IEEE STANDARDS ASSOCIATION

IEEE 2030®

IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads

IEEE Standards Coordinating Committee 21

Sponsored by the
IEEE Standards Coordinating Committee 21 on
Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 2030®-2011

10 September 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

Sponsor

IEEE Standards Coordinating Committee 21 on
Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

Approved 10 September 2011

IEEE-SA Standards Board

Abstract: 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. The IEEE 2030 SGIRM defines three integrated architectural perspectives: power systems, communications technology, and information technology. Additionally, it defines design tables and the classification of data flow characteristics necessary for interoperability. Guidelines for smart grid interoperability, design criteria, and reference model applications are addressed with emphasis on functional interface identification, logical connections and data flows, communications and linkages, digital information management, and power generation usage.

Keywords: communications technology, controls, cyber security, distributed resources, electric infrastructure and reliability, electric power system, electricity customers and loads, EPS, grid architecture, grid operations, IEEE 2030®, information technology, interconnection, interfaces, interoperability, power systems, SCADA, SGIRM, Smart Grid, smart grid reference model

---

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2011 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 10 September 2011. Printed in the United States of America.

BACnet is a registered trademark of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

GSM is a registered trademark, owned by the GSM Association.

HomePlug is a registered trademark of the HomePlug Powerline Alliance, Inc. in the U.S. and other countries.

IEEE and IEEE 2030 are registered trademarks in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

Java is a registered trademark of Oracle and/or its affiliates.

LTE and UMTS are trademarks of the European Telecommunications Standards Institute (ETSI).

The MultiSpeak name is a registered trademark of the National Rural Electric Cooperative Association. Mention of MultiSpeak in this publication is not meant in any way to convey affiliation, endorsement or sponsorship by NRECA or any participant in the MultiSpeak Initiative nor compliance or interoperability of our (product/products) with the MultiSpeak specification.

Object Management Group, OMG, UML, and Unified Modeling Language are either registered trademarks or trademarks of Object Management Group, Inc. in the United States and/or other countries.

The Open Group is a registered trademark of The Open Group in the United States and other countries.

W3C is a registered trademark of the World Wide Web Consortium (registered in numerous countries). Marks of W3C are registered and held by its host institutions: Massachusetts Institute of Technology (MIT), European Research Consortium for Information and Mathematics (ERCIM), and Keio University, Japan.

WiMAX is a trademark of the WiMAX Forum.

ZigBee and Smart Energy Profile are registered trademarks of the ZigBee Alliance, Inc.

PDF: ISBN 978-0-7381-6727-5 STD97148
Print: ISBN 978-0-7381-6728-2 STDPD97148

IEEE prohibits discrimination, harassment and bullying. For more information, visit http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html.
No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied "**AS IS**."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Recommendations to change the status of a stabilized standard should include a rationale as to why a revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854
USA

Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

This introduction is not part of 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.

The sophistication and age of electrical power grids throughout the world vary significantly, and they may vary within a country from area to area or electrical service provider to electrical service provider. Additionally, there is an increasing worldwide demand for building an expansive electricity infrastructure. Satisfying the demands for expansion and for upgrading aging electrical power systems, coupled with the advances in communications and information technologies, has stimulated the concept of "Smart Grid"—a broad term used to include the application of secure, two-way communications and information technology to electrical power grids.

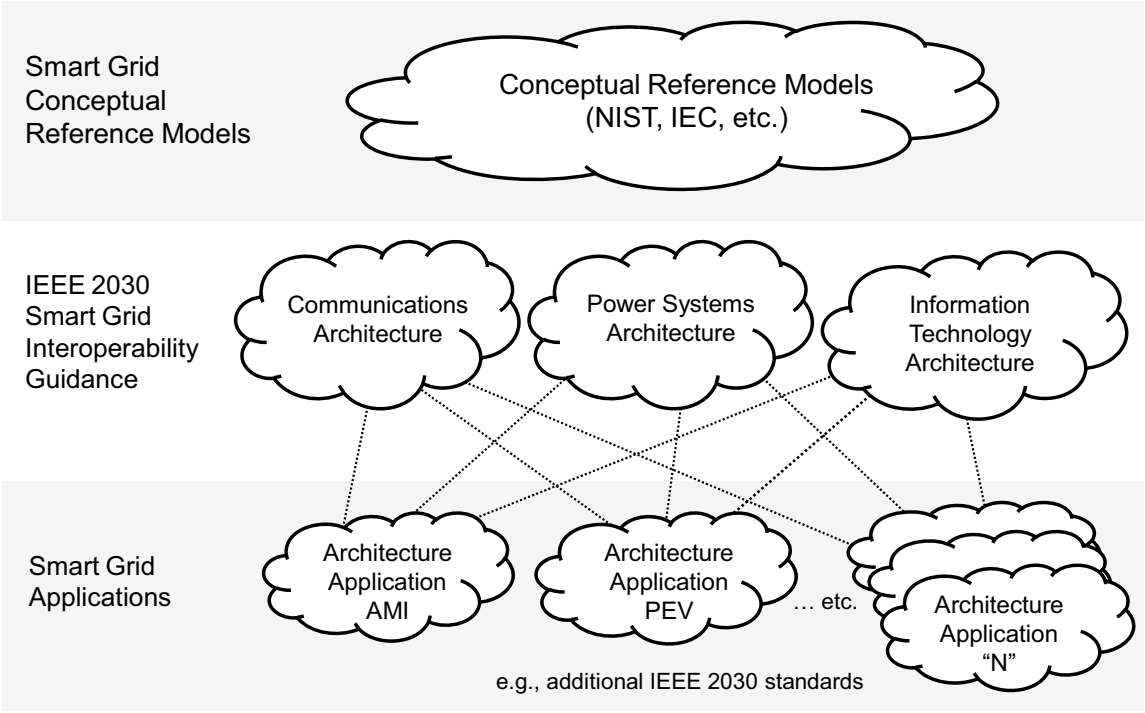
These demands have also driven policy, legislation, and regulation of power systems throughout the world.

The U.S. Energy Independence and Security Act (EISA) of 2007 addresses the coordination of the development of a smart grid interoperability framework. Under EISA Section 1305, the Director of the National Institute of Standards and Technology (NIST) shall have the primary responsibility of coordinating the development of that framework, including soliciting input from private organizations, including the National Electrical Manufacturers Association and IEEE. Further, the scope of the interoperable framework "shall be flexible, uniform, and technology neutral" and "align policy, business, and technology approaches in a manner that would enable all electric resources, including demand-side resources, to contribute to an efficient, reliable electricity network." The International Electrotechnical Commission (IEC) has similar interests in evolving their smart grid concepts and established the IEC Standardization Management Board (SMB) Strategic Group 3 (SG 3) on Smart Grid. It was established to advise the board concerning the technologies associated with the Smart Grid and to identify the needs for new international standards. Currently, there are many (national and international) standardization activities related to the development of smart grid concepts. A smart grid standardization roadmap was developed in 2010 by the IEC that is similar to the framework and roadmap developed by NIST. Standards developing organizations (e.g., IEEE)—using an open and balanced consensus process—are establishing standards for the Smart Grid building off of the conceptual reference models produced by NIST [B17] and others.[a]

IEEE Std 2030-2011 supports EISA, the NIST framework coordination efforts, IEC interests, and additional smart grid applications. It focuses on a systems-level approach to understanding and guidance for *interoperability* components of communications, power systems, and information technology platforms (see Figure a). This guide views the Smart Grid as a large, complex "system of systems" and provides guidance to navigate the numerous smart grid design pathways throughout the EPS, loads, and end-use applications. This interoperability standard lays the foundation for the expanding smart grid applications level shown in Figure a**,** which provides a platform for any number of smart grid applications, i.e., advanced metering infrastructure, plug-in electric vehicles, and other smart grid applications ("N"). These applications may be supported by additional IEEE 2030 standards.

[a] The numbers in brackets correspond to those of the bibliography in Annex A.

Copyright © 2011 IEEE. All rights reserved.



AMI = advanced metering infrastructure
PEV = plug-in electric vehicle
N = other smart grid applications

Figure a—Evolution of smart grid interoperability

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Copyright © 2011 IEEE. All rights reserved.

Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association web site at http://ieeexplore.ieee.org/xpl/standards.jsp, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA web site at http://standards.ieee.org.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/index.html. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: http://standards.ieee.org/reading/ieee/interp/index.html.

Patents

Attention is called to the possibility that implementation of this guide may require use of subject matter covered by patent rights. By publication of this guide, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this guide are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Copyright © 2011 IEEE. All rights reserved.

Participants

At the time this guide was submitted to the IEEE-SA Standards Board for approval, Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage had the following membership:

Richard DeBlasio, *Chair*
Thomas S. Basso, *Vice Chair & Secretary*

David Bassett
John Bzura
James Daley
Douglas C. Dawson
Frank Goodman
Kelvin Hecht
Yiming Hou
Gerald Johnson
Joseph L. Koepfinger
Benjamin Kroposki
Peter McNutt
Thomas Prevost
Mary Reidy
Charles Rogers
Robert Saint
Mark Siira
Timothy Zgonena

At the time this guide was submitted to the IEEE-SA Standards Board for approval, the IEEE 2030 Smart Grid Interoperability Working Group had the following membership:

Richard DeBlasio, *Chair*
Thomas Prevost, *Vice Chair, Task Force 1 Co-Chair*
Thomas S. Basso, *Secretary, Task Force 1 Recorder*
Samuel Sciacca, *Task Force 1 Co-Chair*
Robert M. Grow, *Task Force 2 Co-Chair*
Jeffrey Katz, *Task Force 2 Co-Chair*
Michael Coddington, *Task Force 2 Recorder*
Howard Choe, *Task Force 3 Co-Chair*
Robert Heile, *Task Force 3 Co-Chair*
Connie Komomua, *Task Force 3 Recorder*

Kunle Adeleye
Akira Atsuta
John Banting
Trone Bishop
Sara Biyabani
Donald Bowen
Kuor Chang
Brian Cramer
Ben Crutcher
Catherine Dalton
Subir Das
Partha Datta Ray
Paul Eastman
Alan Esenther
Hamid Gharavi
Jonh Grosspietsch
Joshua Hambrick
Jason Handley
Mariana Hentea
David Hunter
Anthony Johnson
David Kelley
Mike Key
Timothy Kostyk
Atte Lansisalmi
Claudio Lima
Michael Loiacono
Madhav Manjrekar
Neal Mellen
Kimberly Mosley
Yoshihiro Ohba
Michael Pehosh
Zafer Sahinoglu
Robert Saint
Mark Siira
Wayne Stec
Gary Stuebing
Alex Takahashi
William Tamae
Osamu Tomobe
Steve Turner
Randy West

The following list identifies individuals in addition to the working group members who participated in the development of this guide:

Brice Achkir
Dhiraj Adya
Paul Ainslie
Wole Akpose
Farrokh Albuyeh
James Allen
Tom Anderson
Alexander Apostolov
Takashi Aramaki
Haukur Asgeirsson
Thao Attard
Papiya Bagchi
Xiaomin Bai
Hugh Barrass
David Bassett
Jonathan Becker
Philip Beecher
George Bellino
Slav Berezin
Leonard Bernstein
Greg Bernstein

Copyright © 2011 IEEE. All rights reserved.

John Boot
Michael Bourton
Renee' Bovair
Richard Boyd
Markus Braendle
Mike Brown
Steven Buchholz
Anto Budiardjo
John Buffington
Ed Butler
Peter Cain
Mark Carbo
Robert Castellano
Soo-Young Chang
Clint Chaplin
Wei-Peng Chen
Joseph Choghi
Don Christian
Vincent Chua
James Cleary
William Cloutier
Jeffrey Cohen
Carey Cook
Charles Cook
Mike Coop
Stephen Cooper
Bharat Dahal
Robert Dalias
Paul Dixon
Daniel Doan
Jean-Luc Dormoy
Randall Dotson
Liang Downey
Andrew Drozd
Samuel Dubois
Dan Dumond
Peter Ecclesine
Dennis Edwards
John Egan
Stuart Elkins
Simon Ellwanger
Glenn Emelko
Babak Enayati
Jay Endsley
Gary Engmann
Jose Fadul
Jean-Philippe Faure
Thomas Field
George Flammer
Martin Freeman
Darrell Furlong
Stefano Galli
Brian Gaucher
Adam Gauci
Robert Gerard
Sajol Ghoshal
Steven Gladstein
William Godwin
Bill Goodwin
David Gosch
Karine Gosse
Thomas Grabowski
Brian Green
Bob Groppo
Vincent Guillet
Subhash Gullapalli
Adolfo Gutierrez
Phillip Ha
John Halliwell
Richard Harada
Ed Hare
Keith Harley
Kent Harmon
Rajgopal Harnoor
Ben Hartman
Simon Haykin
Julie He
Stefan Heckmann
Donald Heirman
Paul Heitmann
Kenneth Hopkinson
Jarad Howard
Jiankun Hu
Carlos Huerta
Koichi Inoue
Hachidai Ito
Junichi Iwatani
Bharath Iyengar
Charles Jackson
Mirko Jakovljevic
Junghoon Jee
Junho Jo
Charles Johnson
Vibhor Julka
Manoj Karwa
Tatsuya Kato
Jeff Kenward
Brendan Keogh
Steven Kerkmaz
Jihoon Kim
Kyoung-yun Kim
Atsushi Kimura
Stanley Klein
Mark Klerer
Richard Koehl
Joseph L. Koepfinger
Jerry Kolbe
Kevin Komara
Yutaka Kono
Bruce Kraemer
Dick Krause
Padmasri Krishnamurthy
Ryogo Kubo
John Kueck
Puesh Kumar
Nicolai Kuntze
Walt Kutzavitch
Fabrice Labeau
Ismail Lakkis
John Lampe
Lutz Lampe
George Lapiotis
Raluca Lascu
Jim Lawlis
James LeClare
Sangcheol Lee
Tom Leonard
Fuchun Lin
Hongyu Lin
Jianwei Liu
Dong Liu
Oleg Logvinov
Feng Lu
Dan Lubar
Ralph Mackiewicz
Linda Maepa
Faramarz Maghsoodlou
James Magnuson
Syed Mahmud
Arindam Maitra
Brenda Mancuso
Todd Martin
Ralph Martinez
Randy Masciana
Ryusuke Masuoka
Takashi Matsuyama
Anthony Mazy
Omar Mazzoni
Stanley McHann
Tom McLaughlin
Gary McNaughton
Harish Mehta
Richard Meider
Fahrudin Mekic
Al Mendoza
Dan Mepham
Tom Mickus
Willam Miller
Joydeep Mitra
Satoru Miyoshi
Charles Molnar
Massoud Momeni
Antonello Monti
J. Derald Morgan
Robert Moskowitz
Geoff Mulligan
Mort Naraghi-Pour
Thomas Nelson
Albert Nelson
Daniel Nikovski
Hiroaki Nishi
John Norgard
Gregory Obenchain
Yasuo Okabe
Minami Okazaki
Vladimir Oksman
Peter Okunami
John O'Leary
Doug Oliver
Efrain Ornelas
Jim Osborne
Vijay Pargaonkar
Jee-Sik Park
Vladimir Pavlovic
David Pearce
Parthiban Periyaswamy

Copyright © 2011 IEEE. All rights reserved.

Alex Petrov
Kermit Phipps
Lou Pinto
Corey Plender
Anne Pogue
Peter Poulos
Douglas Preece
Neal Probert
Steven Pullins
Anuj Puri
Riccardo Raheli
Jerry Raime
Sridhar Rajagopal
Purva Rajkotia
Rob Ranck
Linda Rankin
Randy K. Rannow
Ramesh Rao
Christopher Reed
Mary Reidy
Jim Reilly
Chuck Reinhart
Bert Reitsma
Moises Ribeiro
Nicholas Ritts
Brandon Rogers
Benjamin Rolfe
William Rose
Masatake Sakuma
Jose Salazar
Ruben Salazar
Dean Samara-Rubio
Sam Sambasivan
Daniel Sammon
Chet Sandberg
Tan Sarihan
Erick Sasaki
Yasuo Sato
Naotaka Sato
Fred Schindler
Rich Scholer
Gregory Scruggs
Richard Seguin
Cristina Seibert
Michio Seita
Vic Shao
Donald Shaver
Gehao Sheng
Siddharth Sheth
Weisong Shi
Shusaku Shimada
Yasuro Shobatake
Cheong Siew
Joel Silverman
Robby Simpson
Brad Singletary
Herbert Sinnock
Elizabeth Sisley
Paul Skare
Lee Smith
Elizabeth Snyder
Nir Soffer
Kapil Sood
Kwok Soohoo
Rob St. Andre
Alexander St. Claire
Doug Staker
Herschel Stiles
Gordon Strachan
Don Sturek
David Su
Louis Szablya
Ben Tabatowski-Bush
Kazuyuki Takada
Shigeru Tamura
Yi Siang Tan
Hiroshi Tanaka
Zhifeng Tao
Kevin Taylor
Tom Taylor
Nathan Tenney
Wesley Terek
Toshiro Togoshi
Kostas Tolios
Bob Triana
Anil Tuladhar
Maher Umari
Sterling Vaden
Cor van de Water
Lorenzo Vangelista
Luis Vargas
Aron Viner
Devendra Vishwakarma
Rahul Walawalkar
Caisheng Wang
Le Yi Wang
Shinan Wang
Xiaogang Wang
Joe Weiss
Andrew Weitzner
Kurt Westermann
Greg Wetzel
Robert White
Bradley Williams
Bartosz Wojszczyk
Anthony Wong
Cheng-Zhong Xu
Murty Yalla
Masaki Yamada
Ece Yaprak
Allan Yeung
Byungsik Yoon
Hongwei Zhang
Jin Zhang
Adrian Zvarych
Jim Zyren

The following members of the individual balloting committee voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

William J. Ackerman
W. Adams
Emmanuel Agamloh
Satish K. Aggarwal
Roberto Aiello
Wole Akpose
Steven Alexanderson
Marcelo Algrain
Chris Ambrose
Jacob Ben Ary
Ali Al Awazi
Michael Bahr
Hugh Barrass
David Bassett
Thomas S. Basso
David Beach
Philip Beaumont
Philip Beecher
Zulema Belyeu
Victor Berman
Martin J. Bishop
Sara Biyabani
Robin Blanton
William Bloethe
Oscar Bolado
Pieter Botman
Donald Bowen
Jeffrey Bragg
Chris Brooks
Gustavo Brunello
John Buffington
Mark Bushnell
William Byrd
John Bzura
Peter J. Calderon
Radhakrishna Canchi
Dan Carnahan
Kuor-Hsin Chang
Clint Chaplin
Arvind K. Chaudhary
Howard Choe
Ger-Chih Chou
Keith Chow
James Cleary
Frances Cleveland
William Cloutier
Michael Coddington
James Cole
John Cole
Stephen Conrad
Terry Conrad
Carey Cook
Charles Cook
Garth Corey

Copyright © 2011 IEEE. All rights reserved.

Jerry Corkran
William Cox
Brian Cramer
Randall Crellin
Paul Croll
John Crouse
Randall Cunico
Jorge Fernandez Daher
Catherine Dalton
Alireza Daneshpooy
Geoffrey Darnton
Subir Das
James Davis
Matthew Davis
Ray Davis
Richard DeBlasio
Joseph Decuir
Em Delahostria
J. Marsden Delapp
Thomas McDermott
Wim D'Hondt
Wael Diab
Patrick Diamond
Paris Dieker
Thomas Dineen
Dieter Dohnal
Jennifer Doman
Kevin Donahoe
Carlo Donati
Gary Donner
Michael Dood
Randall Dotson
Neal Dowling
Richard Doyle
Charles Drexler
Edgar Dullni
Donald Dunn
Sourav Dutta
Paul Eastman
Peter Ecclesine
John Egan
Gary Engmann
Brian Escott
Alan Esenther
Hossam Fahmy
David Farmer
Timothy David Farnham
Jean-Philippe Faure
Rabiz Foda
Paul Forquer
Rostyslaw Fostiak
Fredric Friend
James Frysinger
David Fuschi
James Gardner
Alexander Gelman
Kenneth Gettman
Gregory Gillooly
Mietek Glinkowski
Reinhard Gloger
Tim Godfrey
William R. Godwin
Jerry Goerz
Mariana Goldhamer
Edwin Goodwin
Neil Greenfield
Ron Greenthaler
John Grosspietsch
Randall Groves
Robert M. Grow
Erich Gunther
George Gurlaskie
Ajit Gwal
Russell Haines
Donald Hall
Joshua Hambrick
Dennis Hansen
John Harauz
Edward Hare
Rajgopal Harnoor
David Harris
Timothy Hayden
William Hayes
David Haynes
Shawn Henry
Mariana Hentea
Charles Henville
Marco Hernandez
Lee Herron
Patrick Hery
Gary Heuston
Raymond Hill
Clark Hochgraf
Steven Hodder
Werner Hoelzl
Robert Hoerauf
Peter Hoffman
Robert Holibaugh
Daniel Hoolihan
David Horvath
Ronald W. Hotchkiss
John Houdek
Richard H. Hulett
David Hunter
Tetsushi Ikegami
Noriyuki Ikeuchi
Sergiu Iordanescu
Paul Isaacs
Akio Iso
Atsushi Ito
James Ivers
Raj Jain
Michael Janezic
Junghoon Jee
Alan Jensen
Anthony Johnson
Gerald Johnson
Robert Johnson
Andrew Jones
Geza Joos
Bobby Jose
Joe Natharoj Juisai
Shinkyo Kaku
Innocent Kamwa
Noh-Gyoung Kang
Piotr Karocki
Jeffrey Katz
Chad Kennedy
John Kennedy
Stuart J. Kerry
Siri Jodha Khalsa
Yuri Khersonsky
Morteza Khodaie
Yongbum Kim
Patrick Kinney
Brian Kirby
Harold Kirkham
Stanley Klein
S. Mark Klerer
Hermann Koch
Joseph L. Koepfinger
Gerald L. Kolbe
Lawrence Kotewa
Bruce Kraemer
Benjamin Kroposki
Jim Kulchisky
John Kulick
Saumen Kundu
Joseph Kwak
Marc Lacroix
Thomas Ladson
Chung-Yiu Lam
Daniel Lambert
Paul Lambert
Susan Land
Jeremy Landt
Raluca Lascu
Kang Lee
Tom Leonard
Paul Lindemulder
Jianwei Liu
Daniel Lubar
William Lumpkins
Greg Luri
Bruce Mackie
Elvis Maculuba
Wayne W. Manges
Madhav Manjrekar
Roger Marks
Albert Martin
Pierre Martin
Richard Martin
Michael Maytum
Anthony Mazy
Omar Mazzoni
William McBride
Walter McCannon
John McDaniel
John McDonald
Hank McGlynn
Gary McNaughton
Peter McNutt
Neal Mellen
Gary Michel
William Miller
David Mitton

Copyright © 2011 IEEE. All rights reserved.

Apurva Mody
Daleep Mohla
Paul Molitor
William Moncrief
James Moore
Jose Morales
Kimberly Mosley
David Mueller
Adi Mulawarman
Daniel Mulkey
Jerry Murphy
R. Murphy
Bruce Muschlitz
Soon Ryul Nam
Arun Narang
Tom Nelson
Michael S. Newman
Charles Ngethe
David Nichols
Paul Nikolich
Joe Nims
Gary Nissen
Daniel Nordell
John Notor
Gregory Obenchain
Hans-Wolf Oertel
Yoshihiro Ohba
T. Olsen
Chris Osterloh
Satoshi Oyama
Lorraine Padden
Richard Paes
Panagiotis Papadopoulos
Donald Parker
Bansi Patel
Marc Patterson
Dev Paul
James Pauley
M. Pehosh
Ronald Petersen
James Petranovich
Charles Petras
Ghery Pettit
D. Phelps
Dean Philips
K. James Phillips
Venkatesha Prasad
Craig Preuss
Thomas Prevost
Sridhar Rajagopal
Robert Rallo
Jayaram Ramasastry
Partha Datta Ray
Christopher Reed
Maximilian Riegel
Caryn M. Riley
Michael Roberts
Robert Robinson
Charles Rogers
Benjamin Rolfe
Ervin Root
John Rossetti
Marnie Roussell
Thomas Rozek
D. Daniel Sabin
Randall Safier
Robert Saint
Kazuyuki Sakoda
Osman Sakr
Masatake Sakuma
Chester Sandberg
Steven Sano
Sergio Santos
Vincent Saporita
Naotaka Sato
Bartien Sayogo
Colin Schauder
Thomas Schossig
Robert Schuerger
David Schultz
Andrew Schwalm
Stephen Schwarm
Samuel Sciacca
Christo Searles
Robert Seitz
Shusaku Shimada
Yasuro Shobatake
Stephen Shull
Gil Shultz
Cheong Siew
Mark Siira
Joel Silverman
Mark Simon
Herbert Sinnock
James Smith
Jerry Smith
Aaron Snyder
Yuyin Song
Kapil Sood
Mahesh Sooriyabandara
John Spare
James Sprecher
Joseph Stanco
Dorothy Stanley
Wayne Stec
Adrian Stephens
Raymond Strittmatter
Rene Struik
Walter Struppler
Gary Stuebing
Charles Sufana
Alourdes Sully
Alexander Takahashi
Shinji Tanabe
Joseph Tardo
Richard Taylor
William Taylor
Michael Johas Teener
John Tengdin
David Tepen
Patricia Thaler
Michael Thompson
Robert Thornton-Jones
James Tomaseski
James Tomcik
Thomas Tullia
Steven E. Turner
Demetrios Tziouvaras
Mark-Rene Uchida
Joe Uchiyama
Eric Udren
Sterling Vaden
Luis Vargas
Prabodh Varshney
Charlie Vartanian
Srinivasa Vemuru
John Vergis
Jane Verner
George Vlantis
Carl Wall
Barry Wallen
Reigh Walling
John Walz
John Wang
Daniel Ward
John Webb
Hung-Yu Wei
Robert Weller
Yingli Wen
Kathy Werner
Randall West
Kenneth White
Kenneth White
Robert White
Steven Widergren
A. Wieczorek
Kimball Williams
Harry Worstell
Forrest Wright
Murty V. V. Yalla
Thomas Yohn
Larry Young
Ray Young
Jian Yu
Oren Yuen
Janusz Zalewski
Waldemar Ziomek

Copyright © 2011 IEEE. All rights reserved.

When the IEEE-SA Standards Board approved this guide on 10 September 2011, it had the following membership:

Richard H. Hulett, *Chair*
John Kulick, *Vice Chair*
Robert M. Grow, *Past Chair*
Judith Gorman, *Secretary*

Masayuki Ariyoshi
William Bartley
Ted Burse
Clint Chaplin
Wael Diab
Jean-Philippe Faure
Alexander Gelman
Paul Houzé
Jim Hughes
Joseph L. Koepfinger*
David J. Law
Thomas Lee
Hung Ling
Oleg Logvinov
Ted Olsen
Gary Robinson
Jon Walter Rosdahl
Sam Sciacca
Mike Seavey
Curtis Siller
Phil Winston
Howard L. Wolfman
Don Wright

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Lisa Perry
IEEE Standards Program Manager, Document Development

Matthew J. Ceglia
IEEE Standards Project Manager

Bill Ash
IEEE Standards Strategic Program Manager

Copyright © 2011 IEEE. All rights reserved.

Contents

1. Overview 1

1.1 Scope 1
1.2 Purpose 1
1.3 What this guide provides 2

2. Normative references 2

3. Definitions, acronyms, and abbreviations 3

3.1 Definitions 3
3.2 Acronyms and abbreviations 4

4. The IEEE 2030 smart grid approach 6

4.1 General 6
4.2 The Smart Grid—A complex system of systems 6
4.3 Smart grid architecture 6
4.4 Smart grid interoperability 8
4.5 Privacy and security 9
4.6 Reliability 19

5. The IEEE 2030 smart grid interoperability reference model (SGIRM) 21

5.1 General 21
5.2 The interoperability architectural perspective (IAP) concept 22
5.3 Classification of data flow characteristics 23
5.4 IEEE 2030 SGIRM methodology 27

6. Power systems interoperability 28

6.1 General 28
6.2 IEEE 2030 SGIRM power systems IAP (PS-IAP) 29
6.3 Typical data characteristics in EPS interfaces 41

7. Communications technology interoperability 42

7.1 General 42
7.2 IEEE 2030 SGIRM communication technology IAP (CT-IAP) 42
7.3 Uses of the CT-IAP 56
7.4 Characteristics of smart grid communications network connectivity 56
7.5 Security categorization applied to communications 58
7.6 Key management framework 63

8. Information technology interoperability 65

8.1 General 65
8.2 IEEE 2030 SGIRM information technology IAP (IT-IAP) 65
8.3 Logical description of information technology systems 71
8.4 Information exchange reference interoperability model for IT-IAP 73
8.5 Design framework methodologies and tools 76
8.6 Information security principles for the Smart Grid 79

9. Legacy electric power systems and the Smart Grid 81

Copyright © 2011 IEEE. All rights reserved.

Annex A (informative) Bibliography 82

Annex B (informative) Guidance for implementing security 84

B.1 General 84
B.2 Data classification 85

Annex C (informative) Using IEEE 2030 SGIRM PS-IAP 88

C.1 General 88
C.2 Examples of how to apply the SGIRM methodology to smart grid implementations 88

Annex D (informative) Using IEEE 2030 SGIRM CT-IAP 97

D.1 Interface description template 97
D.2 Examples 97

Annex E (informative) Smart grid interoperability in Object Process Methodology (OPM) notation 106

E.1 Introduction to OPM 106
E.2 View of interoperability within IT-IAP 108
E.3 View of integration within IT-IAP 108
E.4 Application interoperability framework within IT-IAP 108

Copyright © 2011 IEEE. All rights reserved.

IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads

IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Documents." They can also be obtained on request from IEEE or viewed at http://standards.ieee.org/IPR/disclaimers.html.

1. Overview

The overview of this guide provides a concise description of the scope, purpose, and application. The scope explains what is covered in the guide and the purpose explains why the guide is needed. Following the scope and purpose, introductory information in 1.3 is presented on understanding this guide's general application considerations and how to use it. Detailed discussions of technical content are provided in the later clauses of this guide.

1.1 Scope

This document provides guidelines for smart grid interoperability. It also 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 (EPS) with end-use applications and loads. The guide discusses alternate approaches to good practices for the Smart Grid.

1.2 Purpose

This document provides guidelines in understanding and defining smart grid interoperability of the EPS with end-use applications and loads. Integration of energy technology and information and communications

Copyright © 2011 IEEE. All rights reserved.

technology (ICT) is necessary to achieve seamless operation for electric generation, delivery, and end-use benefits to permit two-way power flow with communication and control. Interconnection and intra-facing frameworks and strategies with design definitions are addressed in this guide, providing guidance in expanding the current knowledge base. This expanded knowledge base is needed as a key element in grid architectural designs and operation to promote a more reliable and flexible EPS.

1.3 What this guide provides

1.3.1 General

This guide provides understanding, definitions, and guidance for design and implementation of smart grid components and end-use applications for both legacy and future infrastructures. This document allows for additional functionality beyond what is stated and is meant to accommodate innovation. Because interoperability is achieved through extensive collaboration among many diverse members of the smart grid community, this guide provides the reader with a heightened awareness of the challenges and opportunities of the many different stakeholder roles of a smart grid implementation and a common understanding of the technology drivers of smart grid interoperability. The knowledge base of this guide contributes to a basis for future certification and testing of smart grid components and subsystems.

1.3.2 Intended audience

This guide is intended for the many diverse members of the smart grid community who participate in extensive collaboration for successful smart grid application implementation. This guide should be read in its entirety as it provides the reader with challenges and opportunities, and describes stakeholder roles pertinent to smart grid implementation.

1.3.3 Smart grid interoperability reference model

The IEEE 2030® smart grid interoperability reference model (SGIRM) is a reference tool to provide stakeholders with a common understanding of interoperability criteria from the power system, communications, and information technology perspectives. The IEEE 2030 SGIRM identifies and defines the interfaces between functional domains of the power grid from each of the perspectives and describes the relationships among the domains, including the characteristics of the data that flow between them. The constraints, issues, and impacts on interoperability at these interfaces are considered for each domain. With this information, optimal design criteria for the interoperability of smart grid implementations can be planned. The concept of the SGIRM reference tool is to allow for extensibility, scalability, and upgradeability.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

NISTIR 7628, Guidelines for Smart Grid Cyber Security: Vol. 1, Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements (Aug. 2010).[1]

[1] This document is available on the NIST website at: http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628_vol1.pdf.

Copyright © 2011 IEEE. All rights reserved.