Setting Standards for the Smart Grid: The NIST Interoperability Framework - Interconnection Standards -

Al Hefner

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National Institute of Standards and Technology

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October 30, 2009

Energy Today

- **Today's electric power grid:**
  - **Electricity is generated at large central plants by rotating machines that produce 60 Hz AC**
  - **Electricity is delivered through a unidirectional, passive grid where conversion is achieved using 60 Hz transformers**
  - **Not much storage: Generation must instantaneously match loads using only load shedding at large facilities**
  - **Fault clearing requires large excess grid capacity**

- **Today's fossil energy consumption:**
  - **Transportation is large fraction of fossil energy consumption using low efficiency variable torque combustion engines**
  - **Large central coal plants have lowest energy cost but emit CO2**
  - **Natural Gas (NG) is used at central plants and is delivered through the existing pipeline infrastructure**

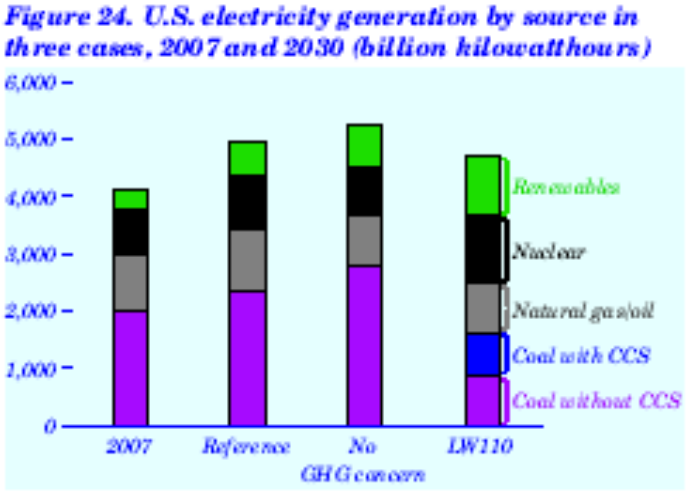
U.S. Electricity Production

Including CO2 Concern !!!

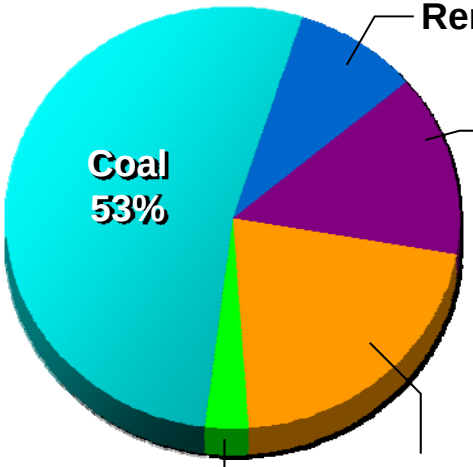
EIA/DOE AEO2009

Annual Energy Outlook

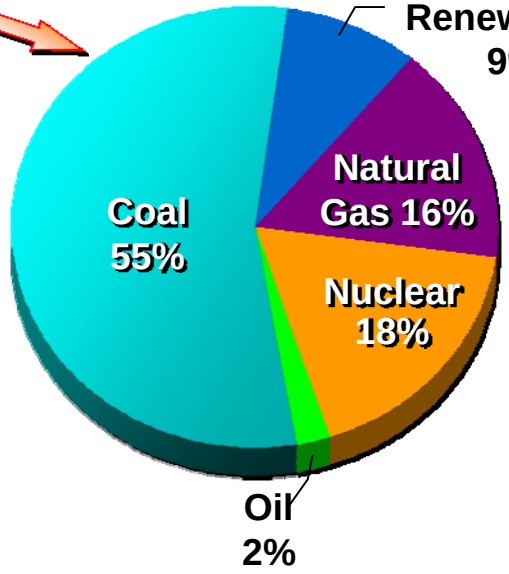
2005



2030



33% Growth



2025

Without CO2 Concern !!!

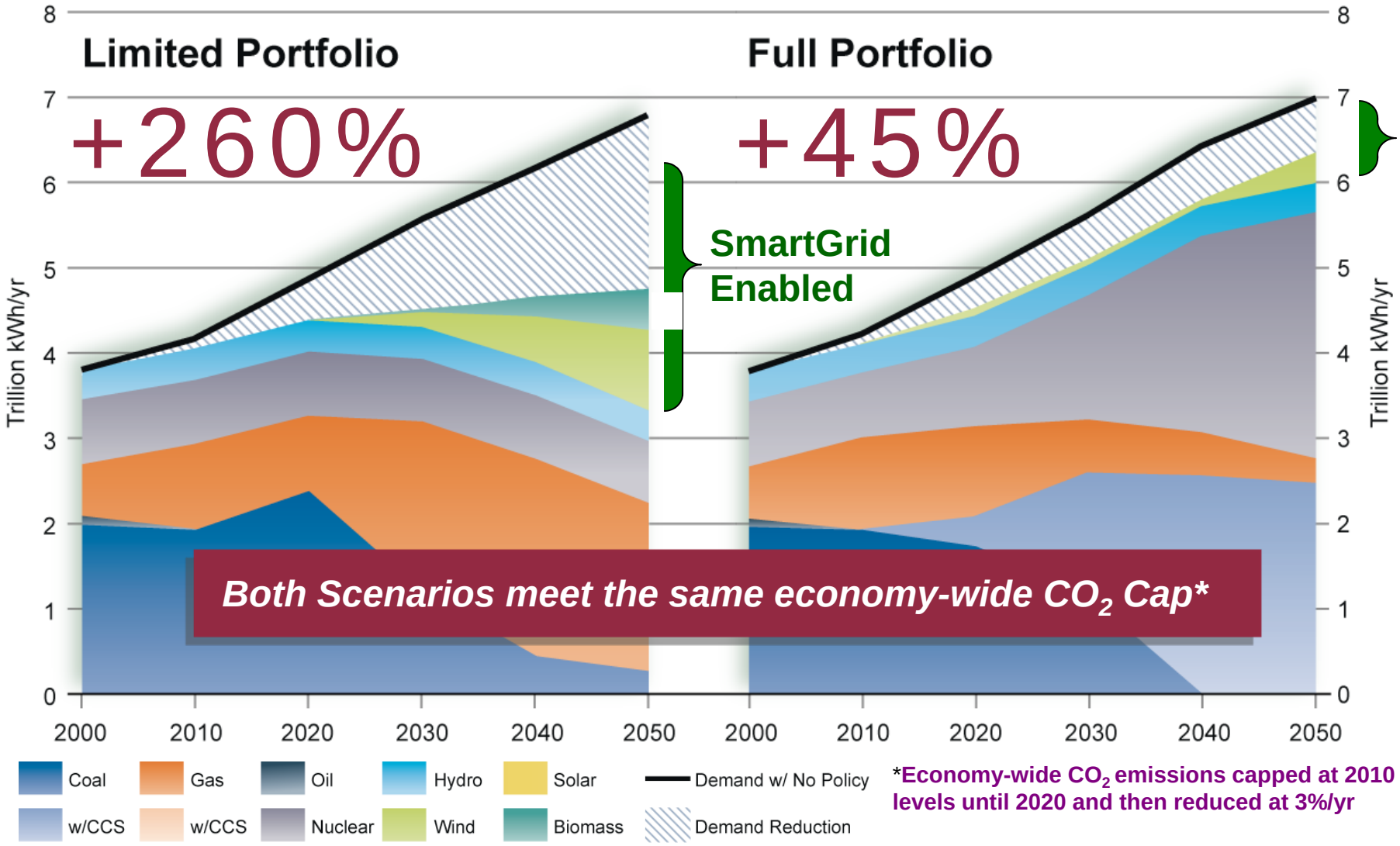
EIA/DOE AEO2004

Annual Energy Outlook

Table A2

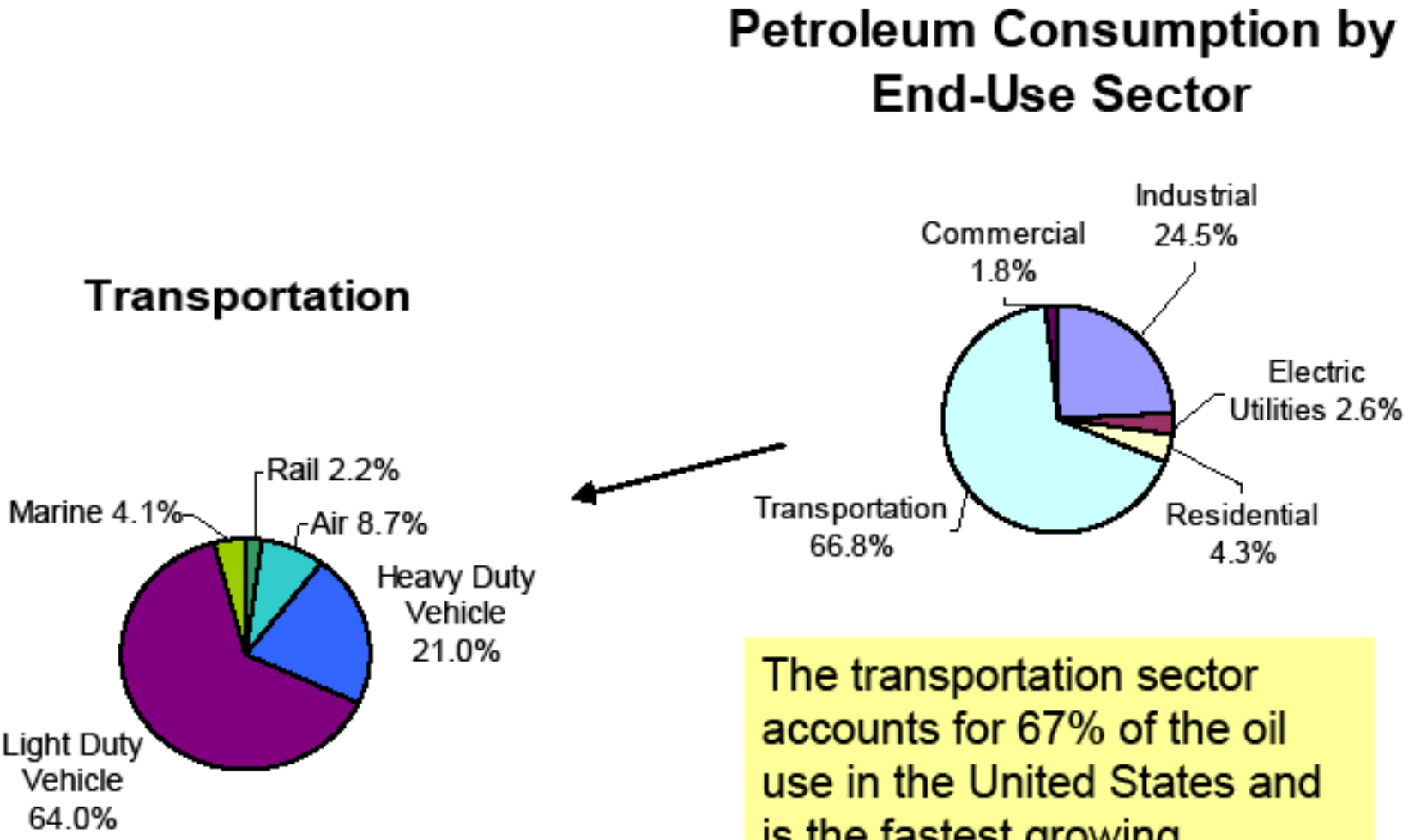
EPRI MERGE Analysis (2008 Revision)

Increase in Real Electricity Prices…2000 to 2050



*Economy-wide CO_2 emissions capped at 2010 levels until 2020 and then reduced at 3%/yr

Transportation Accounts for the Majority of US Oil Consumption



The transportation sector accounts for 67% of the oil use in the United States and is the fastest growing petroleum consuming sector.

Future Energy Transition

- **Renewable and Clean power generation/transportation:**
  - **Gasified coal enables higher efficiency and CO2 capture**
  - **High-megawatt electric drive compressors enable efficient CO2 sequestration at large central coal and NG plants**
  - **Electric power delivery grid is enhanced to enable integration of dispatchable renewable energy sources**
  - **Grid storage is introduced to improve grid stability and larger amounts of variable/intermittent renewable energy sources**
  - **Dispatachable loads and micro-grids enhance grid capacity**
  - **Plug-in vehicles increase efficiency, provide additional grid storage, and use diverse (non petroleum) low CO2 sources**
  - **LNG refrigeration enables long distance transport**

- ***This new paradigm requires advanced cost effective High-Megawatt Power Conditioning Systems (PCS)!***

What Will the Smart Grid Look Like?

- High use of renewables – 20% – 35% by 2020
- Distributed generation and microgrids
- “Net” metering – selling local power into the grid
- Distributed storage
- Smart meters that provide near-real time usage data
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Accelerated Standards Process

- Executives meeting with Secretaries Locke and Chu in May
- Workshops with more than 1500 participants
  - April 28-29, 2009
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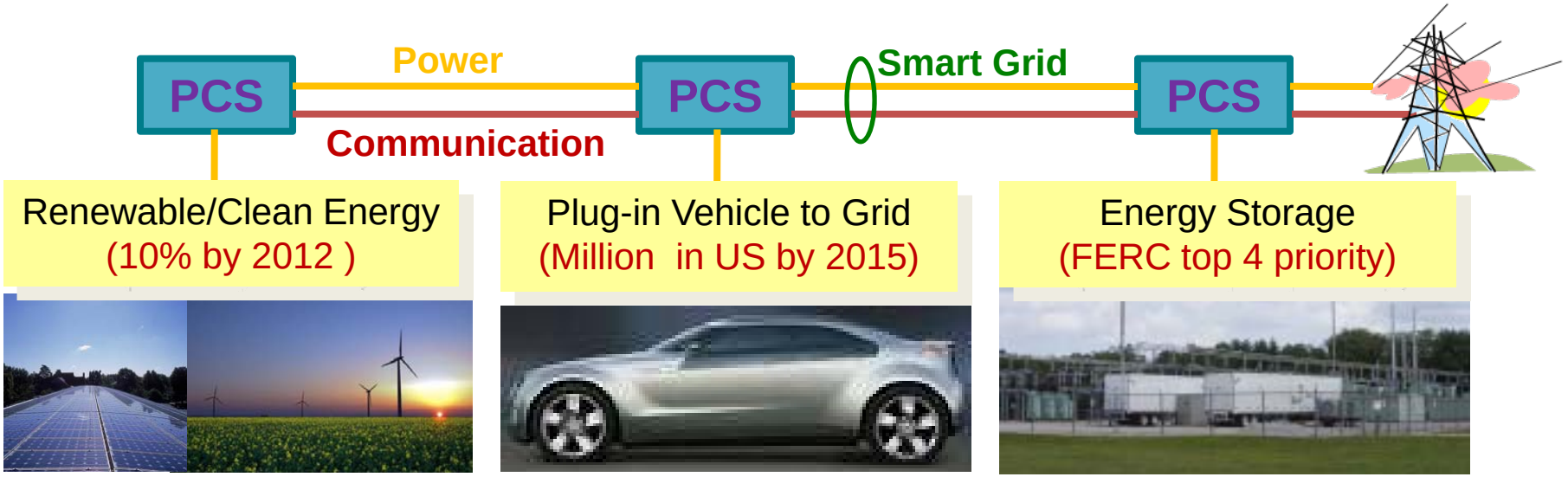
High Penetration of Renewables and PEVs



- Power Conditioning Systems (PCS) convert to/from 60 Hz AC for interconnection of renewable energy, electric storage, and PEVs

- "Smart Grid Interconnection Standards" required for devices to be utility controlled operational asset and enable high penetration:
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  - **Accommodate faults faster, without cascading area-wide events**
  - **Voltage/frequency control and utility controlled islanding**

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Priorities for Standardization

- Demand Response and Consumer Energy Efficiency
- Wide Area Situational Awareness
- Electric Storage
- Electric Transportation
- Advanced Metering Infrastructure
- Distribution Grid Management
- Cyber Security
- Network Communications

What are Priority Action Plans (PAPs)

- NIST workshops identified priority standards issues
  - many standards require revision or enhancement
  - and new standards need to be developed to fill gaps
- 70 standards gaps and issues were identified
- NIST determined which issues require most urgent resolution and selected top 14 to initiate PAPs
- The August SDO Workshop was used to develop the action plan for each priority issue.
- Current status for each PAP is posted on the NIST website
  - broad SDO and stakeholder support and participation
  - aggressive milestones in 2009 or early 2010 established
- NIST and the Smart Grid Interoperability Panel will guide and oversee progress on PAPs and development of new PAPs.

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Priority Action Plans	Target Date
Smart meter upgradeability standard	completed
Common specification for price and product definition	early 2010
Common scheduling mechanism for energy transactions	year-end 2009
Common information model for distribution grid management	year-end 2010
Standard demand response signals	January 2010
Standard for energy use information	January 2010
IEC 61850 Objects / DNP3 Mapping	2010

Priority Action Plans (continued)	Target Date
Time synchronization	mid-2010
Transmission and distribution power systems models mapping	year-end 2010
Guidelines for use of IP protocol suite in the Smart Grid	mid-year 2010
Guidelines for use of wireless communications in the Smart Grid	mid-year 2010
Electric storage interconnection guidelines	mid-2010
Interoperability standards to support plug-in electric vehicles	December 2010
Standard meter data profiles	year-end 2010

Electric Storage Interconnection Guidelines

SG Standards Need

- Interconnection and object model standards needed for:
  - DER grid operational interface with dispatchable: VAR, V, F, etc.
  - support for energy storage devices (ES), including PEV
  - and hybrid generation-storage systems (ES-DER)

PAP Major Objectives

- Revised and updated consistent guidelines and standards:
  - Involve broad set of **Stakeholders**: SDOs, utilities, vendor, etc.
  - **Scoping Document** to determine priorities and timeline for standards development for spectrum of applications (Oct. 09)
  - **IEEE 1547 revisions** for urgent applications (mid-2010)
  - Consistent **object models** for DER, ES, ES-DER in IEC 61850-7-420
  - UL, NEC-NFPA70, SAE **guidelines for safe, reliable implementation**

http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP07Storage

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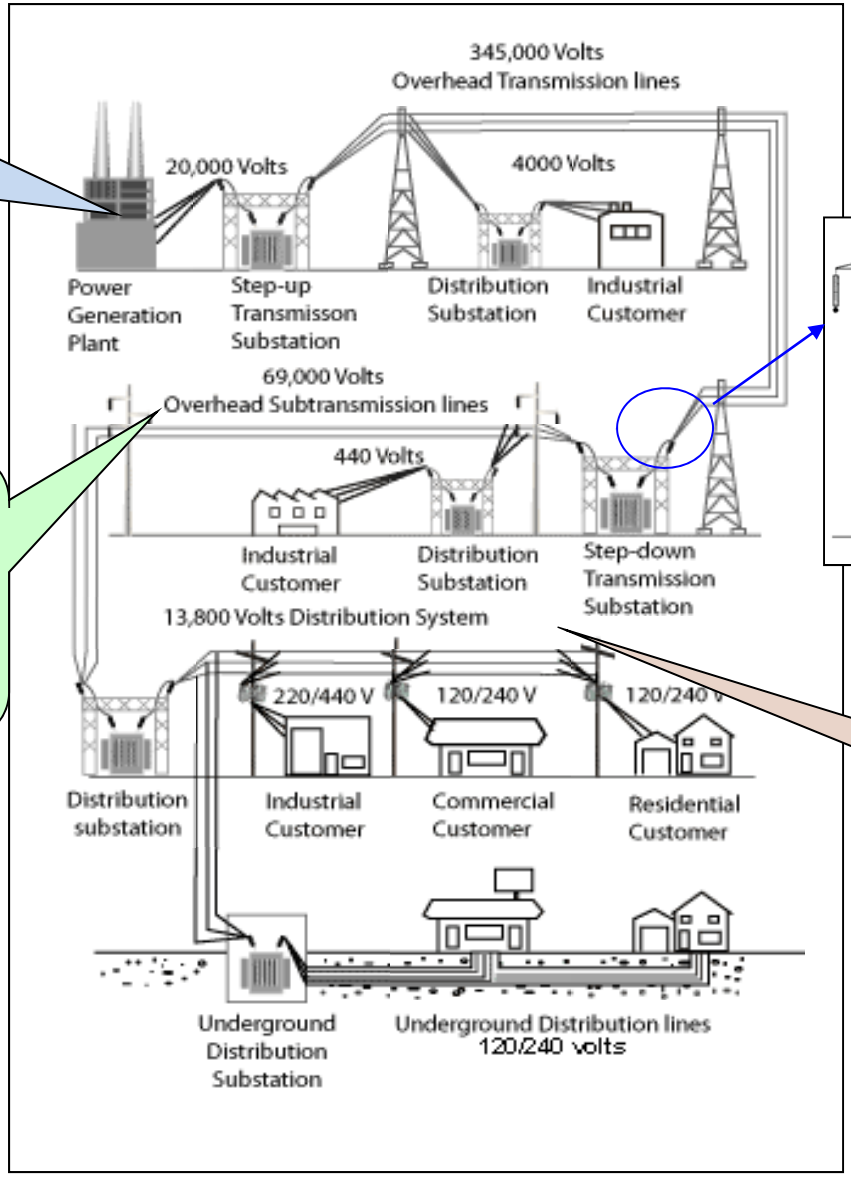
Renewable/Clean Energy Interconnects

Central Station

Clean Coal (IGFC) > 300 MW

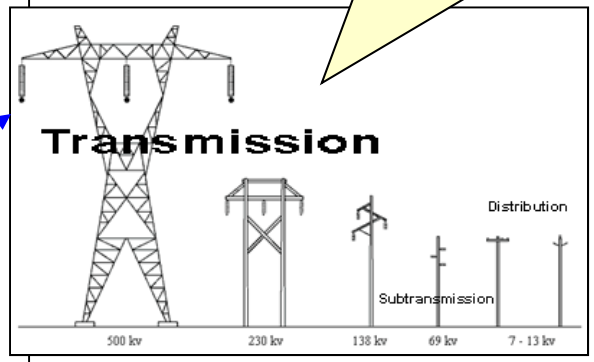
Transmission, sub-transmission

Large wind farms, central PV, biopower, hydro, geothermal, hydrokinetic



Transmission

HVDC, FACTS, Smart Grid, Islanding



Distribution + Consumer

PV, small wind, fuel cells, and Plug-in EV

Storage PAP Task Interactions

Task 0: Scoping Document

Prioritized timeline for ES-DER standards

Task 1: Use Cases

Define requirements for different scenarios

Task 2: IEEE 1547.4 for island applications and IEEE 1547.6 for secondary networks

Task 3: Unified interconnection method with multifunctional operational interface for range of storage and generation/storage.

- Task 3a: IEEE 1547.8.1 – Operational interface
- Task 3b: IEEE 1547.8.2 – Storage without gen
- Task 3c: IEEE 1547.8.3 – PV with storage
- Task 3d: IEEE 1547.8.4 – Wind with storage
- Task 3e: IEEE 1547.8.5 – PEV as storage

PAP 11,12

Task 4: Develop and Harmonize Object Models

IEC61850-7-420 : Expanded to include multifunctional ES-DER operational Interface; harmonized with SEP, CIM, MultiSpeak

Task 5: Safe and Reliable Implementation

UL, NEC-NFPA70, SAE, and CSA

Task 0: Scoping Study Document

SMART GRID

- Ch. 3: EPS Applications
  - Storage
  - Renewable w/ Storage

Appendix 2: Power Electronics Technologies

- Ch. 4: Interconnect
  - Functions
  - Capacities, Cycle cost

Appendix 1: Storage Technologies

- Ch. 8: Storage Types
  - Capacities, Cycle cost
  - Availability, Schedule

UCs

Ch. 6: Business Issues

- 9.2 Business model timeline

Ch. 7: Existing Standards

- 9.3 Standards timeline

Ch. 5: Regulatory Issues

- 10.x Regulation timeline

Scoping Study Outline (Page 1)

1. Executive Summary

2. Introduction

- *NIST Smart Grid Interoperability Framework and Panel*
- *Storage PAP*
- *Goals of this Scoping Study*
- *Discussion*

3. EPS Applications for Dispatchable ES-DER

- *Domain and Location Specific Requirements*
- *Applications*
- *EPS Control Parameters*

Scoping Study Outline (Page 2)

4. Electrical Interconnection of ES-DER

- *Role of Mechanical Rotating Machinery as the grid operational interface for generation and storage*
- *Role of Electronic Power Conditioning Systems (PCSs) as the grid operational interface for generation and storage*
- *Dispatchable DER generation with multifunctional grid operational interface*
- *Dispatchable ES-DER generation-storage with multifunctional grid operational interface*

5. Regulatory Issues for ES-DER

- *Wholesale Regulation*
- *FERC Wholesale Market Deregulation*
- *Retail Regulation*

Scoping Study Outline (Page 3)

6. Business Issues for ES-DER

- *Wholesale / System Markets*
- *Renewable Integration*
- *Utility T&D Grid Support*
- *Commercial and Industrial*
- *Distributed Storage near pad mounted transformer sites*
- *Residential Applications*

7. General Standards and Implementation Guidelines for ES-DER

- *Electrical Interconnection Standards*
- *Standards and guidelines for safe and reliable implementation*
- *Information/Object Model Standards*

Scoping Study Outline (Page 4)

8. **Specific Standards needs for ES-DER Technologies/Applications**
   - *Summary of Storage Technology Data considered in this Scoping Study (details in Appendix 1)*
   - *Comparing Technology with Application Requirements (physical/logical)*
   - *Parameters/Relationships that define capacity/availability/cycle cost for storage technologies/applications*
   - *Examples of companies providing storage technologies*

9. **Detailed Timeline and Specifications for High Priority Standards**
   - *Prioritization of Standards for Development*
   - *Detailed specifications for high Priority Interconnection*

Scoping Study Outline (Page 4)

10. Summary and Recommendations to SDOs/Regulators

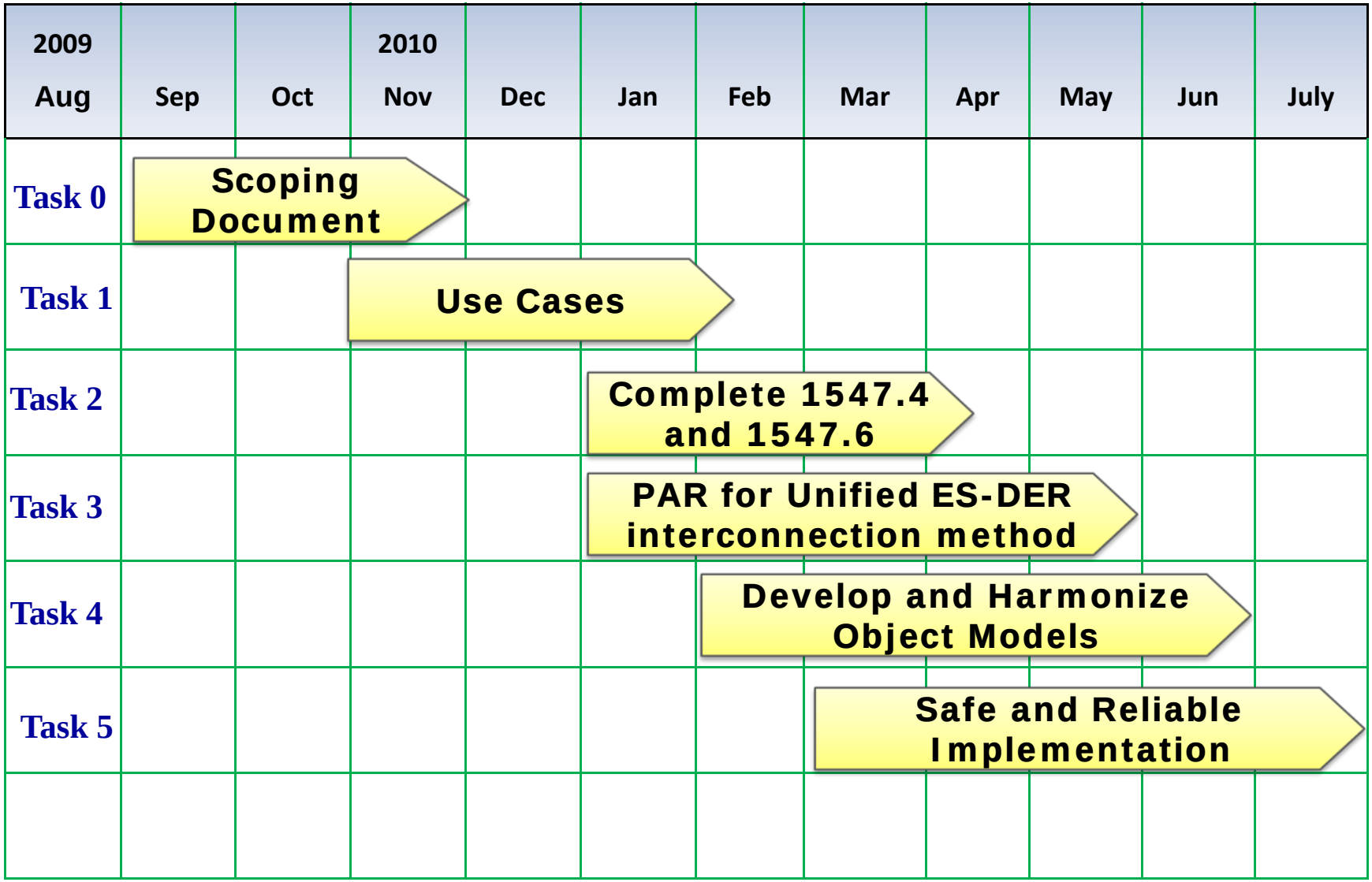
Appendix 1: Storage Technology Type Data and Classification

- *Storage Type data used for the Scoping Study*
- *Classification of Types of Storage*
- *Examples of Companies providing Storage*

Appendix 2: Types of Power Conditioning Systems

- *Battery charger for battery bank energy storage system*
- *Community/residential energy storage*
- *Battery fast charging (filling) station for electric vehicles*
- *STATCOM with energy storage*
- *Storage in wind applications*
- *Solar parks*
- *Renewable power plant monitoring and control*

Use Case Analysis and Other Tasks



Setting Standards for the Smart Grid: The NIST Interoperability Framework - Overview -

Jerry FitzPatrick
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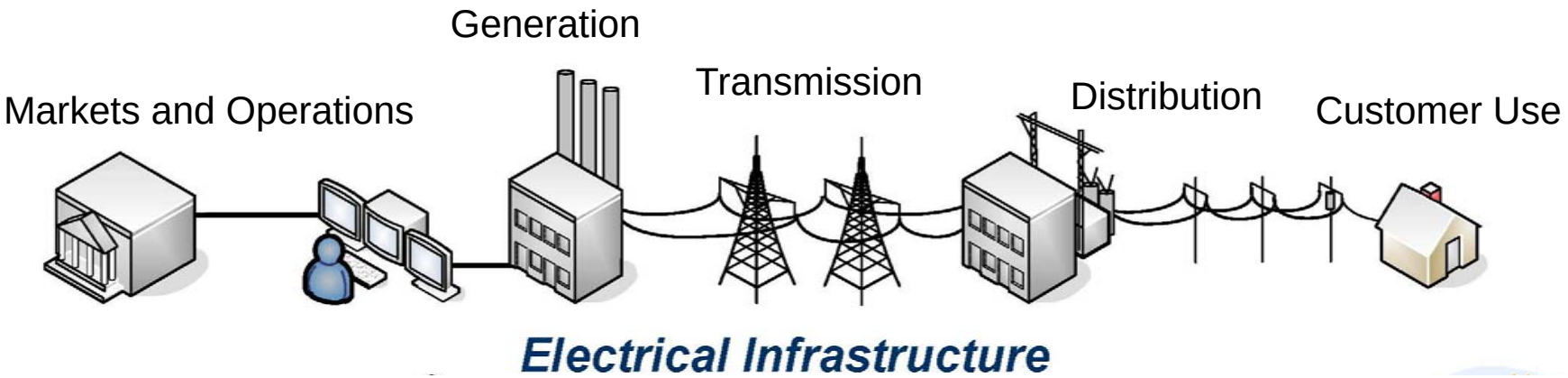
December 11, 2009

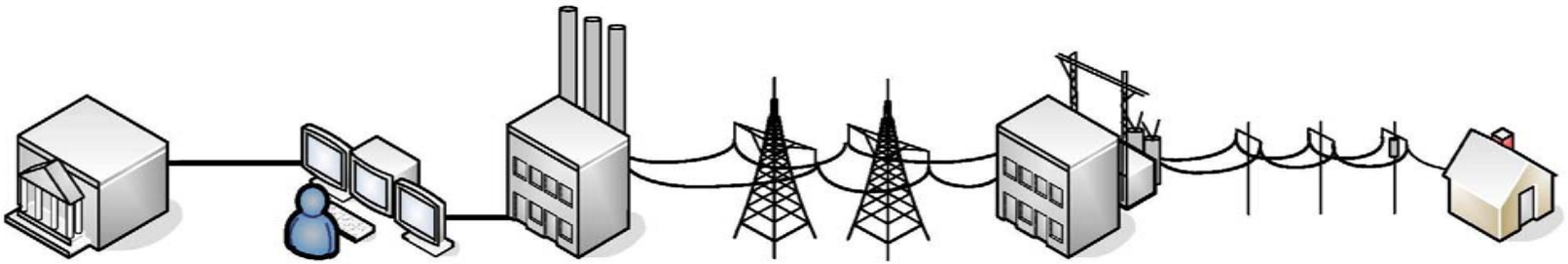
Today's Electric Grid



One-way flow of electricity

Centralized, bulk generation
Heavy reliance on coal and oil
Limited automation
Limited situational awareness
Consumers lack data to manage energy usage

"Smart Grid" = Electric Grid + Intelligence

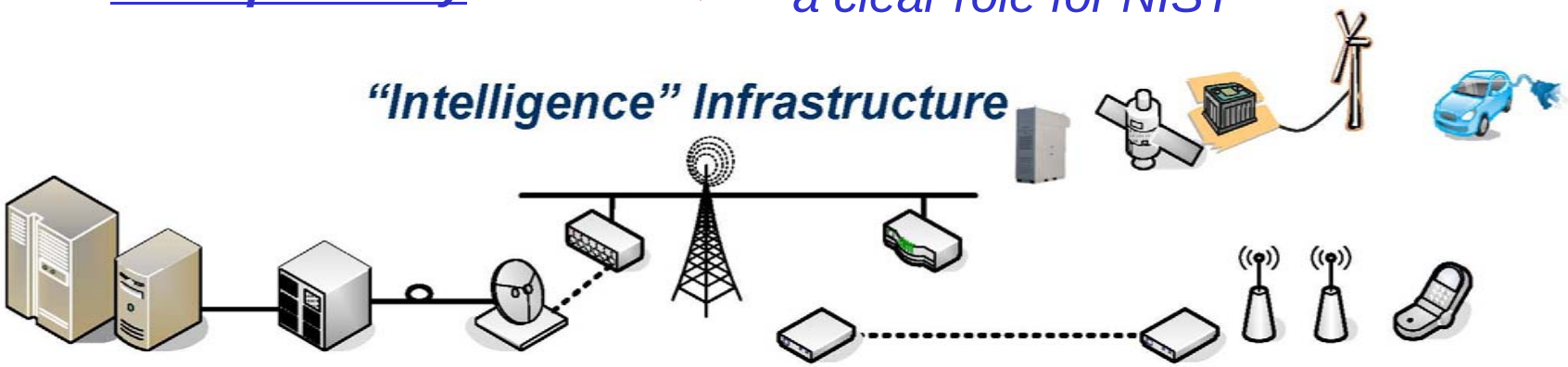


Electrical Infrastructure

Combining electrical and information infrastructure requires interoperability…

Interoperability requires reliable standards and validated performance – *a clear role for NIST*

"Intelligence" Infrastructure



Graphics courtesy of EPRI

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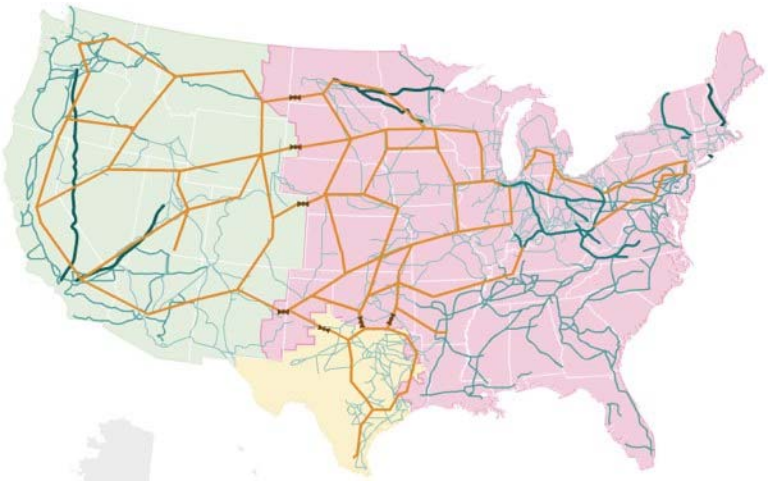
Why Do We Need Smart Grids?

Fundamental Drivers

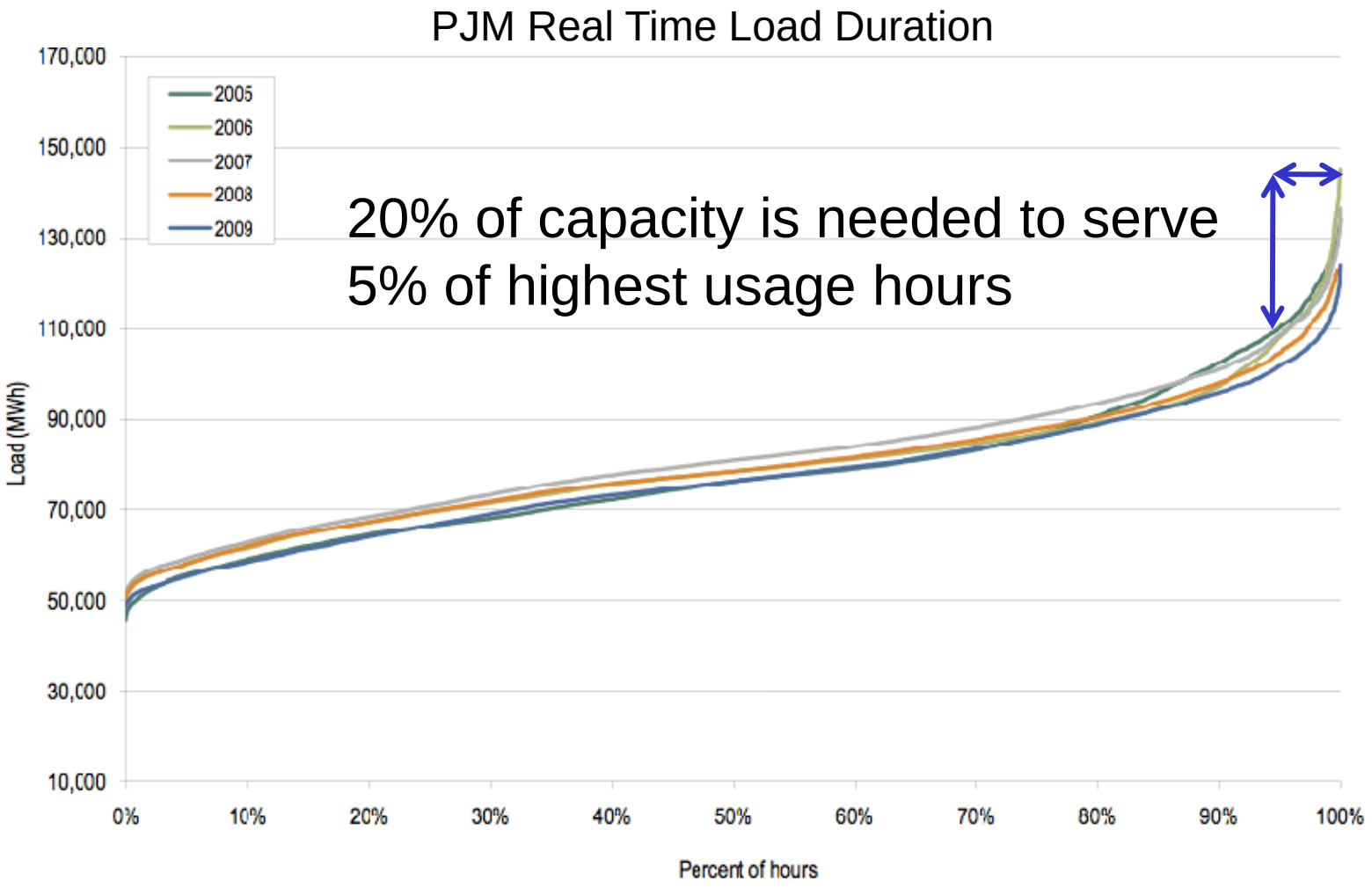
- Climate change
- Energy security
- Lifestyle dependent on electricity
- Jobs



Smart Grid goals

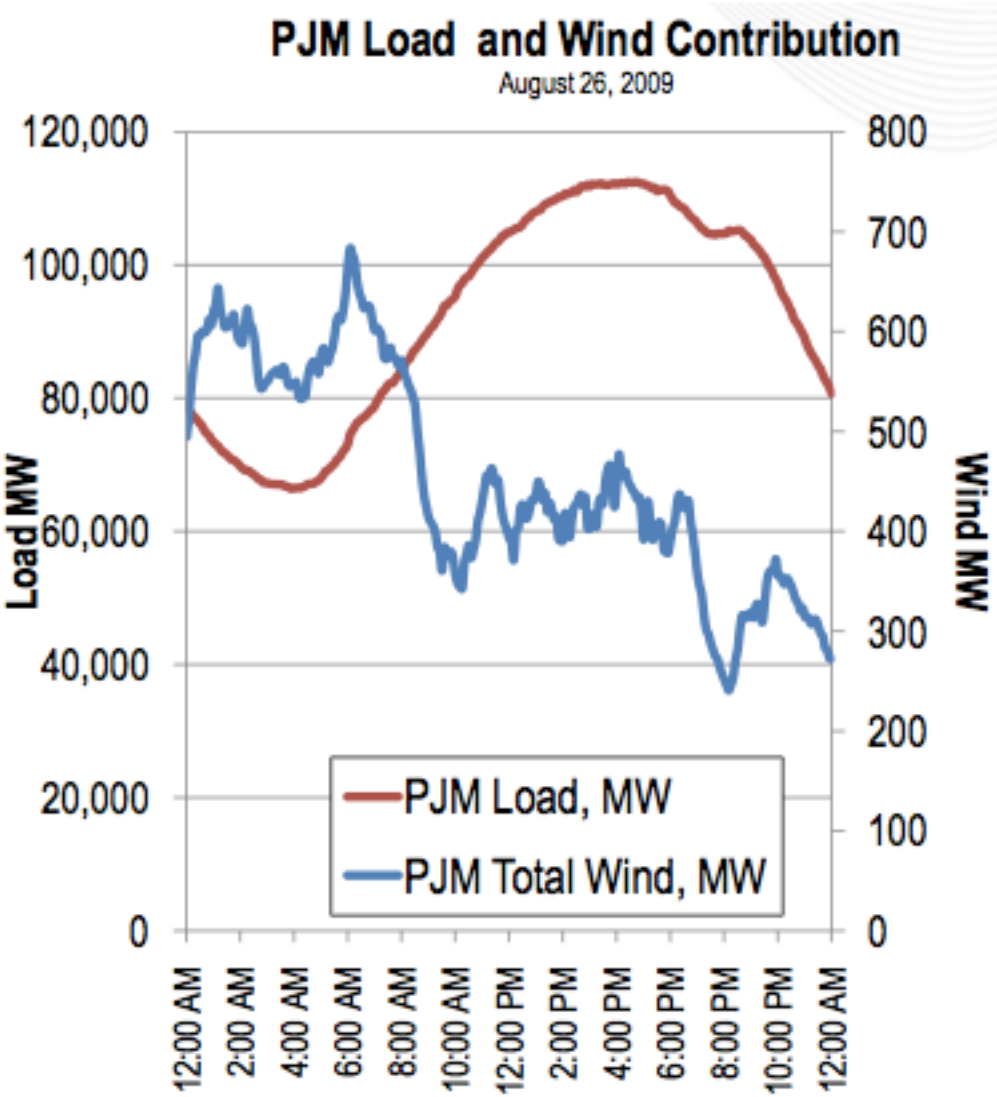
- Reduce energy use overall and increase grid efficiency
- Increase use of renewables (wind and solar don't produce carbon)
- Support shift from oil to electric transportation
- Enhance reliability and security of the electric system

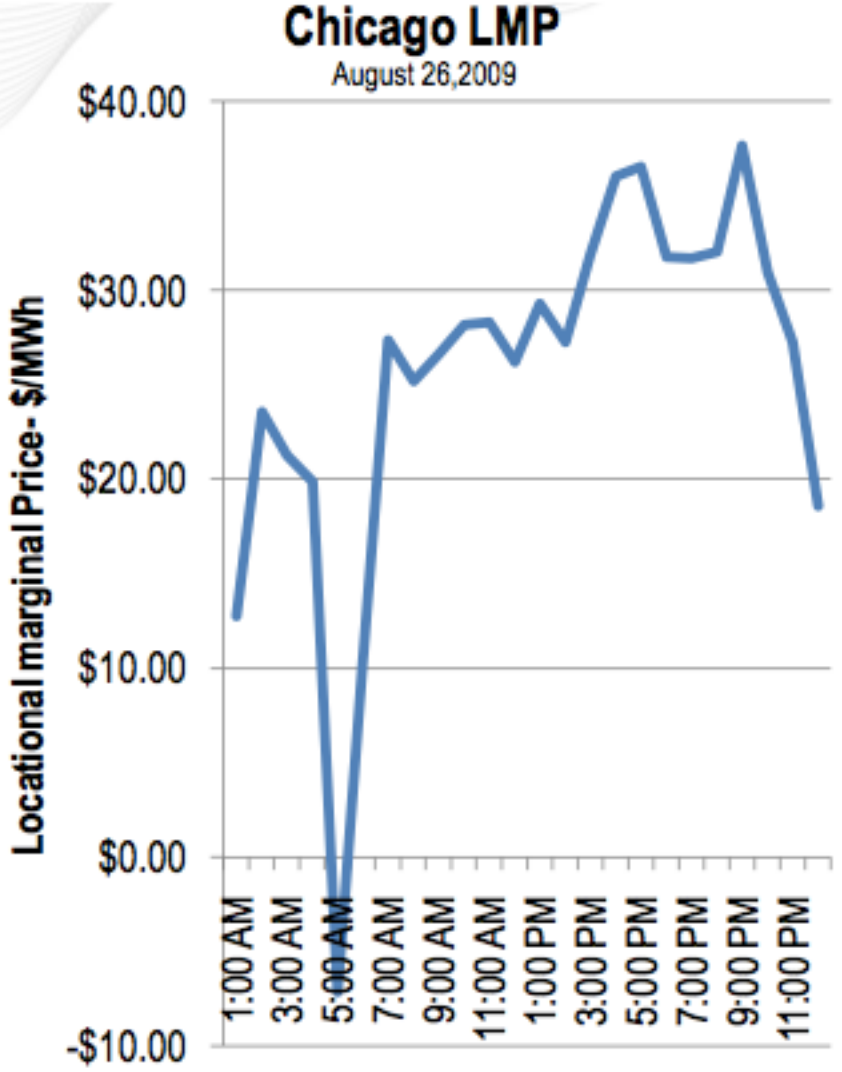
Current Grid is Inherently Inefficient



Source: PJM

Integration of Renewables Presents New Challenges due to Variability





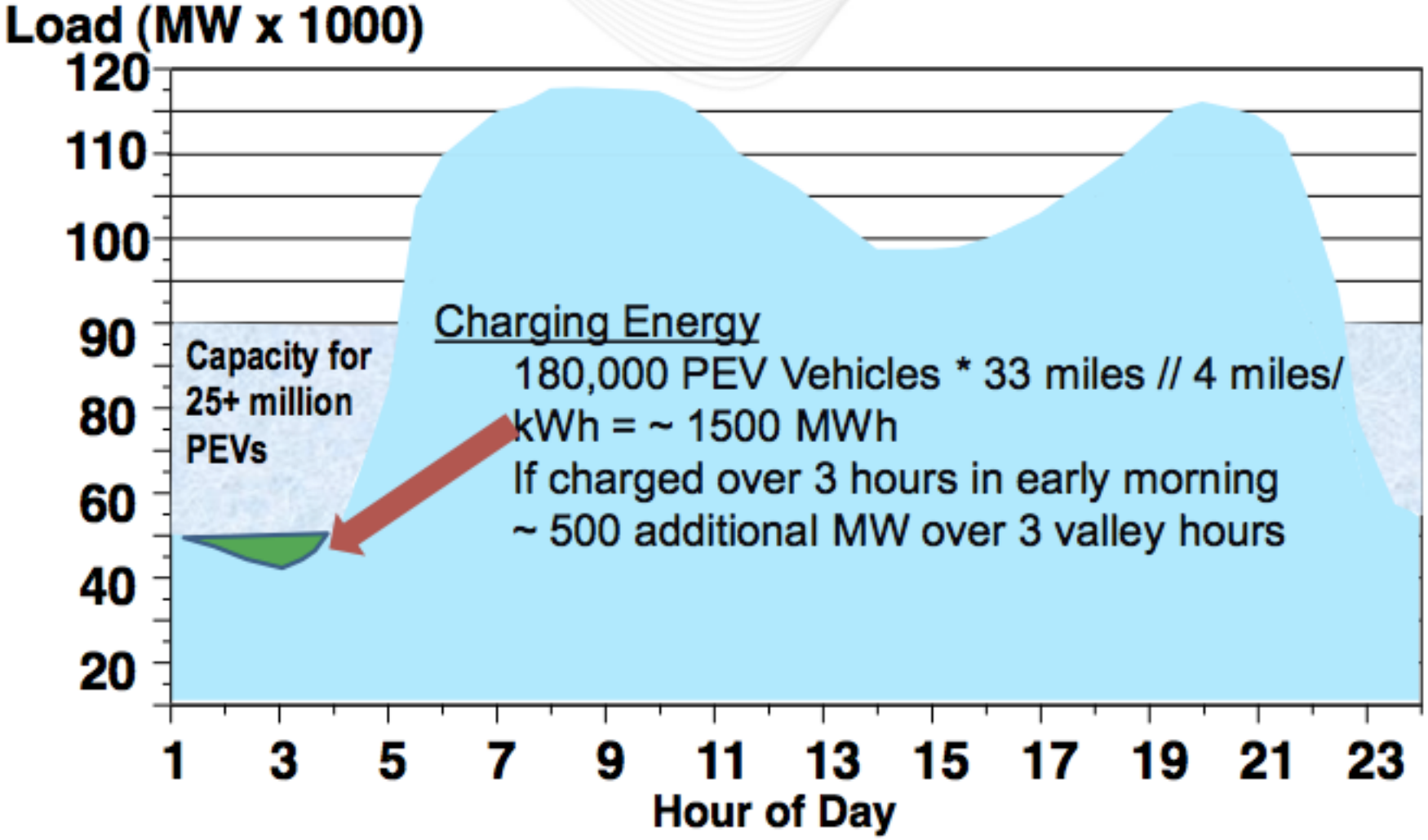
Source: PJM

Why Electric Vehicles?

Electrification of transportation could

- Displace half of US oil imports
- Reduce CO_2 20%
- Reduce urban air pollutants 40%-90%
- Idle capacity of the power grid could supply 70% of energy needs of today's cars and light trucks

Grid Can Handle PEV Demand – if Charging is Managed



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What Will the Smart Grid Look Like?

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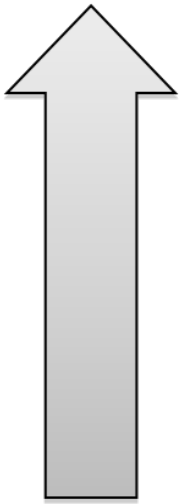
Government Roles in Smart Grid

Federal



U.S. DEPARTMENT OF ENERGY

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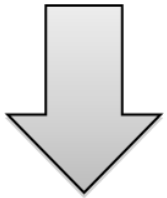
Federal Energy Regulatory Commission



State

Public Utility Commissions

The NIST Role

Energy Independence and Security Act (EISA) of 2007
Title XIII, Section 1305.
Smart Grid Interoperability Framework

In cooperation with the DoE, NEMA, IEEE, GWAC, and other stakeholders, **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**…"

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Energy Independence and Security Act

Defines ten national policies for the Smart Grid:

1. Use digital technology to improve reliability, security, and efficiency of the electric grid
2. Dynamic optimization of grid operations and resources, with full cyber-security
3. Integration of distributed renewable resources
4. Demand response and demand-side energy-efficiency resources
5. Automate metering, grid operations and status, and distribution grid management
6. Integrate `smart' appliances and consumer devices
7. Integrate electricity storage and peak-shaving technologies, including plug-in electric vehicles
8. Provide consumers timely information and control
9. Interoperability standards for the grid and connected appliances and equipment
10. Lower barriers to adoption of smart grid technologies, practices, and services.

Why Do We Need Standards?

Whirlpool Corporation To Produce One Million Smart Grid-Compatible Clothes Dryers by the End of 2011…

Standards needed to communicate price information, schedules, demand response signals

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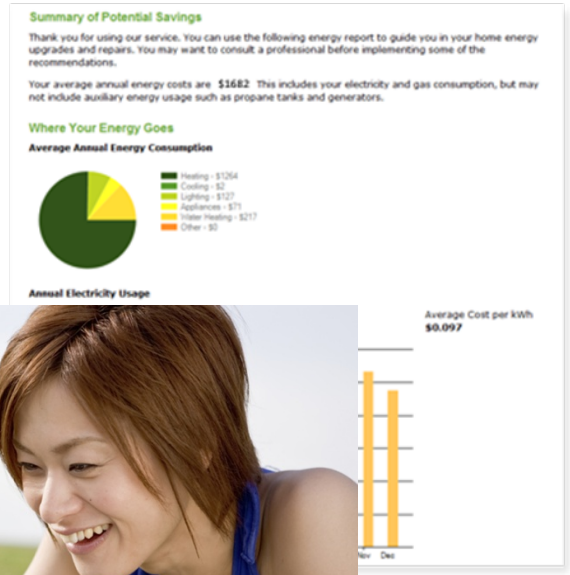
Why Do We Need Standards?

Google PowerMeter

Microsoft® hohm™ beta



Standard interface to access energy usage information from smart meters and utility information systems

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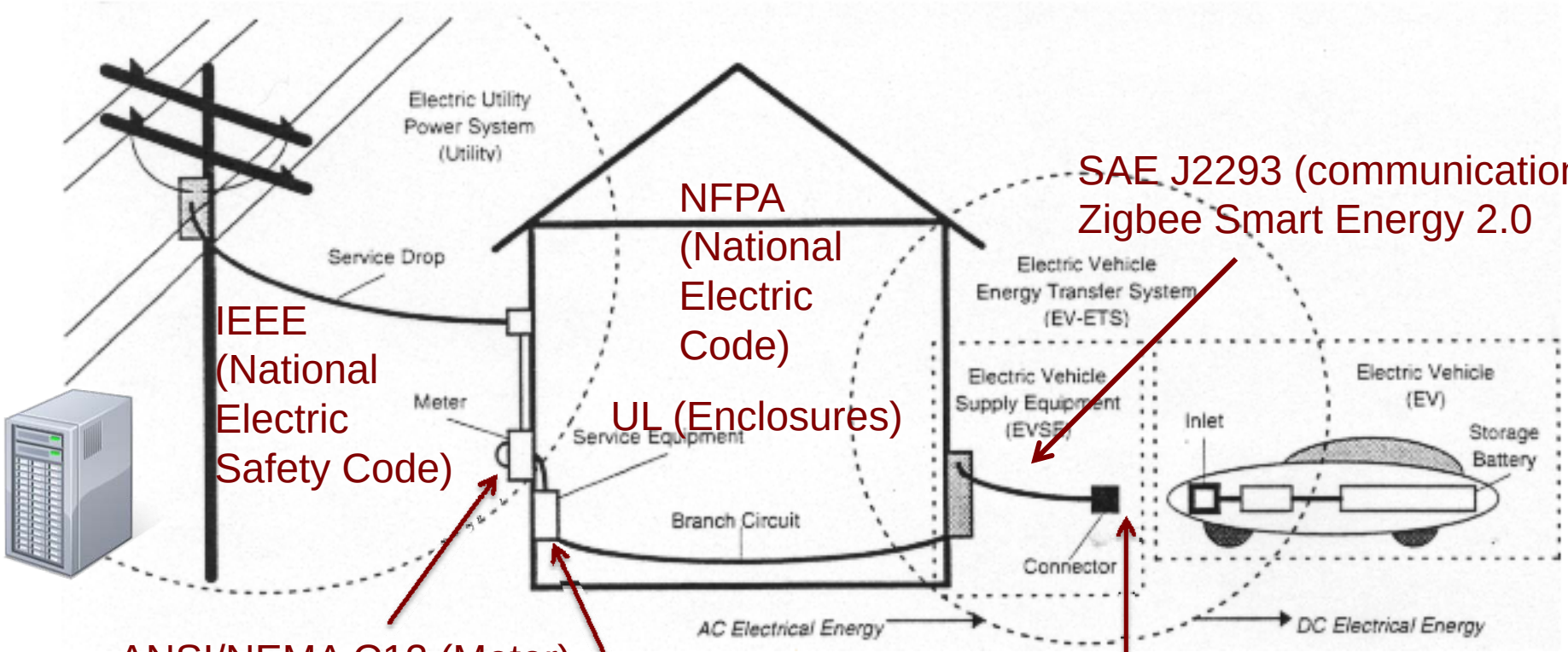
The Need for Standards is Urgent

Example: Smart Meters

- $40 - $50 billion dollar deployment nationwide
- Underway now
- ARRA will acclerate
- Rapid technology evolution
- Absence of firm standards

Source: Congressional Research Service Report

Electric Vehicles Require Many Standards



IEEE (National Electric Safety Code)

NFPA (National Electric Code)

UL (Enclosures)

SAE J2293 (communication)
Zigbee Smart Energy 2.0

ANSI/NEMA C12 (Meter)

SAE J1772 (connector)

IEEE 1547 (distributed energy interconnection)

IEC 61850 and 61970/61968 (information models)

NAESB, OASIS (price and demand response signalling)

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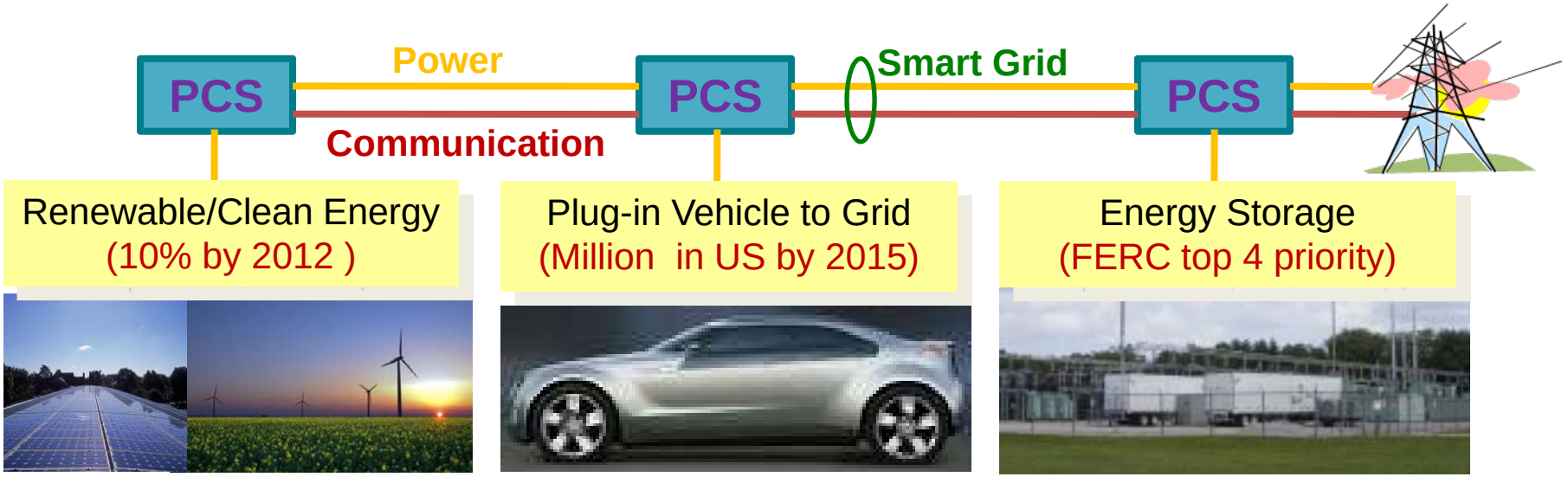
High Penetration of Renewables and PEVs



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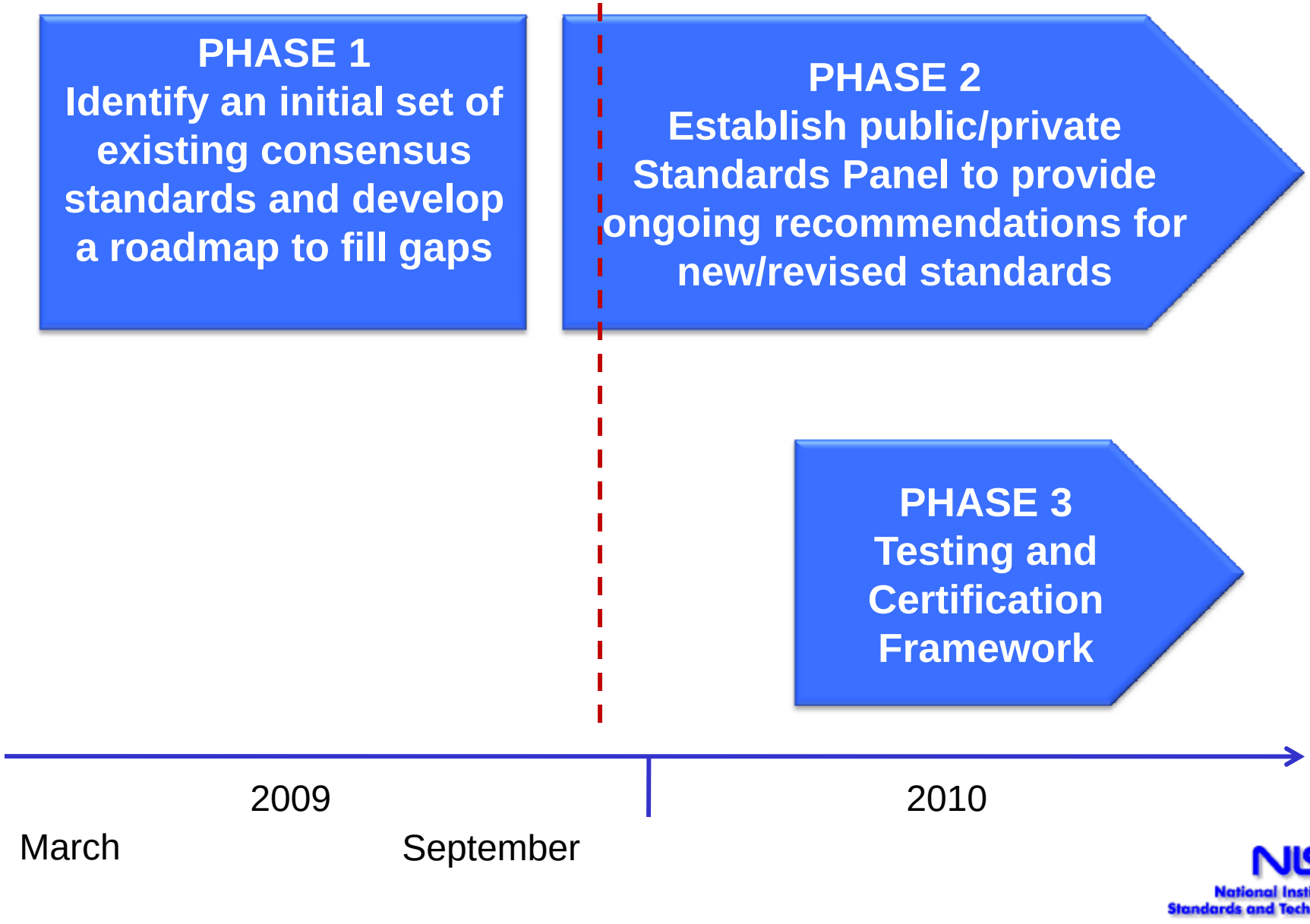
NIST Three Phase Plan



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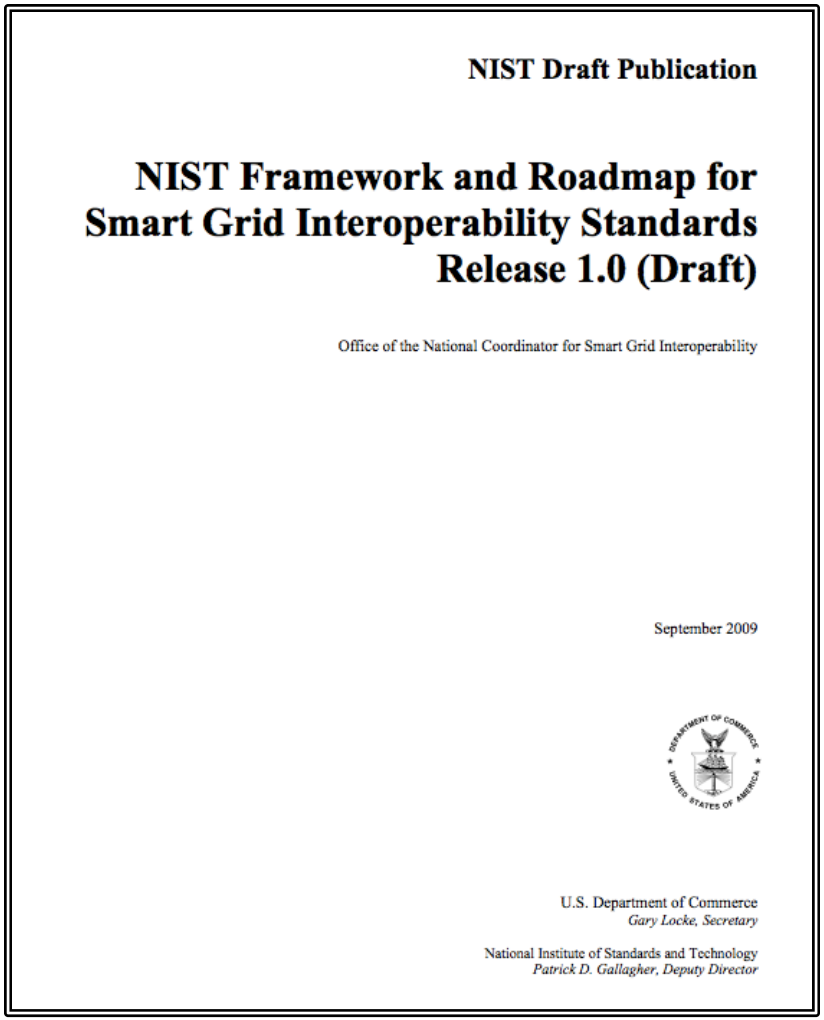
Draft Release 1.0 Framework

- Smart Grid Vision
- Reference Model
- 77 standards identified
- 14 priority action plans to fill gaps
- Cyber security strategy
- Next steps



NIST Draft Publication

NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0 (Draft)

Office of the National Coordinator for Smart Grid Interoperability

September 2009

U.S. Department of Commerce
Gary Locke, Secretary

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

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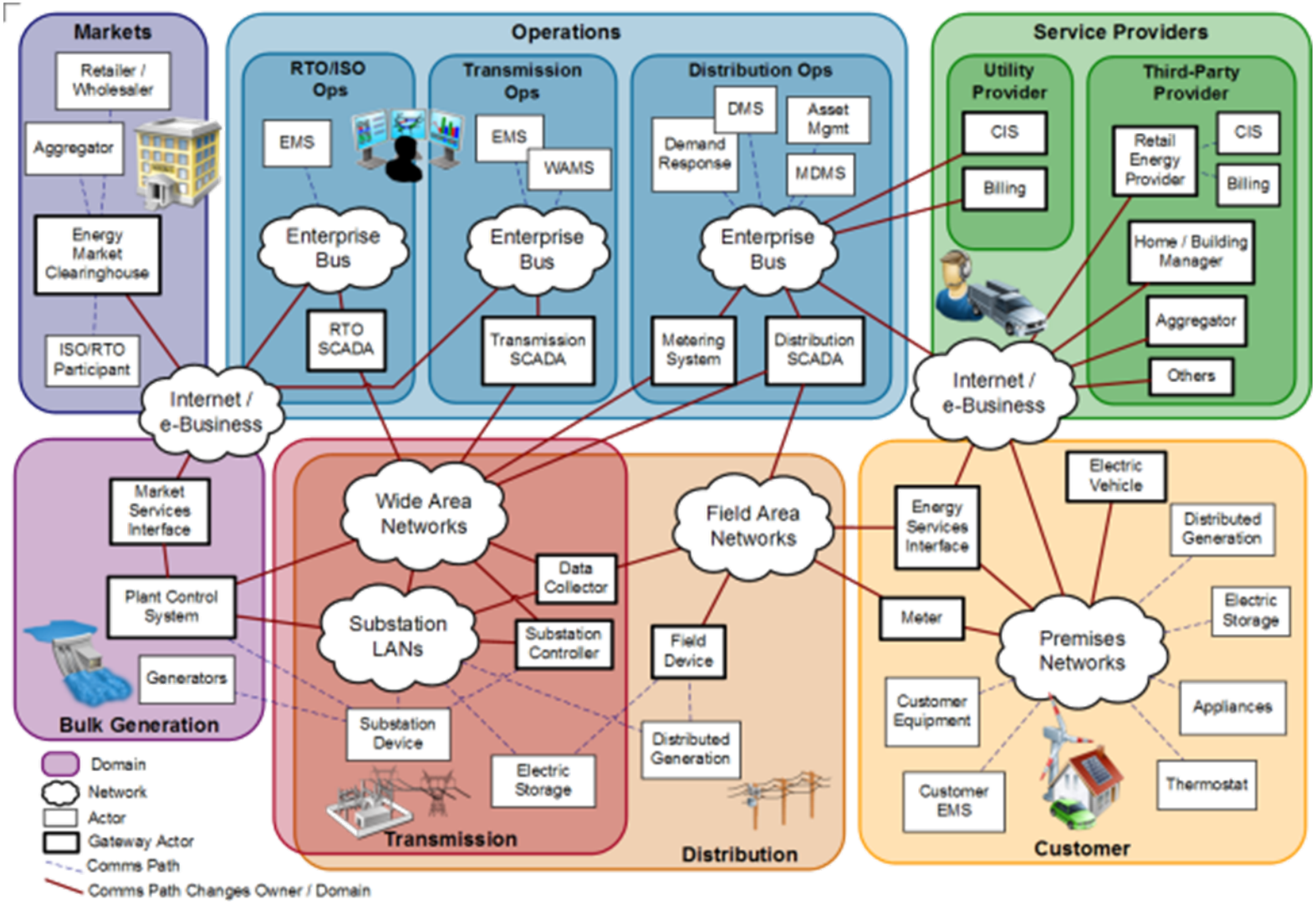
NIST Smart Grid Reference Model



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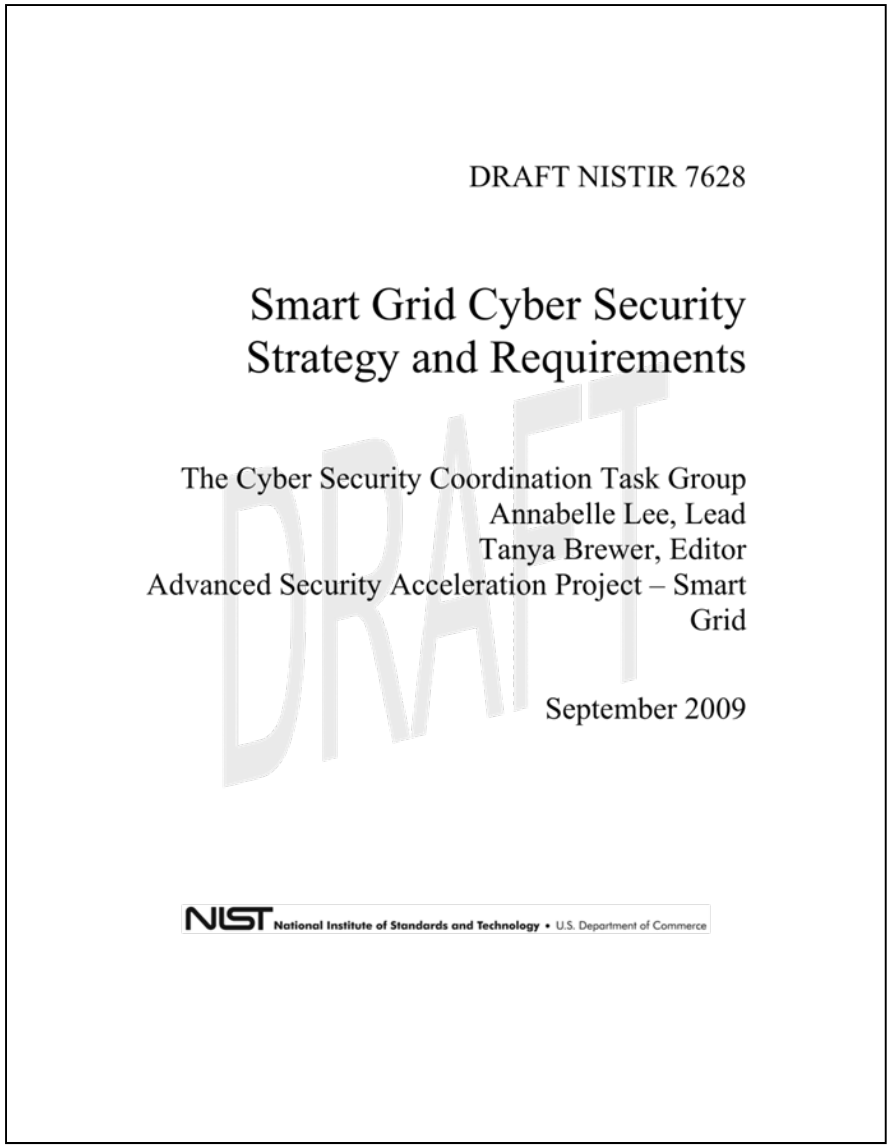
Smart Grid Cyber Security Strategy



DRAFT NISTIR 7628

Smart Grid Cyber Security Strategy and Requirements

The Cyber Security Coordination Task Group
Annabelle Lee, Lead
Tanya Brewer, Editor
Advanced Security Acceleration Project – Smart Grid

September 2009

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- Use Case Analysis
- Risk Assessments
  - Vulnerabilities
  - Threats
  - Impacts
- Security Architecture
- Security Requirements
  - AMI included in draft
- Standards
- Conformance

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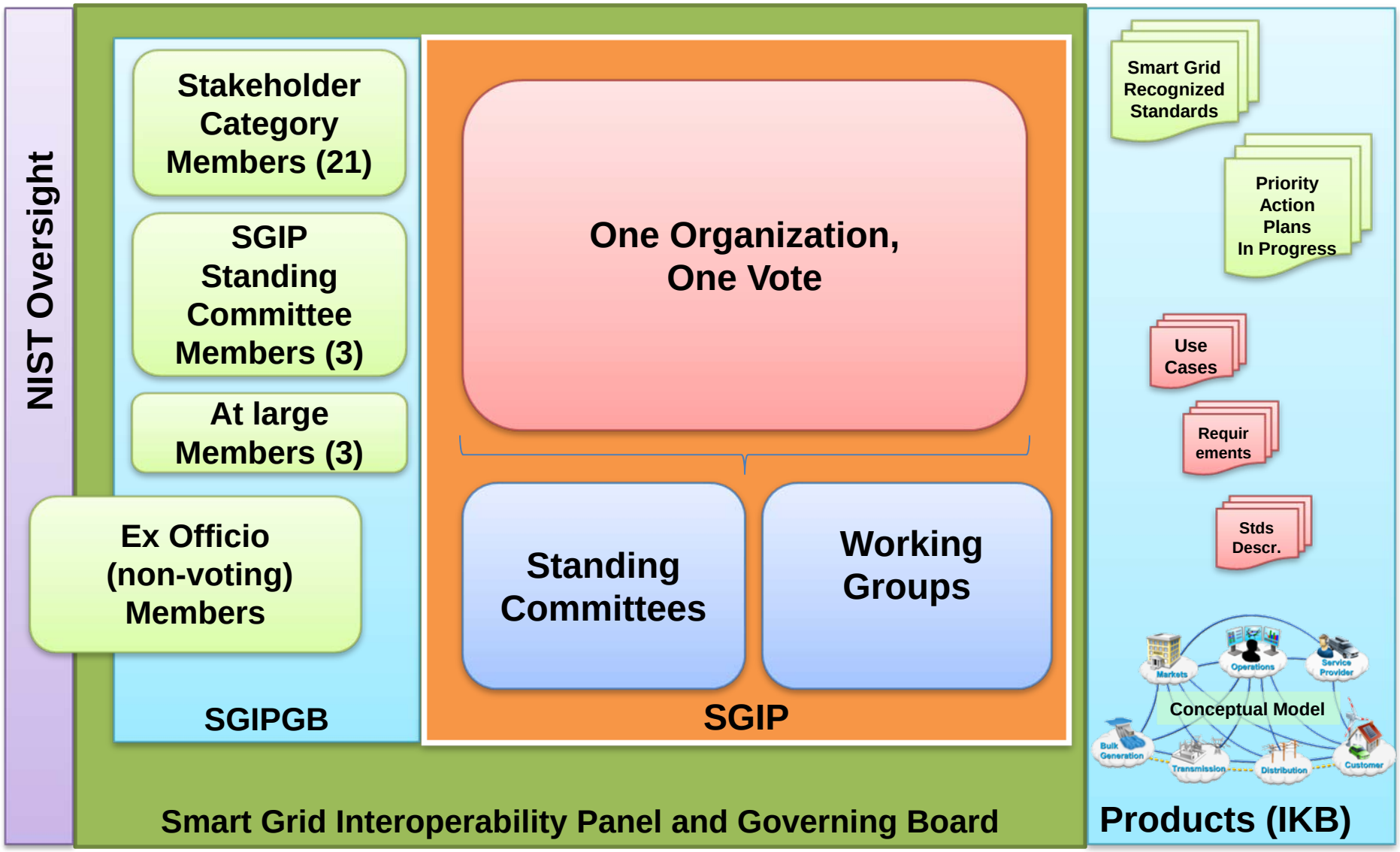
Smart Grid Interoperability Panel

- Public-private partnership formed November 2009
- Permanent body
- Supports NIST in setting standards for U.S. smart grid
- Coordinates, does not develop standards
- Over 360 member organizations at founding
- 22 stakeholder categories – utilities, renewable power suppliers, electric equipment suppliers, ICT, appliance makers, automation suppliers, standards developers, regulators, venture capital, …
- Open, transparent process
- International participation welcome

SGIP Structure



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Smart Grid Stakeholders

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 Federal 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

How Does Your Organization Join SGIP?

- Download and return membership agreement to join
- Call for Governing Board nominations open for three remaining stakeholder groups –
  - nominations due
- SGIP organization members electronically cast ballots
- Webinars to brief public: November 12
  11 am -12 pm ET
- All information is available at
  - http://nist.gov/smartgrid and
  - http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/

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