Smart Grid

A NIST Perspective

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Given by

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

engineering laboratory

Agenda

- About The Technology
- NIST Smart Grid Program
- Framework Concept & Evolution
- Public Information Access
- Challenges for Measurement Science Research Supporting Smart Grid – Research Efforts at NIST

Smart Grid in the U.S.

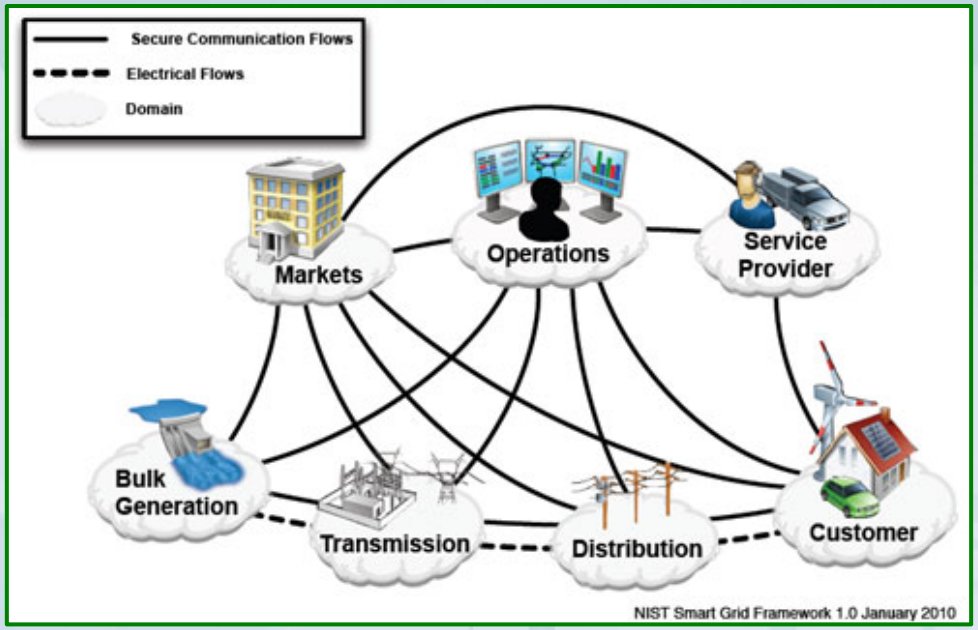
https://www.smartgrid.gov/

What is it? What will it do?

- **"Smart grid" refers to a technology class intended to bring electricity generation, delivery, and usage systems into the 21st century**
  - **Based on computer-based remote control and automation coupled with advances in measurements capabilities and standards.**
- **The two-way communications technology and computer processing used widely in other industries make this possible.**
- **Transforming electricity networks for 2-way (bi-directional) electrical energy flows presents standards and measurements challenges**
  - **Enable consumer access to distributed generation for traditional power plants, wind and solar, and other renewable sources via smart grid technologies**
  - **Benefits to energy producers and consumers – significant improvements in energy efficiency on the electricity grid and in the energy users' homes and offices.**
  - **Enable distributed generation – Supports energy sustainability and independence; Some consumers are beginning to become producers.**

Smart Grid in the U.S.

A NIST Perspective

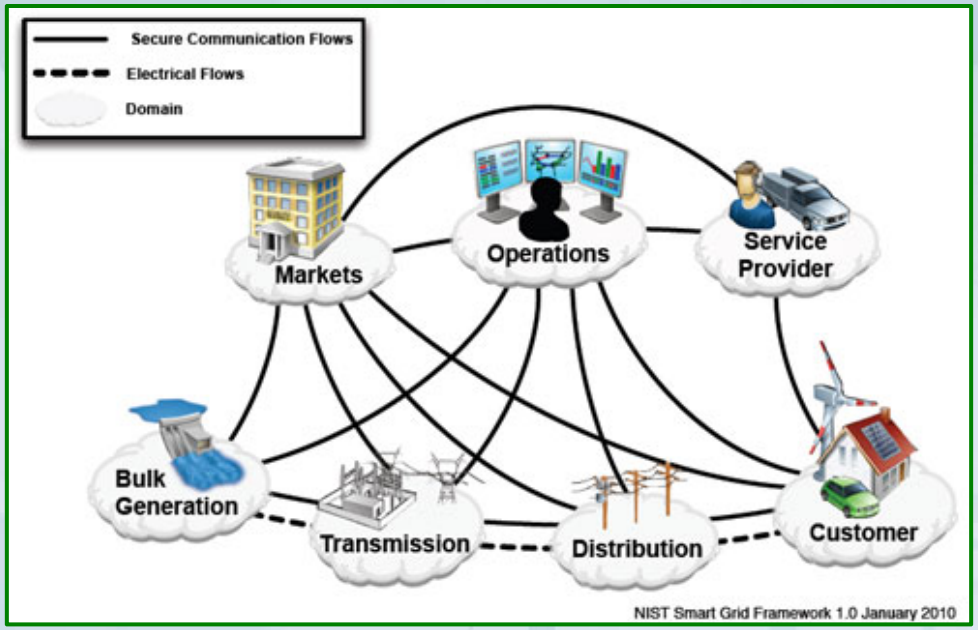


The NIST Smart Grid Program Objective:

- Develop and deploy measurement science advances to enable integration of interoperable and secure real-time sensing, control, communications, information and power technologies to increase efficiency, reliability and sustainability of the nation's electric power grid.
- A combined documentary standards and measurements research-based effort strongly allied with other Federal Agencies and the U.S. Private Sector

Smart Grid in the U.S.

A NIST Perspective



The NIST Smart Grid Program Objective:

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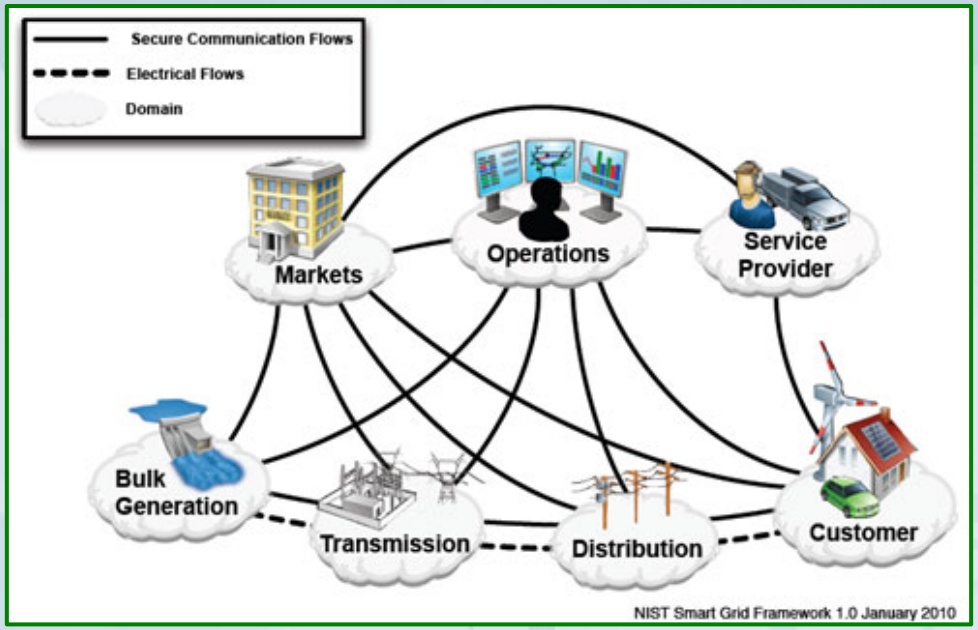
- Promotes advances in cyber security and electrical metrology methodologies and standards for secure energy delivery

Smart Grid in the U.S.

A NIST Perspective

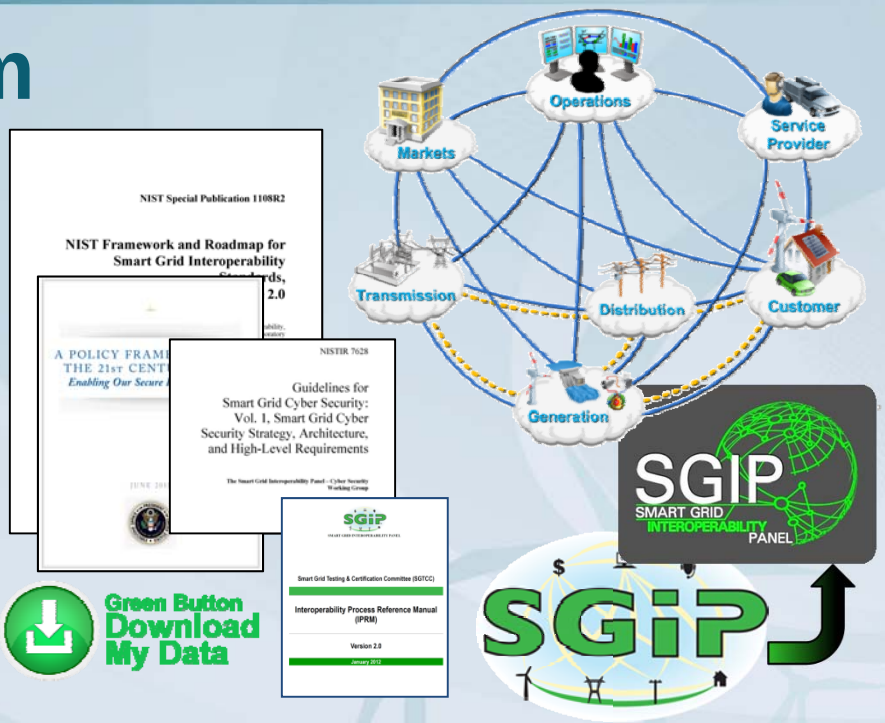


The NIST Smart Grid Program Objective:

- Develop and deploy measurement science advances to enable integration of interoperable and secure real-time sensing, control, communications, information and power technologies to increase efficiency, reliability and sustainability of the nation's electric power grid.
- U.S. Dept. of Energy leads the U. S. Government effort
- NIST has specific responsibilities for cyber security standards and for electrical metrology and standards

NIST Smart Grid Program

- **Standards coordination:**
  - NIST coordinates and accelerates Smart Grid interoperability standards
  - NIST Framework and Roadmap
  - NIST established the Smart Grid Interoperability Panel (SGIP), now an industry-led private-public partnership
- **Measurement science:**
  - NIST Engineering Laboratory leads a multi-Lab smart grid research program:
    - System performance (testbeds, EMC, cyber security, networking and testing)
    - Transmission and distribution grid operations (Phasor Meas. Units, metering)
    - Distributed energy resources (power conditioning systems)
    - End-user interoperation (building controls, energy usage)



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

NIST Virtual Cybernetic Building Testbed

PMU sensor testbed

Power electronics

“Framework” specifically identified in Energy Independence and Security Act

NIST has *“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…”*

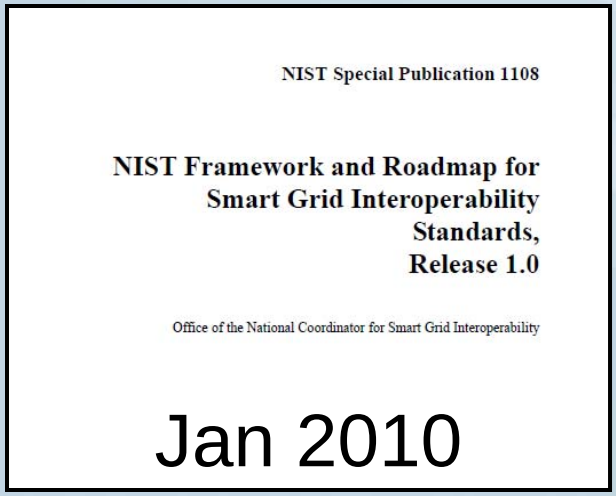
- U.S. Congress directed that the framework be “flexible, uniform, and technology neutral”
- NIST to seek input and cooperation from stakeholders
- Use of standards is a criteria for federal grants (DOE)
- Input to federal (and state) regulators

What is a "Framework"?

- In this context, frameworks are conceptual structures that organize and make clear collective wisdom (vision, principles, underlying structure, functions, requirements, practices, …)
- Frameworks are created with technical expertise and process
  - expertise: collective knowledge, experience infused with creativity
  - process: organized methodology within active stakeholder community

NIST Smart Grid Framework History

Release 1


NIST Special Publication 1108

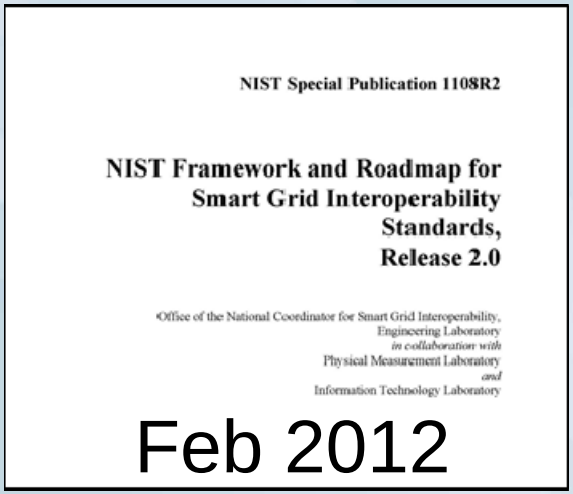
NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0

Office of the National Coordinator for Smart Grid Interoperability

Jan 2010

Key concepts: Identified 75 standards, 16 Priority Action Plans, cyber, architecture conceptual model, energy services interface

Release 2


NIST Special Publication 1108R2

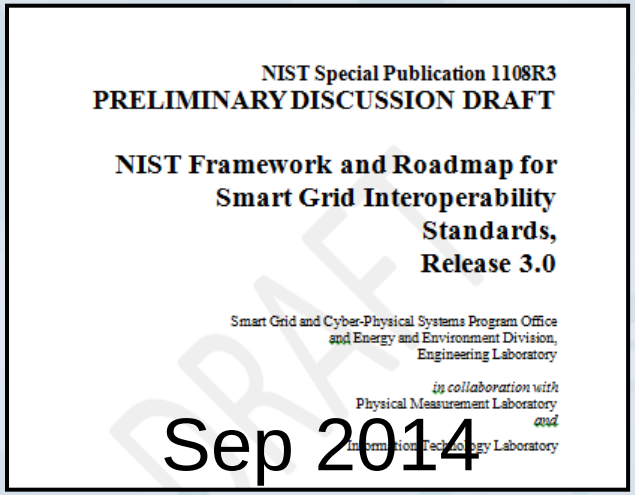
NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0

Office of the National Coordinator for Smart Grid Interoperability, Engineering Laboratory
in collaboration with
Physical Measurement Laboratory
and
Information Technology Laboratory

Feb 2012

Key concepts: Identified 98 standards, 19 PAPs and progress, Smart Grid Interoperability Panel structure/ops, Testing & Certification framework

Draft Release 3


NIST Special Publication 1108R3
PRELIMINARY DISCUSSION DRAFT

NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0

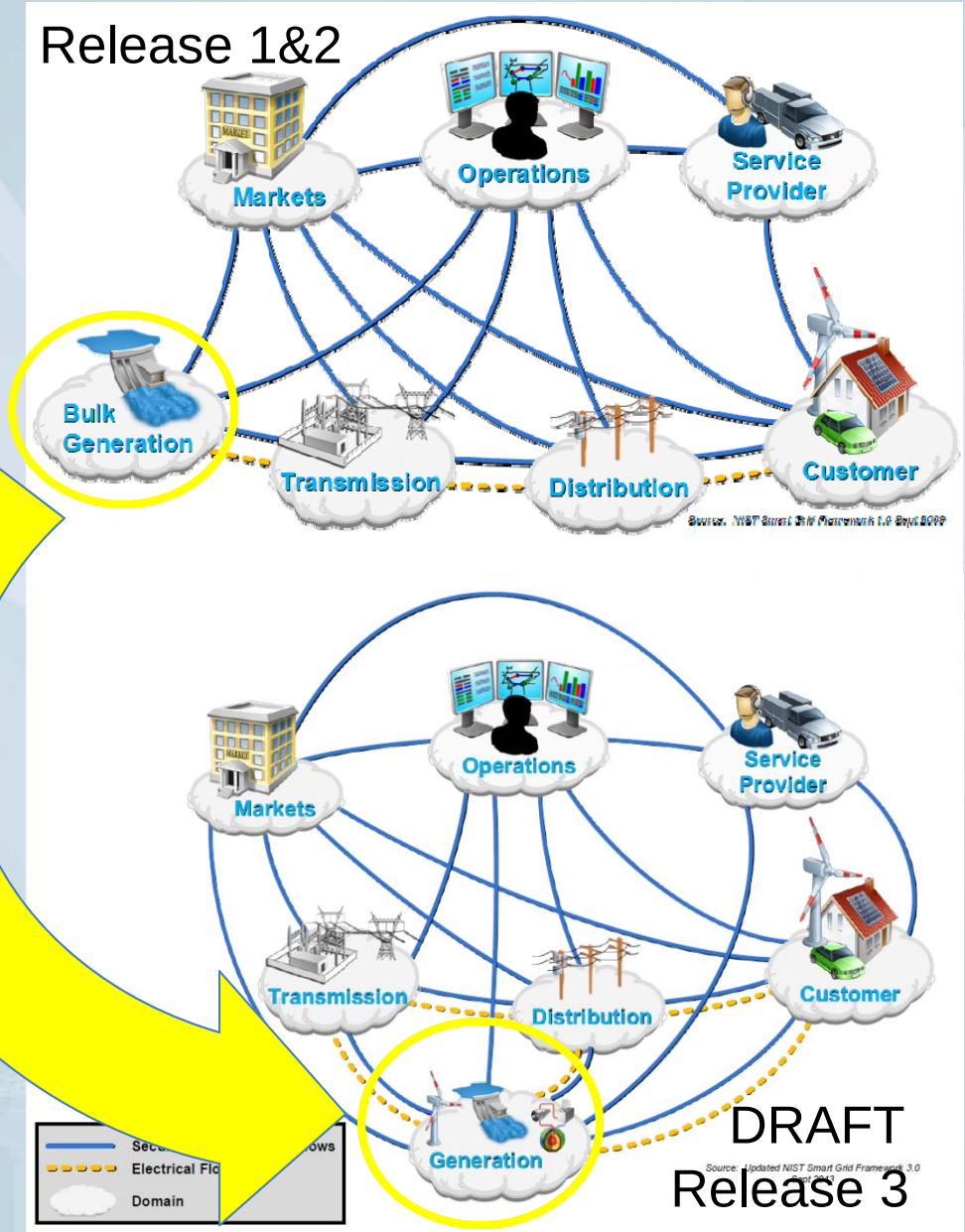
Smart Grid and Cyber-Physical Systems Program Office
and Energy and Environment Division, Engineering Laboratory
in collaboration with
Physical Measurement Laboratory
and
Information Technology Laboratory

Sep 2014

Key concepts: SGIP transition to non-profit organization, architecture harmonization, cybersecurity (NISTIR 7628 rev 1 update Sep 2014)

Framework Conceptual Model: Domains

- Smart Grid Architecture Committee: Int'l coordination
  - EU: SG-CG
  - SGAM: Smart Grid Architecture Model
- Domains
  - Bulk Generation → Generation
- Future work
  - Semantic Framework, …



NIST Framework Organization

<u>Release 3 Table of Contents</u>

Executive Summary

1 Purpose and Scope

2 Smart Grid Visions

3 Smart Grid Interoperability Panel (SGIP)

4 Standards Identified for Implementation

5 Architectural Framework

6 Cybersecurity Strategy

7 Testing and Certification Framework

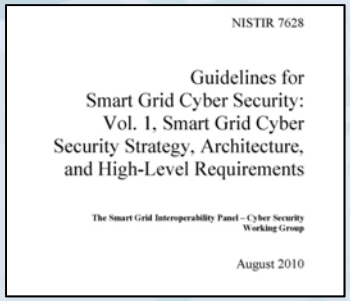
8 Cross-Cutting and Future Issues

Appendix A: List of Acronyms and Abbreviations

Appendix B: Specific Domain Diagrams

Appendix C: Smart Grid Service Orientation and Ontology

Appendix D: SGIP Priority Action Plans (PAPs), Domain Expert Working Groups (DEWGs), and other SGIP Efforts


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

Smart Grid Testing & Certification Committee (SGTCC)

Interoperability Process Reference Manual (IPRM)

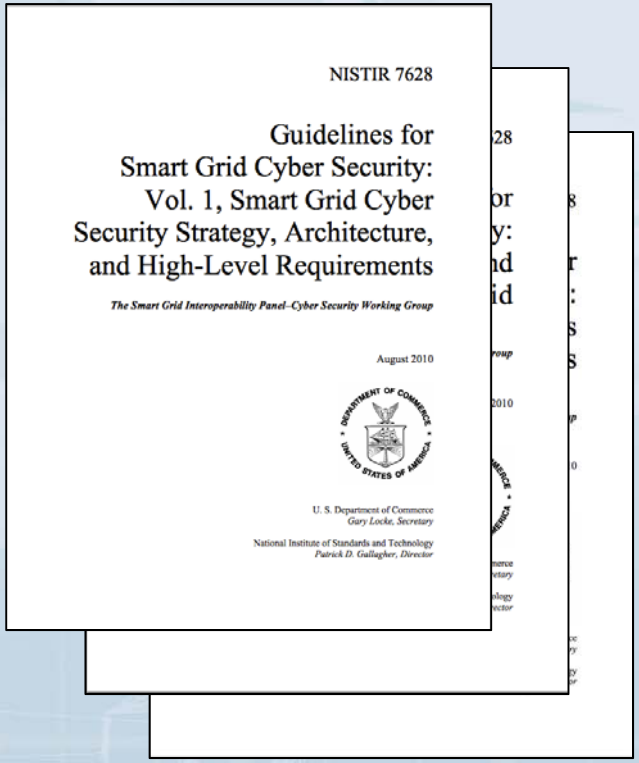
Version 2.0

January 2012

http://www.nist.gov/smartgrid/upload/NIST-SP-1108r3.pdf

NISTIR 7628 (NIST Interagency Report)

- Published August 2010; NISTIR 7628 Rev. 1 Sept 2014
- NISTIR 7628 includes three volumes:
  - Volume 1: Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements
  - Volume 2: Privacy and the Smart Grid
  - Volume 3: Supportive Analyses and Refs.
- NISTIR 7628 provides:
  - cybersecurity strategy overview;
  - high-level requirements for smart grid;
  - tool to support technology development;
  - evaluative framework for assessing risks to smart grid components and systems; and
  - A guide to assist organizations to develop cybersecurity strategies including to mitigate risks and privacy issues pertaining to smart grid customers and uses of their data.


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

U. S. Department of Commerce
Gary Locke, Secretary

National Institute of Standards and Technology
Patrick D. Gallagher, Director

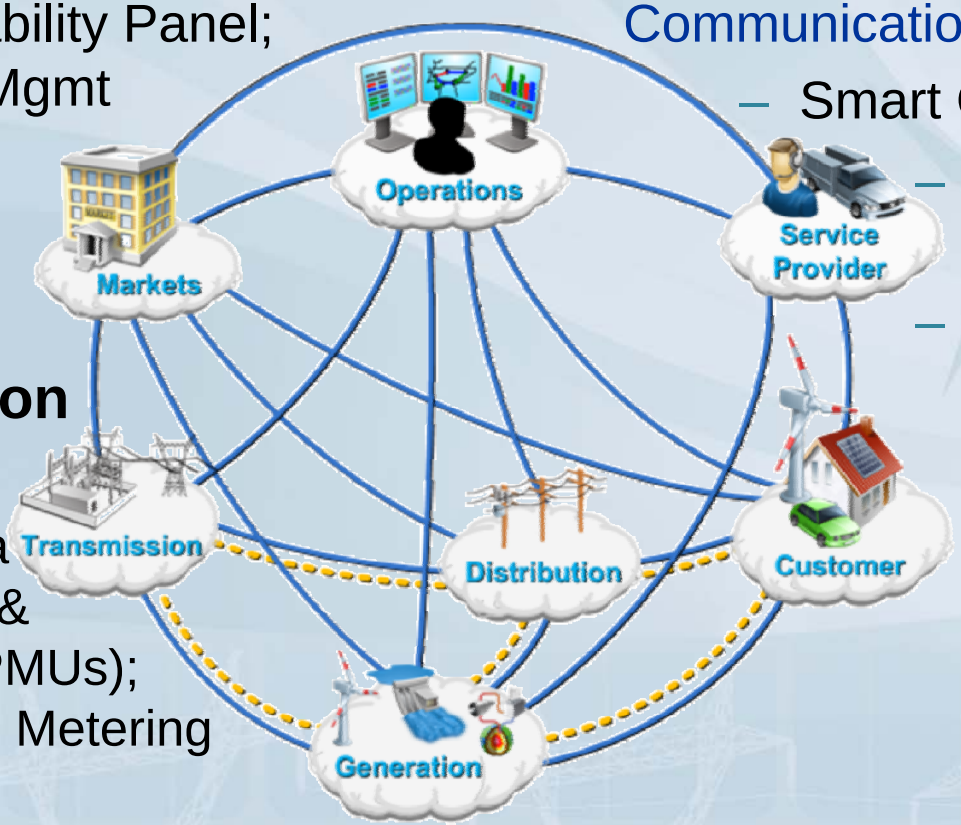
NIST Smart Grid Program

Smart Grid Coordination

- Secretariat; Smart Grid Interoperability Panel; Program Mgmt

Smart Grid System Performance

- Cybersecurity; Timing; Communications Networks; EMC
  - Smart Grid Testbed
    - Testing and Certification
    - Systems Modeling and Simulation (gap)



Transmission and Distribution Operations

- Wide Area Modeling & Control (PMUs); Advanced Metering

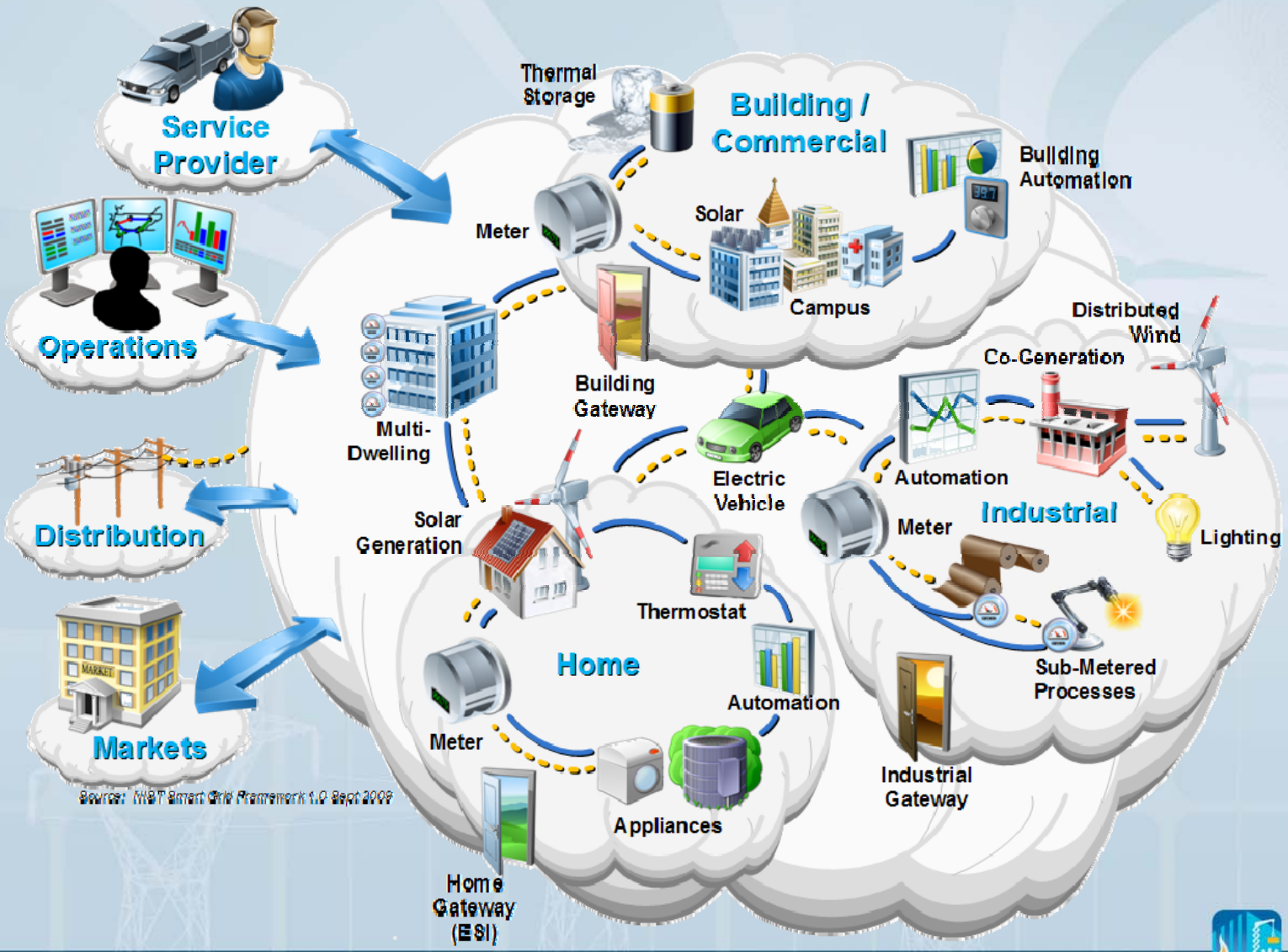
User-to-Grid

- Building Integration

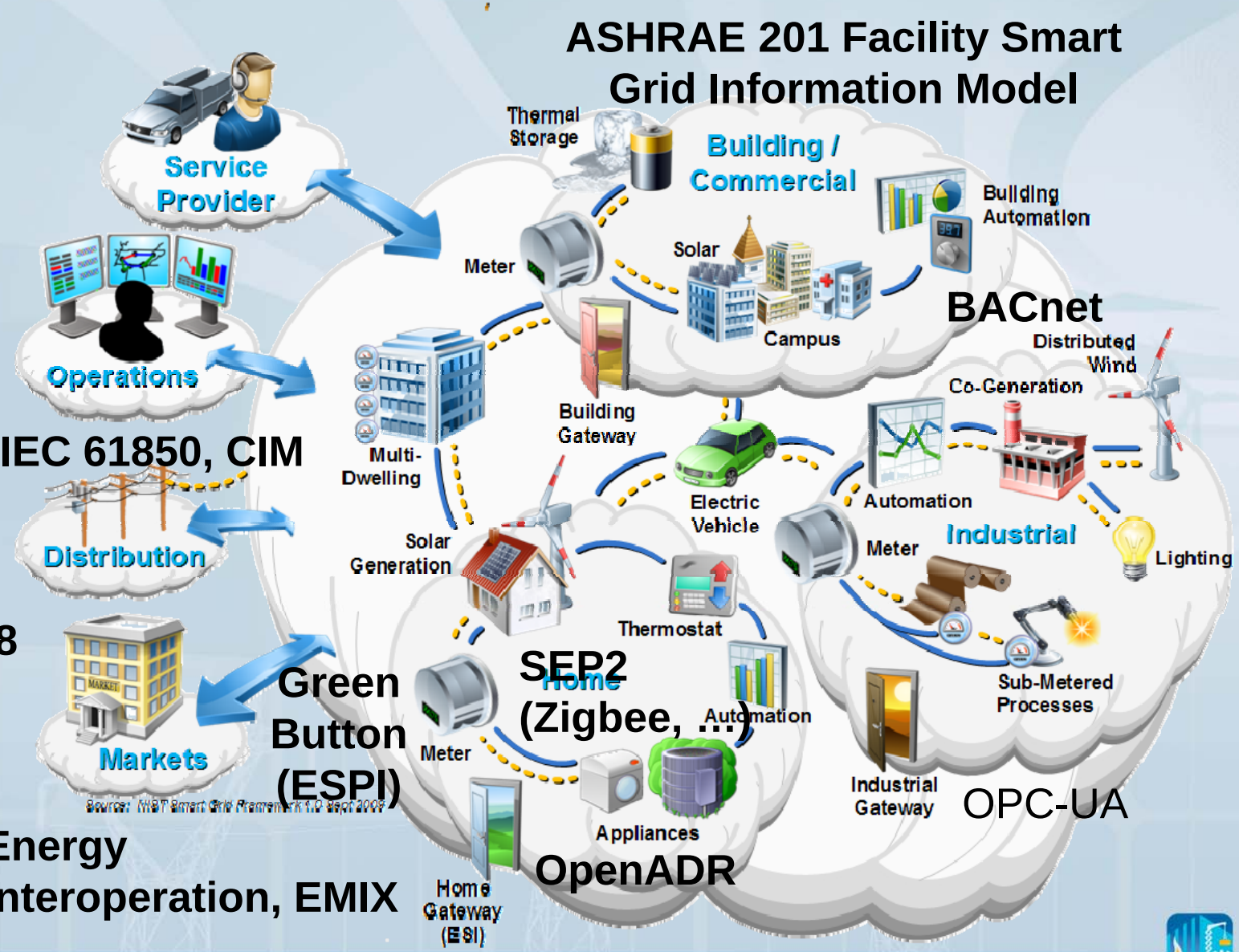
Distributed Energy Resources and Microgrids

- Power Conditioning; Storage (gap)

Consumer Domain



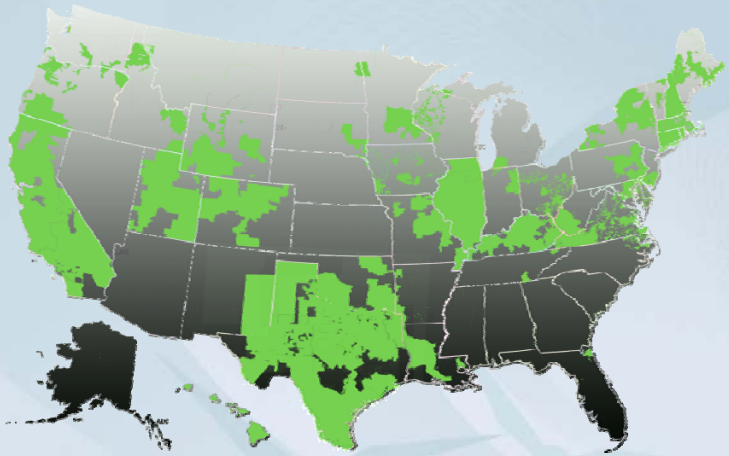
Consumer Domain – Standards



Source: NIST Smart Grid Framework 1.0 Sept 2009

Green Button Initiative

- Enables electronic consumer access to energy data and supports development of ecosystem (apps)
- Available to 60+ million customers in the US and an additional Canada 2.6 million+ customers
- Result of collaboration among White House, NIST, DOE, state regulators, utilities, vendors, SGIP, and North American Energy Standards Board
- Green Button Download My Data and Green Button Connect My Data



Map of US Green Button Commitments

Green Button Connect My Data

Green Button Download My Data

Green Button Download My Data & Connect My Data Now Rolling Out

Green Button
Download
My Data

A customer visits their utility web portal, they can simply login and download their Green Button Data as an XML-formatted file.

Green Button
Connect
My Data

This powerful model allows a consumer to authorize a third-party service provider to receive direct access to their Green Button Data - no need to repeatedly login to their utility and download files. These authorizations are valid for an agreed upon time and can be revoked at anytime by the consumer.

Federal Government Interest in Data Access

- Open Data Initiatives
  - Making government information resources more publicly accessible in "computer-readable" form and encouraging its use by entrepreneurs as fuel for the creation of new products, services, and jobs
  - Project Open Data: http://project-open-data.github.io
  - Examples: Federal Register 2.0, Data.gov, Health Data Initiative, …
- My Data Initiatives
  - Empowering consumers with secure access to their own personal health, energy, and education data
  - Blue Button (health info), Green Button (energy), Education, …

US Federal Government Commitment

Climate Action Plan

"The Administration will ***leverage the 'Green Button' standard*** *– which aggregates energy data in a secure, easy to use format – within federal facilities to increase their ability to manage energy consumption, reduce greenhouse gas emissions, and meet sustainability goals."* The President's Climate Action Plan, June 25, 2013

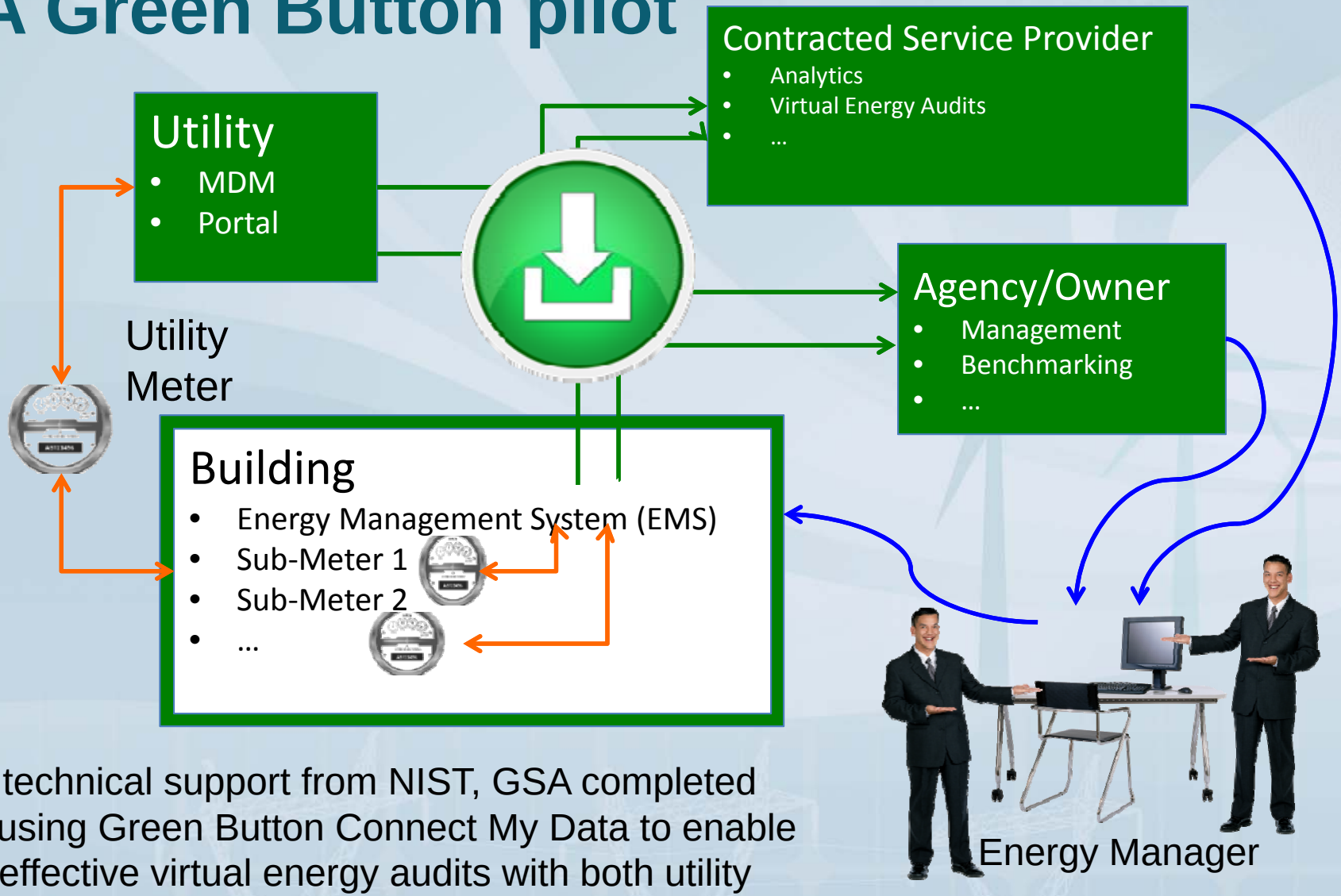
Presidential Memorandum (to all Federal agencies)

"Sec. 3. Building Performance and Energy Management .. each agency shall: ***... incorporate Green Button into reporting****, data analytics and automation, and processes, in consultation with local utilities ..." [.. GSA, EPA pilots ...]* Presidential Memorandum on Federal Leadership in Energy Management, December 5, 2013

How does the NIST Smart Grid Framework help industry?

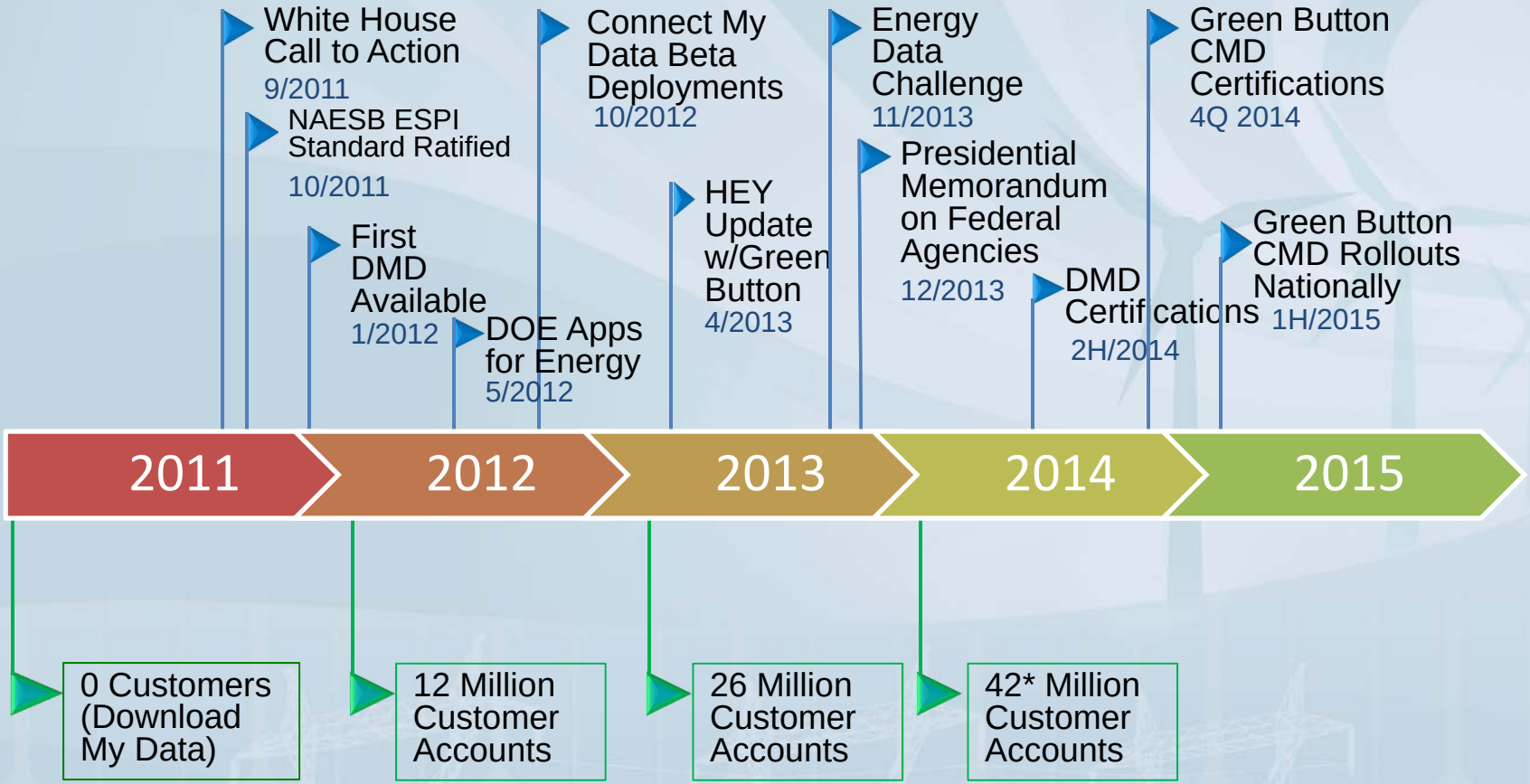
- Supports Standards-based Smart Grid Systems
  - Identifies and builds smart grid community consensus
  - Sustains momentum to identify and address standards gaps
  - Supports healthy commercial ecosystem(s) and utility-vendor interactions
  - Expands international market opportunities through alignment/harmonization
  - Supports innovation and development of new capabilities/solutions (resilience, sustainability, ..)
- Supports Testing/Certification, and Best Practices Identification
  - Connects standards, testing/certification, and implementation efforts to encourage feedback within all stages of technology development lifecycles
  - Identifies national best practices while preserving state/local flexibility
- Reduces Overall Risk
  - Identifies common building blocks to avoid reinventing everything new
  - Supports cost-effective future-looking investments

GSA Green Button pilot



- With technical support from NIST, GSA completed pilot using Green Button Connect My Data to enable cost-effective virtual energy audits with both utility meter data (Pepco) and GSA vendor (Schneider Electric) sub-meter data streams ported via GBCMD into GSA vendor building analytics (FirstFuel)

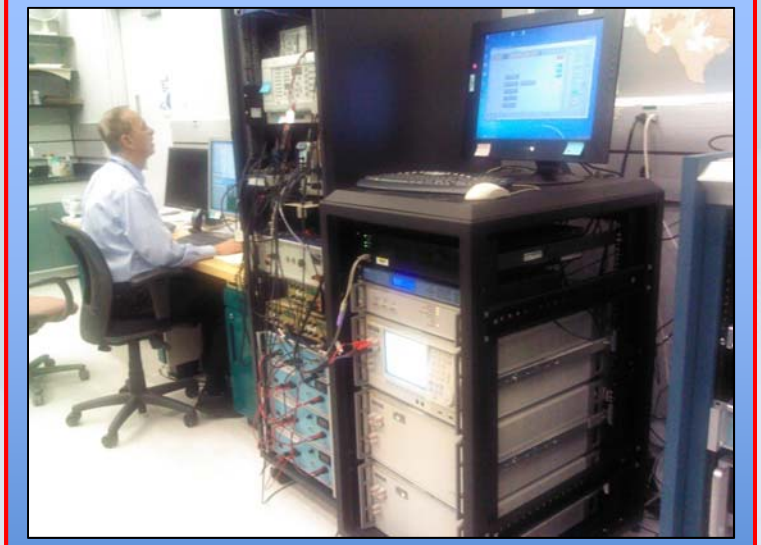
Green Button Evolution



* Represents Customer Accounts with Access to Green Button Data – Primarily Download My Data (DMD)

NIST MEASUREMENT SCIENCE RESEARCH SUPPORTING SMART GRID

Phasor Measurement Unit Performance Assessment



A NIST Grant and technical expertise supported the development of Fluke Calibration's commercially-available, fully-automated PMU calibration system.

NIST is:

- **Developing a portable system to assess performance of PMU calibrators for PMU test laboratories.**
- **Conducting a PMU testing inter-laboratory comparison.**
- **Assessing the performance of PMUs from multiple vendors (both in production and pre-production).**
  - **A NIST Interagency Report is being drafted**
  - **NIST works closely with vendors to re-test new PMU hardware and firmware versions**
- **IEEE Conformance Assessment Program (ICAP) is developing a conformance assessment program for PMUs.**

Advanced Metering in Smart Distribution Grids

Objective:

- Advance measurement science supporting performance assessment of smart meters and associated metering standards
- Develop test procedures advancing accurate & fair electricity metering

Approach:

- A smart meter testing facility to:
  - **Support development of performance test requirements ensuring accuracy for smart meters under field/real-world conditions.**
  - **Verify meter accuracy, first to 0.2% and then upgrading to an accuracy of 0.05% to support the best commercially-available meters anticipated in the near future.**

Outcomes:

- ANSI standard(s) for smart metering
- 10X improvement in measurement accuracy for NIST power and energy meter measurement services

NIST Measurement Science Research Projects

- Cybersecurity for Smart Grid Systems
- Electromagnetic Compatibility of Smart Grid Devices and Systems
- Power Conditioning Systems for Renewables, Storage, and Microgrids
- Smart Grid Communication Network
- Smart Grid National Coordination
- Smart Grid System Testbed Facility
- Wide-area Monitoring and Control of Smart Grid
- Building Integration with Smart Grid
- Smart Grid Testing and Certification
- Precision Timing for Smart Grid Systems

Muchas Gracias

Thank You For Your Attention