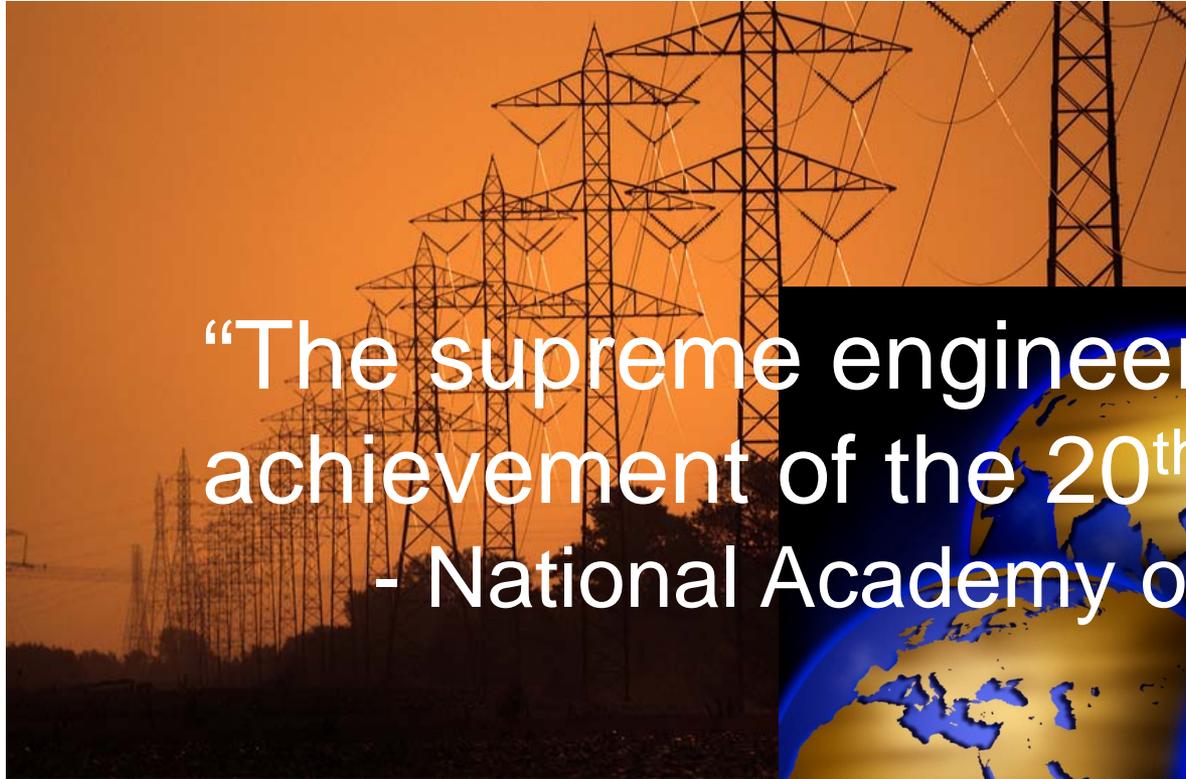

Laying the Foundation for the Electric Grid's Next 100 Years

ETSI Workshop
Standards: An Architecture for the Smart Grid

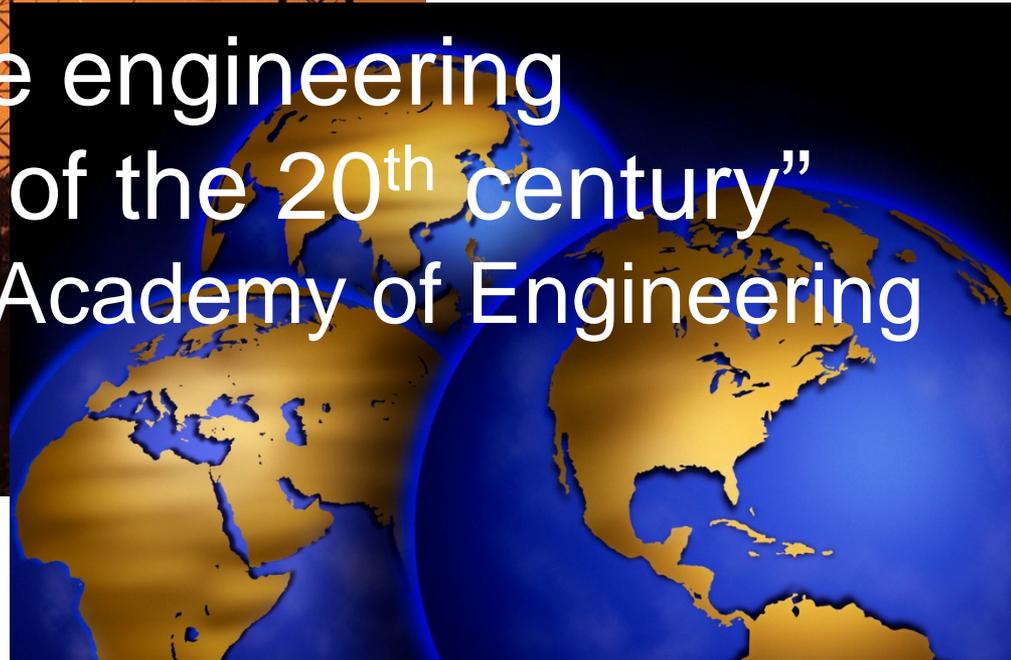
George W. Arnold, Eng.Sc.D.
National Coordinator for Smart Grid Interoperability
National Institute of Standards and Technology
April 5, 2011



The Electric Grid



“The supreme engineering achievement of the 20th century”
- National Academy of Engineering



The Electric Grid 100 Years Ago

It's not too different today!



Wall Street, 1913

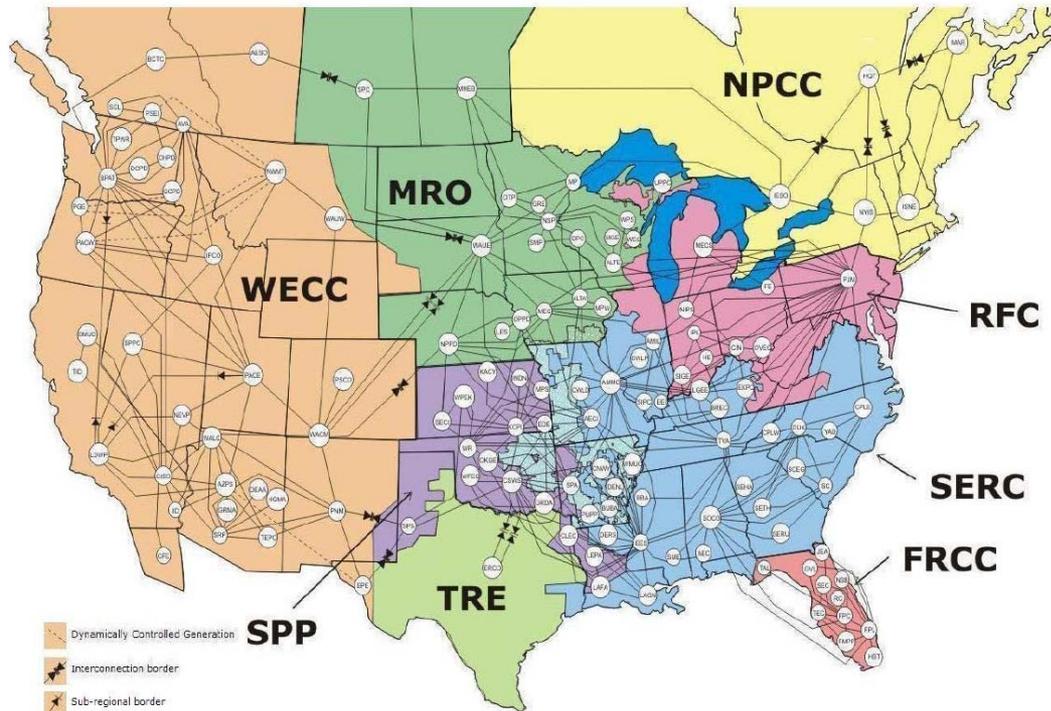
Edison Pearl Street Station, 1882

Example: North American Electric Grid

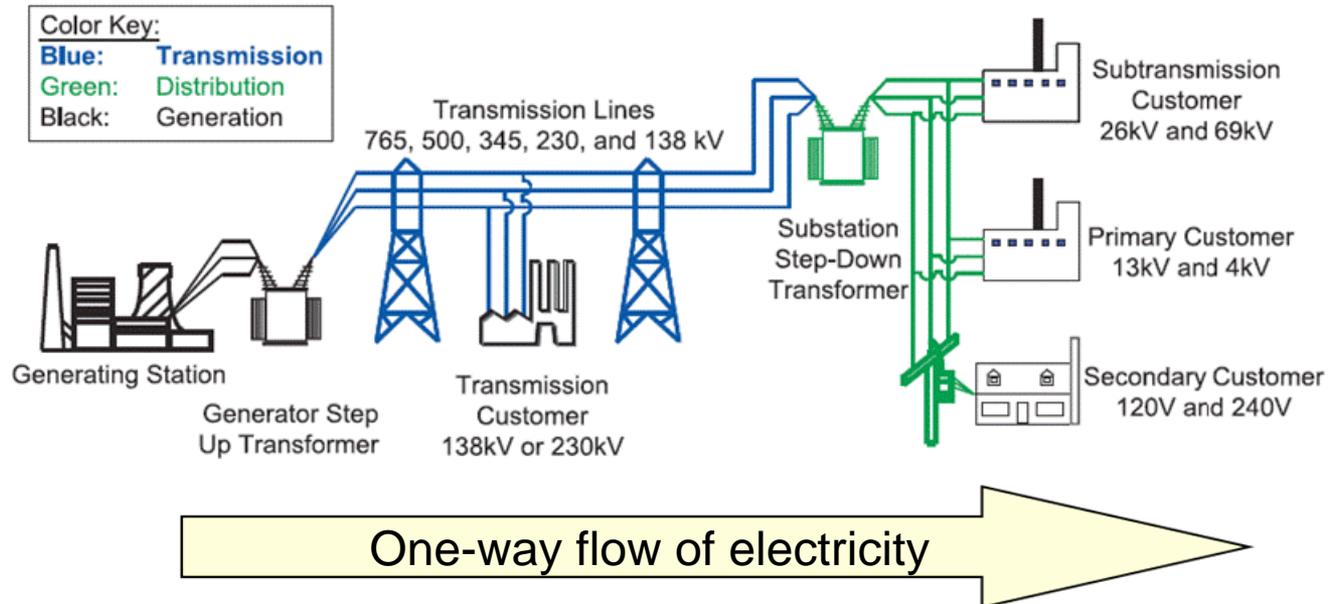
US figures:

- 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

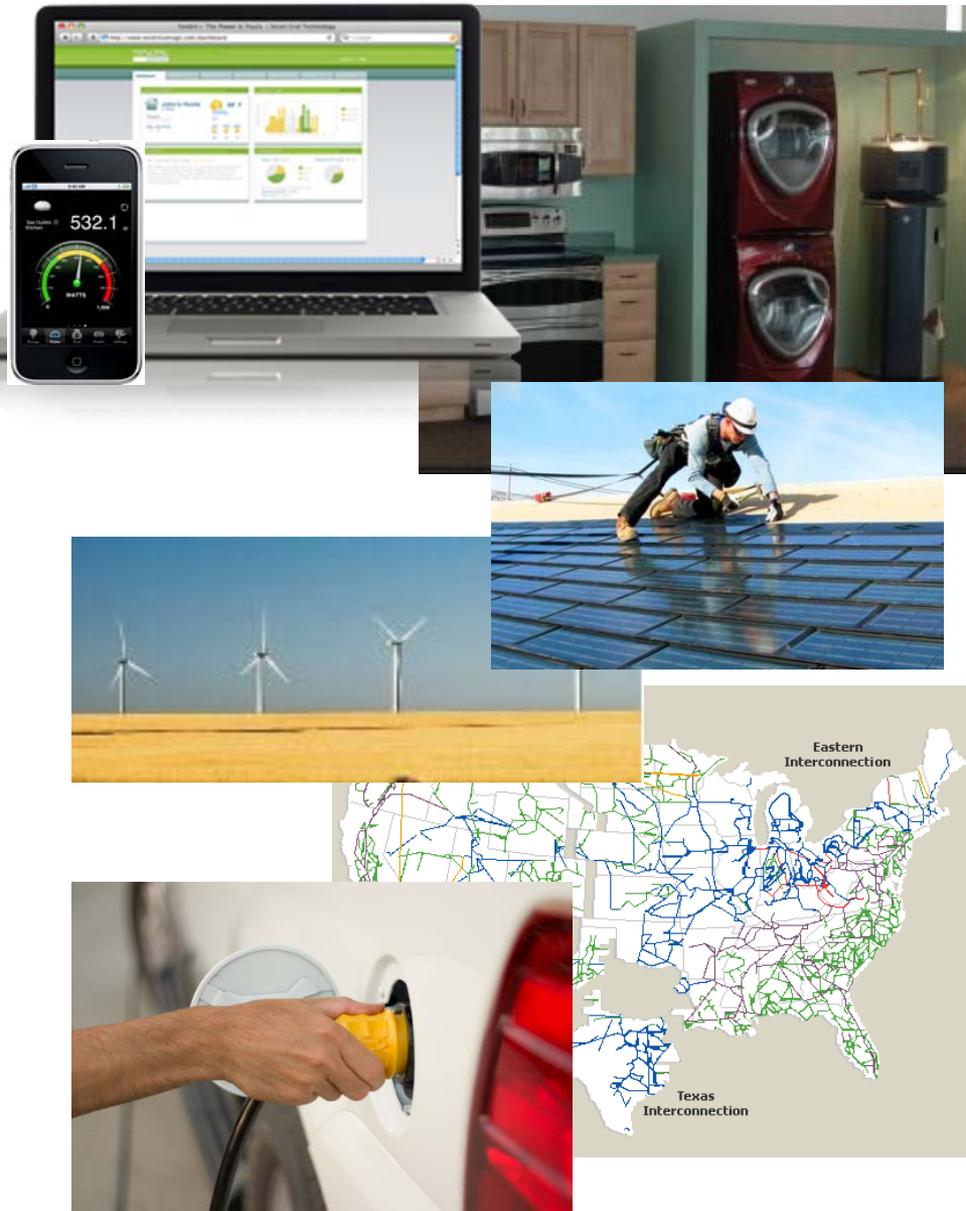


Today's Electric Grid



- *Centralized, bulk generation, mainly coal and natural gas*
- *Responsible for 40% of human-caused CO₂ 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*

What is the Smart Grid?

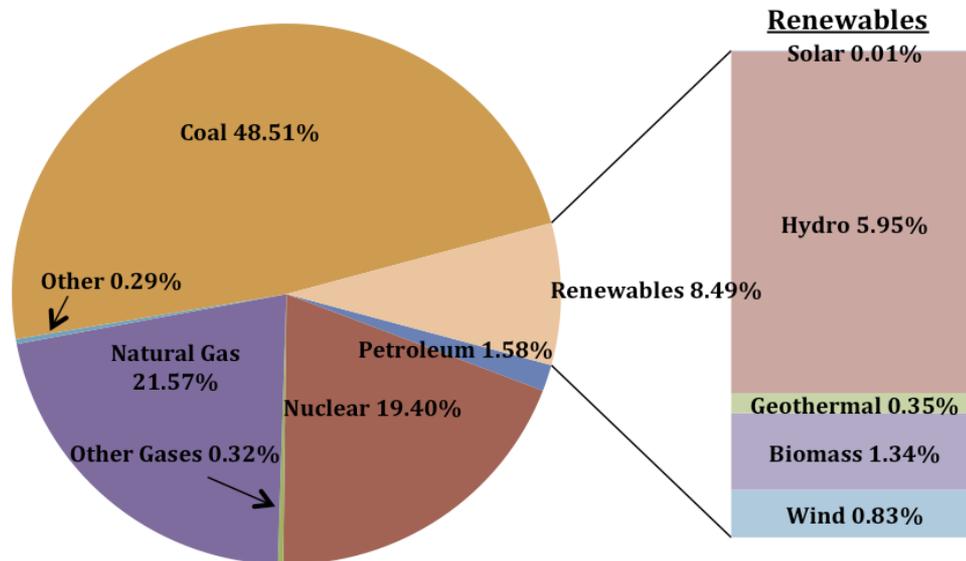


The Smart Grid integrates information technology and advanced communications into the power system in order to:

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

Increasing Efficiency is a Key Priority

2007 Generation by Source

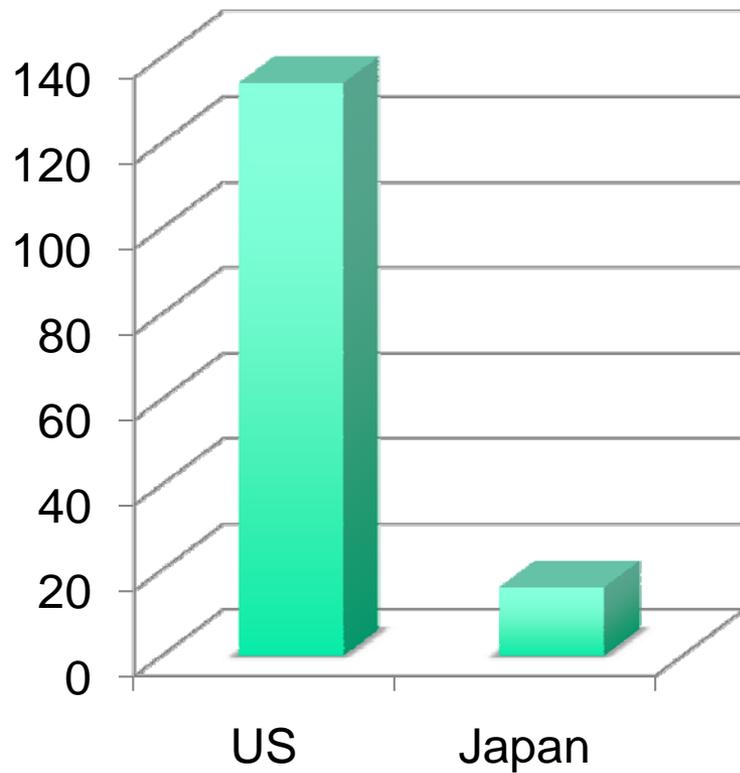


Sources:
(1) DoE EIA
(2) Brattle Group

- 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

Improving Reliability for 21st Century

Power outages Minutes/year/customer



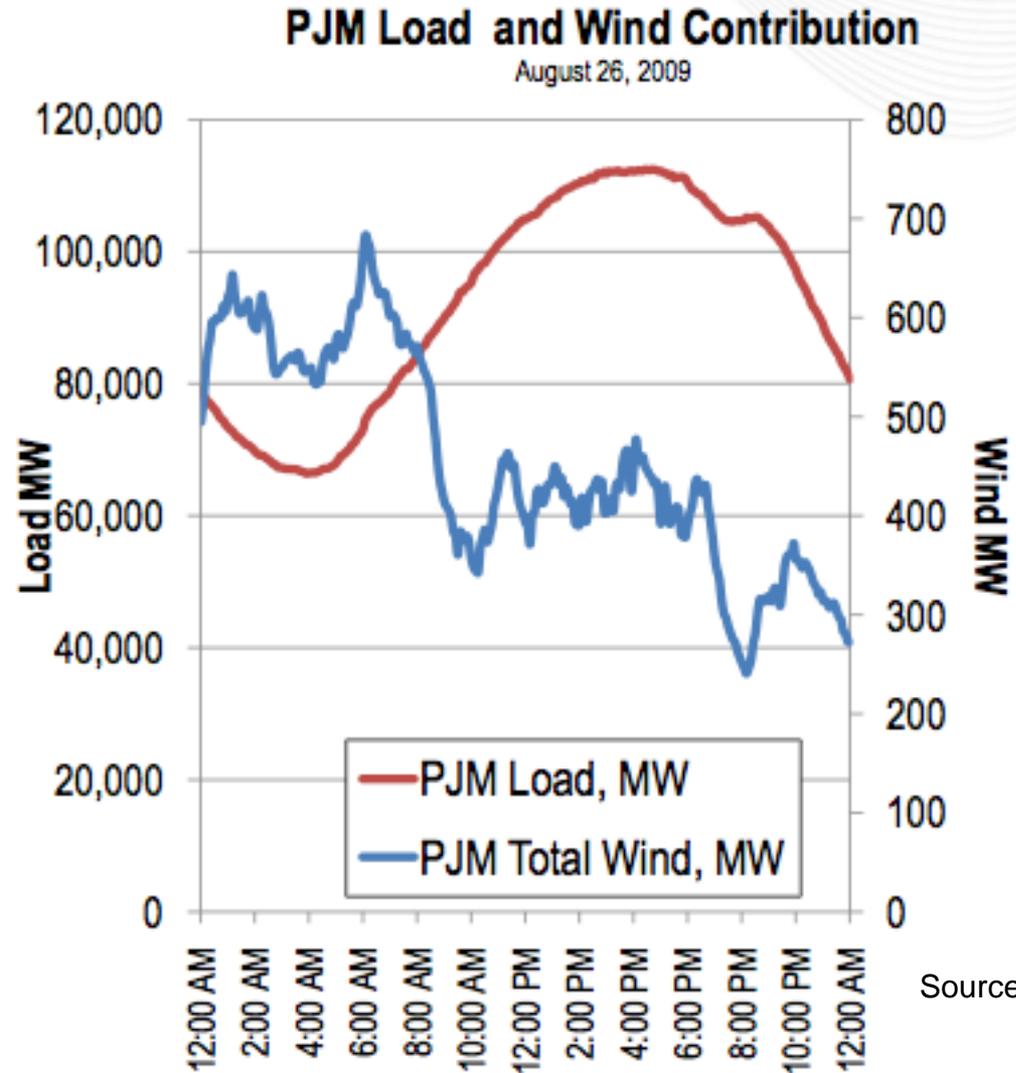
- \$22-\$135 Billion /yr cost to US economy
- Smart grid sensors and automated controls will improve reliability

Sources:

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

Enabling Greater Use of Renewables

- Electricity generation accounts for 40% of human-caused CO₂
- Greater use of wind and solar requires more dynamic grid control and storage



Source: PJM

Enabling Reduced Dependence on Oil



- Idle capacity of the power grid could supply 70% of energy needs of today's cars and light trucks
- Displace half of US oil imports
- Reduce CO₂ 20%
- Reduce urban air pollutants 40%-90%
- Batteries in EVs could provide power during peak demand



Smart Grid – A U.S. National Policy

“It is the policy of the United States to support the modernization of the Nation's electricity [system]... to achieve...a Smart Grid.” Congress, Energy Independence and Security Act of 2007



“We’ll fund a better, smarter electricity grid and train workers to build it...”

President Barack Obama

“To meet the energy challenge and create a 21st century energy economy, we need a 21st century electric grid...” Secretary of Energy Steven Chu

“A smart electricity grid will revolutionize the way we use energy, but we need standards ...” Secretary of Commerce Gary Locke

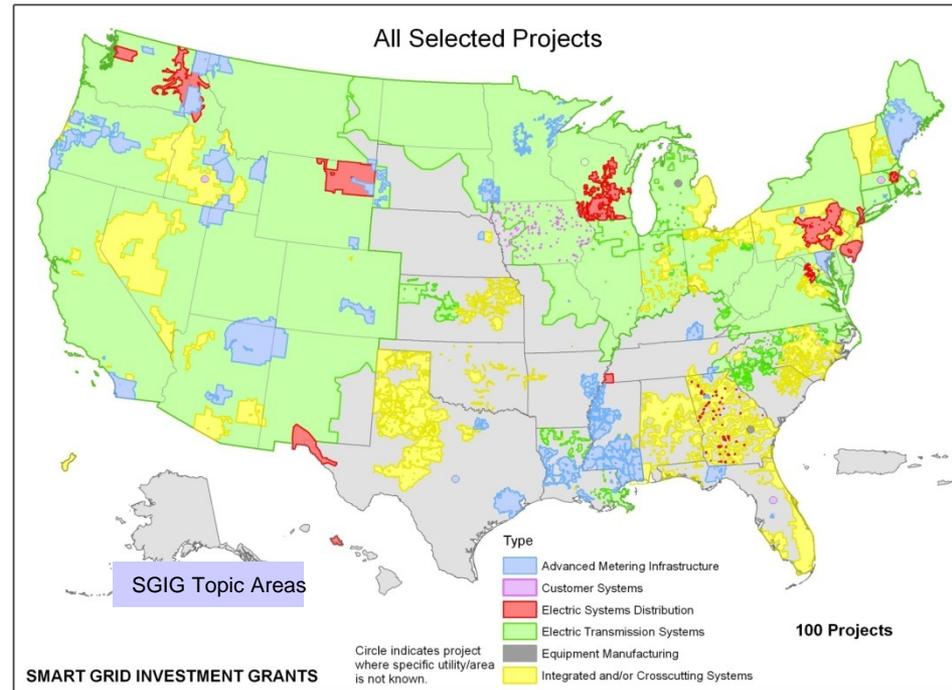


US Smart Grid Investment Grants

| Category | \$ Million |
|-------------------------|------------|
| Integrated/Crosscutting | 2,150 |
| AMI | 818 |
| Distribution | 254 |
| Transmission | 148 |
| Customer Systems | 32 |
| Manufacturing | 26 |
| Total | 3,429 |

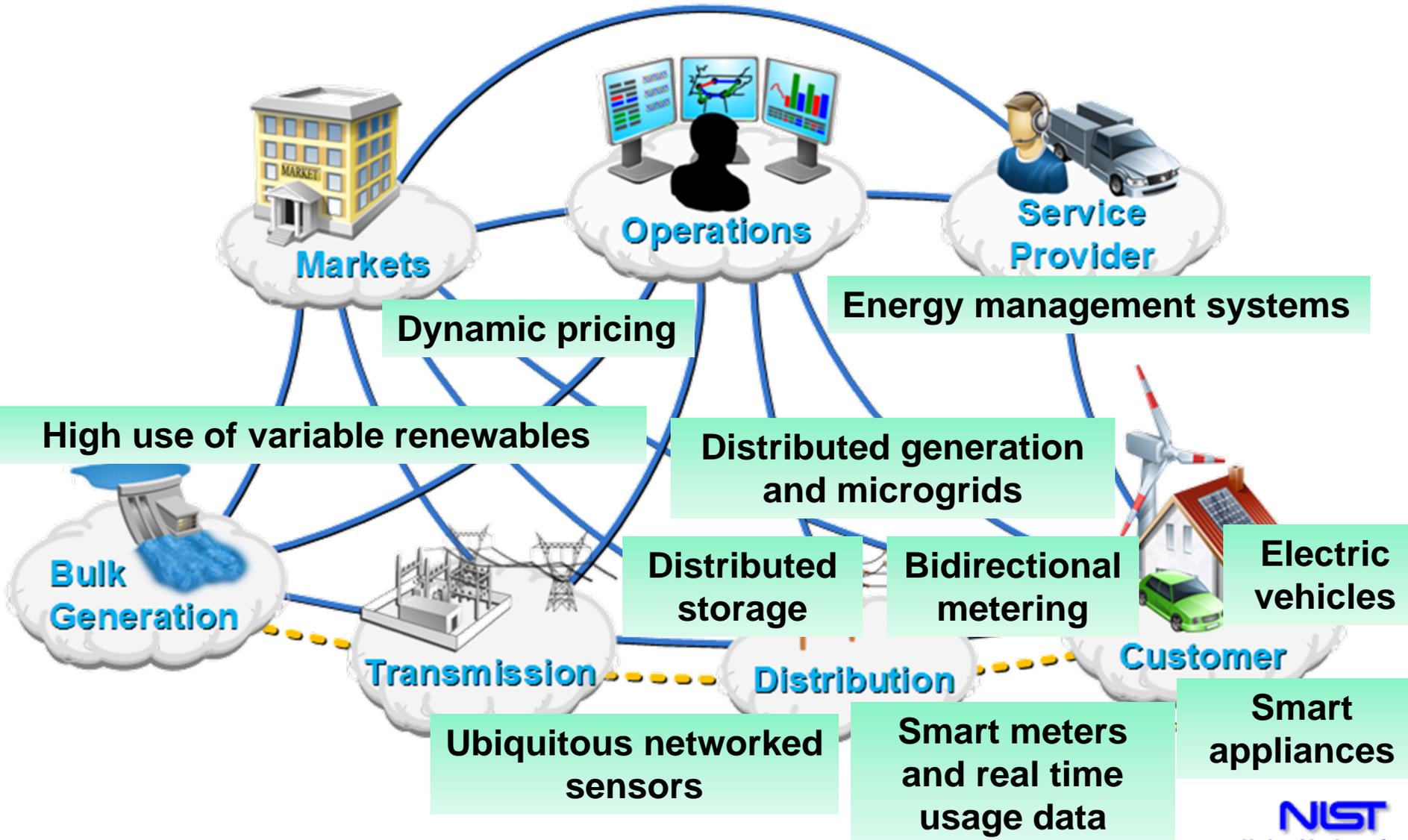
- 18 million smart meters
- 1.2 million in-home display units
- 206,000 smart transformers
- 177,000 load control devices
- 170,000 smart thermostats
- 877 networked phasor measurement units
- 671 automated substations
- 100 PEV charging stations

Geographic Coverage of Selected Projects

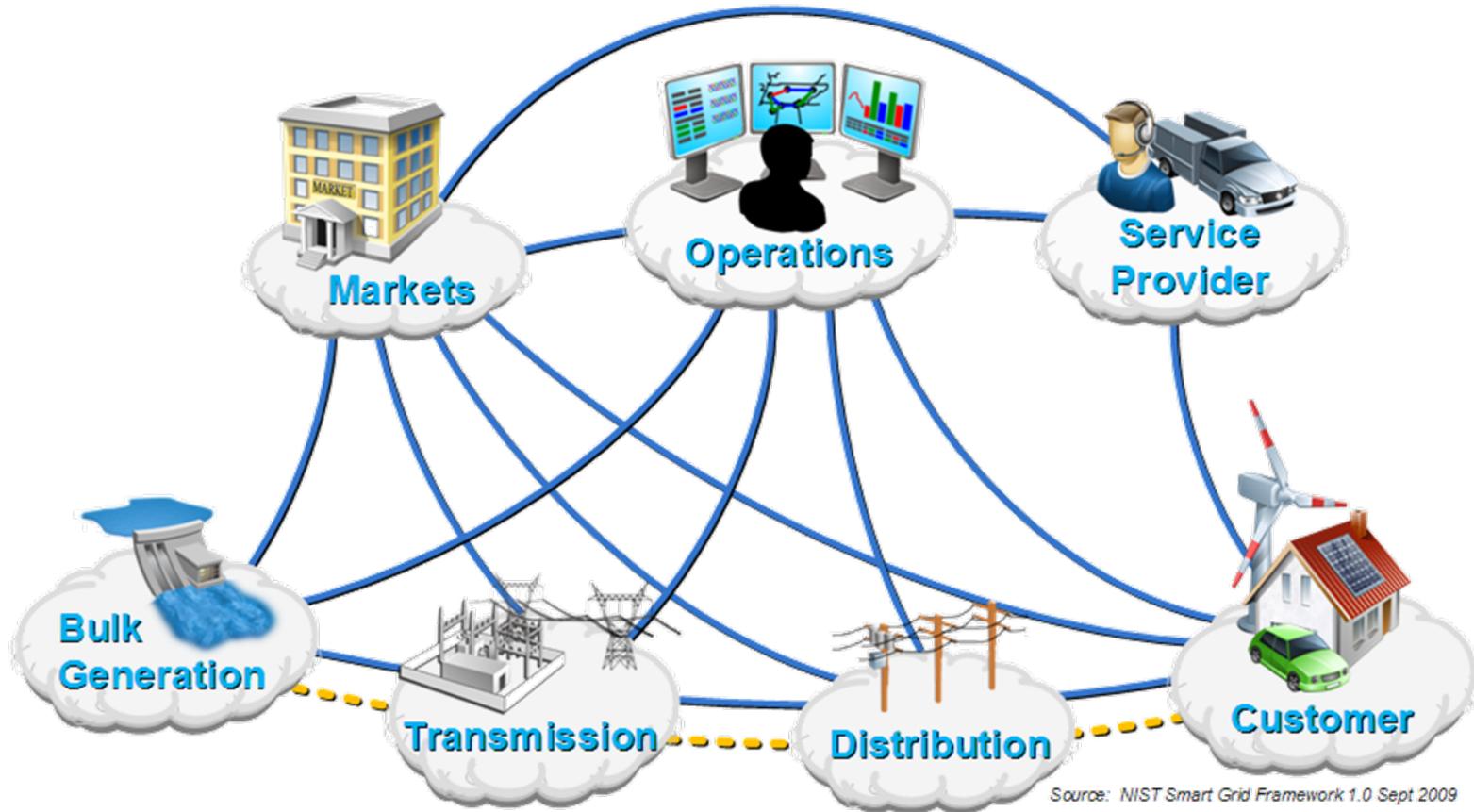


Oct 21, 2009

What Will the Smart Grid Look Like?



Architecture and Standards



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

Standards – Key Aspect of US Policy

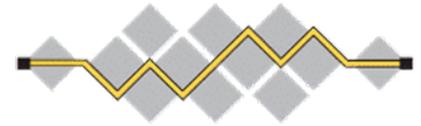
The Energy Independence and Security Act gives NIST *“primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems...”*



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

Standards Come from Many Developers

International



Global
Consortia



Ministry of Knowledge Economy
Korean Agency for Technology and Standards

Regional and
National

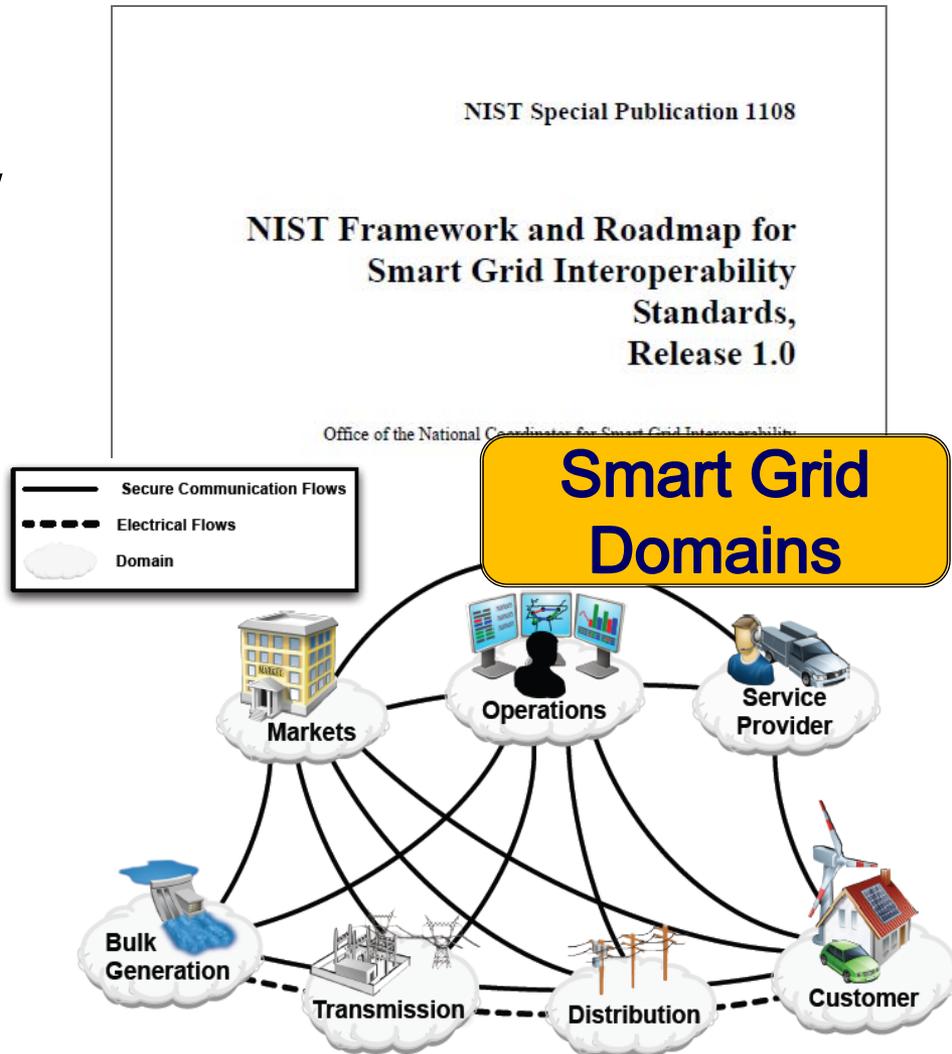


NIST
National Institute of
Standards and Technology

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/>



NIST Smart Grid Framework 1.0 January 2010



Smart Grid Interoperability Panel

- Public-private partnership created in Nov. 2009
- 664 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



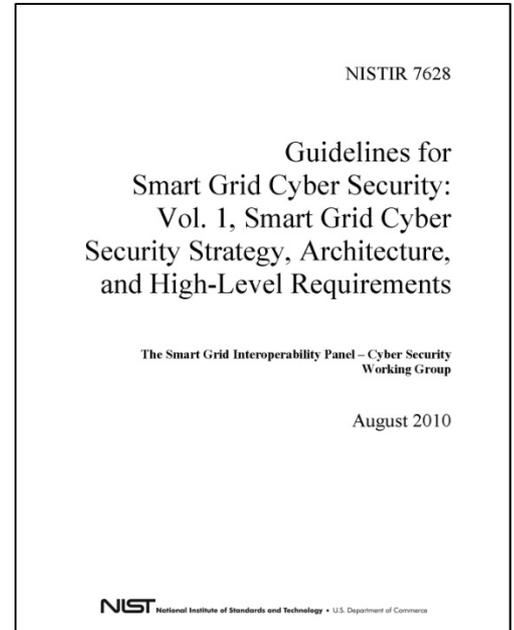
[SGIP Twiki:](#)

<http://collaborate.nist.gov/twiki-bin/view/SmartGrid/SGIP>



Cyber Security Working Group

- Building cyber security in from the start has been a paramount concern
- Permanent Working Group
 - Over 575 public and private sector participants
- August 2010 NIST publishes: *Guidelines for Smart Grid Cyber Security*
- Guideline includes:
 - Risk assessment guidance for implementers
 - Recommended security requirements
 - Privacy recommendations





SGiP Membership

Total # of Member Organizations: 664

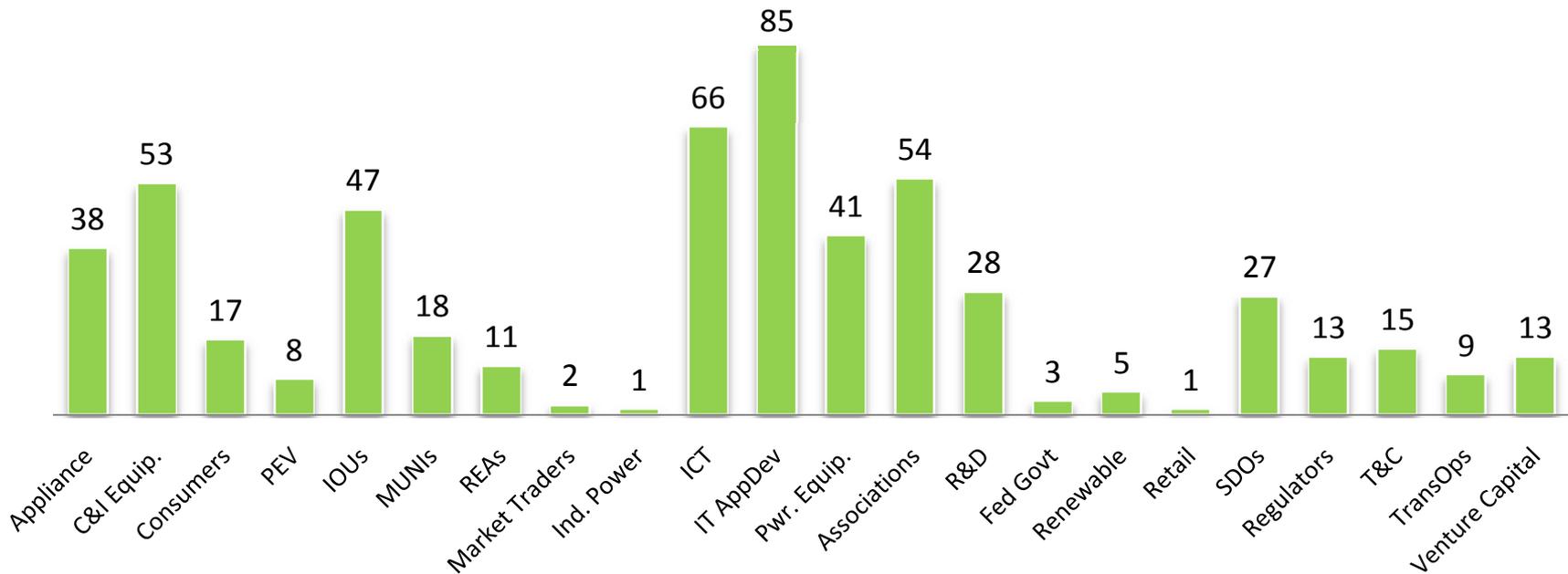
- # of Participating Member Organizations: 555
- # of Observing Member Organizations: 109
- # of Organizations who joined in Q1 2011: 19

Total # of Individual Members*: 1,708

of Organizations by Country

- USA: 592
- Europe: 21
- Asia: 16
- Oceania: 4
- North America (non-US): 29
- South America: 1
- Africa: 1

of Participating Member Organizations by Declared Stakeholder Category



Stakeholder Categories

AS OF 03.15.11

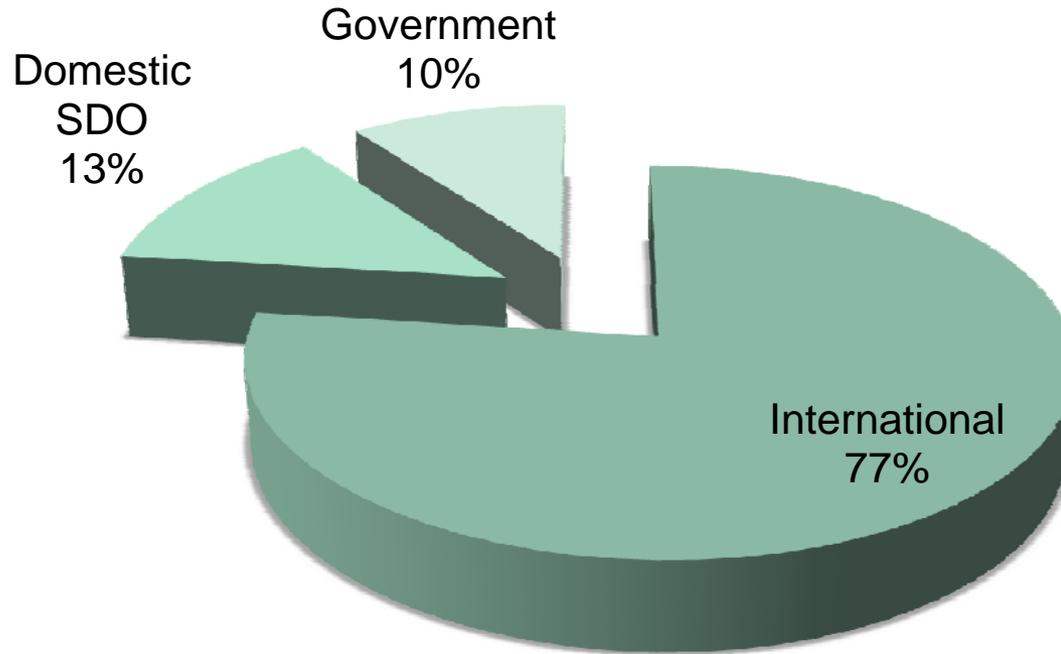
* Omits non-active Signatory Authorities.

Global Collaboration is Key to Success

- The laws of physics do not differ from country to country – the electric grid must obey them!
- There are many technical challenges to solve – sharing knowledge helps all
- Global standards avoid unnecessary adaptations for different markets, resulting in lower costs and greater innovation



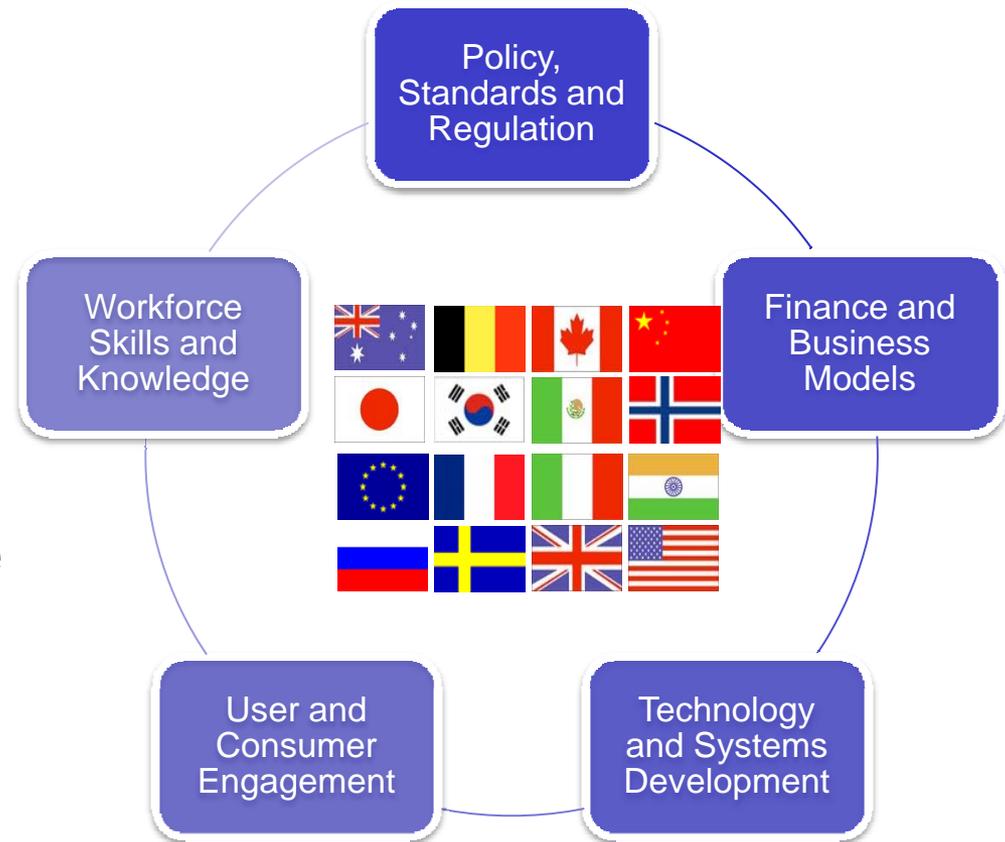
Source of Standards in NIST R1 Framework



- ISO/IEC/ITU
- IETF
- IEEE/SAE/ISA
- Global consortia

International Smart Grid Action Network

- Announced at the first meeting of the Clean Energy Ministerial in July 2010
- Purpose is to accelerate development and deployment of smarter electric grids around the world
- Structured as an IEA implementing agreement



Thank You!

- Web portal: <http://www.nist.gov/smartgrid>
- Contact:
 - George Arnold, National Coordinator
 - Email: george.arnold@nist.gov
 - Telephone: +1.301.975.2232

