NIST Smart Grid Program Overview

George Arnold

Director, Smart Grid and Cyber-Physical Systems Program Office

National Coordinator for Smart Grid Interoperability

Engineering Laboratory

Smart Grid Program Review

March 2, 2012

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

engineering laboratory

Outline

- Problem statement (Heilmeier analysis)
- History
- Organization
- Budget
- Assessment
- Vision
- Agenda

Heilmeyer Questions

- What is the problem, why is it hard?
- How is it solved today and by whom?
- What is the new technical idea; why can we succeed now?
- Why should NIST do this?
- What is the impact if successful and who would care?
- How will you measure progress?

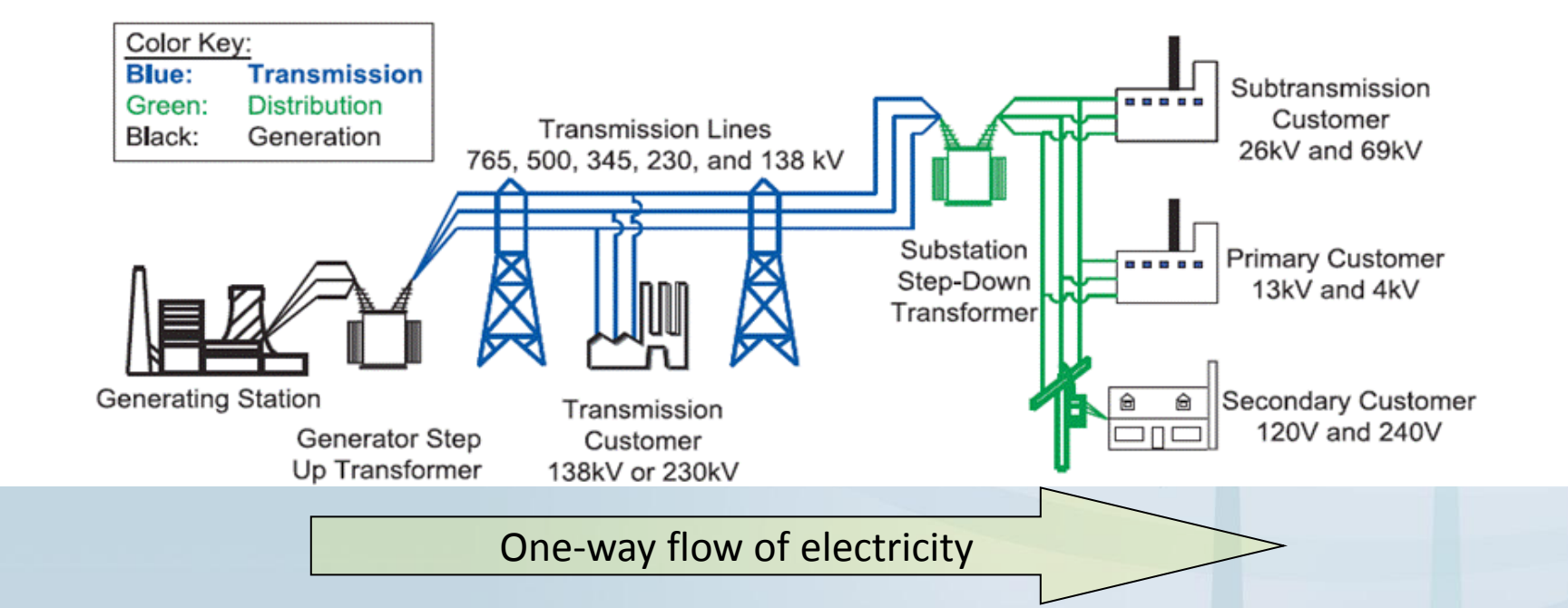
What Is the Problem?

Electric grid 100 years ago - not too different today!

Edison Pearl Street Station, 1882

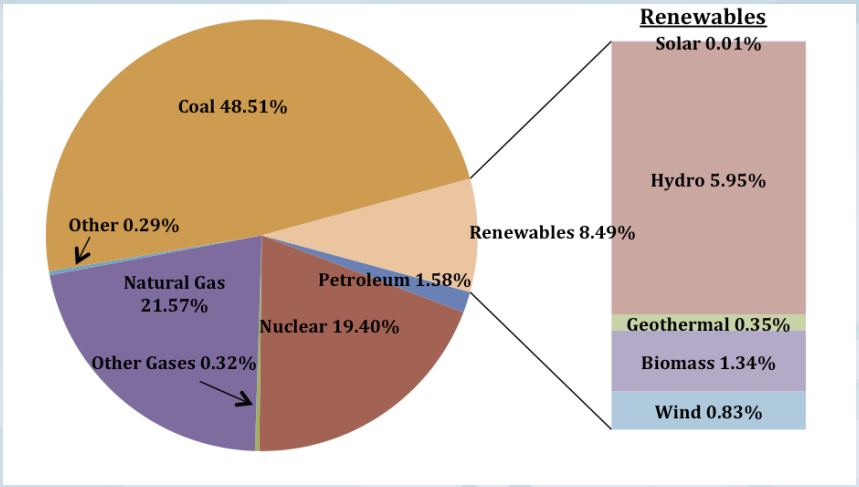
Wall Street, 1913

…Grid Architecture is Much the Same



- *Centralized, bulk generation, mainly coal and natural gas*
- *Responsible for 40% of human-caused CO_2 production*
- *Controllable generation and predictable loads*
- *Sized for infrequent peak demand – operates at 50% capacity*
- *Limited automation and situational awareness*
- *Lots of customized proprietary systems*
- *Lack of customer-side data to manage and reduce energy use*

Smart Grid Business Case



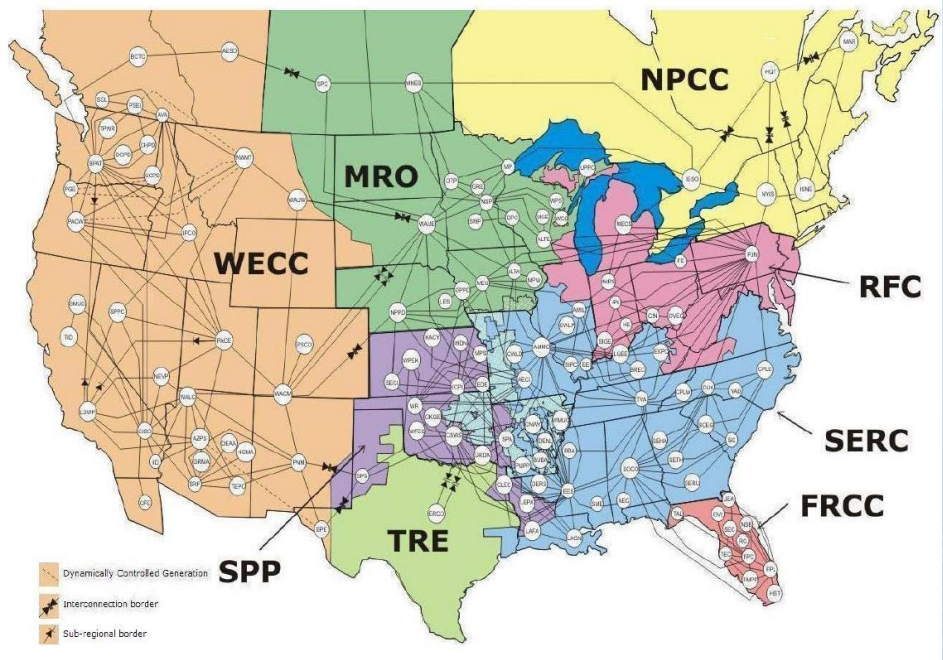
- Significant Grid investment needed over next 20 years just to “keep the lights on”
  - Half of U.S. coal plants are > 40 years old
  - Average substation transformer age > 40 years
- Smart grid helps utilities reduce delivery losses and customers reduce both peak and average consumption – thus reducing investment otherwise needed
- 2011 EPRI study:
  - Smart Grid will cost in the range of $338 - $476 billion over 20 years
  - Resulting benefit estimated at $1.6 - $2 trillion

Why Is It Hard?

Large, fragmented, complex system

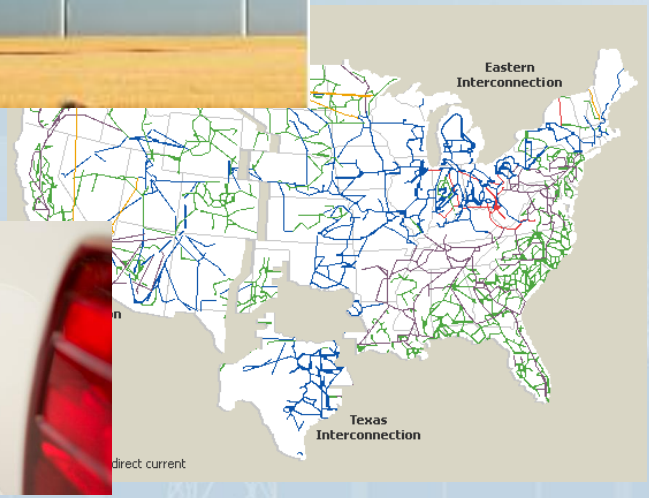
US figures:

- 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

How Is It Solved Today?



- Utilities and their suppliers are integrating 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

By Whom? Stakeholders in the Process

1	Appliance and consumer electronics providers
2	Commercial and industrial equipment manufacturers and automation vendors
3	Consumers – Residential, commercial, and industrial
4	Electric transportation industry Stakeholders
5	Electric utility companies – Investor Owned Utilities (IOU)
6	Electric utility companies - Municipal (MUNI)
7	Electric utility companies - Rural Electric Association (REA)
8	Electricity and financial market traders (includes aggregators)
9	Independent power producers
10	Information and communication technologies (ICT) Infrastructure and Service Providers
11	Information technology (IT) application developers and integrators
12	Power equipment manufacturers and vendors
13	Professional societies, users groups, and industry consortia
14	R&D organizations and academia
15	Relevant Government Agencies
16	Renewable Power Producers
17	Retail Service Providers
18	Standard and specification development organizations (SDOs)
19	State and local regulators
20	Testing and Certification Vendors
21	Transmission Operators and Independent System Operators
22	Venture Capital

Government Roles in Smart Grid

Federal

Office of Science & Technology Policy; National Economic Council; & Council on Environmental Quality

National Science & Technology Council Smart Grid IAWG & Smart Grid Task Force

Other Federal Agencies

Federal Energy Regulatory Commission

State

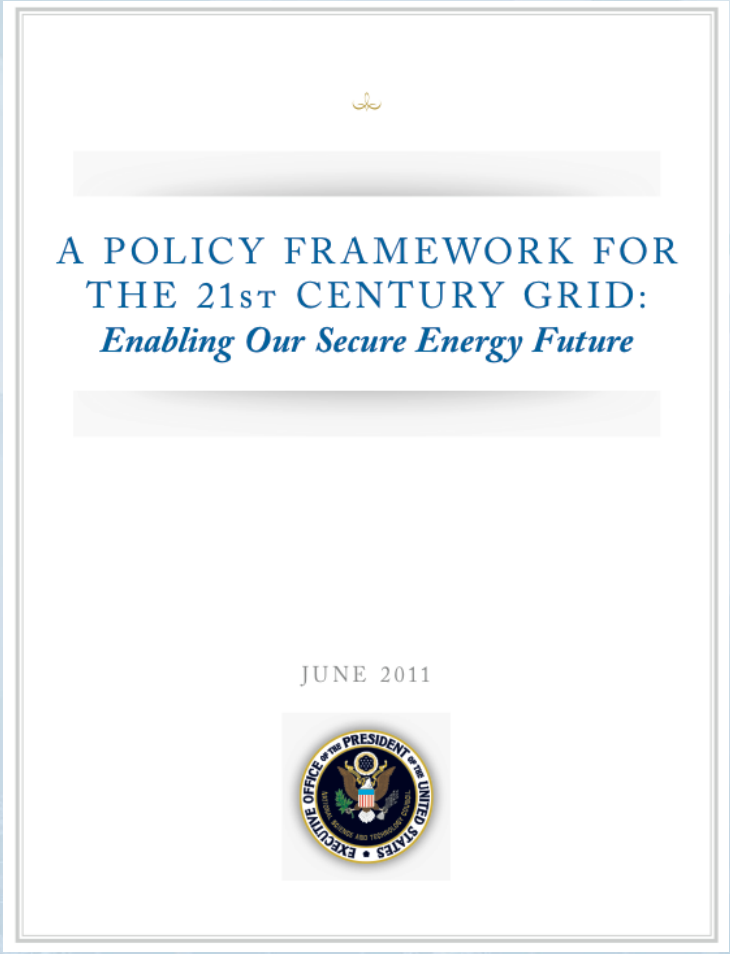
FERC – NARUC Smart Response Collaborative

Public Utility Commissions

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*



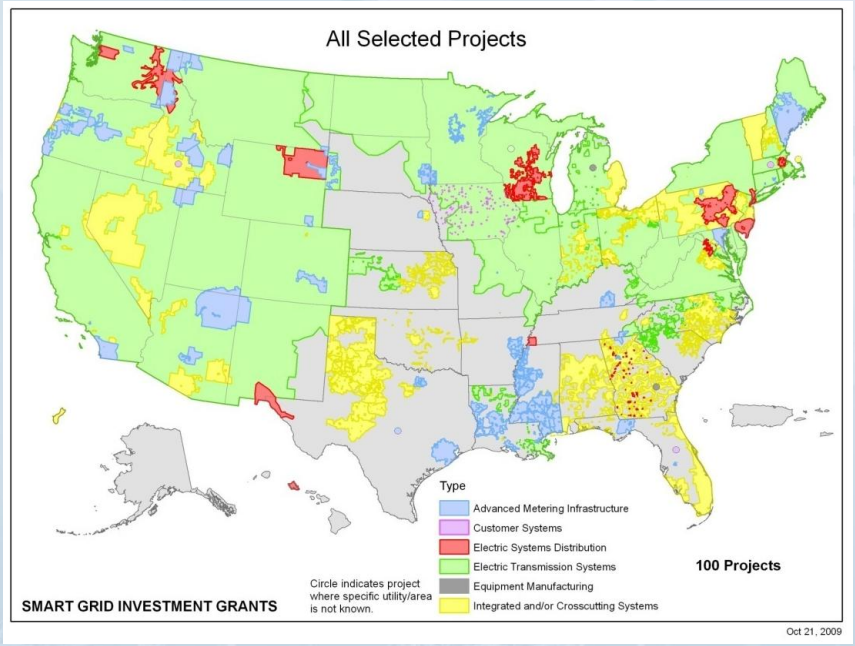
http://www.whitehouse.gov/ostp

US Smart Grid Investment Grants

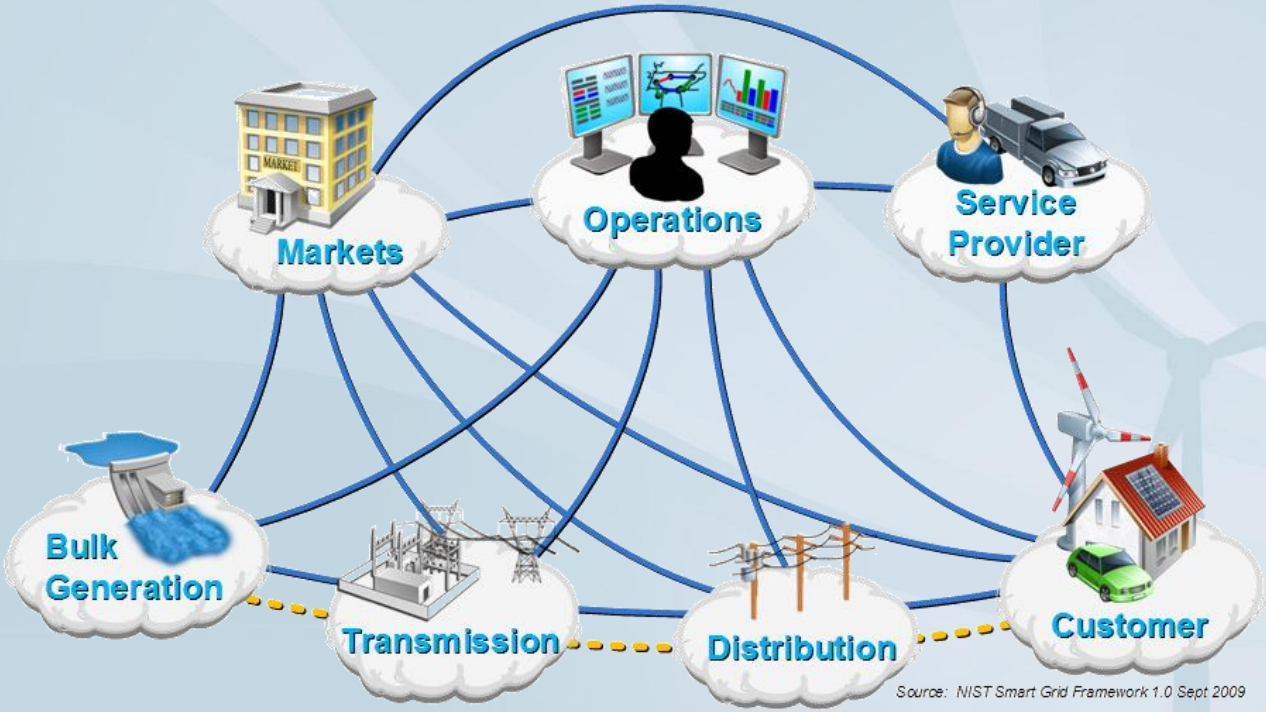
Category	$ Million
Integrated/Crosscutting	2,150
AMI	818
Distribution	254
Transmission	148
Customer Systems	32
Manufacturing	26
Total	3,429

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



What Is The New Idea?



Standardized architectural concepts, data models and protocols are essential to achieve interoperability, reliability, security and evolvability.
New measurement methods and models are needed to sense, control and optimize the grid's new operational paradigm.

Why Can We Succeed Now?

We benefit from similar large-scale experience developing architecture and protocols for modernization of the telecom network and the internet

	Telecom Next Generation Network	Smart Grid
Real-world examples	Verizon FiOS, AT&T Uverse	Xcel Boulder, Colorado
First deployments	2004	2008
Standards coordination started	2003	2008
Release 1 standards issued	2005	2009
Release 2 issued	2008	2012
Standards bodies	~12	27
# standards documents	Hundreds	Hundreds
Nature of standards	Mostly mix & match of existing standards	Mix & match of existing standards and many new

Why Should NIST Do This?

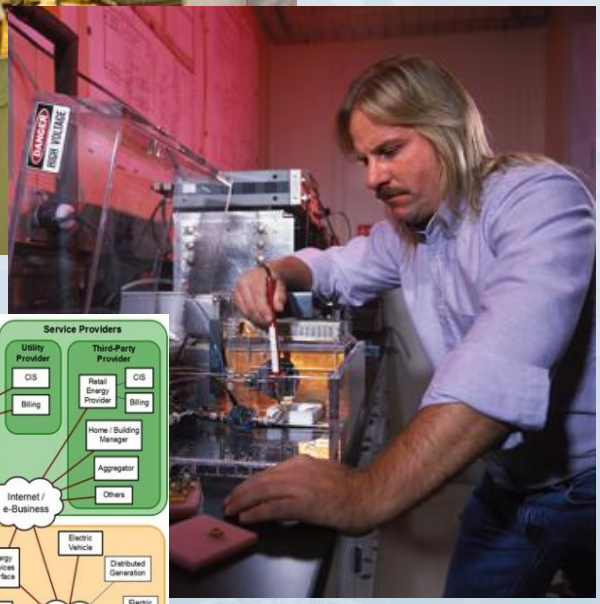
The Energy Independence and Security Act gives NIST

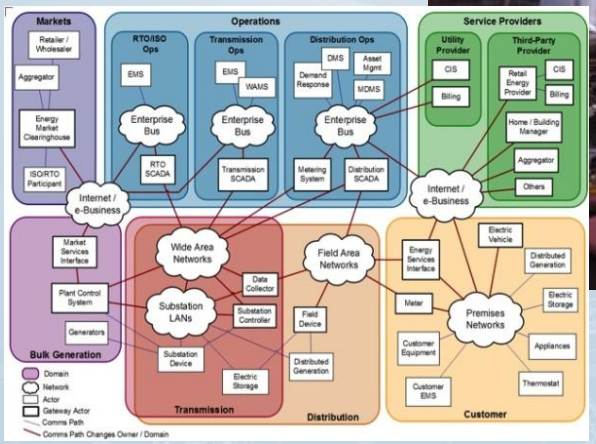
"primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems…"

- 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

NIST Expertise in the Smart Grid

- Metrology
  - Metering
  - Wide area monitoring (synchrophasors)
  - Power conditioning
  - Building energy management
  - Electricity storage
- Standards
  - Interoperability
  - Cybersecurity





Outcomes

- NIST Smart Grid Framework
- New or revised Smart Grid standards and guides
- Cyber-security guidelines and standards
- Testing and certification methods and tools
- New private/public organization (SGIP)
- Measurement methods and services

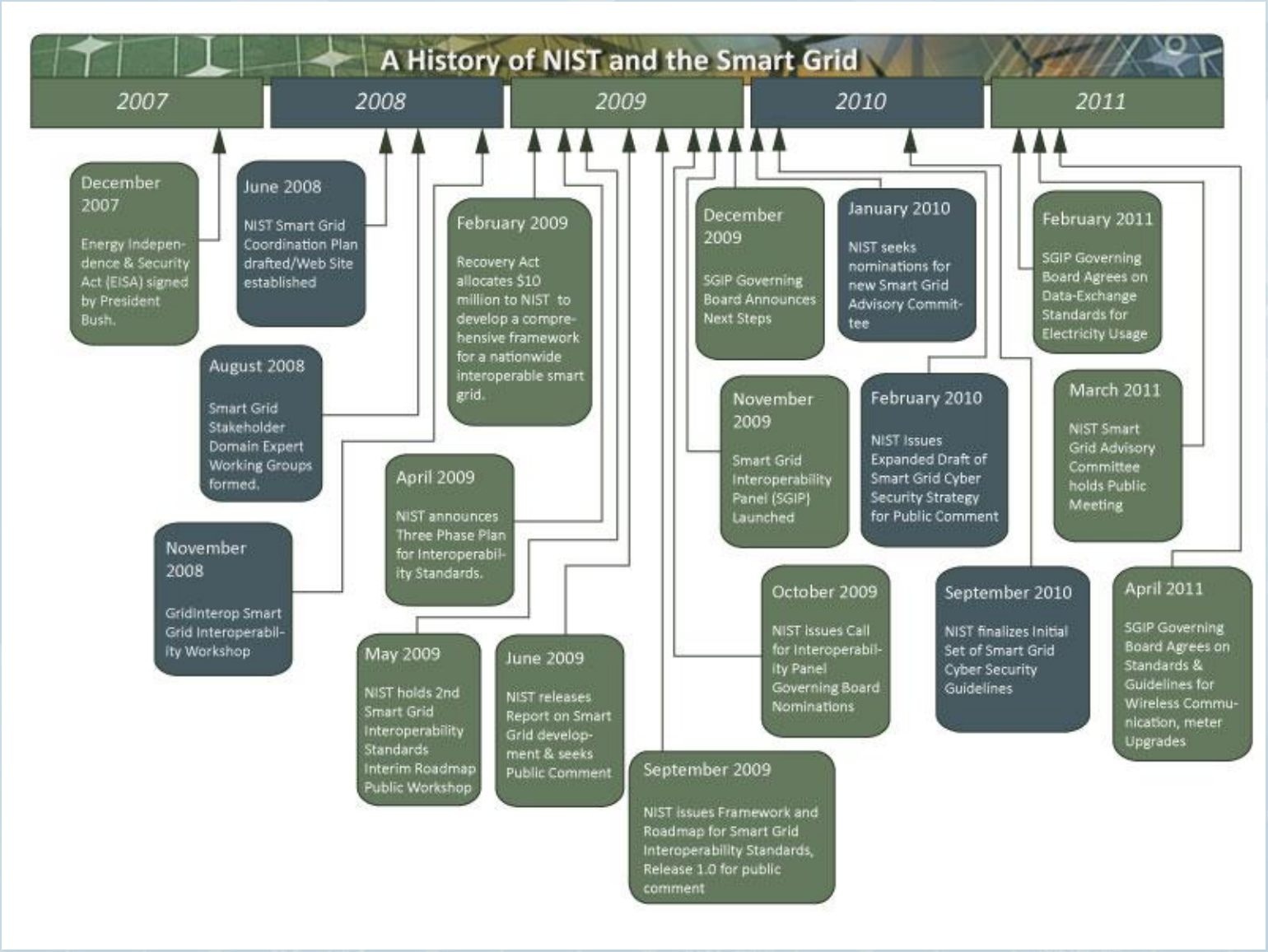
Impacts

- "Future proofs" $ billions in Smart Grid investments
  - Recipients of $3.4 billion of DoE Smart Grid grants were required to use NIST Framework standards
  - FERC and state regulators refer to NIST Framework
- Catalyzes innovation in Smart Grid applications
  - "Green Button" app enabled by NIST/SGIP standards available to 12 million consumers in 2012
- Opens international markets for U.S. Smart Grid suppliers
  - 80% of global grid investments will be made outside U.S.
  - Japan, Korea, EU and China based their Smart Grid frameworks on NIST

Measures of Progress

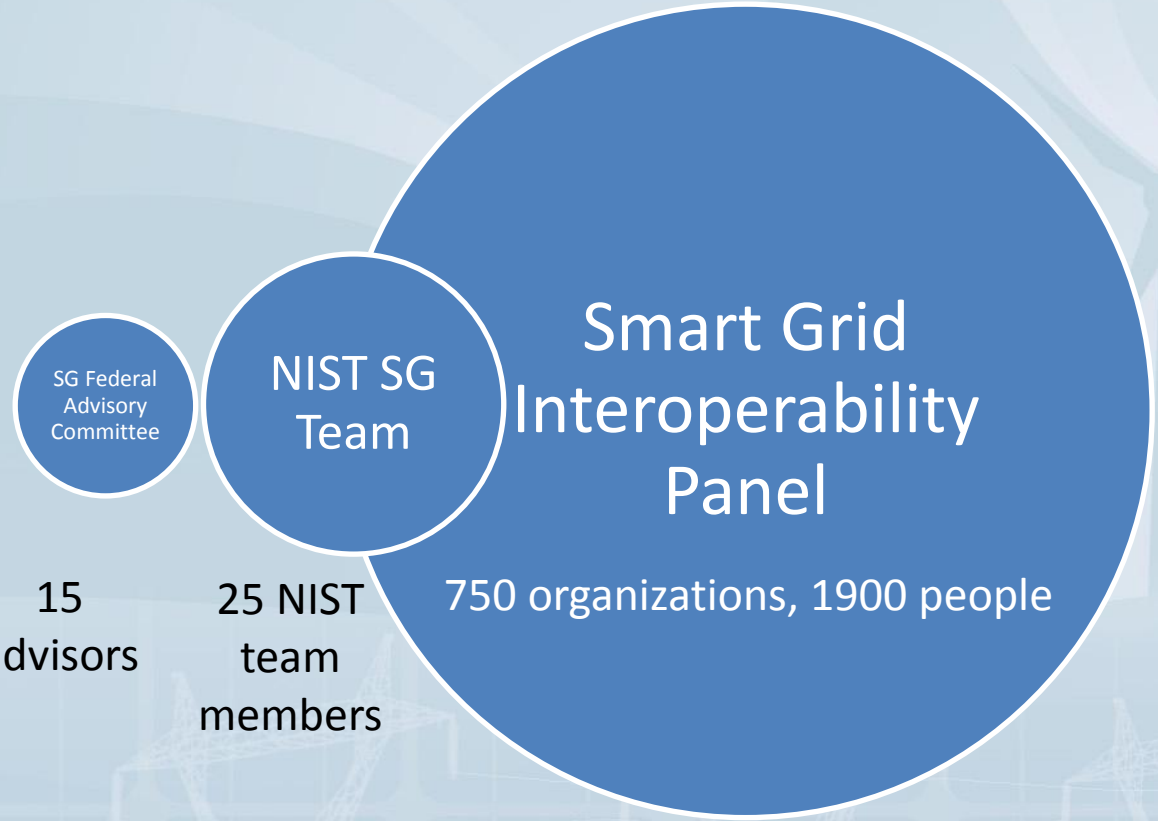
- Adoption of NIST-identified standards by industry
- Use of NIST Framework by regulators
- Timeliness of standards in meeting market needs
- Degree of alignment of international standards with NIST framework
- Availability of testing and certification programs using the NIST Framework
- Industry use of NIST measurement methods in developing and applying new Smart Grid technologies

History


A History of NIST and the Smart Grid
2007
2008
2009
2010
2011
December 2007
Energy Independence & Security Act (EISA) signed by President Bush.
June 2008
NIST Smart Grid Coordination Plan drafted/Web Site established
August 2008
Smart Grid Stakeholder Domain Expert Working Groups formed.
November 2008
GridInterop Smart Grid Interoperability Workshop
February 2009
Recovery Act allocates $10 million to NIST to develop a comprehensive framework for a nationwide interoperable smart grid.
April 2009
NIST announces Three Phase Plan for Interoperability Standards.
May 2009
NIST holds 2nd Smart Grid Interoperability Standards Interim Roadmap Public Workshop
June 2009
NIST releases Report on Smart Grid development & seeks Public Comment
September 2009
NIST issues Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0 for public comment
October 2009
NIST issues Call for Interoperability Panel Governing Board Nominations
November 2009
Smart Grid Interoperability Panel (SGIP) Launched
December 2009
SGIP Governing Board Announces Next Steps
January 2010
NIST seeks nominations for new Smart Grid Advisory Committee
February 2010
NIST Issues Expanded Draft of Smart Grid Cyber Security Strategy for Public Comment
September 2010
NIST finalizes Initial Set of Smart Grid Cyber Security Guidelines
February 2011
SGIP Governing Board Agrees on Data-Exchange Standards for Electricity Usage
March 2011
NIST Smart Grid Advisory Committee holds Public Meeting
April 2011
SGIP Governing Board Agrees on Standards & Guidelines for Wireless Communication, meter Upgrades

(Extended) Organization

"[NIST] shall seek input and cooperation of other relevant federal and state agencies…and private sector entities" – EISA 2007



NIST SG Team Organization

Smart Grid Office, EL

- George Arnold, Director
- Christina Santangelo, Secretary
- Dave Wollman – Standards framework and measurement science program development
- Dean Prochaska – Testing and certification framework and SGIP transformation
- Jeff Mazer – External liaison, research workshop and testbed development
- Cuong Nguyen – Program analyst, SG Federal Advisory Committee management
- Jerry Fitzpatrick (PML) – NIST SG Framework editor-in-chief
- Paul Boynton (PML) – External contract management

Engineering Lab

- Steve Bushby, Dave Holmberg – Building-to-Grid
- Keith Stouffer, Evan Wallace – Industry-to-Grid

Physical Measurement Lab

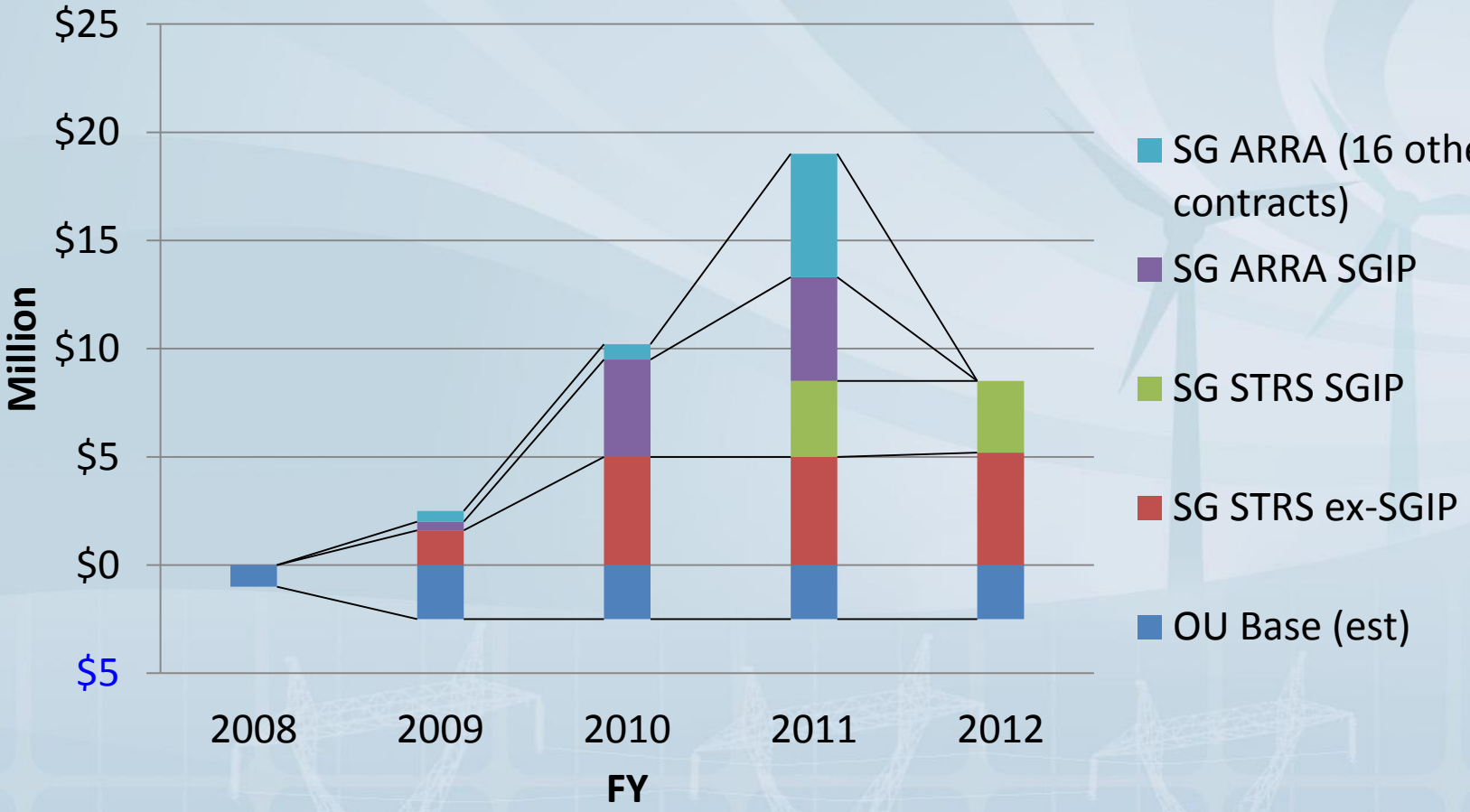
- Jerry Fitzpatrick, Tom Nelson – Transmission and distribution
- Al Hefner – Distributed resources
- Galen Koepke – EMC/EMI Issues

Information Technology Laboratory

- Marianne Swanson, Tanya Brewer – Cyber Security
- Nada Golmie, Hamid Gharavi – Networking
- Eric Simmon – Timing synchronization and architecture

Additional staff (not shown) support the program in EL, PML, ITL, NIST Program Coordination Office, CLA, Standards Coordination Office, and AMD

Budget


$25
$20
$15
$10
$5
$0
$5
Million
2008
2009
2010
2011
2012
FY
SG ARRA (16 other contracts)
SG ARRA SGIP
SG STRS SGIP
SG STRS ex-SGIP
OU Base (est)

Assessments - 1

- NIST SG Federal Advisory Committee report, March 2012
  - "NIST's work to establish Smart Grid interoperability protocols and standards has been carried out both methodically and with a sense of urgency, and NIST is to again be commended for the enormous task it has undertaken and for its many accomplishments over the last two and a half years"
- Federal Energy Regulatory Commission, July 2011
  - "We believe that the best vehicle for developing smart grid interoperability standards is the NIST interoperability framework process, including the work of the SGIP and its committees and working groups…The Commission recognizes and appreciates the comprehensiveness of the smart grid interoperability framework process developed by NIST… we encourage utilities, smart grid product manufacturers, regulators, and other smart grid stakeholders to actively participate in the NIST interoperability framework process to work on the development of interoperability standards and to refer to that process for guidance on smart grid standards"

Assessments - 2

- FAC long-term recommendations
  - NIST will need to organize for changing role by 2015 and beyond
    - Form and structure of Smart Grid business unit
      - Augment technological expertise
      - Greater support for state and federal regulators
    - Research program
      - Focus on its core competence: standards development, metrology, cybersecurity, and testing and certification, but be selective in areas it tries to address
      - Smart grid metrics to aid decision-making
      - Electric power metrology
      - Modeling, especially at system level
      - Cyber-security
      - Accreditation, testing, calibration and certification
      - Facilitate multi-stakeholder Smart Grid research collaboration

The Task Ahead

- Ensure continued strong NIST leadership in Smart Grid standards development and fulfill statutory responsibilities
- Transform SGIP into a self-sustaining legal entity while continuing strong NIST technical and leadership engagement
- Build a strong multi-laboratory SG measurement science research program to meet the Grid's long-term needs

NIST SG R&D Vision

- The Smart Grid is a complex system of systems that incorporates many new technologies and operating paradigms in an end-to-end system that functions very differently than the legacy grid in order to deliver power more efficiently, reliably and cleanly.
- NIST develops the measurement science and standards, including interoperability and cybersecurity standards, necessary to ensure that the performance of the Smart Grid – at both the system, subsystem, and end-user levels - can be measured, controlled, and optimized to meet performance requirements, especially for safety and security, reliability and resilience, agility and stability, and energy efficiency.

NIST SG R&D Program Areas

Systems Aspects

- Architecture and data models
- System modeling
- Economic analysis
- Smart grid testbed
- Testing and certification methods
- Data networking
- Cybersecurity
- Usability
- EMC

Transmission and Distribution

- Metering
- Wide area measurement and control
- Grid-scale storage
- Large-scale renewables integration

Distributed Resources

- Distributed generation
- Distributed storage
- Microgrid operation

Customer Domain

- Commercial building-to-grid
- Industry-to-grid
- Residence-to-grid
- Electric vehicle-to-grid

NIST SG R&D Roadmap

- The roadmap will describe a five-year vision for NIST's R&D effort in each area and a portfolio of proposed and prioritized project plans to realize the vision
  - Boulder workshop August 13-14 will provide key input to determining needs and priorities
- This program review will help us set strategy-driven priorities for different levels of funding
  - Existing
  - FY12-14 funds available as a result of SGIP transition
  - New initiative requests

Agenda – March 2

Time	Topic	Speakers
8:30	Welcome and Expectations	Shyam Sunder
8:45	NIST Smart Grid Program Overview	George Arnold
9:15	Energy Independence and Security Act: NIST Program	Dave Wollman, Dean Prochaska, Cuong Nguyen
10:30	Break	
10:45	Measurement Science Program Introduction	Dave Wollman
11:15	Transmission and Distribution	Jerry Fitzpatrick
12:15	Lunch	
1:30	Distributed Resources	Al Hefner
2:30	Customer Domain	Steve Bushby
3:30	General Discussion	
3:45	Summary of Day 1 and Observations, Guidance	Shyam Sunder
4:00	Adjourn	

Agenda – March 16

Time	Topic	Speakers
8:30	Welcome and Expectations for Day 2	Shyam Sunder
8:45	System Aspects - Cybersecurity - Data networking - Additional aspects including EMC	 Marianne Swanson Nada Golmie Dave Wollman
10:30	Break	
10:45	Gaps and Plans to Address - System modeling	Dave Wollman
11:30	Research Needs Assessment Workshop	Jeff Mazer
12:00	Lunch	
1:15	Smart Grid Testbed	Jeff Mazer
2:00	Discussion	All
2:30	Discussion Wrap-up	George Arnold
3:00 – 3:15	Summary of Day and Observations, Action Items and Next Steps	Shyam Sunder