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

NIST Smart Grid Activities

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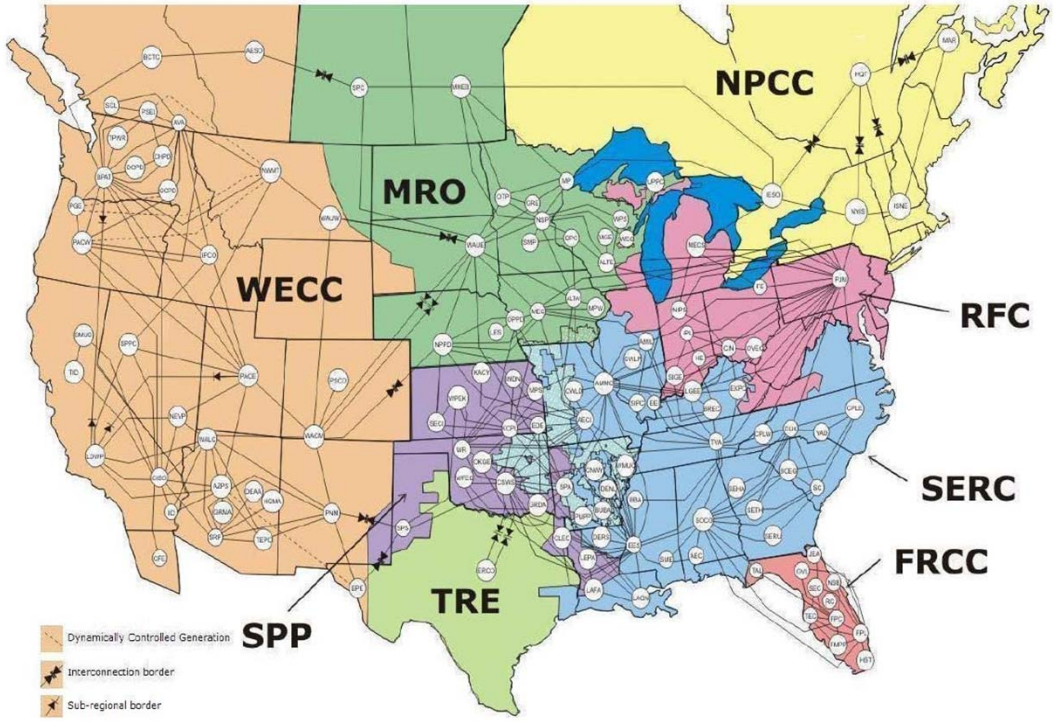
National Institute of Standards and Technology

August 31, 2011

Example: North American Electric Grid

US figures:

- 22% of world consumption



- 3,200 electric utility companies
- 17,000 power plants
- 800 gigawatt peak demand
- 165,000 miles of high-voltage lines
- 6 million miles of distribution lines
- 140 million meters
- $1 trillion in assets
- $350 billion annual revenues

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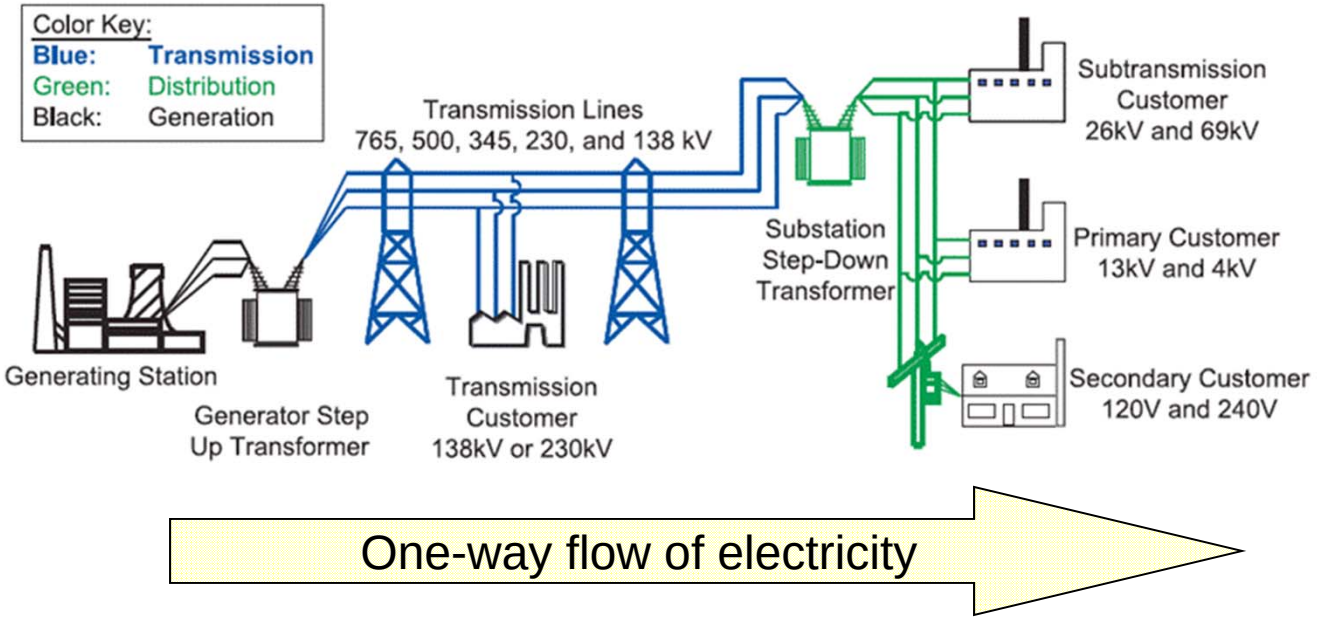
Today's Electric Grid



- *Centralized, bulk generation, mainly coal and natural gas*
- *Responsible for 40% of human-caused CO_2 production*
- *Controllable generation and predictable loads*
- *Limited automation and situational awareness*
- *Lots of customized proprietary systems*
- *Lack of customer-side data to manage and reduce energy use*

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What is the Smart Grid?

The Smart Grid integrates information technology and advanced communications into the power system in order to:

- Increase system efficiency and cost effectiveness
- Provide customers tools to manage energy use
- Improve reliability, resiliency and power quality
- Enable use of innovative technologies including renewables, storage and electric vehicles

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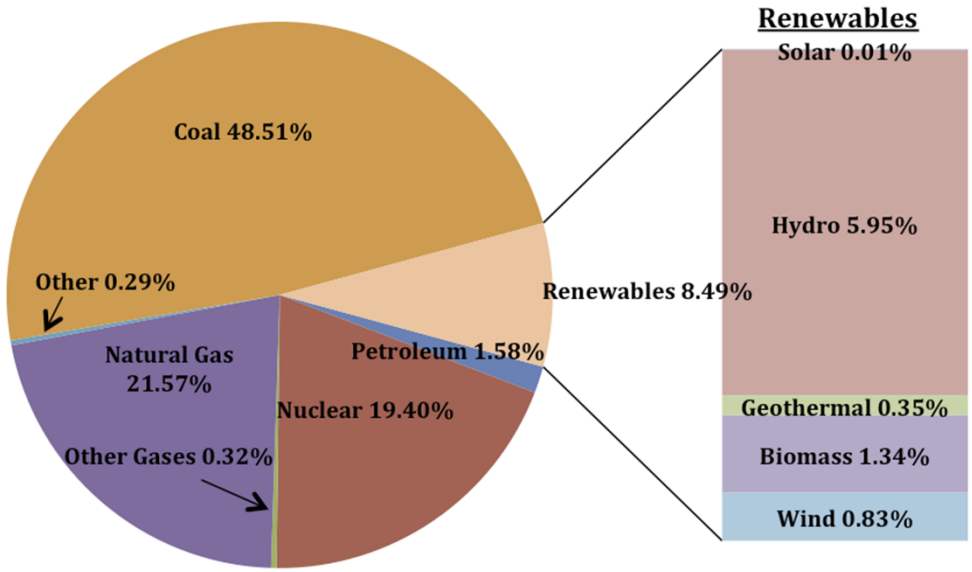
Increasing Efficiency is a Key Priority

2007 Generation by Source



Sources:
(1) DoE EIA
(2) Brattle Group

- Half of U.S. coal plants are > 40 years old
- Average substation transformer age > 40 years
- Projected investment in modernization and expansion: ***$1.5 - $2 trillion*** by 2030
- Smart grid helps utilities reduce delivery losses and customers reduce both peak and average consumption – thus reducing investment otherwise required
  - US per capita annual electricity usage = 13000 kWh
  - Japan per capita annual usage = 7900 kWh

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Why is the Grid Inefficient?

- Wasted energy
  - Generation, transmission and distribution losses
  - Wasteful end use – phantom power, lack of information about consumption
- Capacity factor
  - ~50%
  - System sized for infrequent peak loads

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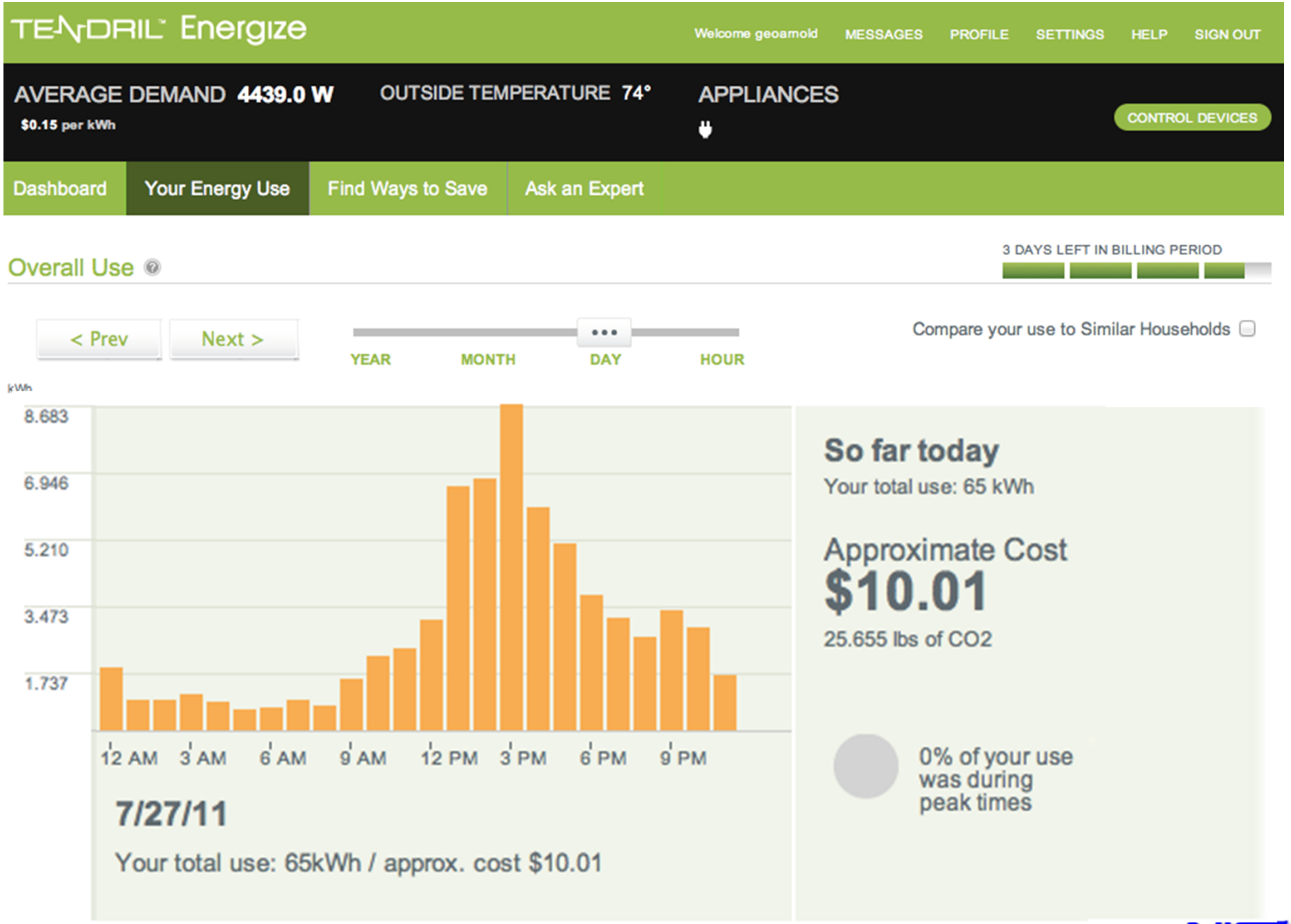

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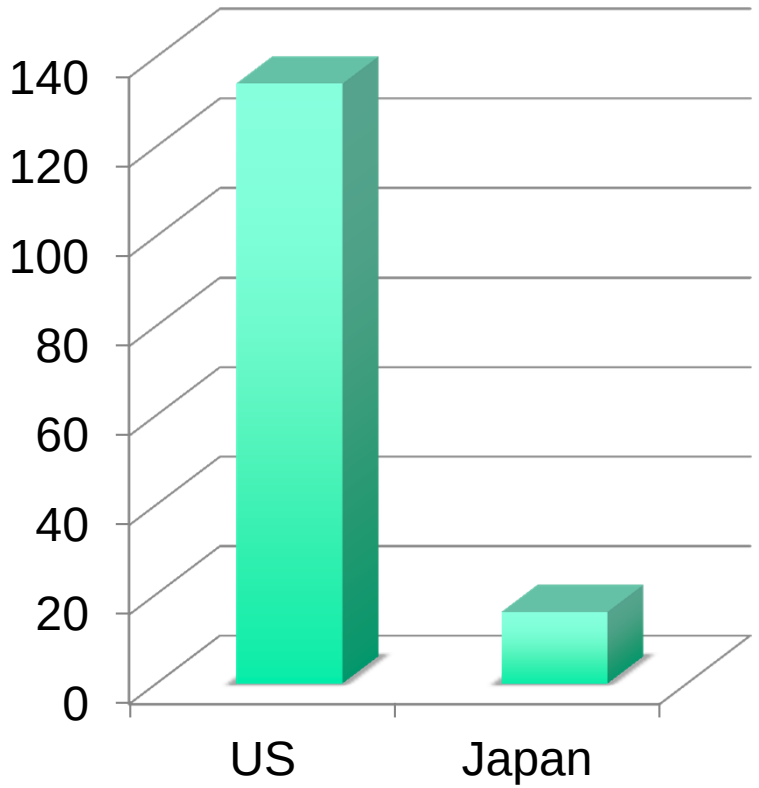
Improving Reliability for 21st Century

Power outages
Minutes/year/customer



- $80 billion/year cost to US economy
- Smart grid sensors and automated controls will improve reliability

Sources:
(1) IEEE Benchmarking 2009 Results Distribution Reliability Working Group
(2) Japan Ministry of Economy Trade and Industry 2010
(3) Lawrence Berkeley National Laboratory

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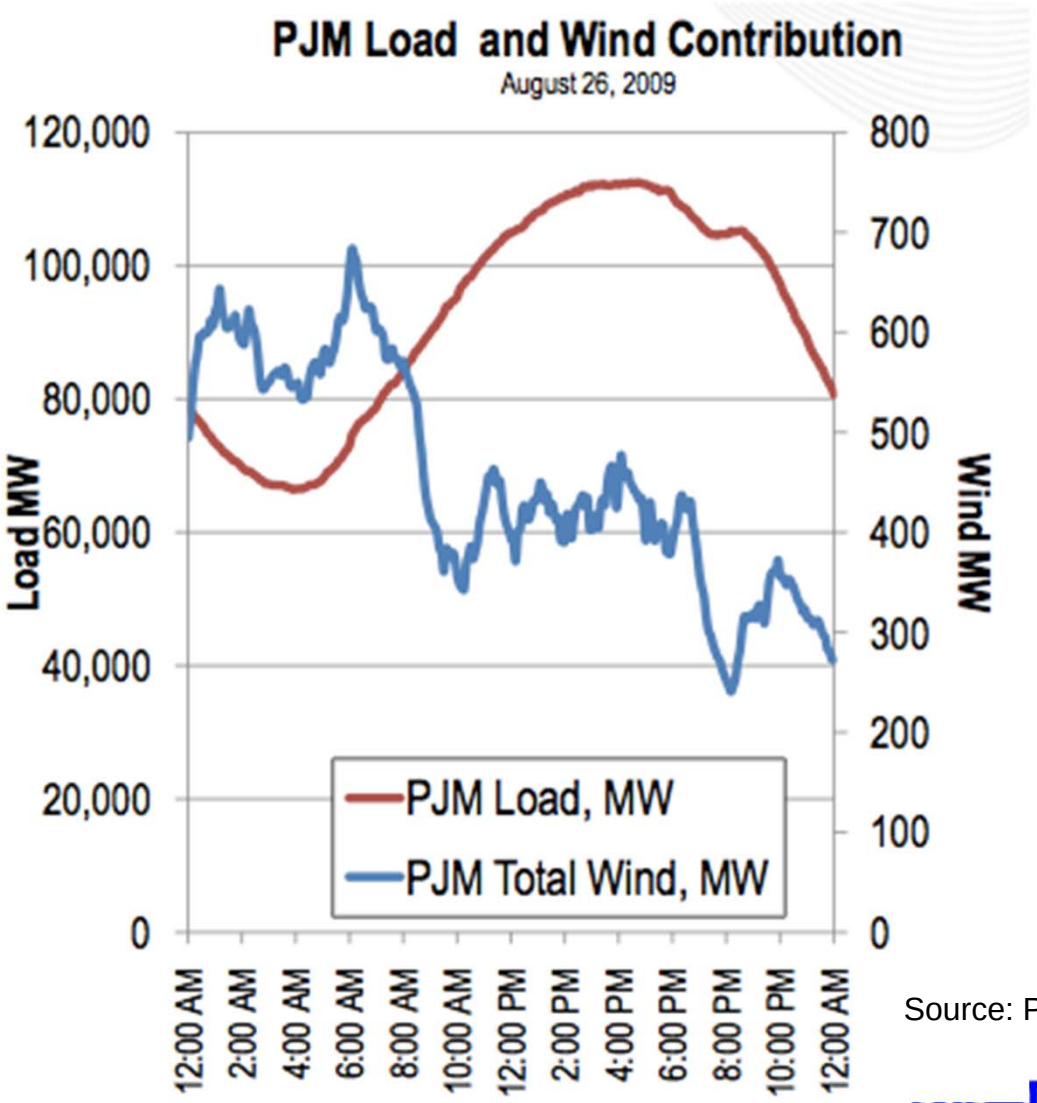
Enabling Greater Use of Renewables

- Electricity generation accounts for 40% of human-caused CO_2
- Greater use of wind and solar requires more dynamic grid control and storage



Source: PJM

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Worldwide Investment in the Grid

- International Energy Agency estimates:
  - $10 trillion over next 20 years
  - 50% in generation
  - 50% in transmission and distribution
  - Does not count customer-side investments
- NIST is driving international standards-setting through bilateral and multilateral engagements

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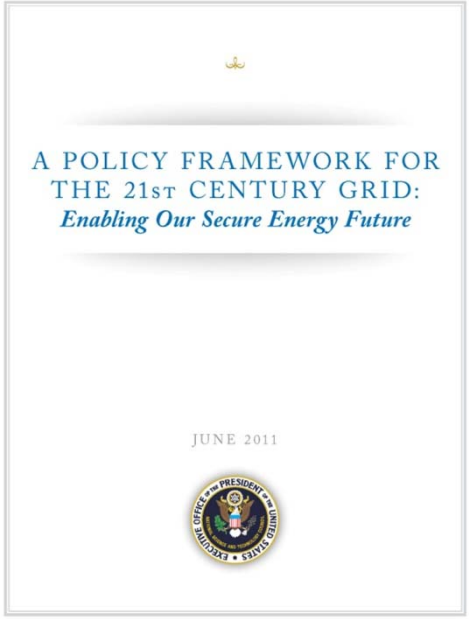
Smart Grid – A U.S. National Policy

- The 2007 Energy Independence and Security Act (EISA) lays out a national policy for the Smart Grid in the U.S.
  - The Act assigned NIST the primary responsibility to coordinate development of standards for the Smart Grid
  - NIST is also supporting future FERC and State PUC rulemaking to adopt Smart Grid standards
- The White House National Science and Technology Council has established a Smart Grid Subcommittee
  - The Subcommittee produced a report that lays out the Administration's policy on Smart Grid
- Key Federal policy recommendations:
  - Enable cost-effective smart grid investments
  - Unlock innovation
  - Empower and inform consumers
  - Secure the grid



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NIST Mission

To promote U.S. innovation and industrial competitiveness by advancing

measurement science,

standards, and

technology

in ways that enhance economic security and improve our quality of life

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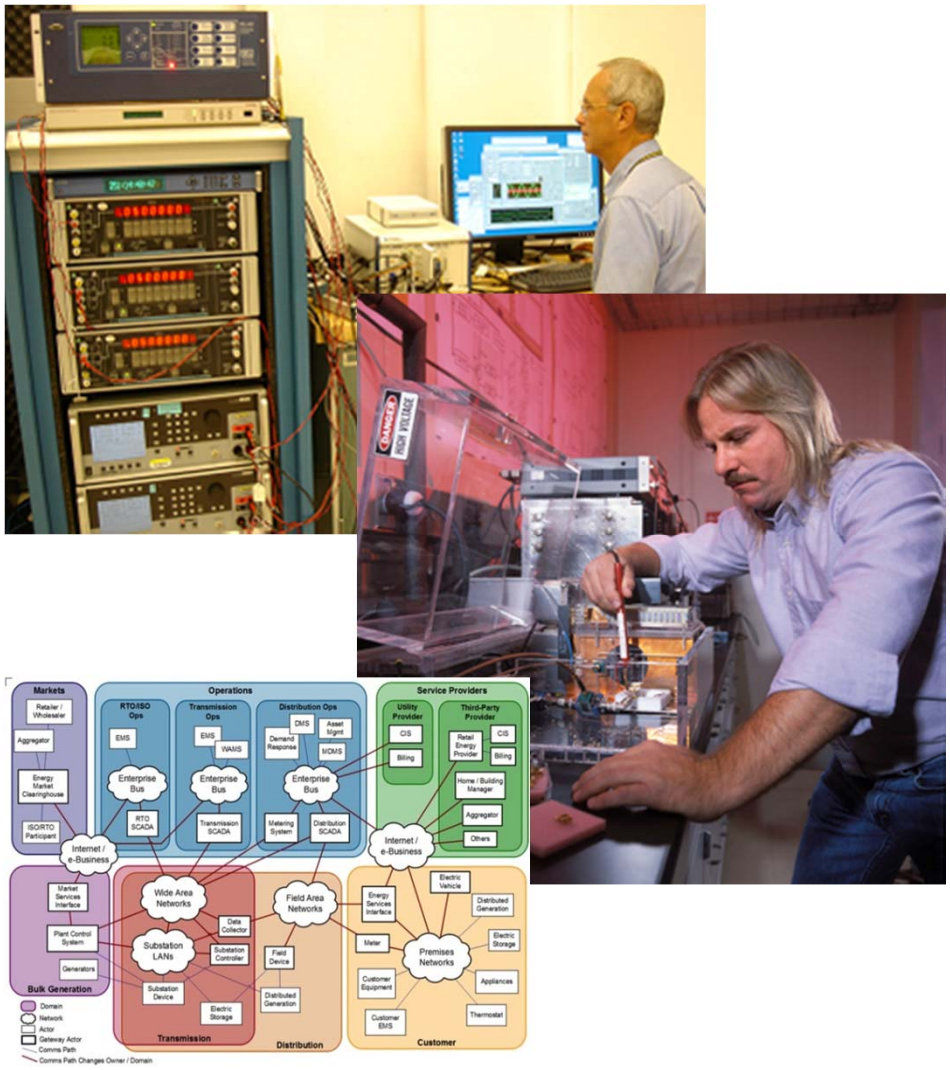
NIST Roles in the Smart Grid

- Measurement research
  - Metering
  - Wide area monitoring (synchrophasors)
  - Power conditioning
  - Building energy management
  - Electricity storage
- Standards (EISA role)
  - Interoperability
  - Cybersecurity



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Stakeholders

- Federal Government
  - White House, DOE, FERC, DHS, FCC, EPA, USDA, …
- State and Local Government
  - State PUCs, NARUC
- Electric Utilities
  - Investor-owned utilities, Municipals, Rural Cooperatives
- Equipment and System Providers
  - Traditional electric suppliers, IT, telecom, building automation, …
- Universities and Research Institutes
- Standards Setting Organizations (nearly 30)
- Other countries developing smart grids (dozens)

NIST Smart Grid Federal Advisory Committee

Dan Sheflin, Chair
Chief Technology Officer
Honeywell Automation and Control Systems

David Owens, Vice-Chair
Executive Vice President Business Operations
Edison Electric Institute

Jon Arnold
Managing Director, Worldwide Power & Utilities Industry
Microsoft Corporation

William O. Ball
Executive Vice President and Chief Transmission Officer
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ALSTOM Grid

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Donald Biggar Willett Professor of Engineering
University of Illinois at Urbana-Champaign

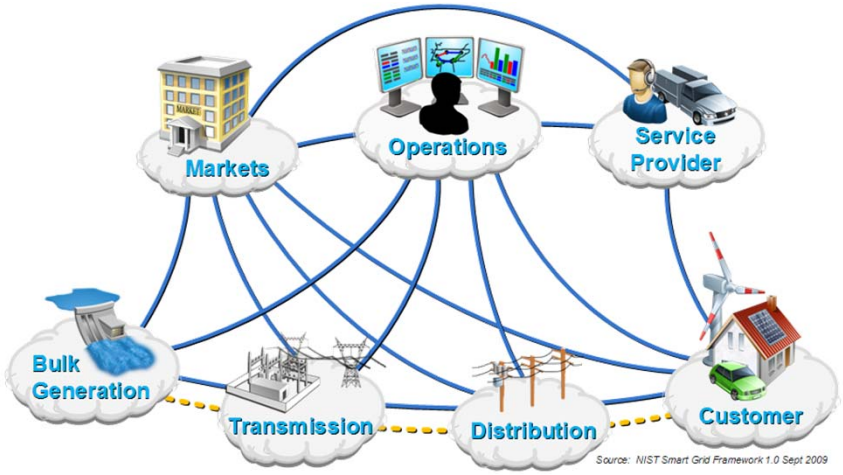
Thomas J. Tobin
Vice President - R&D
S&C Electric Company

David Vieau
Chief Executive Officer and President
A123 Systems

Standards – Key Aspect of US Policy

The Energy Independence and Security Act gives 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…"



- Congress directed that the framework be "flexible, uniform, and technology neutral"
- Use of these standards is a criterion for federal Smart Grid Investment Grants
- Input to federal and state regulators

Standardized architectural concepts, data models and protocols are essential to achieve interoperability, reliability, security and evolvability

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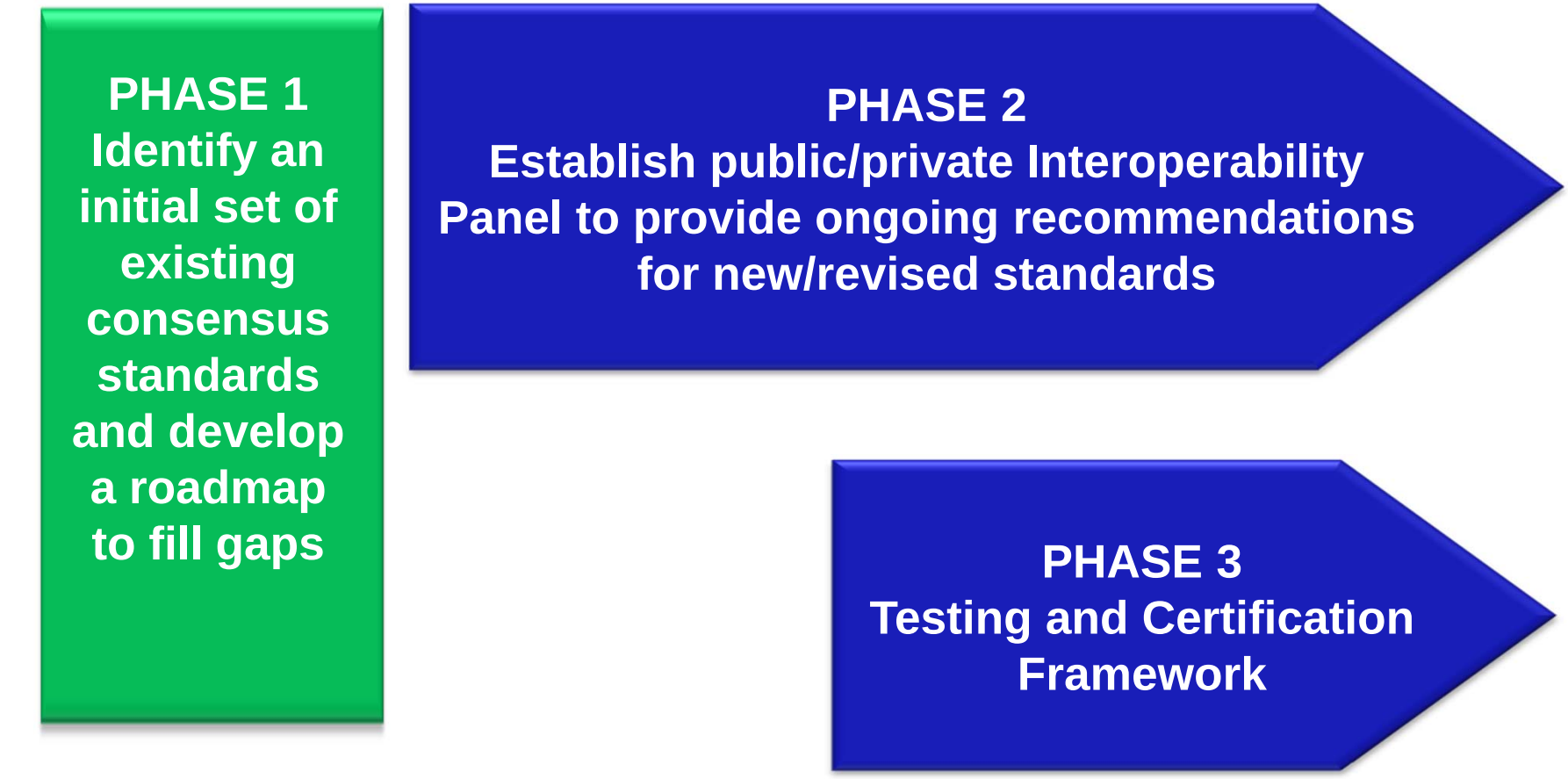
NIST Three Phase Plan



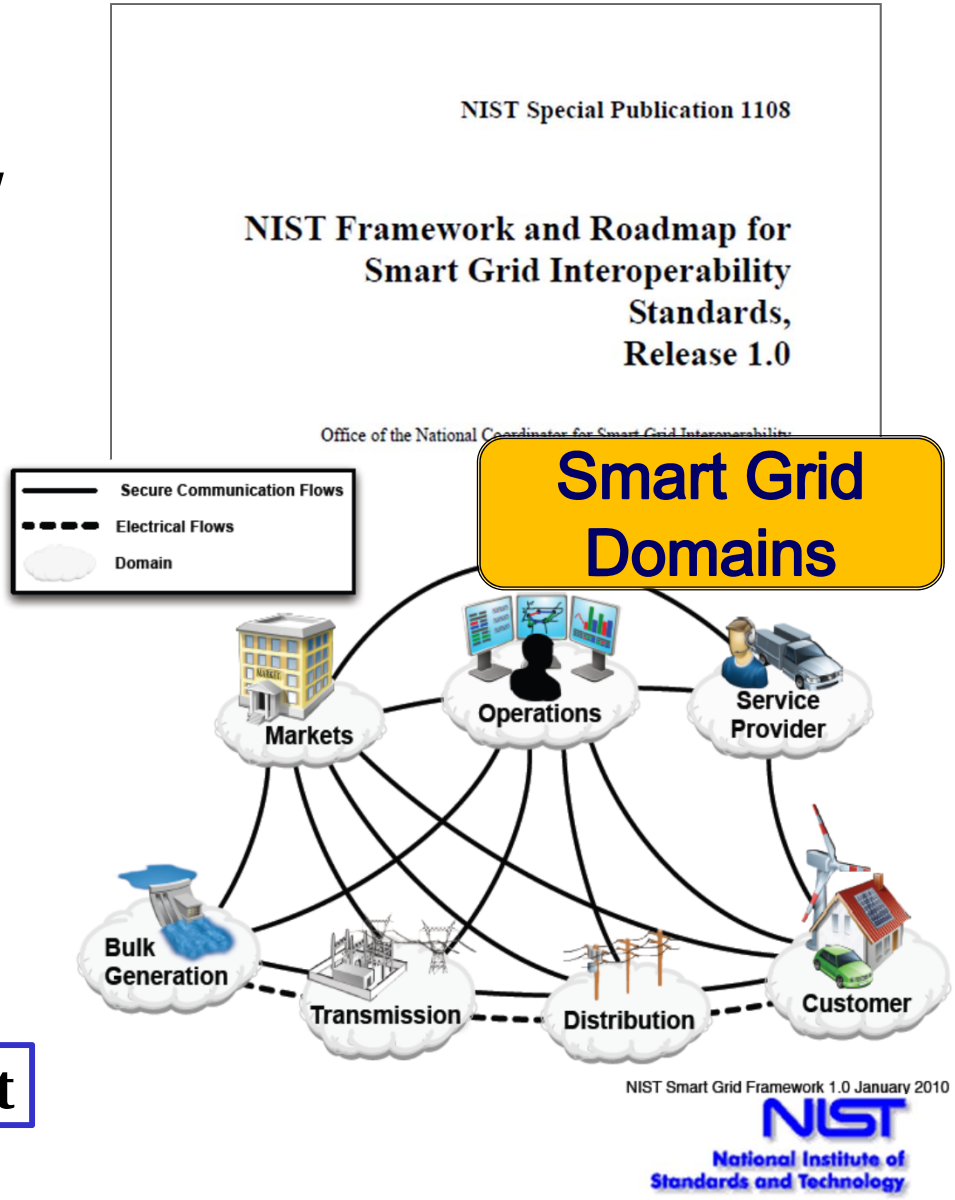
17

NIST Smart Grid Framework and Roadmap 1.0

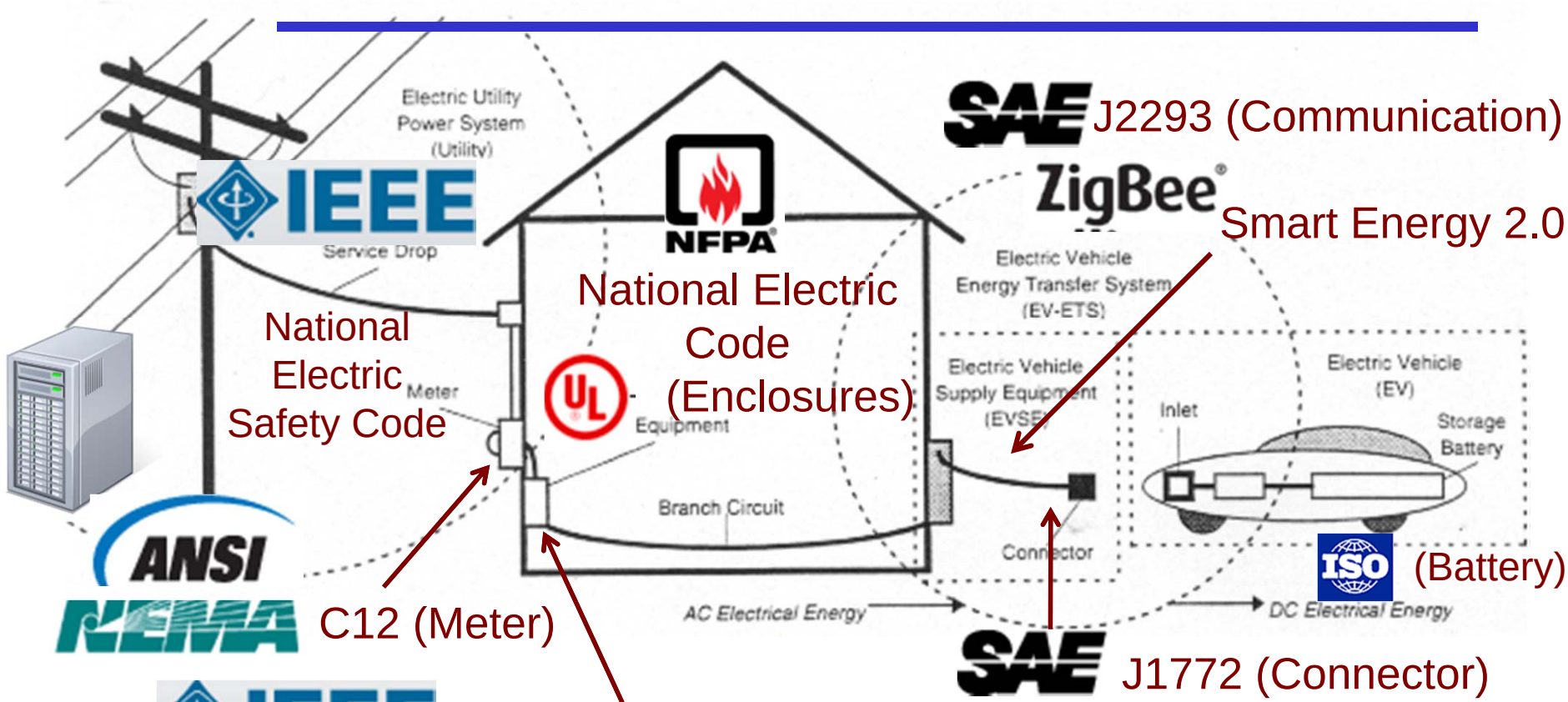
- Published January 2010
  - Extensive public input and review
  - Completed in Less than 1 year
- Smart Grid Vision & Reference Model
- Identified 75 existing standards
- 16 Priority Action Plan Projects are filling key gaps
- Companion Cyber Security Strategy

http://www.nist.gov/smartgrid/

Release 2.0 is Under Development



Electric Vehicles Require Many Standards



IEEE

NFPA

National Electric Code (Enclosures)

National Electric Safety Code

SAE J2293 (Communication)

ZigBee Smart Energy 2.0

ANSI

NEMA C12 (Meter)

ISO (Battery)

SAE J1772 (Connector)

IEEE 1547 (Distributed energy interconnection)

IEC 61850 and 61970/61968 Information models

NAESB OASIS Demand response & price signaling

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Smart Grid Interoperability Panel

- Public-private partnership created in Nov. 2009
- 680 member organizations
- Open, public process with international participation
- Coordinates standards developed by Standards Development Organizations (SDOs)
  - Identifies Requirements
  - Prioritizes standards development programs
  - Works with over 20 SDOs including IEC, ISO, ITU, IEEE, …
- Web-based participation (via link from nist.gov/smartgrid)

SGIP Membership

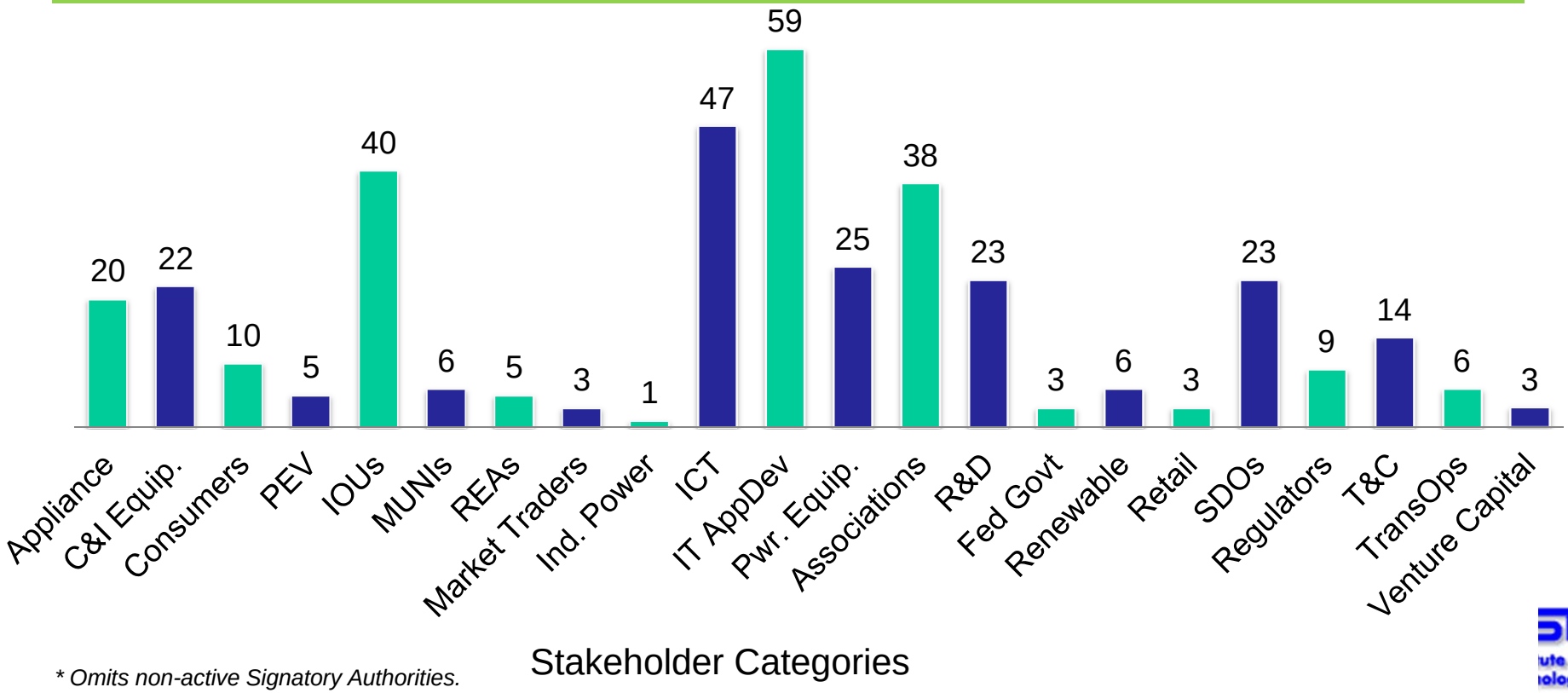
as of 07.04.11

- **Total # of Member Organizations: 680**
  - # of Participating Member Organizations: 372
  - # of Observing Member Organizations: 308
  - # of Organizations who joined in May & June: 9
- **Total # of Individual Members*: 1,794**

of Organizations by Country

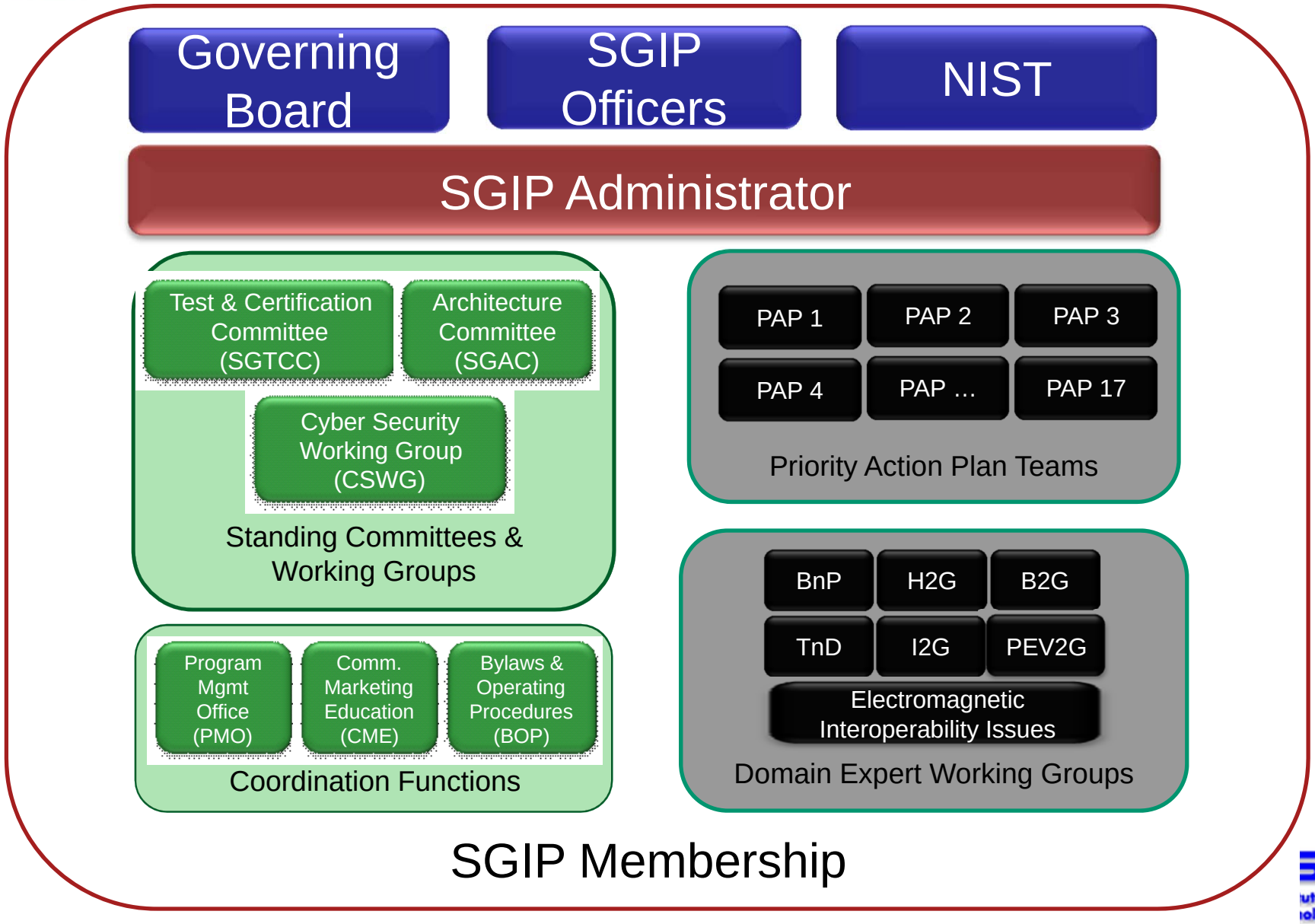
- USA: 604
- Europe: 22
- Asia: 18
- Oceania: 5
- North America (non-US): 29
- South America: 1
- Africa: 1

of Participating Member Organizations by Declared Stakeholder Category



** Omits non-active Signatory Authorities.*

SGIP Organization

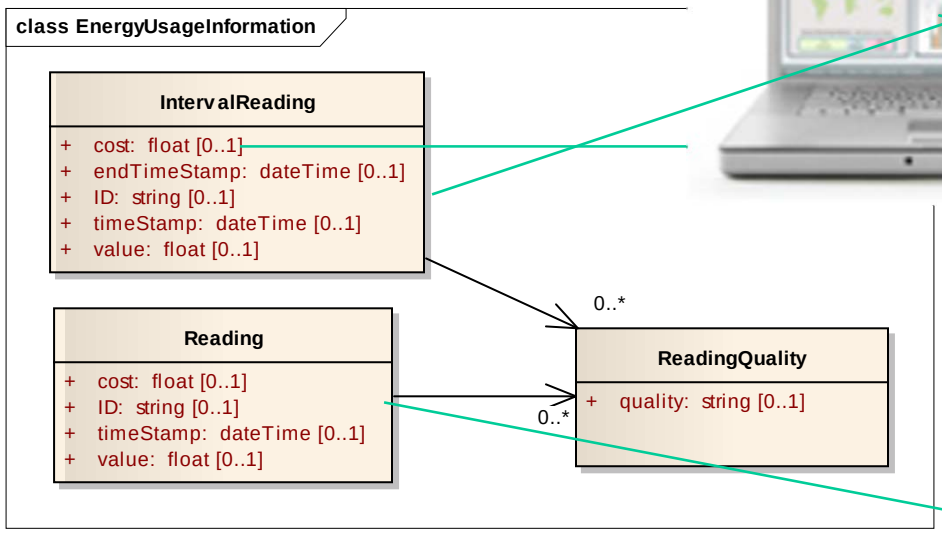


Gaps in Standards Being Addressed by PAPs

Priority Action Plan	Standard(s) or Guideline(s)
PAP 0 - Meter Upgradeability Standard	NEMA Meter Upgradability Standard: SG-AMI 1-2009
PAP 1 - Role of IP in the Smart Grid	Informational IETF RFC
PAP 2 - Wireless Communications for the Smart Grid	IEEE 802.x, 3GPP, 3GPP2, ATIS, TIA
PAP 3 - Common Price Communication Model	OASIS EMIX, ZigBee SEP 2, NAESB
PAP 4 - Common Scheduling Mechanism	OASIS WS-Calendar
PAP 5 - Standard Meter Data Profiles	AEIC V2.0 Meter Guidelines (addressing use of ANSI C12)
PAP 6 - Common Semantic Model for Meter Data Tables	ANSI C12.19-2008, MultiSpeak V4, IEC 61968-9
PAP 7 - Electric Storage Interconnection Guidelines	IEEE 1547.4, IEEE 1547.7, IEEE 1547.8, IEC 61850-7-420, ZigBee SEP 2
PAP 8 - CIM for Distribution Grid Management	IEC 61850-7-420, IEC 61968-3-9, IEC 61968-13,14, MultiSpeak V4, IEEE 1547
PAP 9 - Standard DR and DER Signals	NAESB WEQ015, OASIS EMIX, OpenADR, ZigBee SEP 2
PAP 10 - Standard Energy Usage Information	NAESB Energy Usage Information, OpenADE, ZigBee SEP 2, IEC 61968-9, ASHRAE SPC 201P
PAP 11 - Common Object Models for Electric Transportation	ZigBee SEP 2, SAE J1772, SAE J2836/1-3 , SAE J2847/1-3, ISO/IEC 15118-1,3, SAE J2931, IEEE P2030-2, IEC 62196
PAP 12 - IEC 61850 Objects/DNP3 Mapping	IEEE Std 1815 (DNP3); IEEE P1815.1 (plus anticipated dual logo with the IEC)
PAP 13 - Time Synchronization, IEC 61850 Objects/IEEE C37.118 Harmonization	IEEE PC37.238; IEEE C37.118.1; IEEE C38.118.2; IEC 61850-90-5 (plus anticipated dual logo with the IEEE)
PAP 14 - Transmission and Distribution Power Systems Model Mapping	IEC 61968-3, MultiSpeak V4
PAP 15 - Harmonize Power Line Carrier Standards for Appliance Communications in the Home	DNP3 (IEEE 1815), HomePlug AV, HomePlug C&C, IEEE P1901 and P1901.2, ISO/IEC 12139-1, G.9960 (G.hn/PHY), G.9961 (G.hn/DLL), G.9972 (G.cx), G.hnem, ISO/IEC 14908-3, ISO/IEC 14543, EN 50065-1
PAP 16 - Wind Plant Communications	IEC 61400-25
PAP 17 - Facility Smart Grid Information Standard	New Facility Smart Grid Information Standard ASHRAE SPC 201P
PAP 18 - SEP 1.x to SEP 2 Transition and Coexistence	TBD – Guidelines and/or best practices

Energy Usage Information Standard

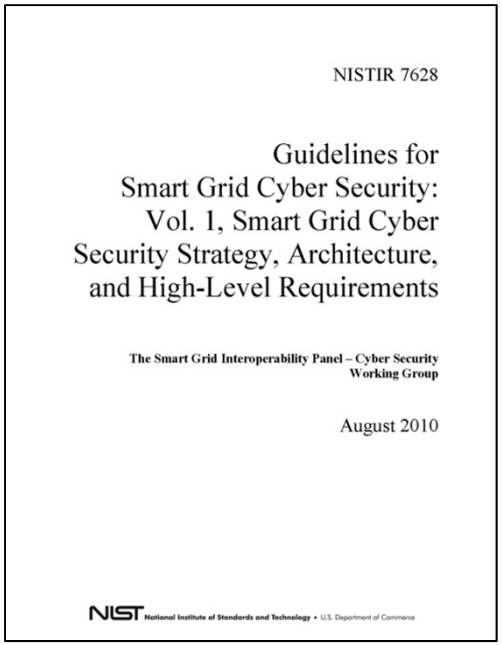
Standardizes data elements available to consumers or authorized 3rd party application providers



- Work initiated (SGIP PAP10) - July 2009
- Requirements finalized - June 2010
- Standard developed and published by NAESB - December 2010

Cyber Security Working Group

- Permanent Working Group
  - Over 650 public and private sector participants
- August 2010 NIST publishes: *Guidelines for Smart Grid Cyber Security*
  - Risk assessment guidance for implementers
  - Recommended security requirements
  - Privacy recommendations
- Collaborating with:
  - DOE NESCOR on SEP 1.0 and 1.1 guidance
  - DOE/NERC/NIST on risk management document
  - NERC Task Force on Cybersecurity


NISTIR 7628

Guidelines for Smart Grid Cyber Security: Vol. 1, Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements

The Smart Grid Interoperability Panel – Cyber Security Working Group

August 2010

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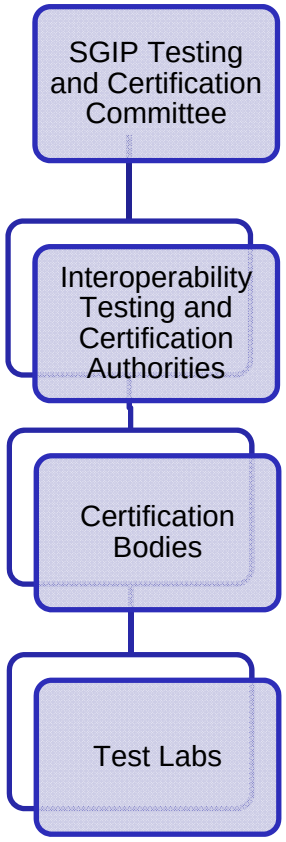
Testing and Certification Framework

- Defined in SGIP Interoperability Process Reference Manual (IPRM)

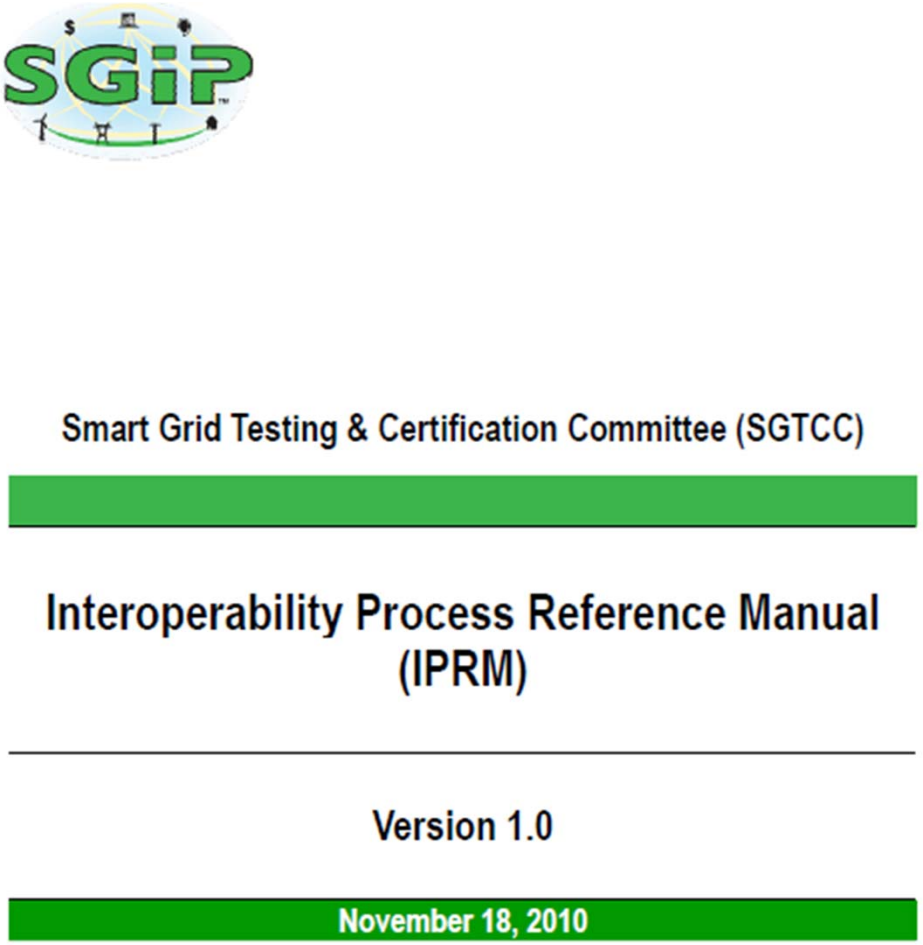


SGIP IPRM documents requirements and best practices for ITCAs, CBs and TLs

ITCAs establish T&C schemes for specific domains/use cases and accredit CBs and TLs
Initially-identified ITCAs: NEMA, UCAIug 61850, OpenADR, and Multispeak

Certify test results

Perform conformance and/or interoperability testing to specified test cases


Smart Grid Testing & Certification Committee (SGTCC)

Interoperability Process Reference Manual (IPRM)

Version 1.0

November 18, 2010

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Interoperability Standards and Regulation

- EISA Section 1305 directs that:

"At any time after the Institute's work has led to sufficient consensus in the Commission's judgment, the Commission shall institute a rulemaking proceeding to adopt such standards and protocols as may be necessary to insure smart-grid functionality and interoperability in interstate transmission of electric power, and regional and wholesale electricity markets."

How Do Standards Get "Adopted"?

- Purely voluntary
  - Many standards that are already in widespread use in the market may not need any regulatory action
- Encourage
  - Some standards may need "help" to accelerate market adoption
  - There are a number of ways regulators can encourage the use of standards without mandating them
- Mandate
  - Some standards that are critical to grid safety, reliability or security may need to be mandated

Issues

- What does regulatory “adoption” imply?
- When is it “necessary” that regulators adopt standards?
- What does “consensus” refer to?
  - Technical content of standard? Whether they are needed for the Smart Grid? Whether they should be adopted in regulation?
- To initiate consideration of these issues, in October 2010, NIST identified 5 families of standards for FERC consideration
  - These IEC standards are “foundational” standards covering common information models and protocols for utility energy management systems, substations, distribution systems, inter-control center communications
  - Among the most mature standards identified in the NIST Framework
  - First standards that had undergone cybersecurity reviews

NIST Activities Going Forward

- Framework Release 2.0
- SGIP
  - Executing work program
  - Process improvements to address utility concerns
  - Testing and certification programs
  - Cybersecurity standards and guidelines
- Continuing engagement with FERC and state regulators on standards matters
- Driving international standards to promote export opportunities for U.S. suppliers