facilitator and grid optimiser</li> <li>Develop demand response and demand side management programmes</li> <li>Aggregate distributed energy resources and e-mobility</li> <li>Balance the power grid</li> </ul>	<ul style="list-style-type: none"> <li>IEC 61968/61970/62325 (CIM)</li> <li>IEC 62056 (DLM/COSEM)</li> <li>IEC 61850 series</li> <li>SEP 2.0, Open ADR, ...</li> </ul>

Table 1: Standards for smart grid functionalities and services for DSOs

Source: <https://www.edsoforsmartgrids.eu/wp-content/uploads/public/DSO-Priorities-Smart-Grid-Standardisation.pdf>

### New Standards:

- New Standards
- New versions of old standards

## Smart Grid Standards for Evaluation (244 Standards)

# Standards Evaluation Methodology

NIST Identified SG Standards\_List\_April\_23\_2018\_Song AMG.xlsx - Excel

Song, Eugene (Fed)

No.	Standard Family	Standard No.	Standard Name	Information Model	Communication	Performance	Test method	Communication Mapping	Model Mapping	Guideline & Practice	Security	(Types)	Description	Characteristics	Domain, subdomain and components	Use Cases	T&C	NIST 3.0	SEPA CoS	IEC CoS
1		ANSI C12.1-2014	ANSI C12.1-2014: Electric Meters - Code for Electricity Metering <a href="https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%20C12.1-2014">https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%20C12.1-2014</a>			x						Measurement performance	This standard establishes acceptable <u>performance criteria</u> for new types of ac watt-hour meters, demand meters, demand registers, pulse devices, and auxiliary devices. It describes acceptable in-service performance levels for meters and devices used in revenue metering. It also includes information on related subjects, such as recommended measurement standards, installation	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.	<ul style="list-style-type: none"> <li>• Operations/distribution operations/Metering system</li> <li>• Transmission/substation Devices</li> <li>• DERs / (Field Device, meter)</li> <li>• Customers/Meter</li> </ul>	<ul style="list-style-type: none"> <li>• personnel to determine if an outage is still valid. The OMS Poll is a multicast which can be initiated manually or automatically.</li> <li>• Outage Management System Poll Unicast</li> <li>• Outage Notification: This use case addresses the Outage Notification message generated by the Smart Meter and how this message gets generated into a trouble ticket.</li> </ul>		x		
5		ANSI C12.18-2006	ANSI C12.18-2006: American National Standard for Protocol Specification for ANSI Type 2 Optical Port. <a href="https://www.smartgrid.gov/document/ansi_c1218_2006ieee_p1701mc12_18_protocol_specification_ansi_type_2_optical_port">https://www.smartgrid.gov/document/ansi_c1218_2006ieee_p1701mc12_18_protocol_specification_ansi_type_2_optical_port</a>	x	x	x						Communication, information model, performance, security	This standard describes the criteria required for <u>communications</u> 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 communications 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 communications 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.	<ul style="list-style-type: none"> <li>• Operations/distribution operations/Metering system</li> <li>• Transmission/substation Devices</li> <li>• DERs / (Field Device, meter)</li> <li>• Customers/Meter</li> </ul>	<ul style="list-style-type: none"> <li>• Outage Restoration Notification: Utility implements integrated management of Distributed Energy Resources</li> <li>• Performing Real Time Price Option: This use case addresses the process of computing the Real Time Price (RTP) signals for the Smart Grid Dispatch.</li> </ul>		x	x	
6		ANSI C12.19-2008	ANSI C12.19-2008: American National Standard for Utility Industry End Device Data Tables. <a href="https://www.smartgrid.gov/document/ansi_c1219_2008ieee_p1377mc12">https://www.smartgrid.gov/document/ansi_c1219_2008ieee_p1377mc12</a>	x								Information model	This standard provides a <u>common data structure</u> for use in transferring data to and from utility End Devices, 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 particular feature-set and related function such as Time-of-use, Load Profile, etc. Table data is transferred from or to the	This Standard defines a Table structure for utility application data to be passed between an End Device and any other device.	<ul style="list-style-type: none"> <li>• Operations/distribution operations/Metering system</li> <li>• Transmission/substation Devices</li> <li>• DERs / (Field Device, meter)</li> <li>• Customers/Meter</li> </ul>	<ul style="list-style-type: none"> <li>• Remote Programming Smart Meter: Meter Remote Connect &amp; Disconnect: This use case addresses the messages exchanged between customer information system (CIS) and Smart Meter through</li> </ul>		x	x	

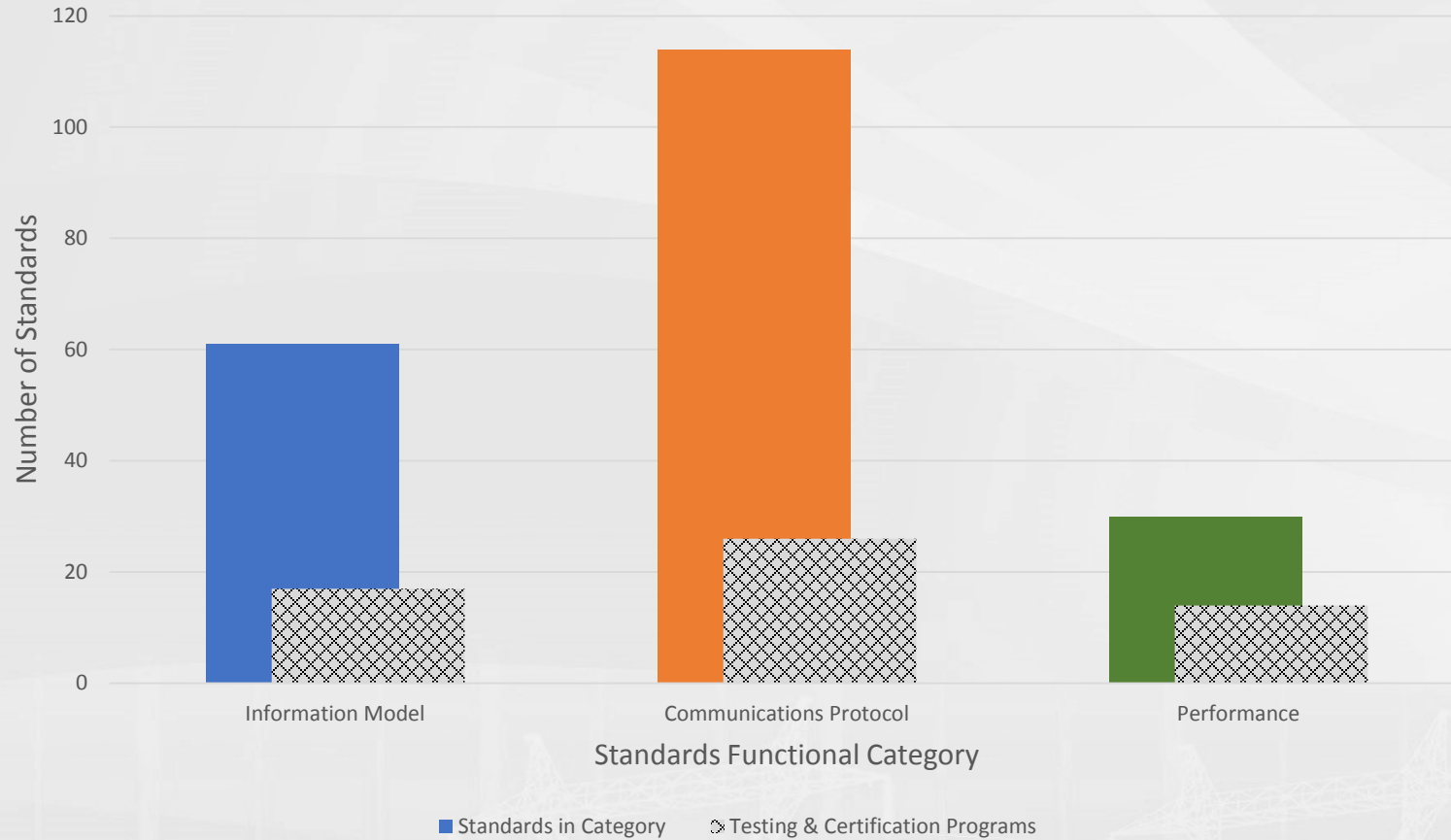
Sheet1

Ready Calculate

85%

# Preliminary Data Analysis

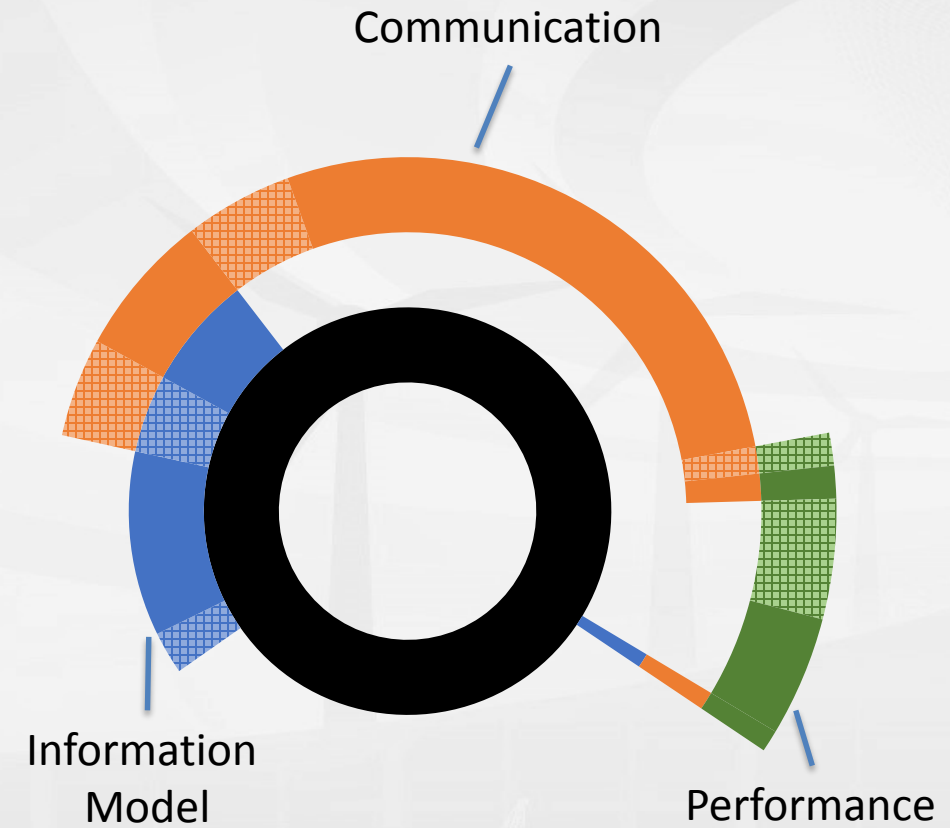
## Smart Grid Standards and Associated Testing & Certification



17/61

26/114

14/30



# Gaps persist in assuring interoperability

- The collection of standards that support grid modernization continues to grow and diversify.
- There remains a gap in the availability of testing and certification programs to ensure that standards have been implemented appropriately and consistently to support interoperability of devices and systems.
- Even as some standards are converging on a subset of requirements, they are typically on parallel pathways.