GE
Energy

Smart Grid Applications, Standards Development and Recent Deployments

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Smart Grid Applications

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How is a Smart Grid Created?

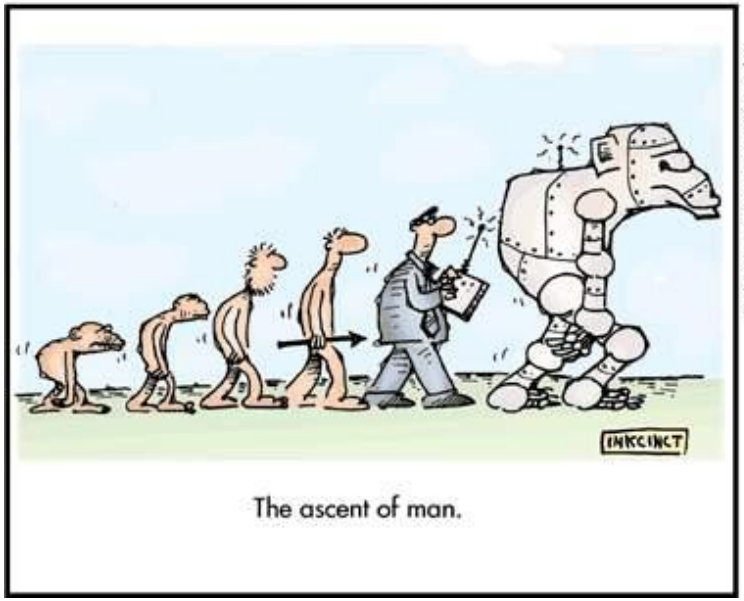
Not created all at once – will *evolve* over many years

Created through the incremental deployment and integration of *system intelligence*

Intelligent systems deployed to meet specific business and regulatory *drivers*

Each utility has

- Different starting points
- Different drivers
- Different paths
- Different deployment rates



Smart Grid View

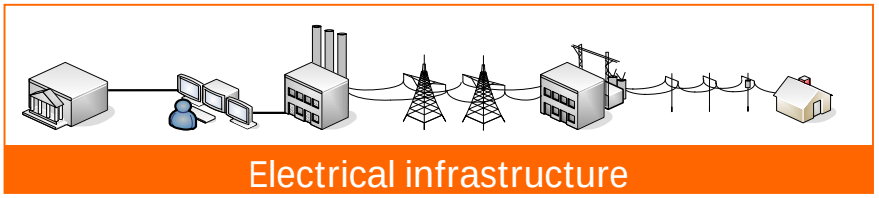
The integration of electrical and information infrastructures, and the incorporation of automation and information technologies with our existing electrical network.

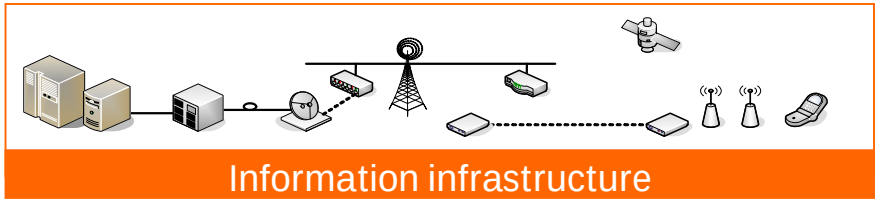
Comprehensive solutions that:

- ✓ Improve the utility's power reliability, operational performance and overall productivity
- ✓ Deliver increases in energy efficiencies and decreases in carbon emissions
- ✓ Empower consumers to manage their energy usage and save money without compromising their lifestyle
- ✓ Optimize renewable energy integration and enabling broader penetration

That deliver meaningful, measurable and sustainable benefits to the utility, the consumer, the economy and the Environment.

More Focus on the Distribution System





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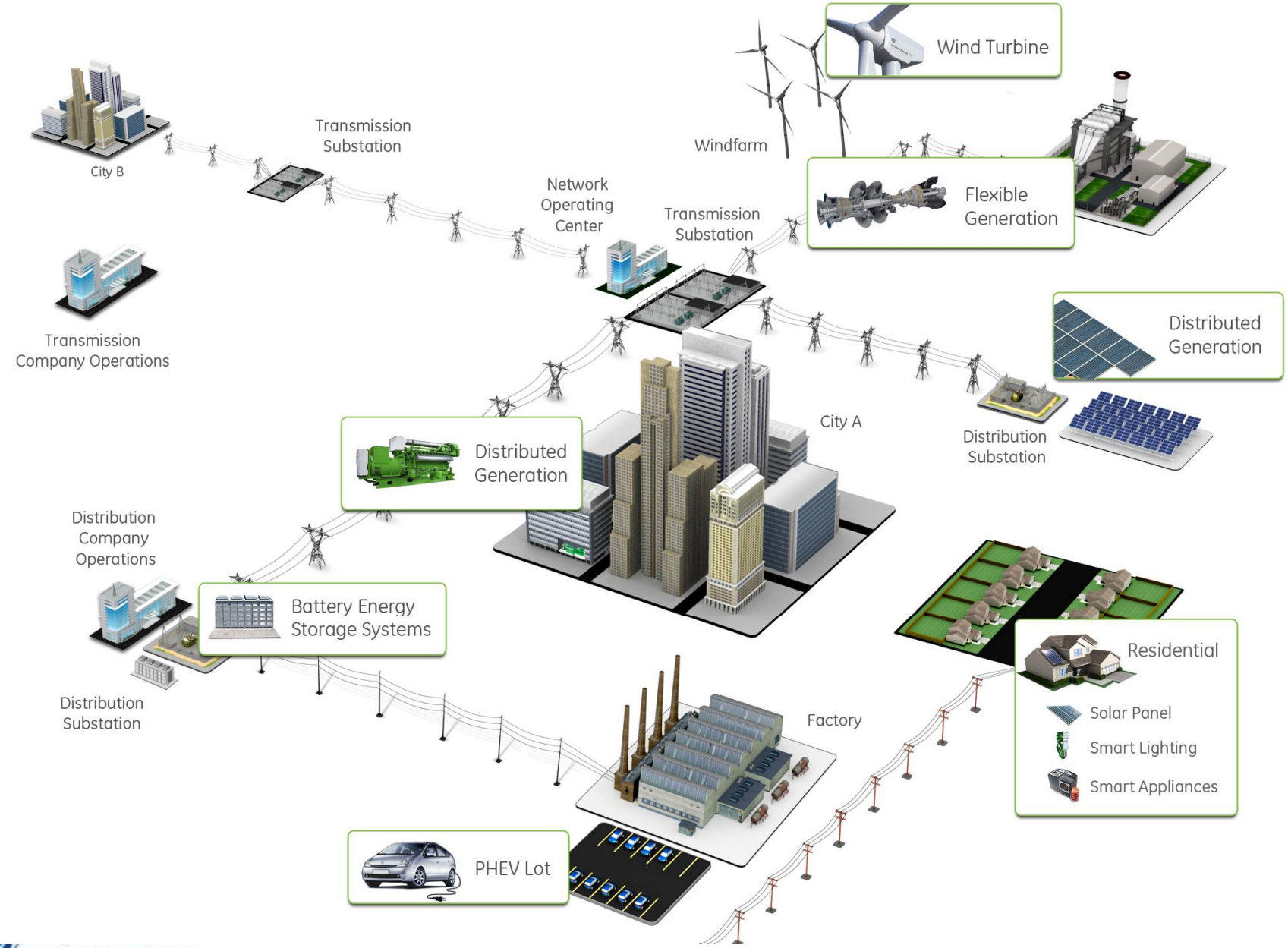
Growing Complexity In Modern Grids…



A “Smarter” Grid

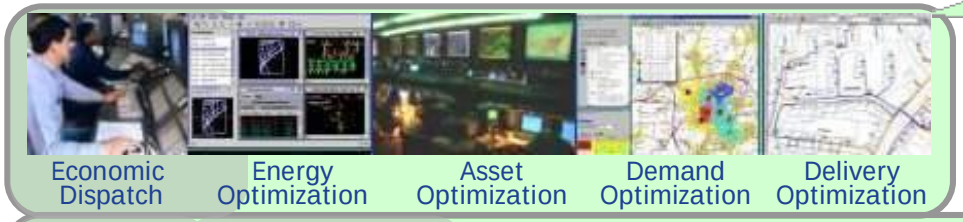
Enabled
Utility Managers

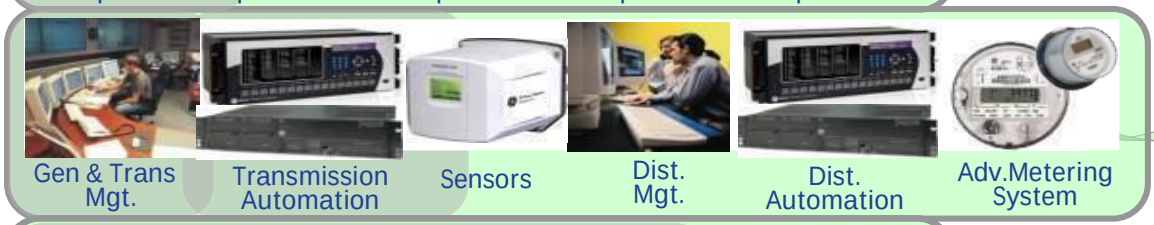
‘New Applications enabled by Additional Infrastructure’

Management
“ Applications”

Control
“How Power Flows”

Heavy Metal
“ Generate & Deliver Power”





Enabled
Consumers

Old Grid
Smart Grid Adds

Old Grid

- You call when the power goes out.
- Utility pays whatever it takes to meet peak demand.
- Difficult to manage high Wind and Solar penetration
- Cannot manage distributed generation safely.
- ~10% power loss in T&D

Smart Grid

- Utility knows power is out and usually restores it automatically.
- Utility suppresses demand at peak. Lowers cost. Reduces CAPEX.
- No problem with higher wind and solar penetration.
- Can manage distributed generation safely.
- Power Loss reduced by 2+%… lowers emissions & customer bills.

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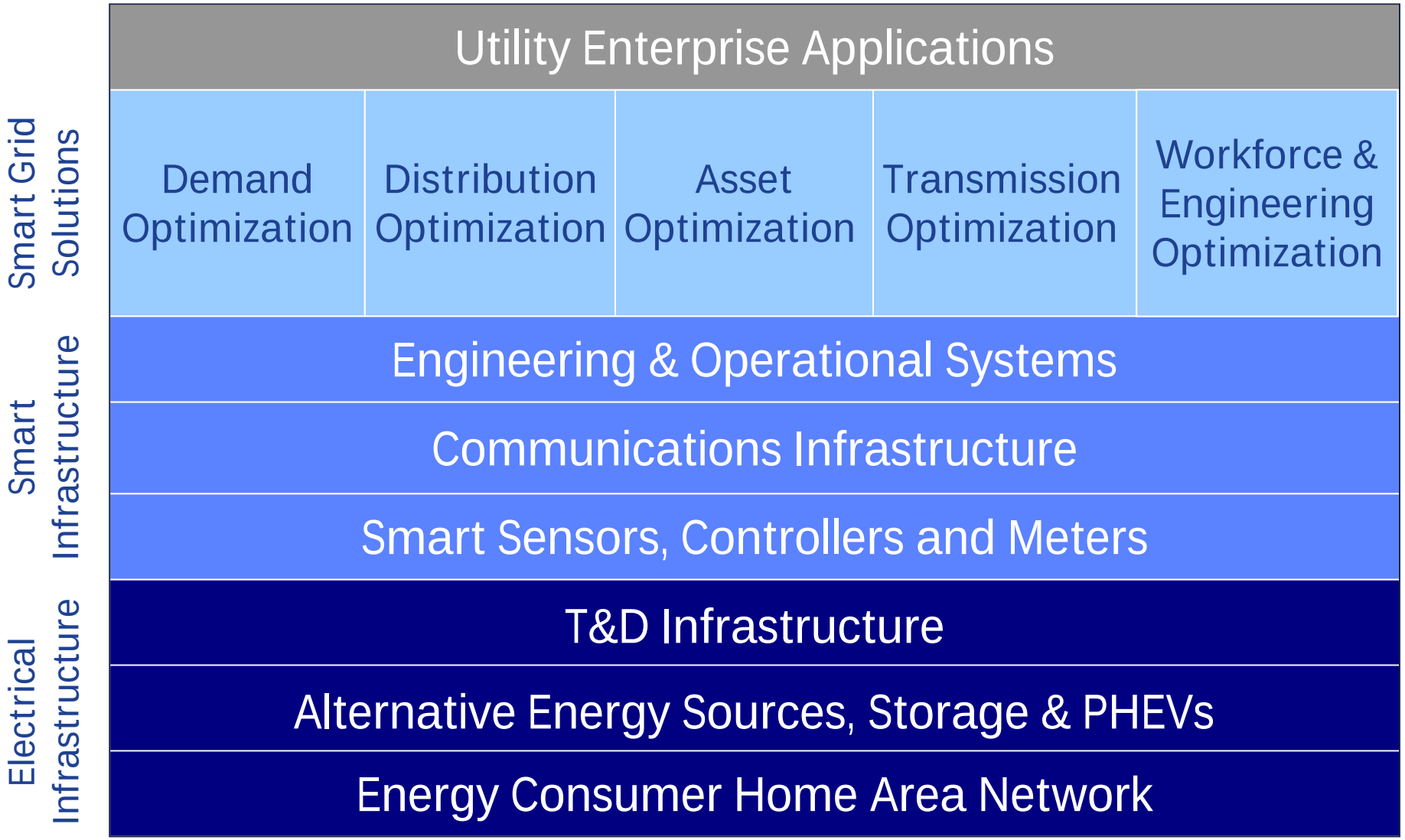
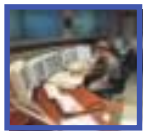
Smart Grid Framework

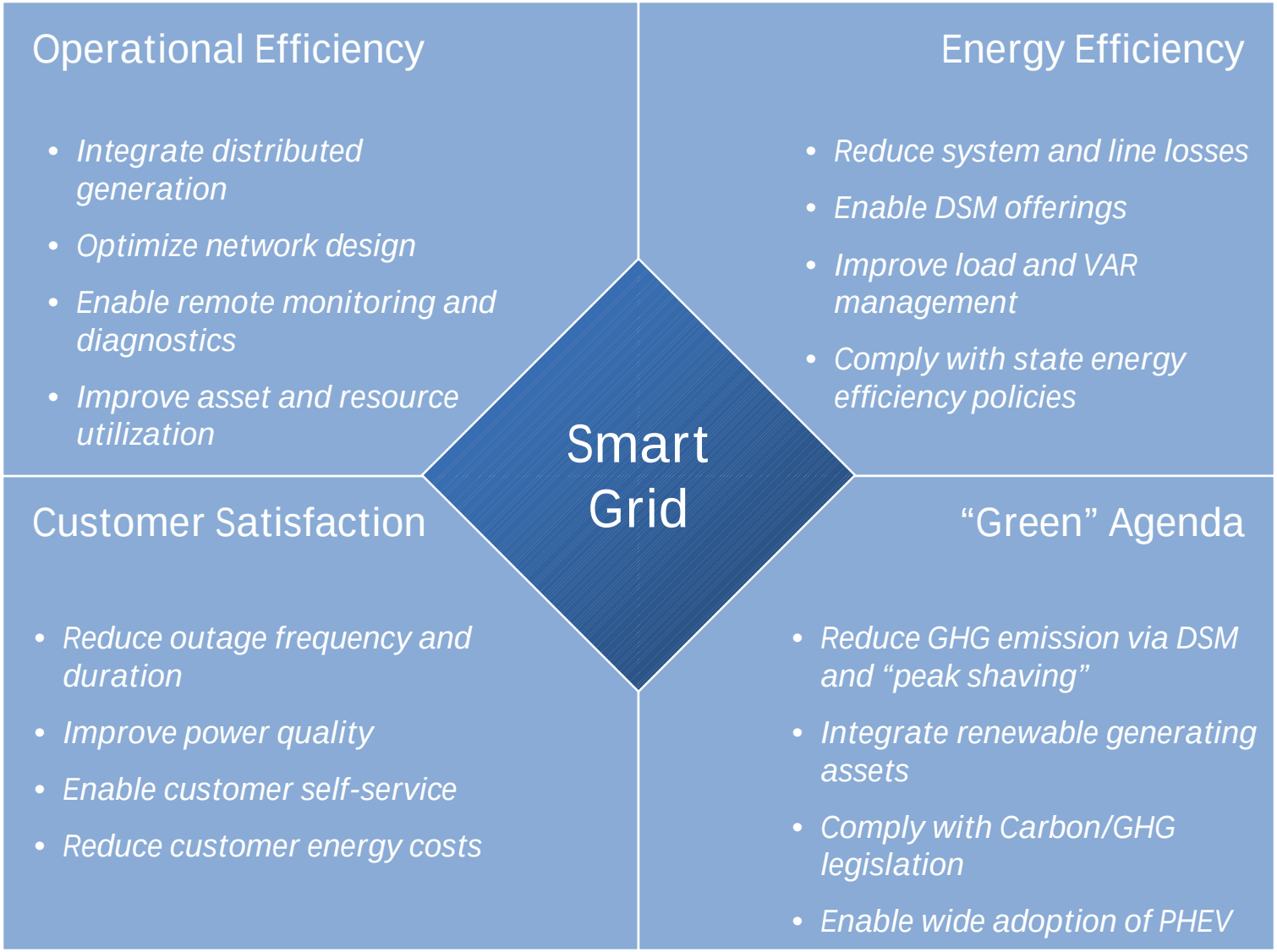


The Future Home …

Elements of Today's Smart Grid

Offerings	Customer Benefits	Future Enablers
 Grid-Friendly Renewables	• Controllability: Ramp, curtail… • Reduced uncertainty: forecast	• Stronger tie with utility EMS • Coordination with DER & loads
 Grid Control Systems	• Operating efficiency • System reliability	• 'Ever Green' Service • Modular applications
 Substation Digitization	• Modular/standard • Less cost, time, risk	• IEC 61850 Compliant • Open architecture
 Intelligent Electronics	• Performance monitoring • Control devices	• Standards based • IEC 61850 compliant
 Monitoring & Diagnostics	• Asset protection • Life extension	• Progressive offering • Long term services
 Communications Infrastructure	• Performance visibility • Remote control	• Seamless NMS, Security • Multi-applications
 Smart Metering	• Customer billing • Demand management	• Software upgradeable
 Smart Appliances & Home Controls	• Participation in DR programs • Utility bill savings	• Standards based • Software upgradeable

Smart Grid Benefits



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Hurdles to Smart Grid Widespread Adoption

- ✓ Lack of comprehensive, long-term and integrated Smart Grid strategies and roadmaps tied to quantifiable benefits
- ✓ Substantial capital investment required up front
- ✓ Regulatory structures that do not fully recognize the benefits of smart grid technologies (e.g., decoupled rates)
- ✓ Utility business models that minimize risk and ties returns to electricity revenue
- ✓ Interoperability and the need for faster, more comprehensive development of standards, including physical and cyber security
- ✓ The need to move away from isolated pilots from “testing” to “phased deployments” on a larger scale (“city-scale”)
- ✓ Availability and capability of smart grid educational tools for policymakers, regulators and consumers to change thinking and attitude to smart grid technologies

Smart Grid Standards Development

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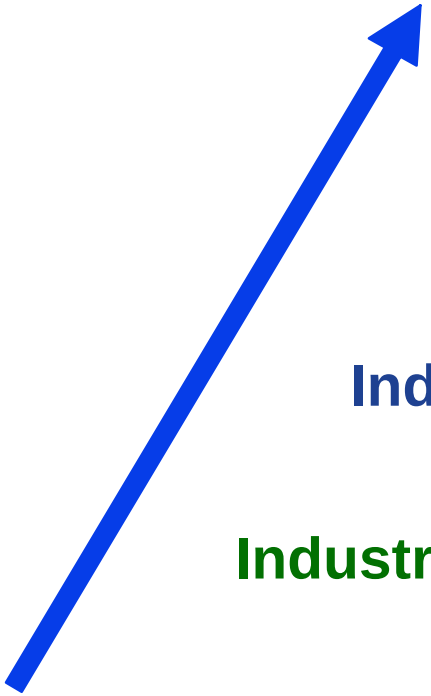
Who Makes Standards, Anyway?



International Standards (ISO, IEC)

National Standards (ANSI, NIST, IEEE)

Industry Standards - formalized practice

Industry Practice - informal practice

Proprietary Systems - vendor specific

But the Process is Not Trivial

Inertia of existing practices

Proprietary “standards”

De jure (by law) and de facto (in fact or actually) standards

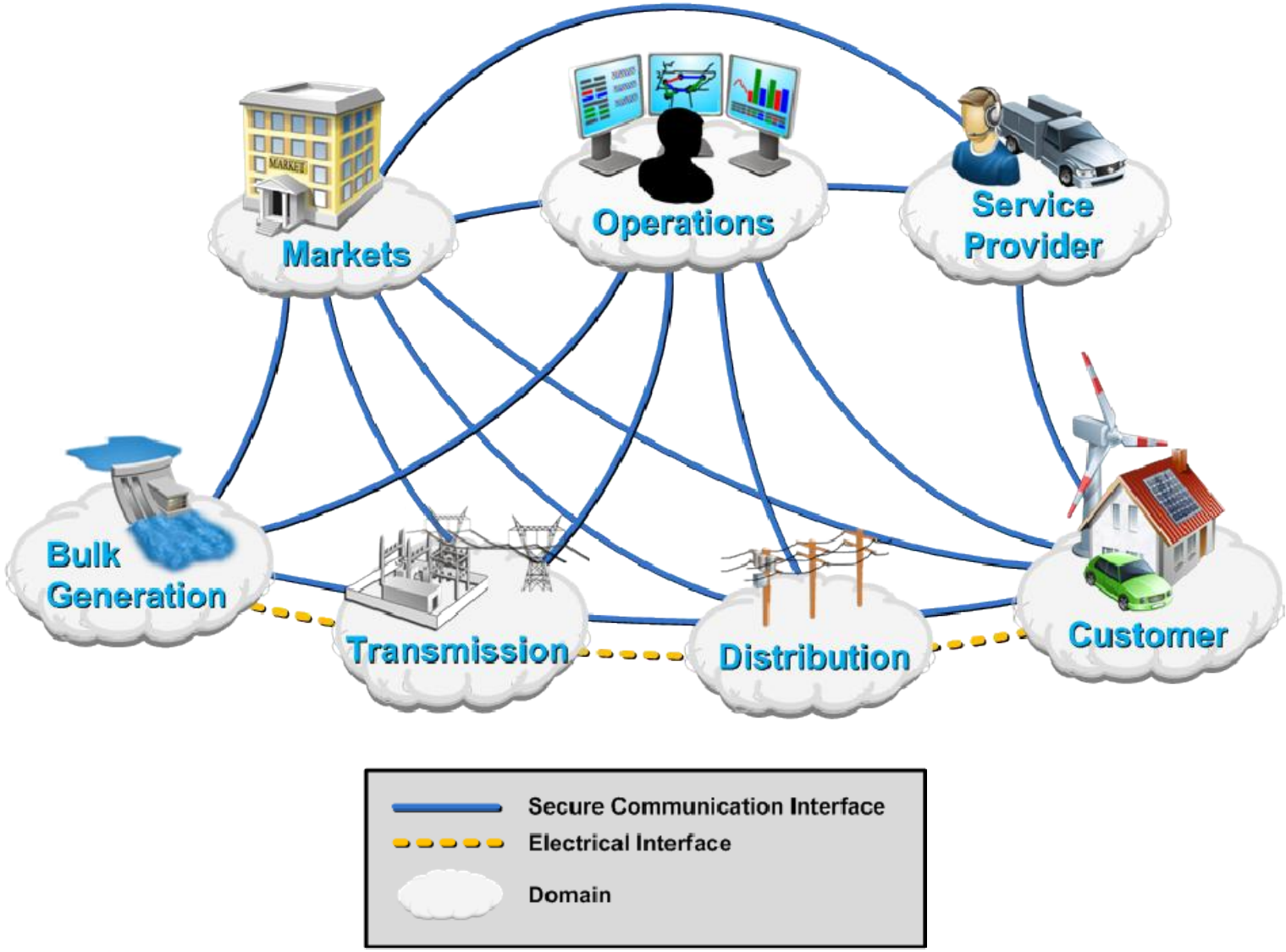
Defining a vision

Identifying existing standards to use as building blocks

Gaining consensus

Hammering out details, details, details, details, details.....

NIST Conceptual Model



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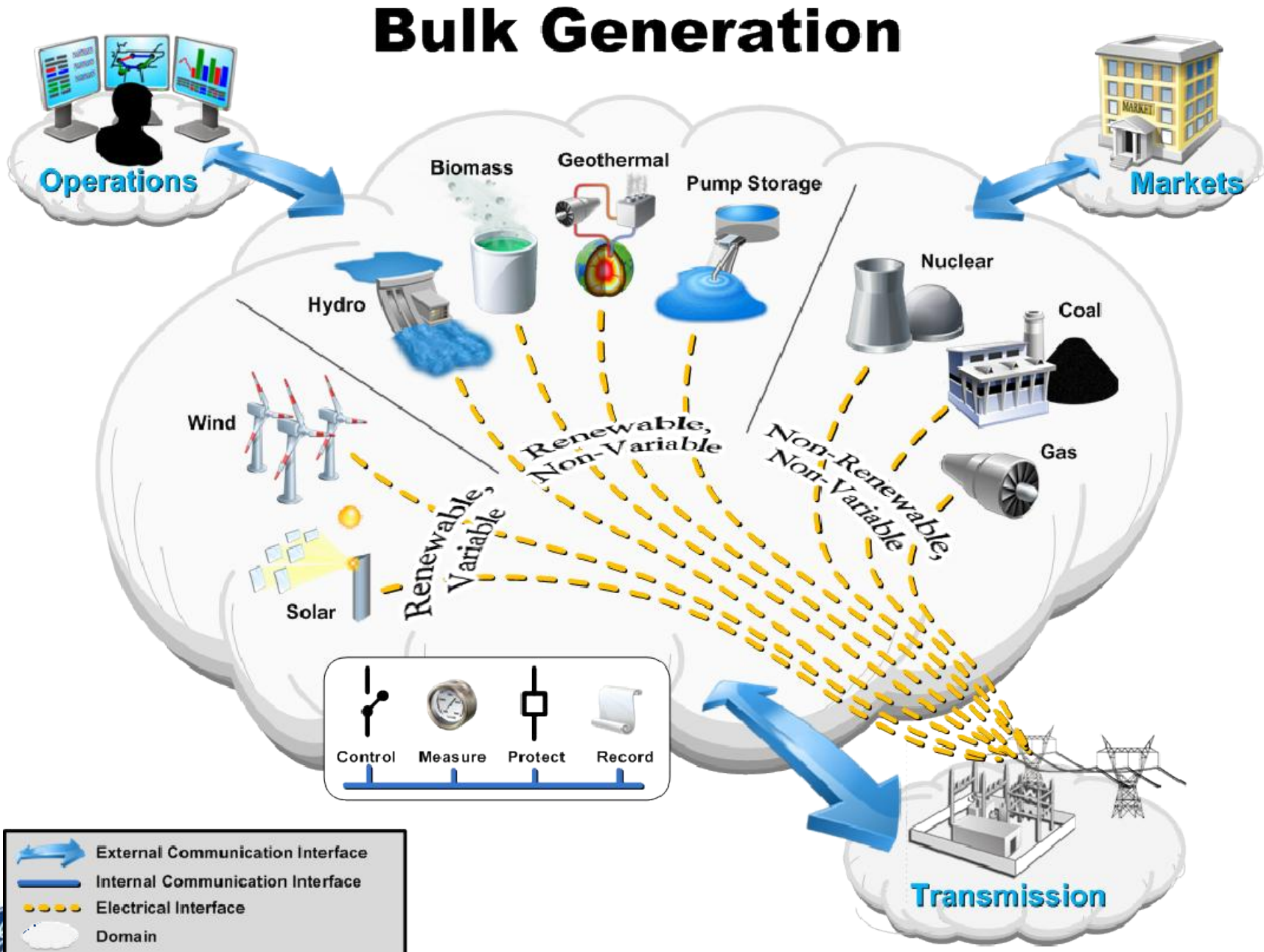
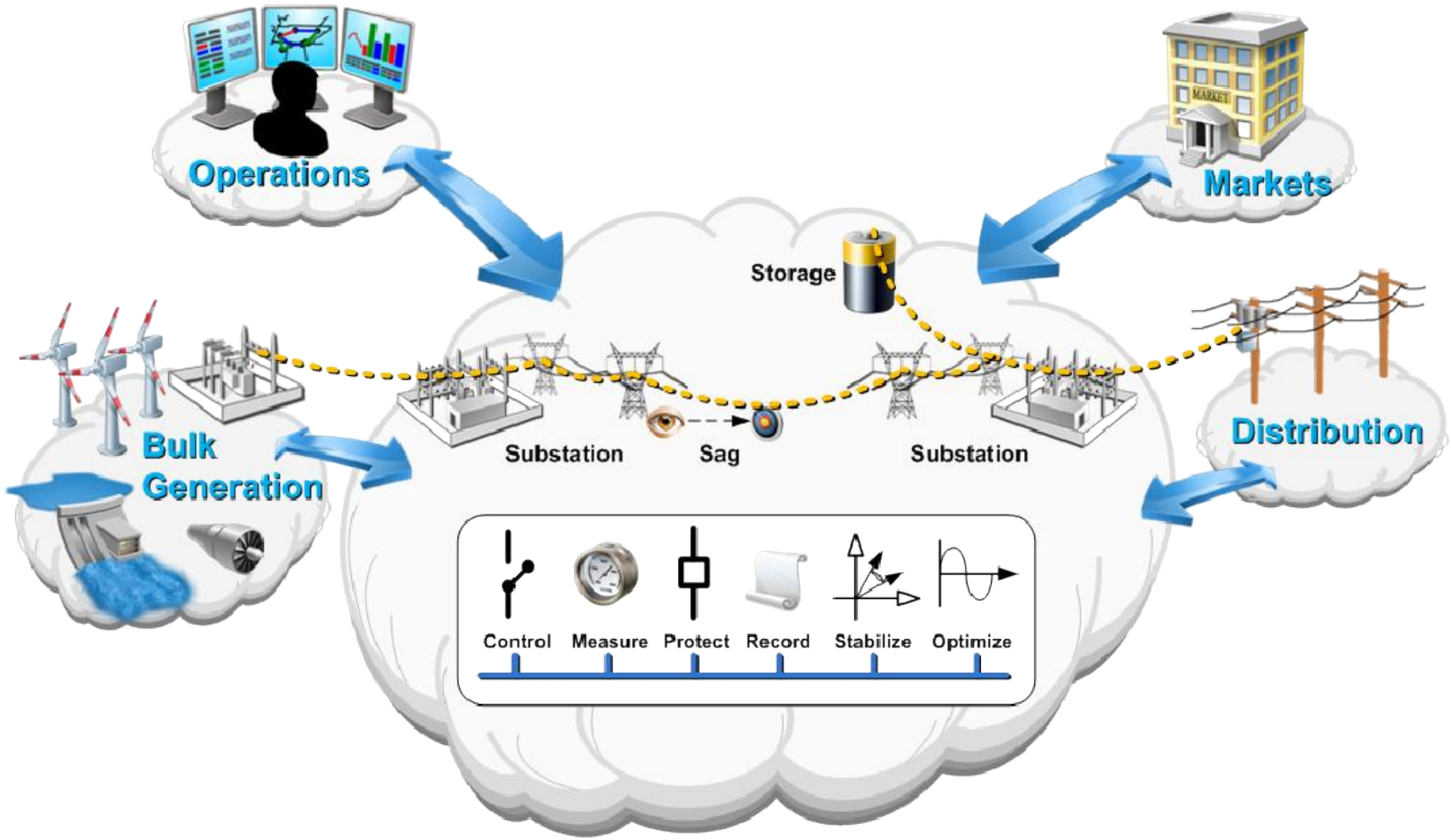
Bulk Generation



Transmission



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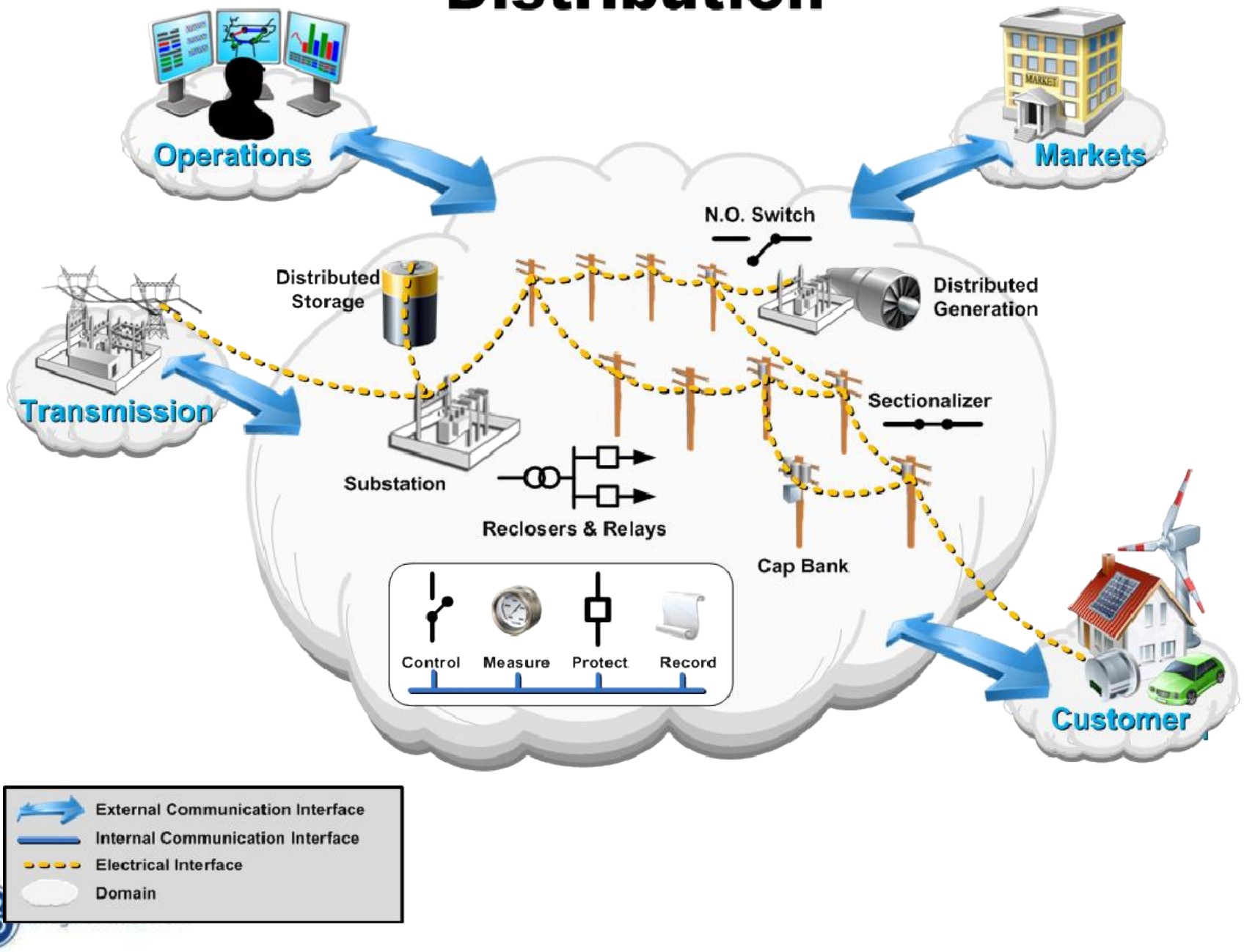
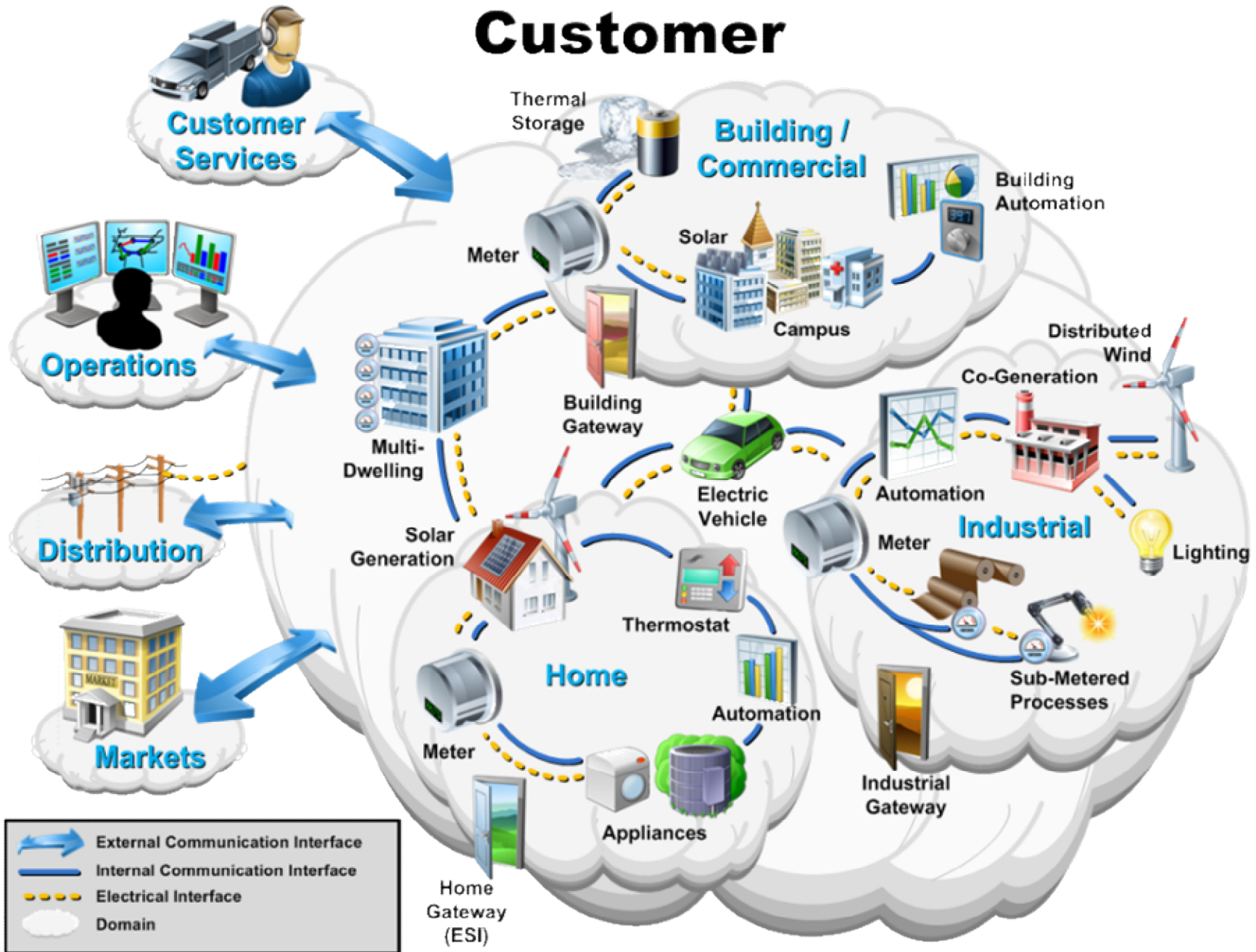
Distribution





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The NIST Role

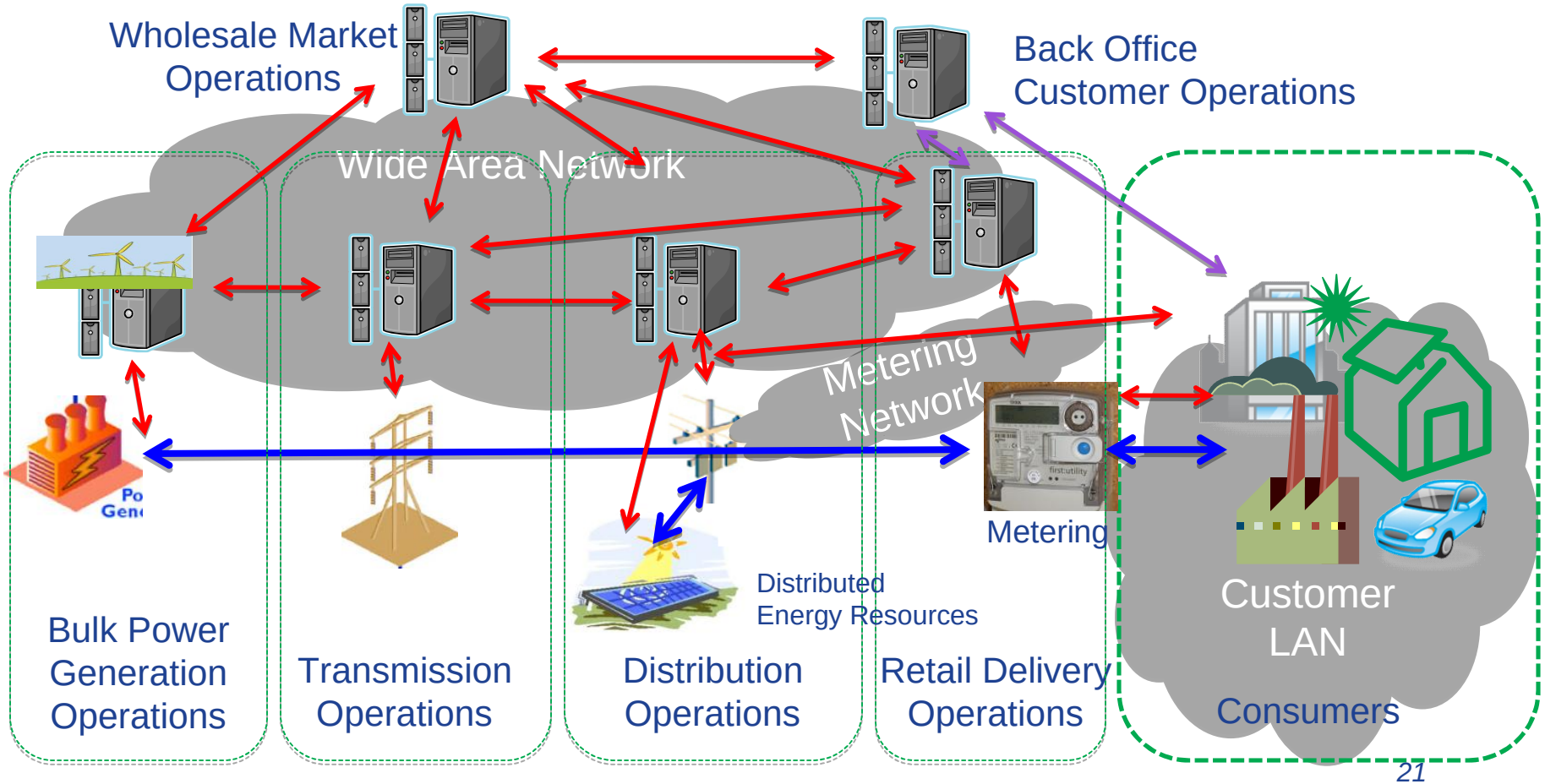
Energy Independence and Security Act (EISA) of 2007
Title XIII, Section 1305
Smart Grid Interoperability Framework

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…"

What Interoperability Standards are Needed?

Standards are needed for each of the interfaces shown to support many different smart grid applications. Standards are also needed for data networking and cyber security.

Electricity Information Data Communication



We Need A Standards Roadmap

Capabilities

Priorities

Architecture

Standards

Release Plan

Responsibilities

Governance

Conformity (including testing and certification where appropriate)

NIST Plan was developed after listening to key industry concerns

Open, participative process – 80% of electric grid is owned and operated by private sector

Utilities recognize need for speed, but want a systematic, not ad hoc process

Standards should be developed by private sector standards bodies, with NIST coordination

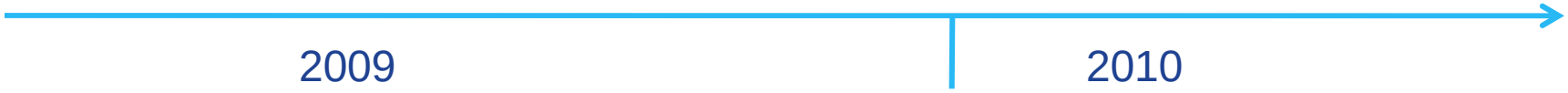
Standards are necessary but not sufficient – conformity regime (including testing and certification where appropriate) is essential

NIST Three Phase Plan

PHASE 1
Recognize a set of initial existing consensus standards and develop a roadmap to fill gaps

PHASE 2
Establish public/private Standards Panel to provide ongoing recommendations for new/revised standards to be recognized by NIST

PHASE 3
Conformity Framework
(including Testing and Certification)



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NIST- Recognized Standards Release 1.0

Following the April 28-29 Smart Grid Interoperability workshop, NIST deemed that sufficient consensus has been achieved on 16 initial standards

On May 8, NIST announced intention to recognize these standards following 30 day comment period

NIST's announcement recognized that some of these standards will require further development and many additional standards will be needed.

NIST will recognize additional standards as consensus is achieved

Standard	Application
AMI-SEC System Security Requirements	Advanced metering infrastructure (AMI) and Smart Grid end-to-end security
ANSI C12.19/MC1219	Revenue metering information model
BACnet ANSI ASHRAE 135-2008/ISO 16484-5	Building automation
DNP3	Substation and feeder device automation
IEC 60870-6 / TASE.2	Inter-control center communications
IEC 61850	Substation automation and protection
IEC 61968/61970	Application level energy management system interfaces
IEC 62351 Parts 1-8	Information security for power system control operations
IEEE C37.118	Phasor measurement unit (PMU) communications
IEEE 1547	Physical and electrical interconnections between utility and distributed generation (DG)
IEEE 1686-2007	Security for intelligent electronic devices (IEDs)
NERC CIP 002-009	Cyber security standards for the bulk power system
NIST Special Publication (SP) 800-53, NIST SP 800-82	Cyber security standards and guidelines for federal information systems, including those for the bulk power system
Open Automated Demand Response (Open ADR)	Price responsive and direct load control
OpenHAN	Home Area Network device communication, measurement, and control
ZigBee/HomePlug Smart Energy Profile	Home Area Network (HAN) Device Communications and Information Model

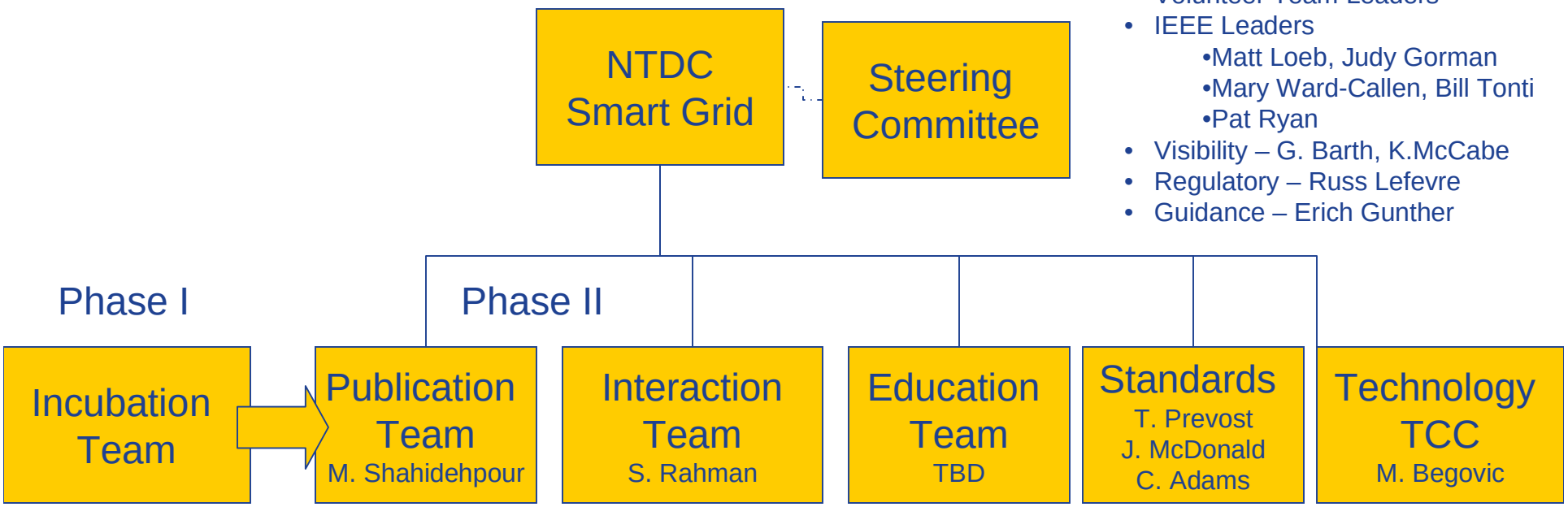
IEEE NTDC (New Technology Direction Committee) Smart Grid Objectives

Organize, coordinate, leverage, and build upon the strength of IEEE and its Societies for Smart Grid

Requires:

- Awareness through public visibility efforts
- Internal and external IEEE collaboration
- Prompt action
- Facilitate world-wide stakeholder interaction
  - Educate, coordinate and package existing products / activities
  - Provide new smart grid venues … through web tools, conferences, publications, education
  - Share best practices, understand regional differences

Results are to increase revenue, membership



- Leverage existing materials
- Find quick-hits

Create
- SG journal
- SG portal
- Blog tools
- Clearingho use
- Glossy magazine

- Facilitate the use of journal, portal, tools
- Establish new conferences
- Promote conferences, web tools, internally and externally

- Tutorials
- Speakers bureau
- Plain Talk
- Podcasts
- Webinar

- Road map
- Standards developmt
- External coordinatn
- Testing critiera
- Interop. certification

- Identify new areas
- Identify groups of mutual interest
- Highlight developmts
- Recommend new areas

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Smart Grid Recent Deployments

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AEP Smart Grid Project

Summary

- American Electric Power is one of the largest electric utilities in the United States, delivering electricity to more than 5 million customers in 11 states
- 36,000 MW of generating capacity; 39K miles of transmission lines, 208K miles of distribution lines

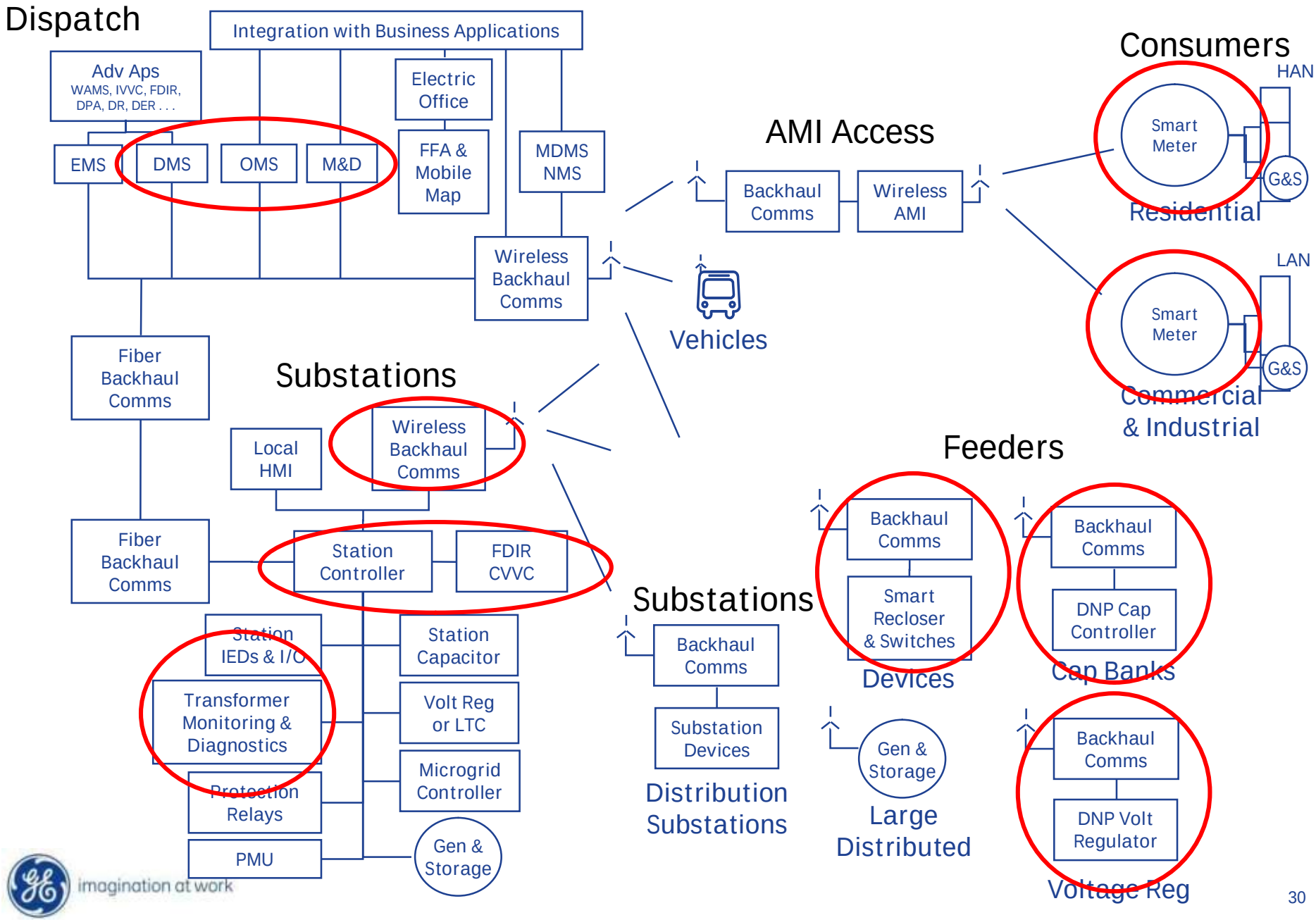
Drivers

- Enhanced Customer Experience (Customer control, tools to understand usage)
- Operational Efficiencies (Reduce operational costs of the network)
- Energy Efficiency
  - Utilize AMI infrastructure for Automation

Status

- Partnership developed to work together toward developing, demonstrating, & deploying Smart Grid solutions.
- Implement Smart Grid solutions to over 5MM customers by 2015
- First Smart Grid pilot complete in South Bend, IN. Next city-scale project in planning phase.
- GE and AEP working as partners to develop most effective Smart Grid

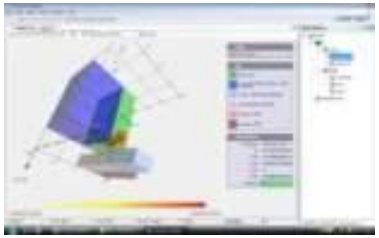
AEP Project – Integrated System View



AEP Project – Solutions Delivered

Demand Optimization

- Smart meters with AMI
  - Time of use pricing
- Home Area Network
- Smart Appliances



Delivery Optimization

- Integrated Volt/Var Control
  - Analysis of theoretical and measured results
  - Analysis of financial benefits (MW, MWH, MVAR, and MVARH savings)
- Smart meters linked to Outage Management System (OMS)
- ENMAC DMS
- Poweron OMS
- Integration of DMS and OMS
- Leverage AMI for Distribution Automation

Asset Optimization

- Remote transformer monitoring of “at-risk” transformers.

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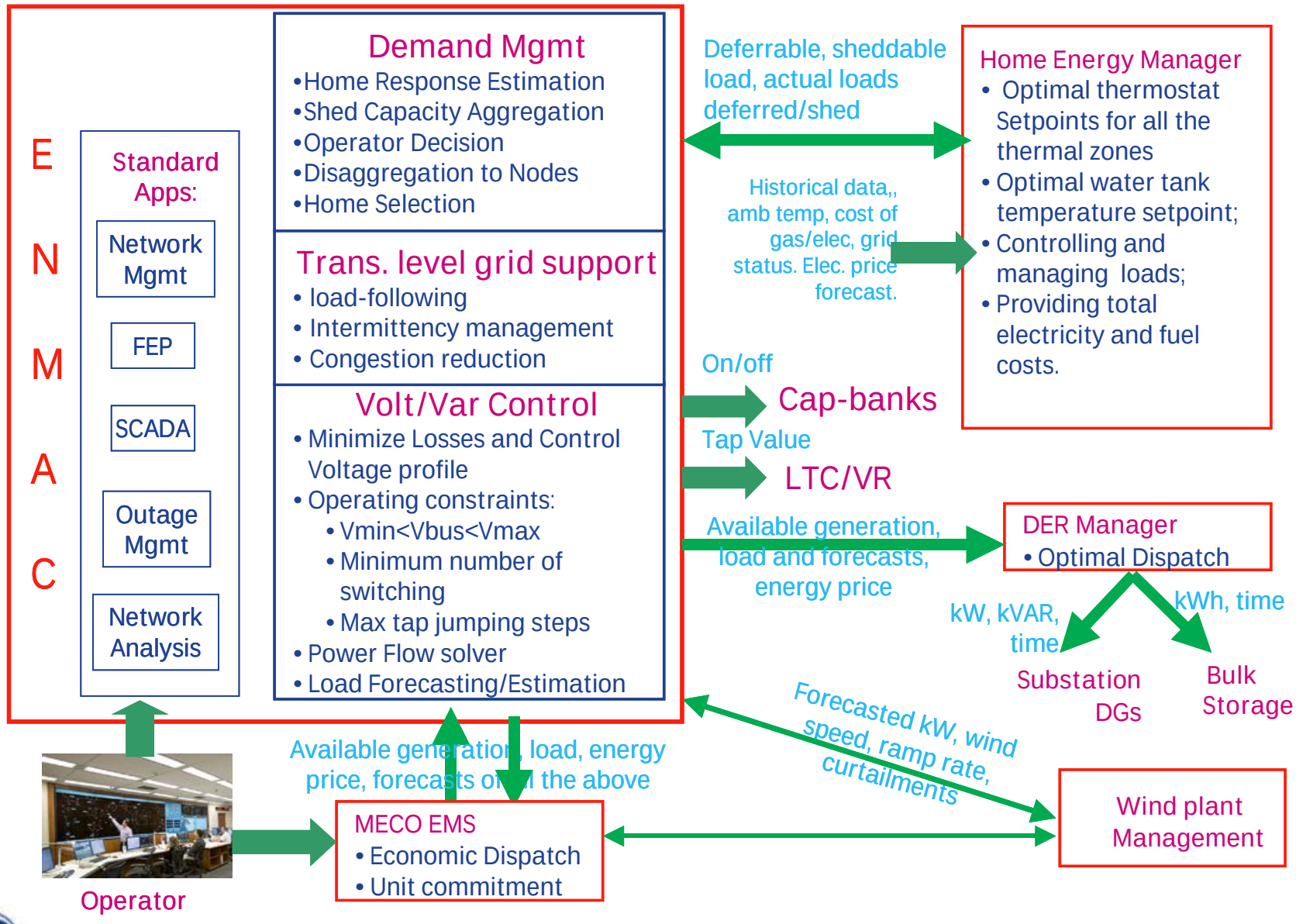
Maui Smart Grid Project

Develop a Smart Grid controls and communication architecture capable of *coordinating DG, energy storage and loads to*:

- Reduce peak load by 15% relative to loading on the distribution circuit.
- Mitigate the impacts of short-timescale wind and solar variability on the grid

Maui - Functional Description



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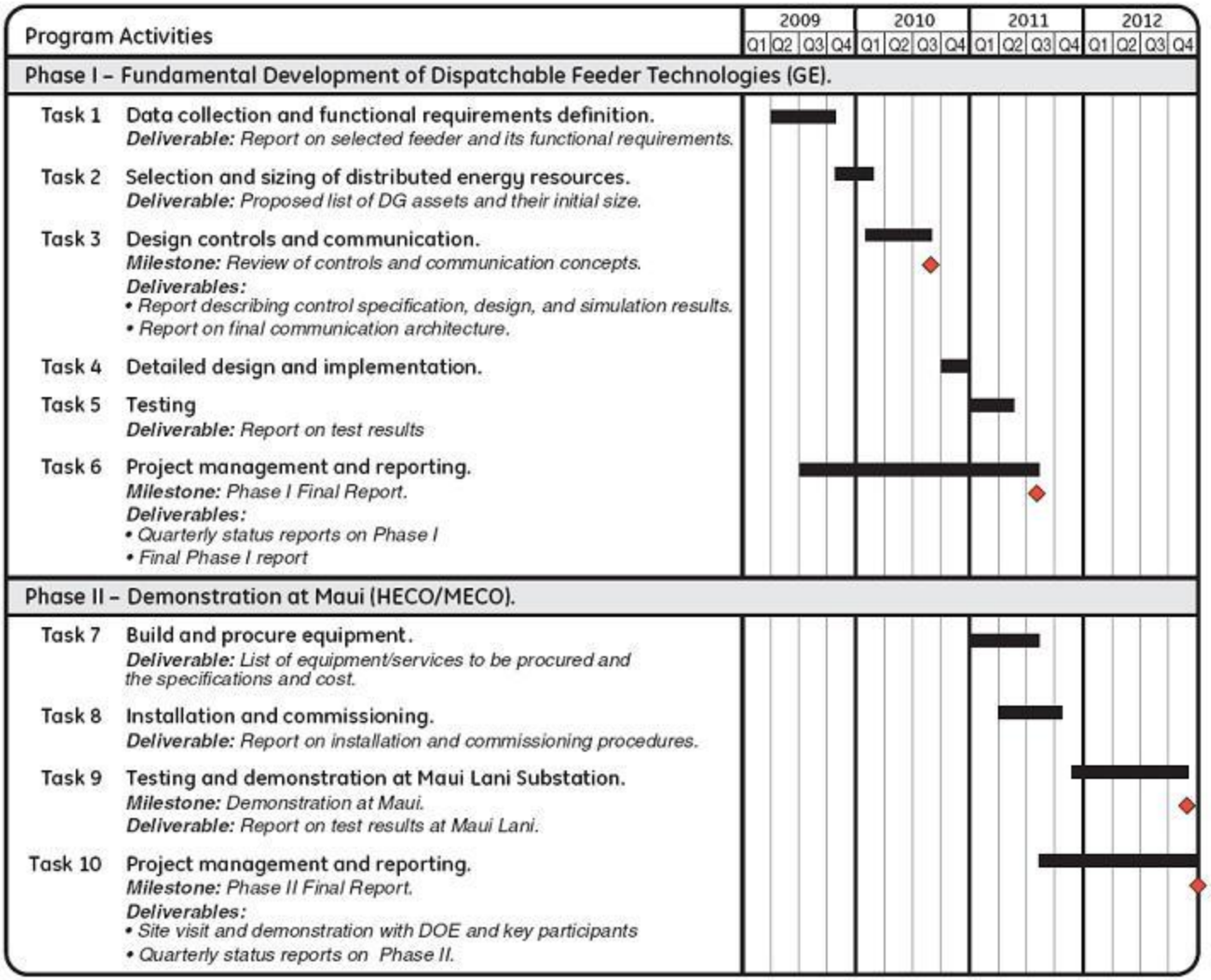
Maui - Project Timeline



Collaborations & alliances are critical

- $200M smart grid initiative
- ~800-1,000 “green collar” jobs
- Public/private alliance
  - ✓ GE
  - ✓ City of Miami
  - ✓ FPL
  - ✓ Cisco
  - ✓ Silver Spring Networks
- ~1MM customers involved
  - ✓ Smart Meters
  - ✓ Demand Management
  - ✓ Distribution Automation
  - ✓ Substation Intelligence
  - ✓ Distributed Generation
  - ✓ Enterprise Systems

ENERGY smart MIAMI

“It’s time for action. With projects like Energy Smart Miami, we can stimulate the economy today and build a brighter, cleaner tomorrow. It’s truly a win-win.”

Carol Browner

Assistant to the President for Energy and Climate Change

Energy smart cities

Miami proposes to lead the nation in energy efficiency with $200 million smart grid initiative

The Miami Herald

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Posted on Sunday, 04.26.09

Miami: A 'green' leader

Regarding the April 21 story *Green push could help save power at home*: Congratulations to the city of Miami for being one of the first major U.S. cities to develop a smart grid to reduce energy consumption. Such innovation lays groundwork for a green U.S. economy.

Installing solar panels, building wind turbines, renovating buildings to make them more energy efficient, constructing the Smart Grid are all jobs that can't be outsourced. Moreover, Miami is rapidly becoming the "Greenway to the Americas" for energy- and water-saving products and services.

President Obama's economic-recovery package made a down payment on a clean-energy future, and Miami's Smart Grid is an important first step. Now Congress needs to follow with strong, comprehensive climate and energy legislation to kindle the green economy and put our country and Miami back on the path to prosperity.

Scope and revenue

- Average city scope ~200k endpoints
- Revenue pool ~$500/endpoint
- ~20 cities in wave 1 …. New York, Chicago, Detroit, San Francisco, London, Lyons
- Implementation over 2-3 yrs

Global growth + city scale expansion … $1B/yr opportunity

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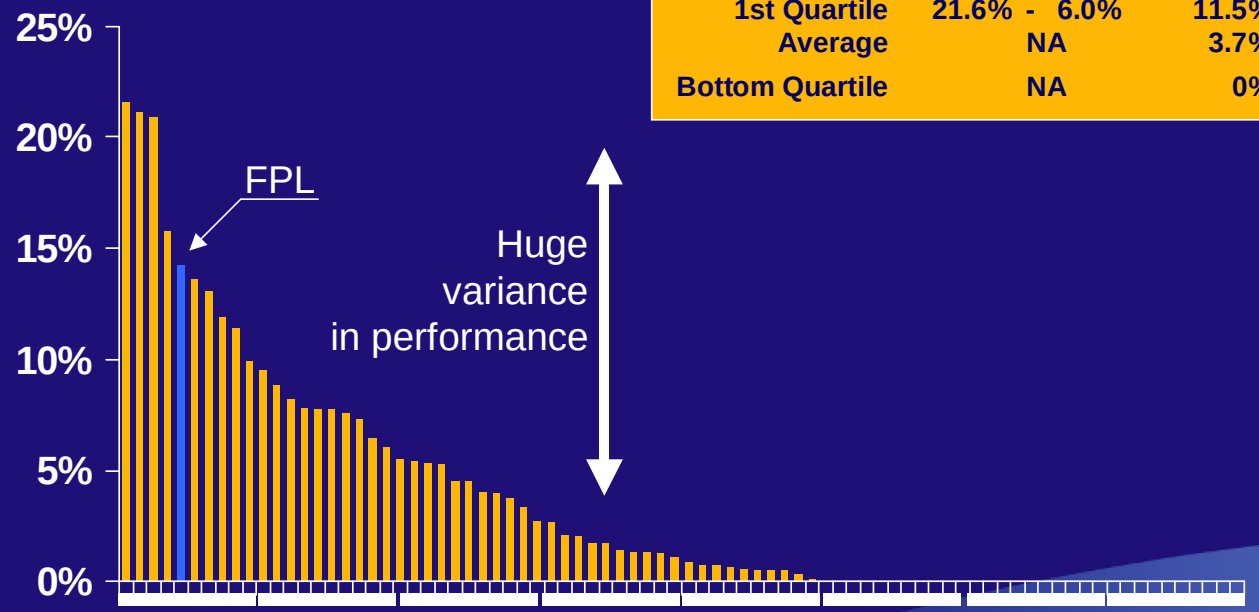
DSM

DSM as percent of peak demand

	Range	Average
1st Decile	21.6% - 11.9%	16.5%
1st Quartile	21.6% - 6.0%	11.5%
Average	NA	3.7%
Bottom Quartile	NA	0%



82 utilities with peak demand >= 3000 MW

31 have 0%

Source: DOE EIA 2005

DSM (continued)

Are the traditional utility DSM programs the best we can come up with?

What HASN'T Changed

- Outdated regulatory structure
- Programs largely the same for 20 years
- Market execution

What HAS Changed

- Higher fuel and electricity prices
- More efficient appliances
- More efficient buildings
- Smart appliances
- Enhanced communications
- Smart meters
- Internet /home computers
- Inexpensive wired and wireless networks
- Cheap chips
- Larger homes and emergence of more energy-consuming appliances
- New tech-savvy generation
- Competition blurred accountability for DSM