IEEE-SA Standards-related activities for Smart Grid

Bill Ash
Strategic Program Manager
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Smart Grid: A New Business Frontier
One of the largest opportunities of this century

**About $13 trillion** will be spent on modernizing power grids worldwide by 2030, of which “hundreds of billions” will flow to smart grid projects

- Source: *Smart Grid Today*
Smart Grid: The Next Revolution
Complex Smart Grid Market

Communications Network Security Layer

Communications Network Management Layer

Utility Local Area Network (LAN)
Regional/Metropolitan Area Networks (MAN)

Backbone/Core Networks
Substation Network
Wide Area Networks (WAN)

Public Internet
Backhaul
Last Mile
Customer Premises

Standards Interoperability

Distribution Substation Network “hot spots”

NAN/AMI: Neighborhood Area Network/Advanced Metering Infrastructure
EAN/AMI: Extended Area Network/Advanced Metering Infrastructure
FAN: Field Area Network

Backhaul

HAN: Home Area Network
BAN: Business/Building Area Network
IAN: Industrial Area Network

IEEE STANDARDS ASSOCIATION
Policy and Regulation

- EU
  - 20/20/20 Mandate April 2009
    - climate and energy package

- US
    - NIST
      - “primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems.”
    - NIST is not an SDO

- China
  - 12th 5 Year Plan

- India
  - 12th 5 Year Plan
IEEE Smart Grid Standards Initiatives

- Incubation and bringing new technologies from research into standards development
- New development
  - Interoperability of electric power, IT, and Communications systems
  - Powerline communications and Networking, Renewable interconnection, Automotive interconnection, Storage, High voltage technology
- 100+ foundational standards updated for Smart Grid
- Market acceptance and implementation
Standards Activity Life Cycle
Pre-Standards Activities
Pre-standards Activities

- Long term visions of what the smart grid in each technology space will look like 20 to 30 years out.
- Forward looking use cases, applications scenarios for SG, and corresponding enabling technologies for SG of the future snap shots of years 2015, 2020, 2030, and beyond.
Smart Grid Communication: 2030 and Beyond

- Communication Theory, Signal Processing and Control
- Communication Media
- Information Theory and Network Science
- Paradigms and Enabling Technologies
- Quality of Service Mechanisms and Traffic Characteristics
- Overlay Networks
- Peer-to-Peer
- Security
Smart Grid Vision for Power: 2050

- Make
- Move
- Use
- Operating and Control
Smart Grid Control Systems: 2030 and Beyond

- Current Practice
- Drivers for Change
- Scenarios
- Research Challenges
- Short-term and Long-term Moves and Recommendations

dx/dt = f(x, y, u, w)  
y = g(x, y, u, w)  
A nonlinear highly uncertain and dynamical complex system

IEEE STANDARDS ASSOCIATION
Smart Grid IT: 2030 and Beyond

- Cyber Security
- Software System Engineering
- Operations, Monitoring, and Control
- Planning, Analysis, Simulation
- Communication & Networking
- Computing
- Visualization & Data Management
Intelligent Vehicles and Smart Grid: 2030 and Beyond

- Systems, Operations, Services
- Infrastructures for Intelligent Vehicle’s and the SG
- Intelligent Vehicle
- V2X Communication
- Connected Traveler
- Social, Economic, Political
IEEE Smart Grid Research Technology Initiatives

• Electric Vehicles/Wireless Power Transfer
• Power Magnetics/Power Electronics for Distributed Resources
• Data Analytics
• Nano and Molecular Communications
Technology Research

– Wireless transfer of Power
  • Initial workshop held at the IEEE IES 2011 in Melbourne Australia
  • Produce peer-reviewed technical papers and a technology roadmap on the development of EVWPT infrastructure solutions to overcome existing limitations of wired power transfer solutions
  • Outcome of the workgroup activities will serve as technology strategy guideline for clean transportation and as inspiration for the work of researchers, R&D engineers, entrepreneurs, standardization committees and policy makers
  • International expert to provide significant input for standardization and innovation activities in the domain of wireless charging of electrical vehicles
Power Magnetics/Power Electronics for Distributed Resources

Conventional Transformers

7.2 kV 120/240V
60Hz 60Hz

- Low cost, reliable, efficient
- Size and weight, power quality

Solid State Transformer (SST)

7.2 kV 120V / 240V
2.8A 60Hz 60Hz

- Voltage regulation, power factor correction
- Reduction in magnetic materials
- Bi-directional power flow
- Enables active management of load and source (DRER, DESD)

Future Renewable Electric Energy Delivery and Management Systems Center
Standards Activities
Key Areas of IEEE Standards...

- **Smart Grid**
  - IEEE 2030-2011 Guide to Interoperability
  - IEEE 1547 series interconnections between utility and distributed resources (DR), Micro-grids, Secondary Networks.
  - IEEE 1366 Guide for Electric Power Distribution Reliability Indices
  - IEEE 802 Series – Networking
  - IEEE 1901-2010 Broadband over Power Line Networks
  - IEEE Smart meter series

- **Green Technology**
  - IEEE 1888 Series: Ubiquitous Green Community Control Protocol and Networks
  - IEEE P802.3az: Energy Efficient Ethernet
  - IEEE 1680 series (Environmental assessment of electronic products)
  - IEEE P1595, Standard for Quantifying Greenhouse Gas Emission Credits from Small Hydro; Wind Power; Baseline Projects; and Grid
Key Areas of IEEE Standards...

- **Power Quality**
  - IEEE 1159 Recommended Practice for Monitoring Electric Power Quality
  - IEEE 1159.3-2003 Recommended Practice for the Transfer of Power Quality Data
  - IEEE C37.232-2007 Recommended Practice for Naming Time Sequence Data Files
  - IEEE 1250 - Guide for Identifying and Improving Voltage Quality in Power Systems
  - IEEE 1409 - Guide for the Application of Power Electronics for Power Quality Improvement on Distribution Systems Rated 1 kV Through 38 kV
Enabling Consumer Connectivity Through Consensus Building

Smart Grid into Home Devices Standards
IEEE 1675 / IEEE 1775
IEEE 2030 / IEEE P2030.1
IEEE 1901 / IEEE P1901.2
IEEE 1815

Home Networking Standards
IEEE 802
IEEE 1901
IEEE P1901.2
IEEE 1815

Smart Grid into Home Devices Standards
IEEE 1547 Series
(Distributed Energy Interconnection
Solar, Wind, Storage, etc.)
IEEE 2030

Smart Metering Standards
IEEE P1377
IEEE 1701
IEEE 1702
IEEE P1703
IEEE P1704
IEEE P1705

Home Networking Standards
IEEE 802 / IEEE 1901
IEEE P1901.2 / IEEE P1905.1
(Communication Inside the Home)

Electric Vehicle Standards
IEEE 802 Series / IEEE 1901
IEEE P1901.2 / IEEE 1609 Series
(Vehicular Communications)
IEEE 2030 / IEEE P2030.1

IEEE STANDARDS ASSOCIATION
IEEE 2030® Spans Three Distinct Perspectives

Designed for and developed by:

- **Power & Energy**
  Defines the numerous data flows necessary for reliable, secure, bi-directional flow of power and energy throughout the entire electric power system

- **Communications**
  Identifies the communications infrastructure necessary for smart grid, from high-speed synchrophaser data to in-premise meter and customer notification systems

- **Information Technology (IT)**
  Defines the system-to-system communications requirements and data flow to leverage individual systems into a system of systems
IEEE 2030®

- World’s first system-of-systems foundational standard created from the ground up to inform smart grid interconnection and interoperability

- A roadmap to the interfaces that engineers encounter in bringing the smart grid to global consumers

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 Std 2030™-2011

IEEE
3 Park Avenue
New York, NY 10016-5997
USA
10 September 2011
Methodological Interoperability Framework composed of:

- Three Interoperability Architecture Perspectives (IAP):
  - Power System (PS)
  - Communications Technology (CT)
  - Information Technology (IT)
- IAPs Interoperability Tables

IEEE 2030® Smart Grid Framework

Evolution of Smart Grid Interoperability

- Conceptual Reference Models (NIST, IEC, etc.)
  - IEEE 2030
  - Smart Grid
  - Interoperability
  - Guidance
  - Communications Architecture
  - Power Systems Architecture
  - Information Technology Architecture
  - Smart Grid Applications
    - Architecture Application AMI
    - Architecture Application PEV
    - ... etc.
    - Architecture Application “N”

E.g., additional IEEE 2030 standards
Two-Levels SG System Architecture

Inter-System Smart Grid Reference Architecture

Entity A

Entity B

Entity C

Demarcation Point

E1

E4

E3

E2

protocols, PHY/MAC layer, data flows mapping table

Inter-system (actor) connection/ interface

another connection/ Interface option between actors

Intra-System Smart Grid Reference Architecture

Entity B1

Entity B2

Entity B3

“Subsystem”

E1

B1

B2

B3

B4

B5

B6

E2

E4

Sub-System Level (phase 2)
one level down

System Level (phase 1)
SG Architecture Development Methodology
IEEE 2030 Series Ongoing Smart Grid Projects

- IEEE 2030 Series – Smart Grid Interoperability
  • IEEE P2030.1 Guide for Electric-Sourced Transportation Infrastructure
  • IEEE P2030.2 Guide for Energy Storage Systems Integrated with the Electric Power Infrastructure
  • IEEE P2030.3 Standard for Test Procedures for Electric Energy Storage Equipment and Systems
  • IEEE P2030.4 Guide for Control and Automation Installations Applied to the Electric Power Infrastructure
  • IEEE2030.100 Recommended Practice for Implementing an IEC 61850 Based Substation Communications, Protection, Monitoring and Control System
IEEE P2030.1™ – Guide for Electric-Sourced Transportation Infrastructure

- Addresses applications for road-based personal and mass transportation
- 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
- Designed to benefit:
  - Utilities,
  - Manufacturers
  - Transportation providers
  - Infrastructure developers, and
  - End users of electric-sourced vehicles (EVs)
IEEE P2030.1™ Working Group Status

- **Group effort to develop and complete the guide**
  - Task Forces remain area expertise
  - All work together to produce single consensus document

- **Globalization**
  - Expand sources and collaboration
  - Ensure global application

- **Plan**
  - June 2013 - Submit for Mandatory Editorial Coordination
  - July 2013 - Ballot
  - October 2013 - Submit to IEEE for approval
Roadmap Approach

- **Four Stages**
  - PEV Introduction and Impact Assessment
  - Faster and Smarter Charging
  - Bi-directional Power Flow
  - PEV as a Distributed Energy Resource

- **For each stage**
  - **Objectives**
    - Goals
    - Key Process Areas
  - **Viewpoints**
    - Technology
    - Standards and Guidelines
    - Market Structure
  - **Impediments**
    - Impacts and Barriers
PEV Roadmap Framework Stages

- Stage 1 - PEV Introduction and Impact Assessment
  - Near term goal
    • Analysis and groundwork for PEV adoption
  - Key Process Area
    • PEV charging equipment standardization (e.g. Communication, Interoperability).
    • PEV end-to-end acquisition process (e.g. Program Enrollment, Installation).
    • Pilot Tariff and Services Impact Analysis.

- Stage 2 - Faster and Smarter Charging
  - The next step
    • Widespread adoption of PEV.
    • Demand matches supply.
  - Key Process Area
    • Accurate measurement of PEV power consumption (e.g. submetering).
    • Service provider/utility back-office integration.
PEV Roadmap Framework Stages

- **Stage 3 - Bi-directional Power flow**
  - **Working toward the 2030 vision and goals**
    - PEV used as power source.
    - Integrated with renewables.
  - **Key Process Area**
    - PEV/Grid Physical interoperability.
    - Advanced use cases for power flow and communication (e.g. bi-directional).

- **Stage 4 - PEV as a DER in a fully Integrated grid**
  - **End game as we see it now**
    - Optimized system level efficiencies.
    - Secure and sustainable system.
  - **Key Process Area**
    - End-to-end integrated communication systems.
    - Decentralized control and pricing systems.
PEV Roadmap Framework

- **Technology**
  - Integrated Communications
  - Sensing and Measurement
  - Advanced Components
  - Advanced Control Methods
  - Consumer Interfaces

- **Standards and Guidelines**
  - Interoperability
  - Safety / Reliability
  - Security
  - Privacy

- **Market Structures**
  - Role of third parties
  - Billing
  - Zoning and Permitting

- **Impacts and Barriers**
  - System Impact Mitigation Needs
  - Barriers to reach next stage
Feedback based on recent experiences with IEC61850 clearly demonstrated several major issues related to:

- **Instantaneous interoperability** between different suppliers is **not optimal and does even not currently work** in some vendor combinations.

- **Engineering efforts** required to implement the standard in a substation are **huge**:

- **Interoperability over the lifetime** of secondary systems equipment in a substation is **crucial** for protection and control applications.
IEEE P2030.100

- **Title:** Recommended Practice for Implementing an IEC 61850 Based Substation Communications, Protection, Monitoring and Control System

- **Scope:** This recommended practice outlines the necessary steps and procedures a utility should undertake to implement an IEC 61850 substation in a multi-vendor equipment environment. The document addresses equipment configuration, equipment procurement specification, documentation procedures and general design philosophy that will condense the IEC61850 standard into a practical working implementation guide. The recommended practice also defines baseline information sets and functionality for IEC 61850 devices to allow users to implement similar design philosophies between vendors of IEC 61850 equipment.
IEEE Standards for Utility Automation

- IEEE C37 Series for Synchrophasers
  - C37.118 series, P37.242 PMU testing and installations, PC37.244 Phasor Data Concentrator Requirements
- IEEE 1815 – Distribution Network Protocol
- IEEE P1815.1 - Exchanging Information Between Networks
- IEEE 1588 – Time Synchronization
- IEEE C37.238 - Precision Time Protocol in Power System Applications
- IEEE 802 Series – Networking
- IEEE C37.1 Standard for SCADA and Automation Systems
IEEE Standards for Smart Grid Renewables


IEEE Std P1547.5™ Draft Technical Guidelines for Interconnection of Electric Power Sources Greater than 10MVA to the Power Transmission Grid

IEEE Std 1547.6™(2011) Draft Recommended Practice for Interconnecting Distributed Resources With Electric Power Systems Distribution Secondary Networks

IEEE Std P1547.7™ Draft Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection

IEEE Std P1547.8™ Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Standard 1547
IEEE Standards for Cyber Security

- IEEE 1686 - Standard for Substation Intelligent Electronic Devices (IED) Cyber Security Capabilities
- IEEE P37.240 - Standard for Cyber Security Requirements for Substation Automation, Protection and Control Systems
- IEEE 1711 - Cryptographic Protocol for Cyber Security of Substation Serial Links
- IEEE 1402 - Standard for Physical Security of Electric Power Substations
IEEE 1686 Scope

Defines and specifies cyber security functions and features of Intelligent Electronic Devices (relays, RTUs, meters, bay controllers, transformer monitors)

- Electronic Access
- Device Operation (front panel, computer port)
- Configuration
- Configuration Software
- Firmware Revision
- Data (file) Retrieval
- Encryption of Communications
Ultra High Voltage Systems

- **IEEE P1860** Draft Standard for Voltage and Reactive Power in 1000kV or Greater (Ultra High Voltage) AC Systems
- **IEEE P1861** Draft Standard for Acceptance Tests on Sitehand-Over Test of 1000kV or Greater (Ultra High Voltage) AC Electric Equipment and Commissioning Procedures
- **IEEE P1862** Draft Standard for Overvoltage and Insulation Coordination of 1000kV or Greater (Ultra High Voltage) AC Transmission Projects
**Building Automation**

- **IEEE 1888-2011** Standard for Ubiquitous Green Community Control Network Protocol

- **IEEE P1888.1** Draft Standard for a Ubiquitous Community Network: Control and Management

- **IEEE P1888.2** Draft Standard for Ubiquitous Green Community Control Network: Heterogeneous Networks Convergence and Scalability

- **IEEE P1888.3** Draft Standard for Ubiquitous Green Community Control Network: Security
Post Standards Activities
IEEE Conformity Assessment Program (ICAP)

- Bridges IEEE standards development activities with proven testing and certification frameworks
  - Encompasses all aspects of
    - Conformity assessment-self declaration
    - Third-party assessment/testing
    - Interoperability
  - Help accelerate market adoption of new products and technologies
Global Standards Development: Partners for Smart Grids.

..Enabler and Catalyst:
- Provide leadership to develop consensus
- Provide environment for collaboration
- Enable expeditious standards development
- Ensure integration across all involved communities to address future technology deployment
- Speed interoperable technology to market
- Ensure certification and compliance for end user adoption
IEEE-SA Smart Grid Portal

- Single location to identify all IEEE Standards, publications, conferences IEEE resources associated with Smart Grid

www.smartgrid.ieee.org
Thank You!

Bill Ash
Strategic Program Manager
IEEE Standards Association
w.ash@ieee.org
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