The Latest Development of Smart Grid Standards and Pilot Projects

Jinyun Zhang

TR2010-093  November 2010

Abstract

This talk will provide an overview of smart grid standardizations in US and IEEE. In particular, the latest development and future directions of NIST Smart Grid Interoperability Panel (SGIP) activities on Priority Action Plans (PAPs) will be presented. The status of IEEE P2030 and other IEEE development related to smart grid will be explained. Along with strategic international standard activities, numerous pilot projects have been initiated to evaluate new technologies and demonstrate the advantages of the smart grid. Several high profile pilot projects including the one from Mitsubishi Electric Corporation will be introduced and discussed.

SmartGrids China 2010
The Latest Development of Smart Grid Standards and Pilot Projects

Dr. Jinyun Zhang
IEEE Fellow & MERL Fellow
Manager, Digital Communication

November 2, 2010
For SmartGrids China2010
Outlines

• **Part 1: Smart Grid Standards**
  • US Development Roadmap
  • NIST SGIP
  • IEEE P2030
  • IEEE 1547
  • IEEE 802.15.4g
  • IEC/ITU-T/IETF

• **Part 2: Pilot Projects**
  • Advanced Metering Infrastructure Projects
  • Regional Demonstration Projects
  • The First Smart City Project – Boulder, Colorado
  • National Grid’s Smart City Project – Worcester, MA
  • Smarter City – Boston, MA
  • Mitsubishi Electric’s Experimental Center
  • Tiered Communication Networks – Oklahoma Gas & Electric

• **Concluding Remarks**
Smart Grid Standardization in US

**Phase 1:** Identify an initial set of existing consensus standards and develop a roadmap to fill gaps

**Phase 2:** Establish public/private Standards Panel to provide ongoing recommendations for new/revised standards

**3rd phase:** Testing and Certification Framework

---

**Q1 2009**

**Q2 2009**

**Q3 2009**

**Q4 2009**

**Q1 2010**

**Q2 2010**

**Q3 2010**

**Q4 2010**
Phase 1 Outcomes

- NIST issued first release of framework for smart grid interoperability
  - January 19, 2010: NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0
- NIST identified 25 existing smart grid-related standards
- In addition, NIST identified additional 50 standards, specifications, profiles, requirements, guidelines, and reports for further review

1. ANSI/ASHRAE 135-2008/ISO 16484-5 BACnet – A Data Communication Protocol for Building Automation and Control Networks
2. The ANSI C12 Suite
3. ANSI/CEA 709 and CEA 852.1 LON Protocol Suite
4. DNP3
5. IEC 60870-6/TASE.2
6. IEC 61850 Suite
7. IEC 61968/61970 Suites
8. IEEE C37.118
9. IEEE 1547 Suite
10. IEEE 1588
11. Internet Protocol Suite, including but not limited to IETF RFC 2460 (IPv6)
12. Multispeak
13. OpenADR
14. OPC-UA Industrial
15. Open Geospatial Consortium Geography Markup Language
16. ZigBee/HomePlug Smart Energy Profile 2.0
17. OpenHAN
18. AEIC Guidelines v2.0
19. Security Profile for Advanced Metering Infrastructure, v 1.0
22. IEC 62351 Parts 1-8
23. IEEE 1686-2007
24. NERC CIP 002-009
25. NIST Special Publication (SP) 800-53, NIST SP 800-82
NIST Smart Grid Interoperability Panel (SGIP)

SGIP Structure

- Governing Board
- SGIP Officers
- NIST
- SGIP Administrator
  - Test & Certification Committee (SGTCC)
  - Architecture Committee (SGAC)
  - Cyber Security Working Group (CSWG)

Standing Committees & Working Groups

- Program Management Office (PMO)

Coordination Functions

- H2G
- TnD
- B2G
- I2G
- PEV2G
- BnP

Domain Expert Working Groups

- Priority Action Plan Teams
  - PAP 1
  - PAP 2
  - PAP 3
  - PAP 4
  - PAP 5
  - PAP...

SGIP Membership (1639)

- Organization member
  - SGIP Participating Member (529)
  - SGIP Observing Member (74)

- Person representative
  - Voting Representative
  - Participating Representative(s)
  - Observer Representative

H2G: Home to Grid; TnD: Transmission & Distribution; B2G: Building to Grid; I2G: Industry to Grid; PEV2G: Plug-in EV to Grid; BnP: Business & Policy

Deliverables

- Use Cases
- Requirements
- Stds Descr.
SGIP Member Distribution – As of July 2010

- Total # of Member Organizations: 603
  - # of Participating Member Organizations: 529
  - # of Observing Member Organizations: 74
  - # of Organizations who joined in June: 19

- Total # of Individual Members*: 1,639
  * Omits Signatory Authorities who are not also

# of Participating Member Organizations by Declared Stakeholder Category

- Undeclared: 46
- Appliance: 38
- C & Equip.: 41
- Consumers: 13
- PEV: 6
- IOUs: 44
- MUNIs: 17
- REAs: 10
- Market Traders: 1
- Ind. Power: 1
- ICT: 47
- IT AppDev: 38
- Pwr. Equip.: 52
- Associations: 76
- R&D: 23
- Fed. Govt.: 2
- Renewable: 3
- Retail: 1
- SOOs: 25
- Regulators: 11
- T & C: 11
- TransOps: 9
- Venture Capital: 14
### NIST Smart Grid Priority Action Plans (PAPs)

<table>
<thead>
<tr>
<th>#</th>
<th>Area of Interest</th>
<th>Priority Action Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>General</td>
<td>Role of IP in the Smart Grid</td>
</tr>
<tr>
<td>1</td>
<td>Demand response</td>
<td>Common Price Communication Model</td>
</tr>
<tr>
<td>2</td>
<td>EV, PV, Battery control</td>
<td>Electric Storage Interconnection Guidelines</td>
</tr>
<tr>
<td>3</td>
<td>AMI, WASA, Distribution system</td>
<td>Wireless Communications for the Smart Grid</td>
</tr>
<tr>
<td>4</td>
<td>BEMS and Home appliances</td>
<td>Standard DR and DER Signals</td>
</tr>
<tr>
<td>5</td>
<td>Smart Meter</td>
<td>Meter Upgradeability Standard</td>
</tr>
<tr>
<td>6</td>
<td>Common Semantic Model for Meter Data Tables</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Standard Meter Data Profiles</td>
<td>Standard Meter Data Profiles</td>
</tr>
<tr>
<td>8</td>
<td>Common Semantic Model for Meter Data Tables</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Standard Energy Usage Information</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>CIM for Distribution Grid Management</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>IEC 61850 Objects/DNP3 Mapping</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>IEC 61850 Objects/DNP3 Mapping</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Electric Storage Interconnection Guidelines</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Harmonize Power Line Carrier Standards for Appliance Communications in the Home</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Time Synchronization, IEC 61850 Objects/IEEE C37.118 Harmonization</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Transmission and Distribution Power Systems Model Mapping</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Facility Smart Grid Information Standard</td>
<td></td>
</tr>
</tbody>
</table>
PAP Development Timeline

2011 SGIP Plenary Meetings and Webinars (attendance required for Participating Members)

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 21</td>
<td>Virtual</td>
<td>Webphone access will be posted by Dec. 15, 2010</td>
</tr>
<tr>
<td>March 29-31</td>
<td>Spring Face-to-Face: Dallas, Austin, Nashville</td>
<td>Registration will be opened by Jan. 15, 2011</td>
</tr>
<tr>
<td>May 26</td>
<td>Virtual</td>
<td>Webphone access will be posted by Apr. 15, 2011</td>
</tr>
<tr>
<td>July 12-14</td>
<td>Summer Face-to-Face: Montreal (International)</td>
<td>Registration will be opened by May 15, 2011</td>
</tr>
<tr>
<td>Sept. 15</td>
<td>Virtual</td>
<td>Webphone access will be posted by Aug. 15, 2011</td>
</tr>
<tr>
<td>Dec. 5-9</td>
<td>Winter Face-to-Face: Phoenix in conjunction with GridInterop</td>
<td>Registration will be opened by Sept. 15, 2011</td>
</tr>
</tbody>
</table>
IEEE P2030 – Objectives & Timeline

- Consists of three task forces, writing committee and WG.

**GOAL**

To provide guidelines for interoperability of 3 systems in each of 7 smart grid domains

Each task force produces a reference architecture for entire smart grid infrastructure

Companies like PGN, a fortune 500 utility company with 22GW generation capacity is adopting P2030 reference communications architecture in its grid networks.

**IEEE P2030 Roadmap**

WG: Working Group; WRTG: Writing Task Group; NREL: National Renewable Energy Laboratory
IEEE P2030 – Updated Architecture & Status

- Total 196 comments for IEEE P2030 Draft 3.0.
- The writing committee responded to all the comments in September 2010.
- There is still some text missing for clauses on
  - Communications technology interoperability
  - Privacy
  - Technology aspects
  - Regulatory aspects
- Draft version 4.0 will be released for comments in late December 2010
IEEE 1547 – Standard Development

- **Objectives**
  - Specifies standards for Interconnecting Distributed Resources with Electric Power Systems
  - Provides a uniform criteria and requirements relevant to the performance, operation, testing, safety considerations and maintenance of the grid connection of DR.
  - Focuses on 60 Hz systems

- **Focus**

- **Status**
  - 4 standards under development: IEEE P1547.4, IEEE P1547.5, IEEE P1547.6, IEEE P1547.7
IEEE 1547 – Status of Adoption

State Implementation of Interconnection
American National Standard IEEE 1547

- According to IEEE 1547.8 chair, 1547 has been used/tracked by other countries interested stakeholders
- The IEC-IEEE are currently pursuing an IEC Publicly Available Specification based on IEEE 1547
IEEE 802.15.4g – Smart Utility Networks

- One of the first effort to address the smart grid’s need
- A PHY amendment to 802.15.4 to facilitate very large scale process control applications such as the utility smart-grid network capable of supporting large, geographically diverse networks with minimal infrastructure, with potentially millions of fixed endpoints

- Current Status
  - The working group is planning to have a letter ballot between September and November, 2010
  - They plan to seek conditional approval for RevCom in July 2011.
IEC/SG3 and TC8 Smart Grid Activities

IEC/SMB/SG3 (Smart Grid)
- Review of roadmap (completed)

IEC/TC8 (Systems aspects for electrical energy supply)
- Call for AHG4 members (5/14-7/9)

Reference Architecture Task Team (RATT)
(Germany, Switzerland, Sweden, US, France)
- To collect and analyze use cases,
- To develop general reference architecture of smart grid

Use Case Task Team
(Italy, France, Germany, Japan)
- To collect use cases from related IEC TCs and NIST

7/2 Workshop @Paris
SG3 and related 25 TC/SCs

Report of roadmap (completed)

Report to RATT on June 1

10/13-14 SG3 meeting @Seattle
10/11-15 IEC GA @Seattle
2011/10/24-28 TC8 meeting in Australia

Now

Start AHG4 activity
Set up task forces if necessary to create use cases by categories

Not started as of Oct. 15

ITU-T: Focus Group on Smart Grid (FG Smart)

Work items of FG-Smart
- To clarify work area of ITU-T
- To collect Smart Grid use cases discussed by other SDOs
- To study telecommunication architecture
- To study requirements

Meeting schedule
2010/6/14-6/16 (1st)
2010/8/2-8/5
2010/10/11-15

WTSA: World Telecommunication Standardization Assembly,
TSAG: Telecommunication Standardization Advisory Group, SG: Study Group,
IETF Development Status

◆ 6LoWPAN (IPv6 over Low power WPAN) WG
  Internet protocol suite to use IPv6 on low power and lossy network such as IEEE 802.15.4
  → necessary to introduce IPv6 into networking among smart meters

◆ ROLL (Routing Over Low power and Lossy networks) WG
  Routing protocol for low power and lossy network in factory, home, buildings, and town

ISOC: Internet Society
IAB: Internet Architecture Board
IETF: Internet Engineering Task Force
IESG: Internet Engineering Steering Group
IRTF: Internet Research Task Force
IRSG: Internet Research Steering Group
ICANN: Internet Corporation for Assigned Names and Numbers
Advanced Metering Infrastructure Projects in US

Total Recovery Act Funding Awarded: >$1.3B
Total Project Value: >$3.6B
The largest single award: $200M (CenterPoint Energy, Baltimore Gas and Electric Company, Duke Energy)
The largest project: $1B (Duke)
Regional Demonstration Projects in US

The largest project: $177M with the largest award of $88M:
- WA, Pacific Northwest Smart Grid Demonstration Project,

Total Recovery Act Funding Awarded: >$435M
Total Project Value: >$877M

This is the largest project of $177M with $88M Recovery Act Funding - spanning 5 states, affecting 60,000 consumers, demonstrate and validate new technologies, provide two-way communication between distributed generation, storage, assets and the existing grid infrastructure, …
The First Smart City – Boulder, Colorado

- First functioning smart grid project in the world – led by Xcel Energy
- Integration of wind/solar power generation and electric vehicles
- Currently 24,000 homes are connected to smart meters
- Variable pricing and demand response will be tested
- Project Capital Cost*: $15M (Original Estimate) → $45M (Current Estimate)
  *
  >$100M including operational and maintenance cost

Controversy:
- Xcel's performance has generated a lot of heat and criticism because of extreme cost overruns. Other have criticized the company for not delivering everything it promised.
- Hearings began in August on Xcel's SmartGridCity Cost Recovery
National Grid’s Smart Grid City - Worcester, MA

- Aggressive Plan: $57M (not funded by government; 15,000 customers will be involved)

- **Plug-in Hybrid Vehicles (PHEV)**
  - Store energy in their batteries. When connected to the grid, they can provide power back to the grid during times of peak demand

- **Renewable Energy Sources**
  - Wind turbines and solar panels are integrated to the smart distribution grid

- **Smart Homes**
  - Tracks usage information through smart meters.
  - Customer will have a variety of ways to learn and take the most cost-effective energy usage option

- **Advanced Communications**
  - Including communication equipments and sensors on the grid, enable utilities to monitor, identify and quickly correct problems

**Status**
- Last October, National Grid announced the plan
- In this July, they are requested by MA DPU to provide additional information for approval
- It is expected to be approved this fall
Smarter City - Boston, MA

- **Boston has been named a 2010 Smarter City for Energy** (July 2010 update)
  - Boston has taken some major initiatives to make wind energy a viable alternative, and wind now ranks as one of the city's top three fuel sources for electricity.
  - Renewable energy is 11.7% of total and growing.
  - By 2015, Boston's solar power will be 25MW from current 0.5MW.
Mitsubishi Electric Smart Grid Experimental Center

- **Objective**
  - Support the adoption of sustainable power supplies worldwide

**Entering the smart grid market**

- Japanese market
- Global markets
- Achievement of Environmental Vision 2021

**Contribution to achieving low carbon society**

- Decreasing carbon dioxide emissions from production by 30% in FY 2021 compared to that of FY 1991
- Decreasing carbon dioxide emissions from power generation

**Investment in experimental facilities, simulating the form of electric grids in 2020**

- Reduction of fossil-fuel energy by best-mix of energy sources
- Saving energy through visualizing energy consumption
- Increase of energy-supplied homes

**Mitsubishi Electric’s smart grid business will support sustainable power supply**
Mitsubishi Electric Smart Grid Experimental Center

**Development Plan**
- 7 billion yen (US$ 80 million) Investment (2010～2011)
- Build in three production sites to allow all-round experiments

**Mitsubishi Electric Smart Grid Experiment**
- Commercial Network
- Power System Simulator
- Access & Substation Equipment
- Weather Monitoring Instruments
- Residential Photovoltaic System
  - All-electric powered Appliances
  - Home Gateway
  - Rechargeable Battery
- Simulated Interface
- Data Center

**Locations**
- Amagasaki
- Wakayama
- Ofuna

**Systems**
- Hydro Pump Storage Generator Simulator: 200kW
- Rechargeable Battery: 500kW
- Mega Solar System: 4MW
- Wide-area Network
- Experimental Network (6.6kV)
- Power System Information Network
- Advanced Metering Infrastructure (Wireless Mesh Network)
- Distribution Automation System

**Infrastructure**
- Smart Meter: 150
- EV Charge Station
- Supply & Demand Control System
- Advanced Metering Infrastructure System
Tiered Communication Networks – Oklahoma G&E

- **Development Status**
  - OG&E has more than 779,000 customers, 42,000 smart meters have been installed
  - Focus on 1) AMI and wireless technology; 2) Distribution automation

1. Microwave @6GHz, 50 miles
2. Data Access Point Network: WiMAX @3.65GHz, 10-20 miles
3. AMI: Mesh networks with 900MHz radios, <1 miles
4. HAN: ZigBee based
Concluding Remarks

- SGIP plays a key role in smart grid evolution
  - Its recommendations are likely to become regulations
- IEEE P2030 produces a new guidelines on interoperability
  - It is on track for March 2011 Sponsor Ballot
- Various new standardization activities are happening
  - IEEE 1547 series, IEEE 802.15.4g, IEC/SG3/TC8, ITU-T/FG Smart, IETF/6LoWPAN/ROLL
- Tremendous development efforts are happening
  - Large number of AMI and regional demonstration projects
  - Many smart city, smart home, and smart grid experimental systems
- However, it is at the early stage
  - There are many challenges and obstacles
  - It will be a continuing evolution

Acknowledgement

Thanks to Dr. Zafer Sahinoglu (MERL), Dr. Keisuke Kojima (MERL) and Dr. Masaharu Ogawa (Mitsubishi Electric) for their contributions to this presentation