GE Digital Energy

The "Smarter" Grid: Today vs. Yesterday

Concepts, Solutions, Standards, Policy, Recent Deployments and Lessons Learned

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United States Energy Association (USEA)
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Smart Grid Concepts

Smart Grid View

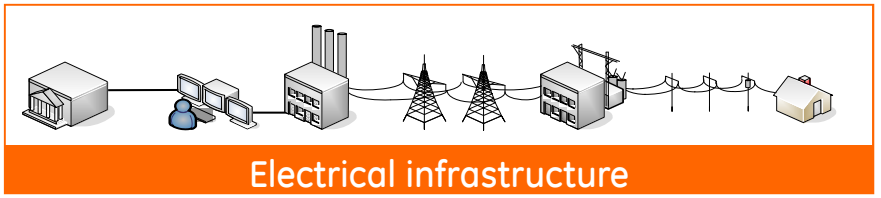
The integration of electrical and information infrastructures, and the incorporation of automation and information technologies with our existing electrical network.

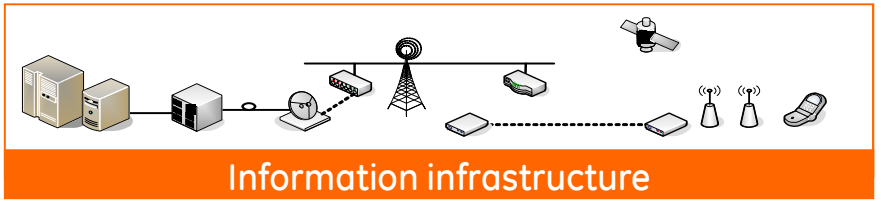
Comprehensive solutions that:

- ✓ 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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A "Smarter" Grid

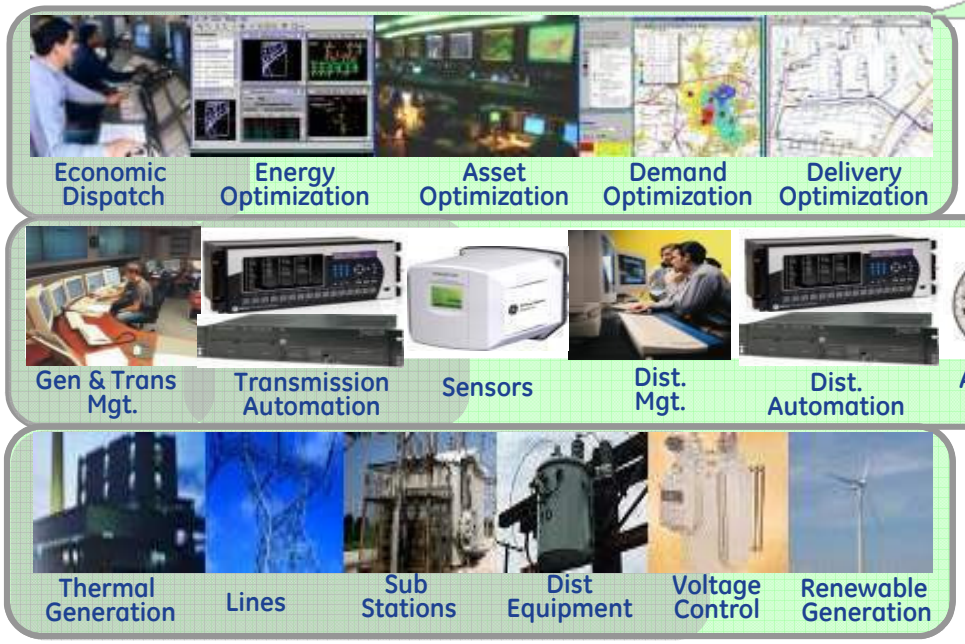
Enabled
Utility Managers

'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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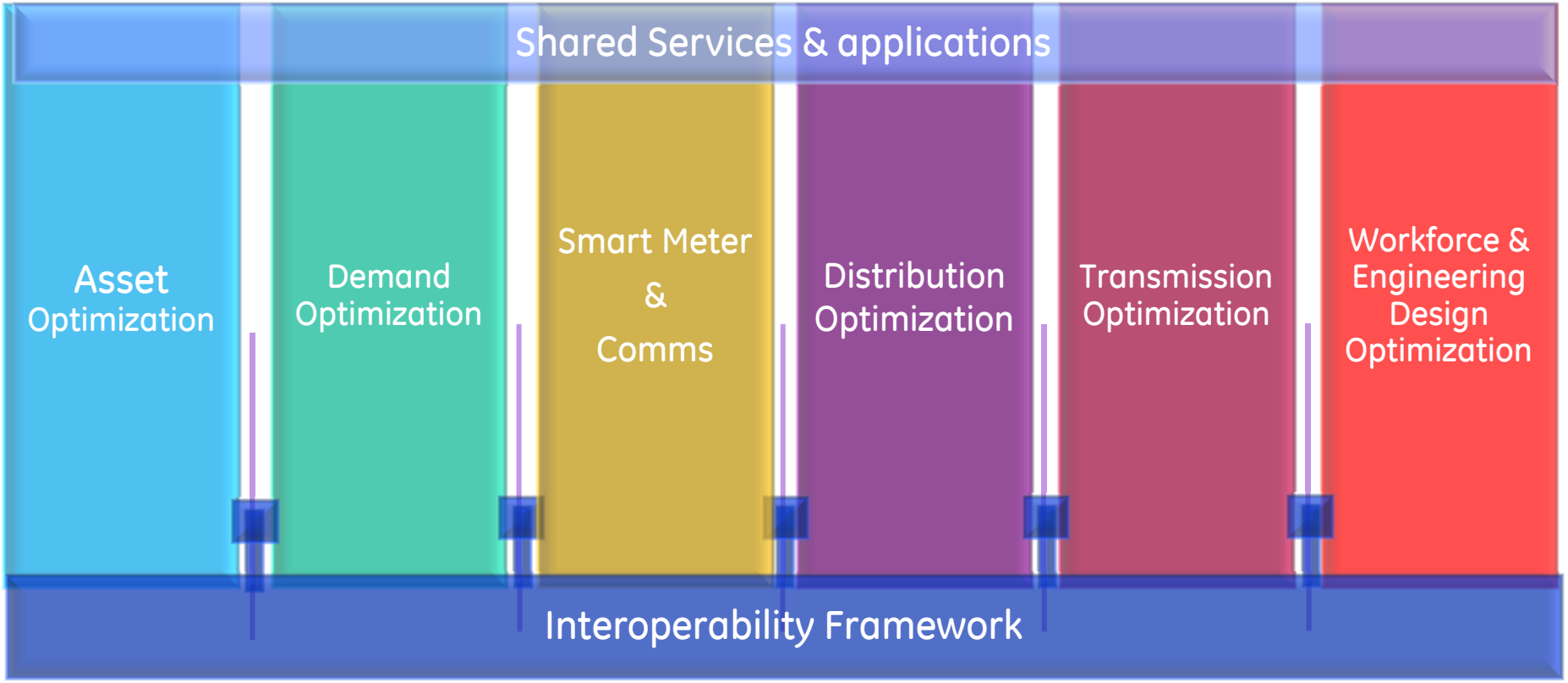
Smart Grid Solutions

Smart Grid Holistic Solutions



Transitioning from products/systems to holistic solutions

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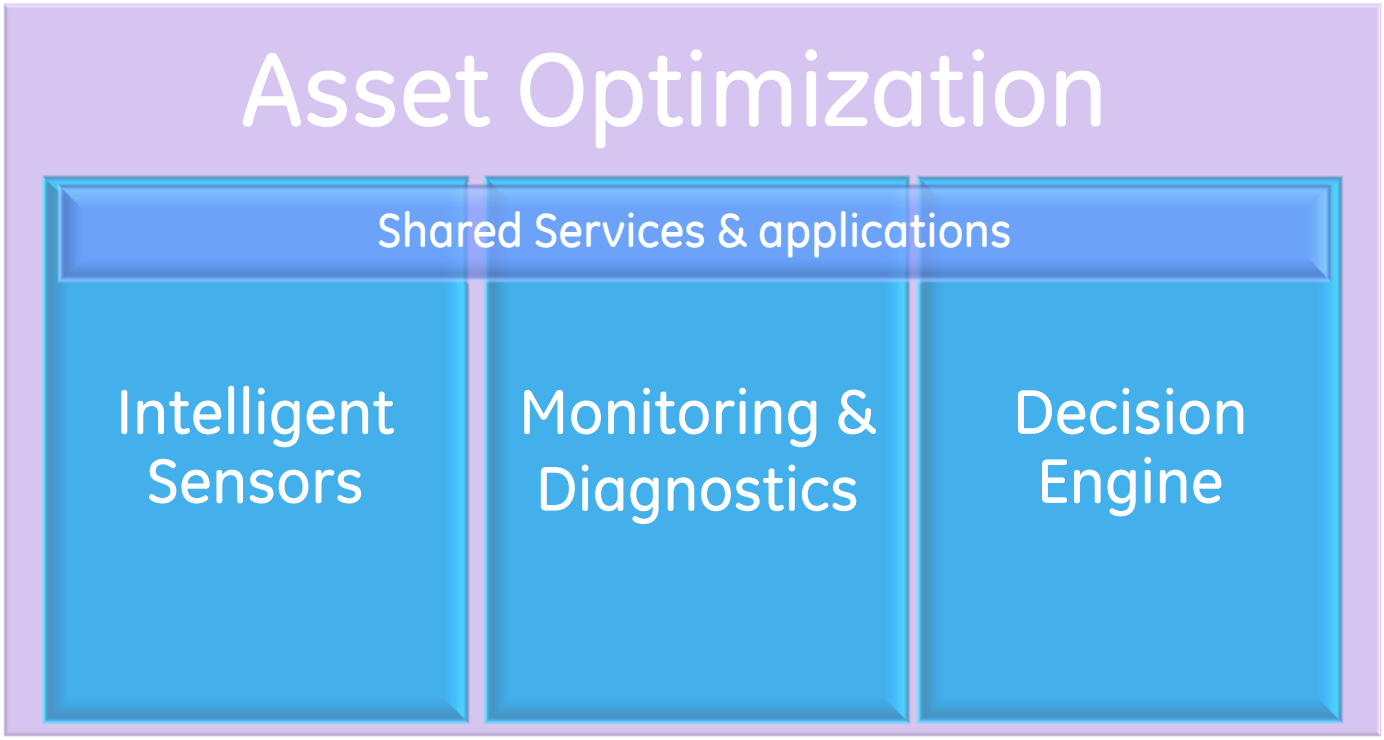
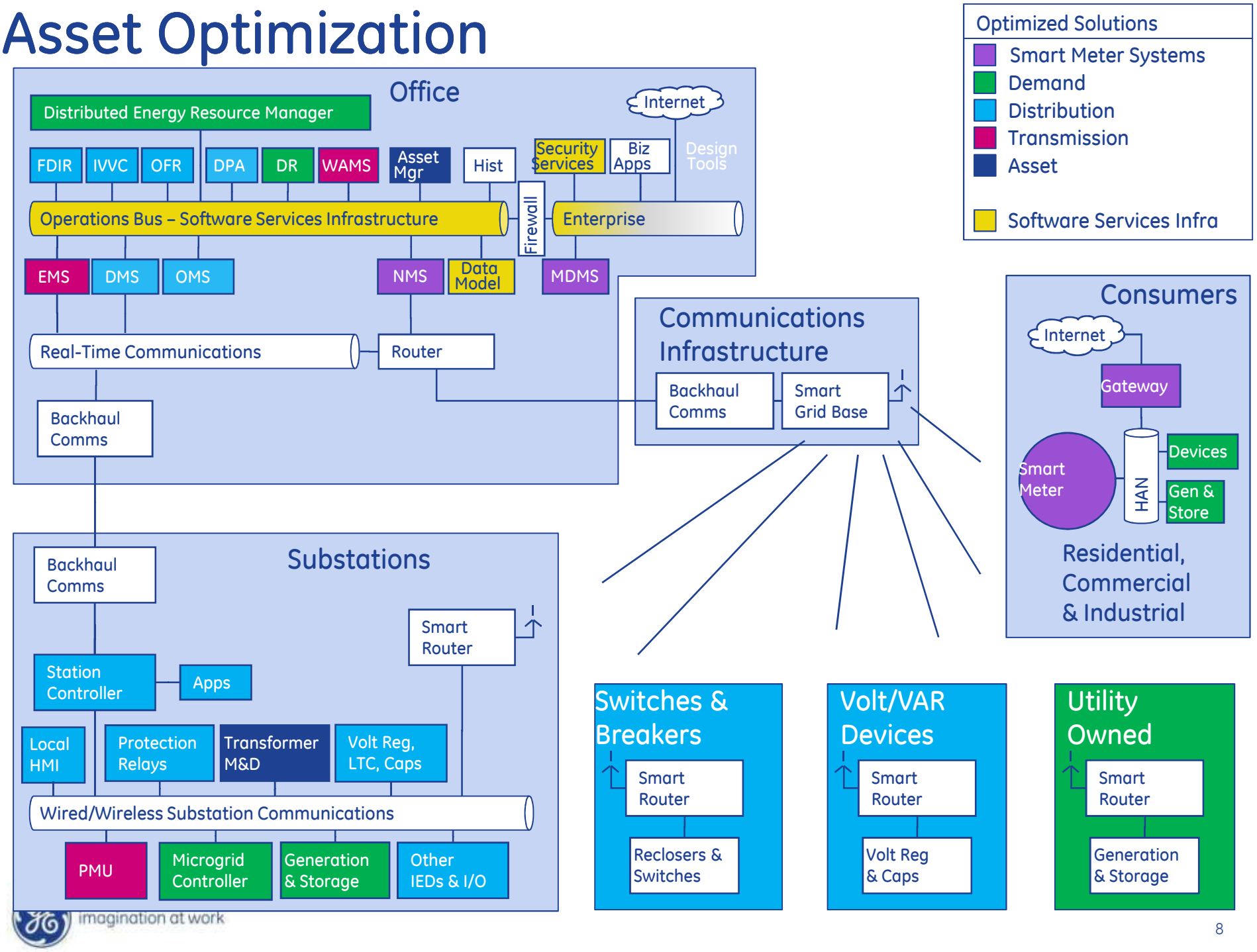
Asset Optimization

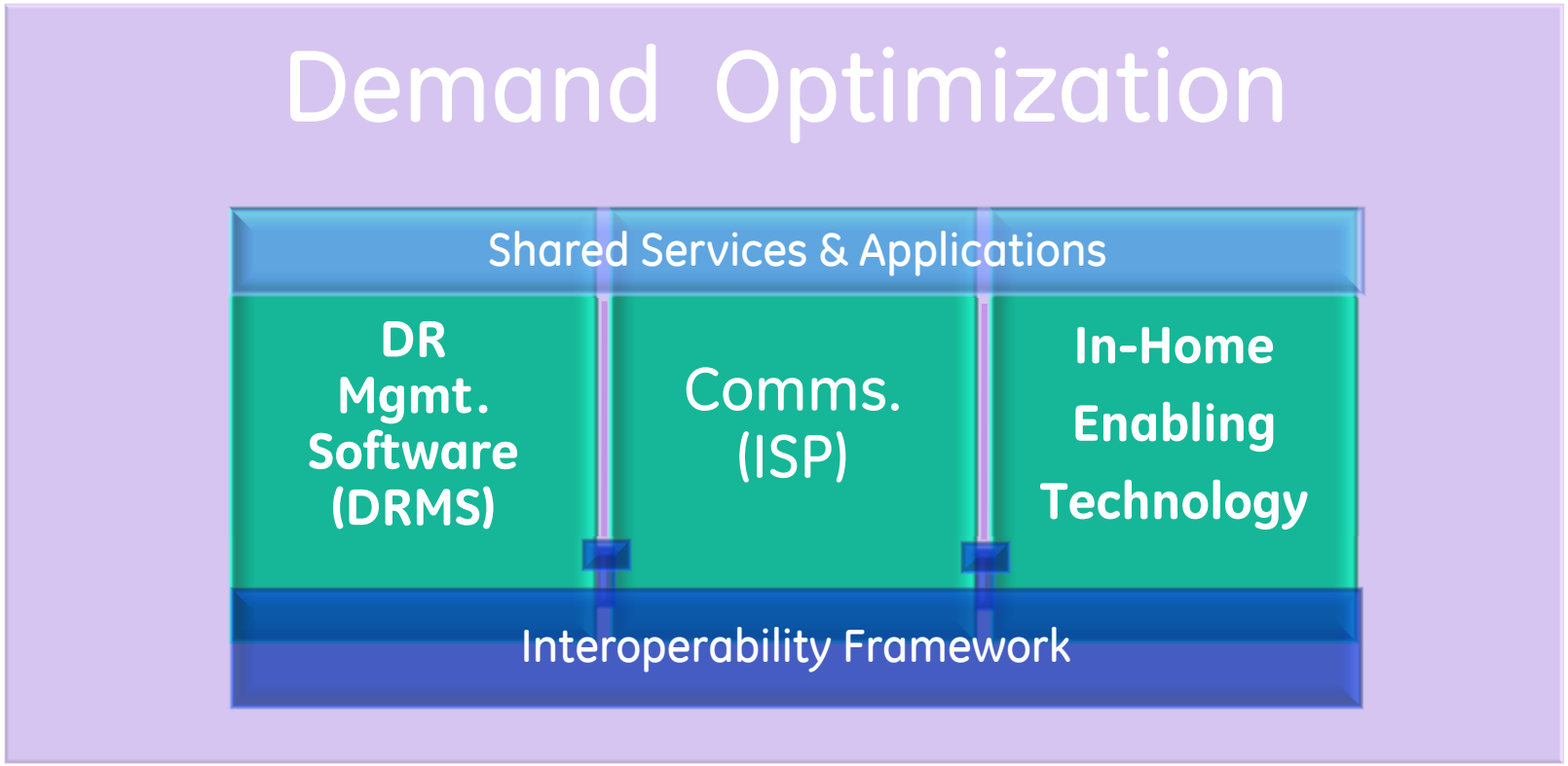


Reduce Capex and risk of failure by proactively monitoring critical assets to predict problems and prevent failures

Asset Optimization

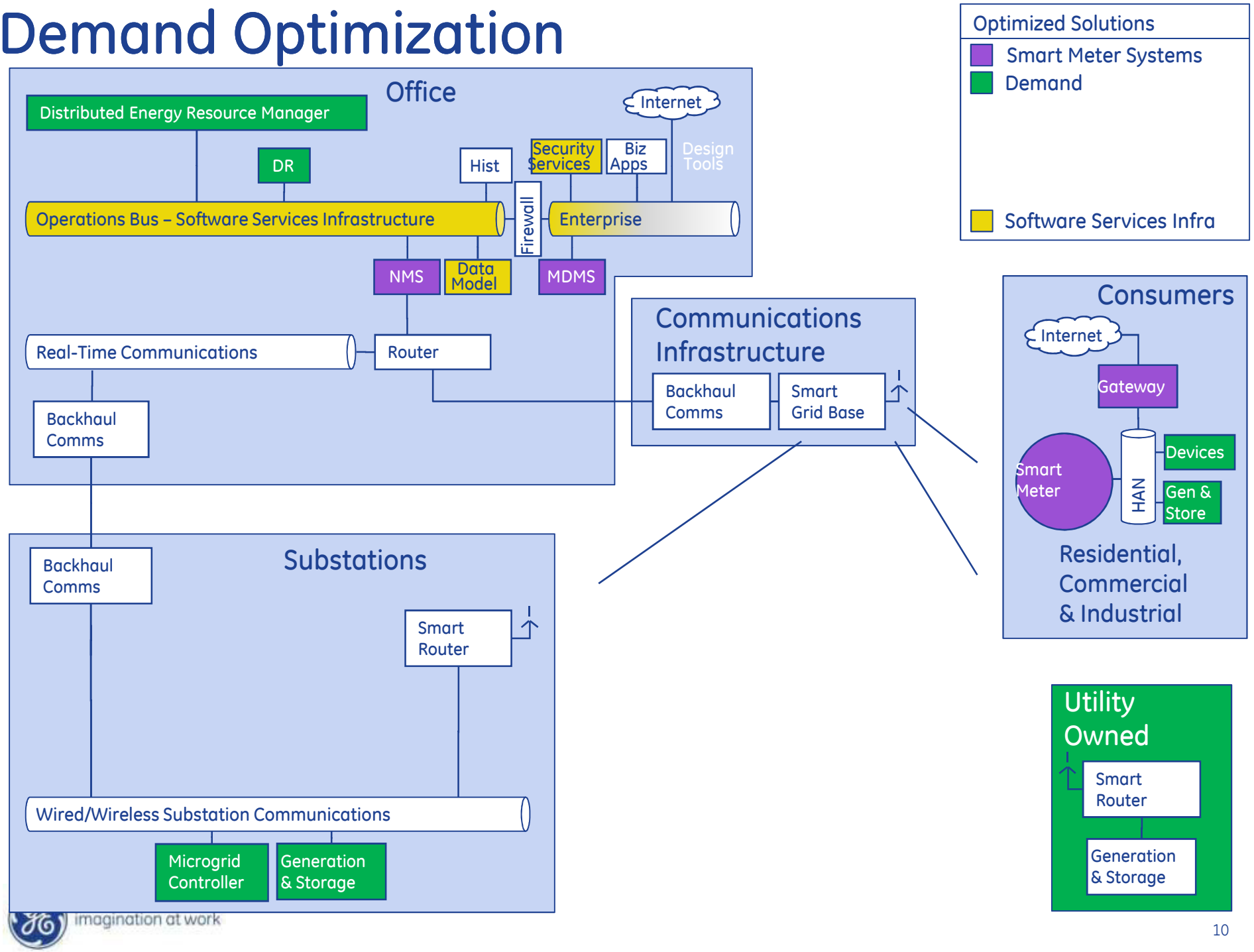


Demand Optimization

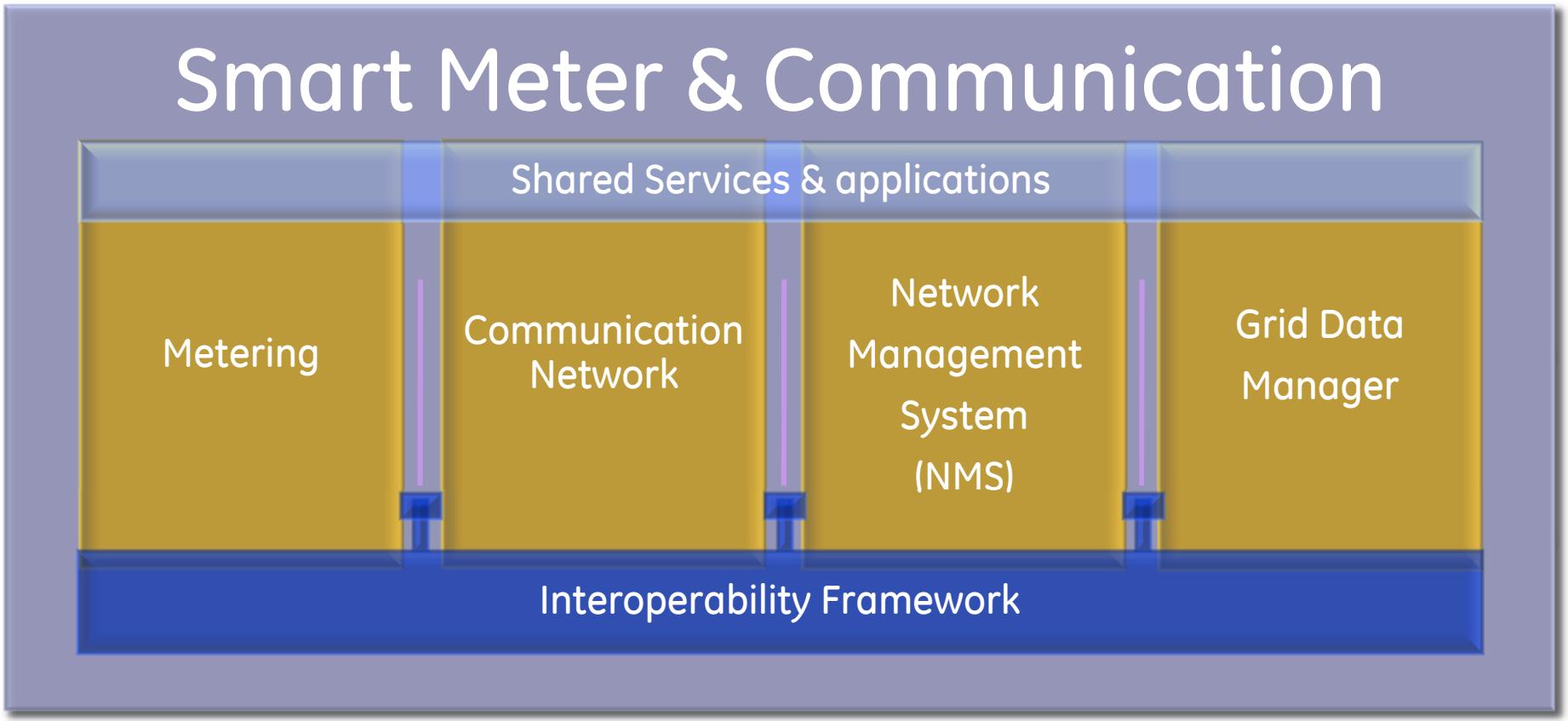


Defer grid upgrades, optimize generation by managing peak via control of power consumption

Demand Optimization



Smart Meter System



Enabling technology for network connectivity, consumer enablement, demand optimization, and improved grid operations

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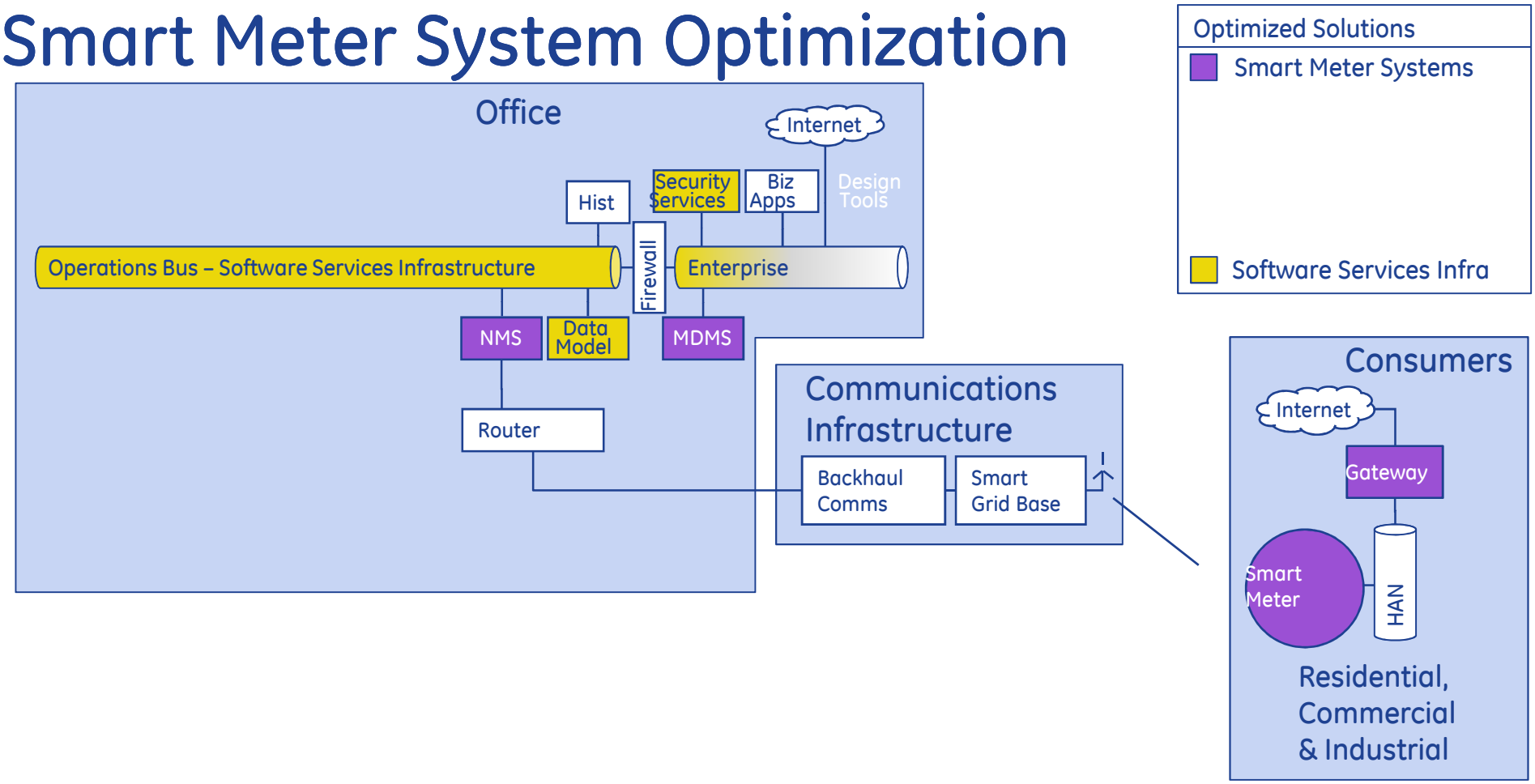
Smart Meter System Optimization



Smart Meters/AMI Integration with GIS, OMS and DMS

Smart Meters/AMI

- Meter Readings
- Voltage => DMS
- Last Gasp Communication => OMS

GIS

- Network Model Information => OMS, DMS

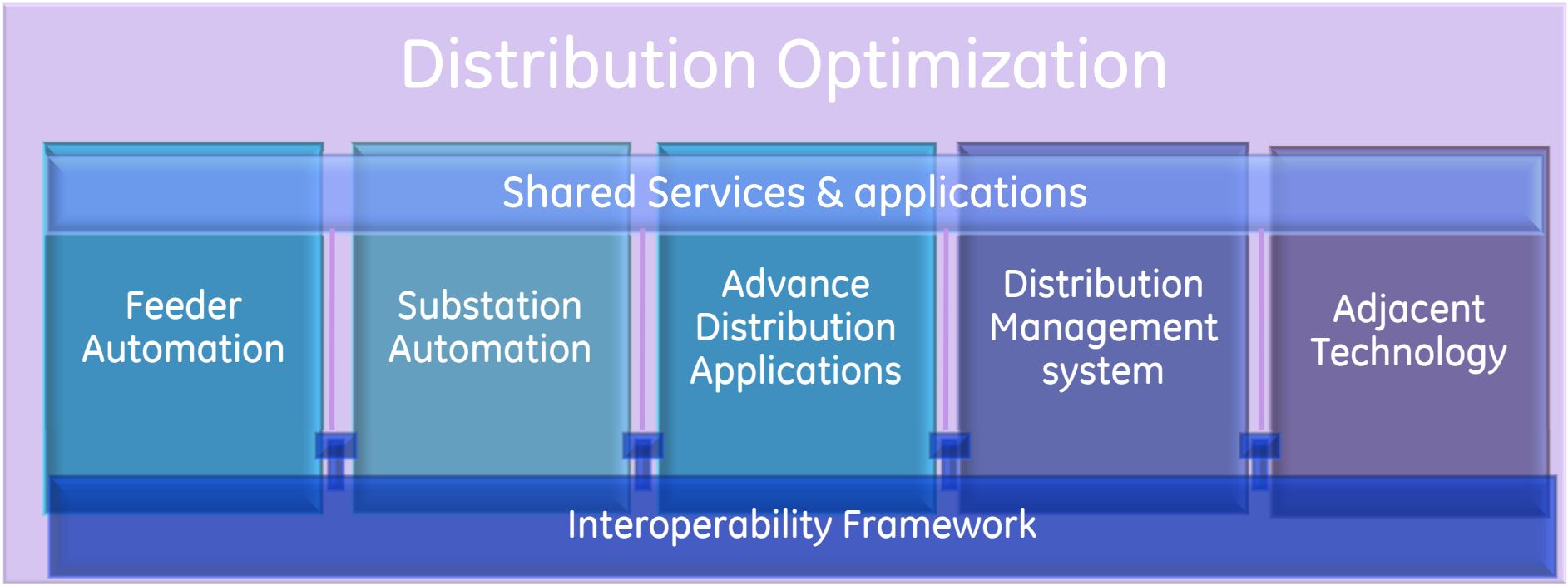
DMS

- Status Changes => OMS

Customers

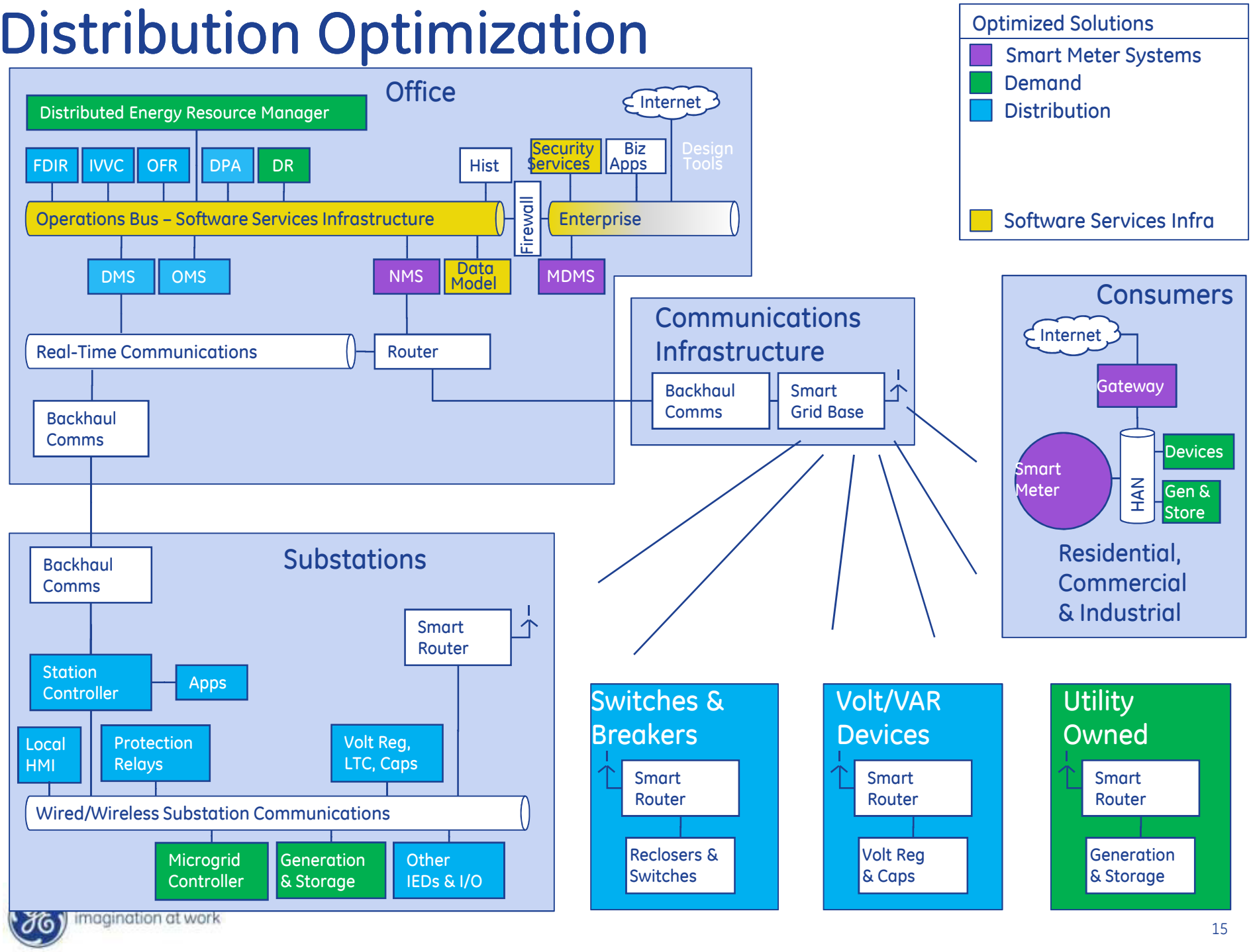
- Phone Calls => OMS
- Social Media => OMS

Distribution Optimization

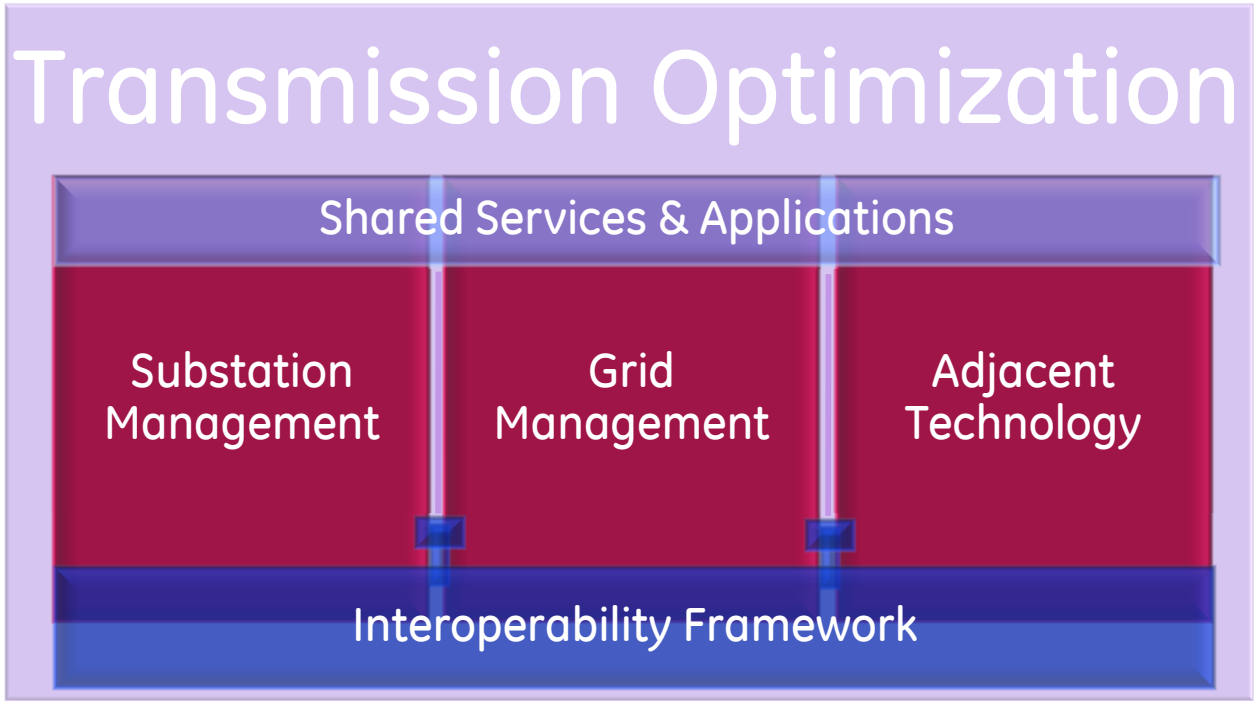


Less energy waste and higher profit margin by reducing delivery losses in distribution system

Distribution Optimization

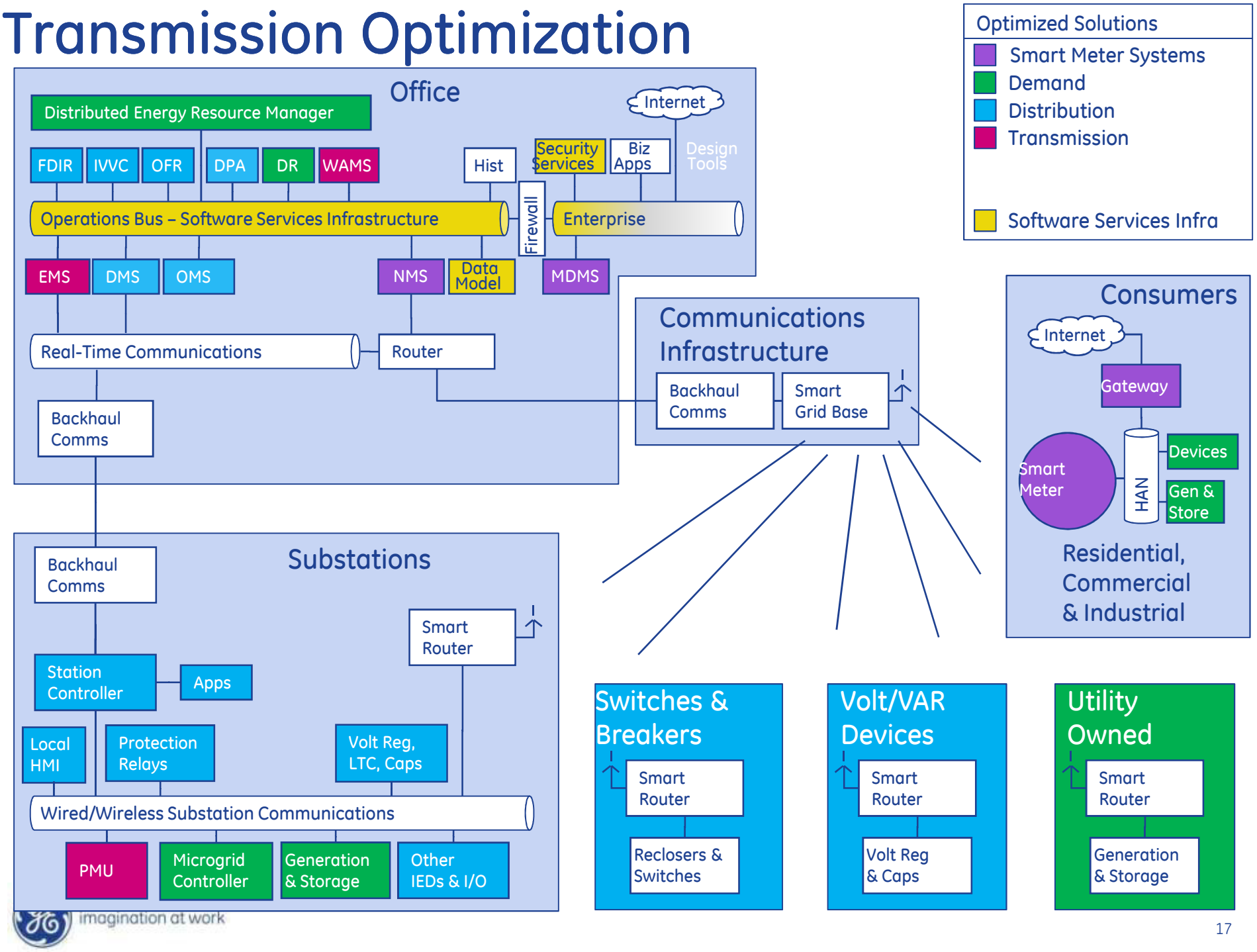


Transmission Optimization

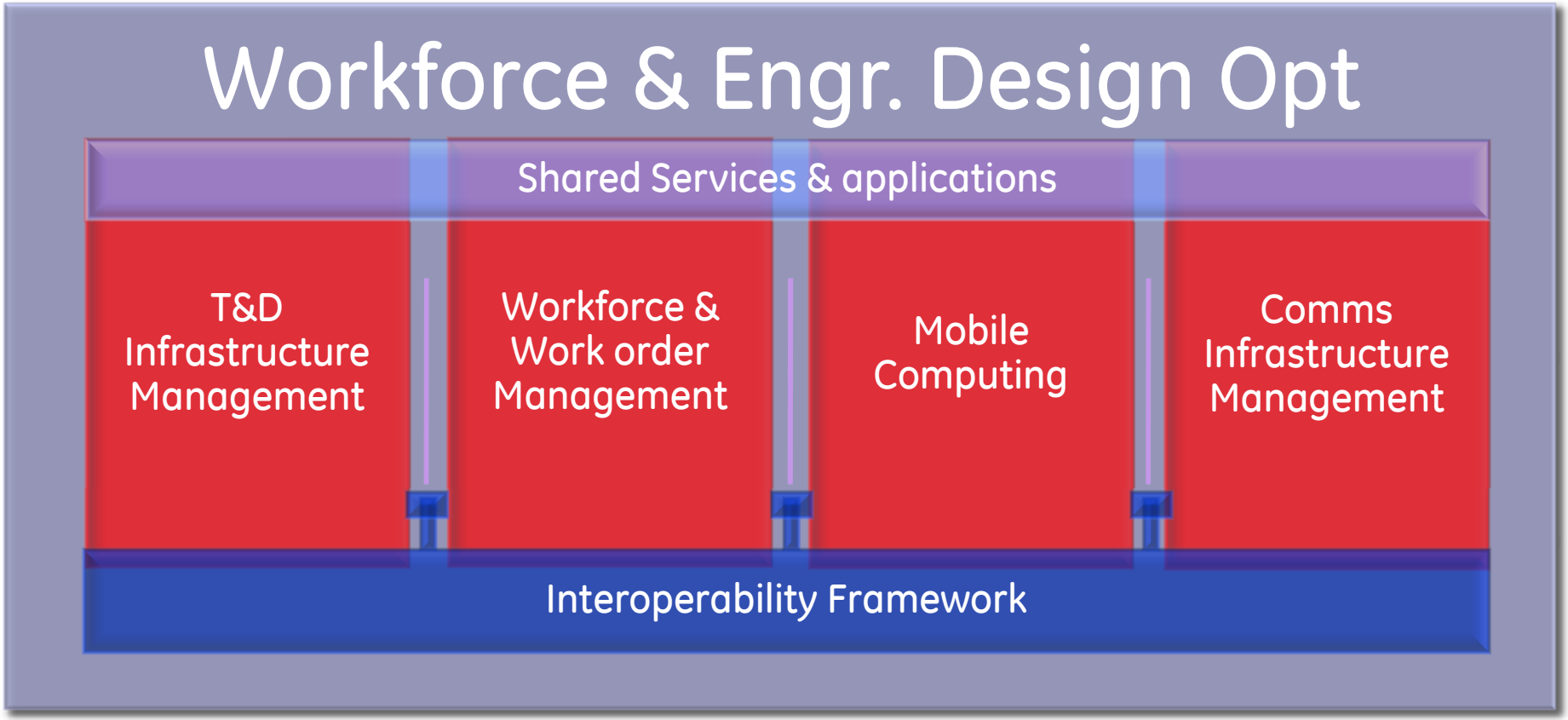


Improve return on assets, enhance electric reliability and raise situational awareness

Transmission Optimization



WEDO



Increase productivity and reduce planning and design costs.
Reduce miles driven and increase field crew productivity.

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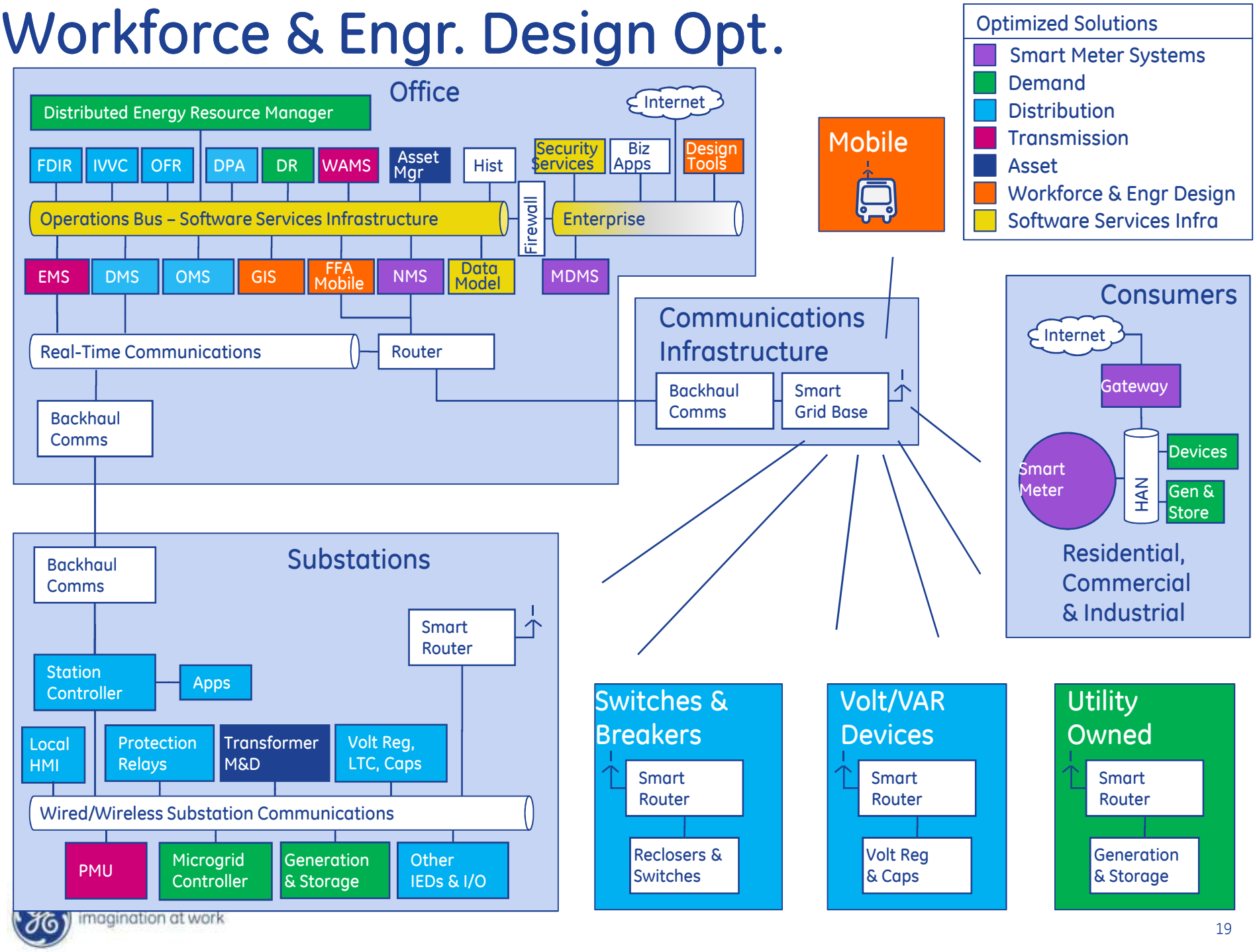
Workforce & Engr. Design Opt.



Smart Grid Standards Development and Interoperability

A Brief History

Nov. 2009 – Formation of SGIP

Jun. 2010 – Formation of SGFAC

Dec. 2011 – SGFAC Report to NIST

Dec. 2011 – NIST reports “curtailed funding” for SGIP in 2013

Apr. 2012 – Draft of SGIP 2.0 Business Sustainment Plan

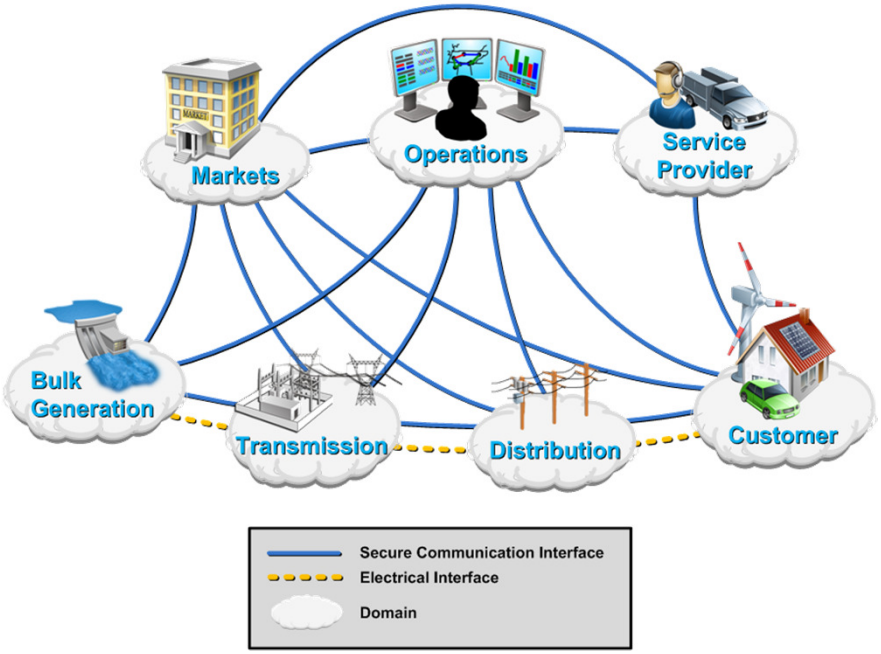
May 2012 – Comments on Business Sustainment Plan from SGFAC

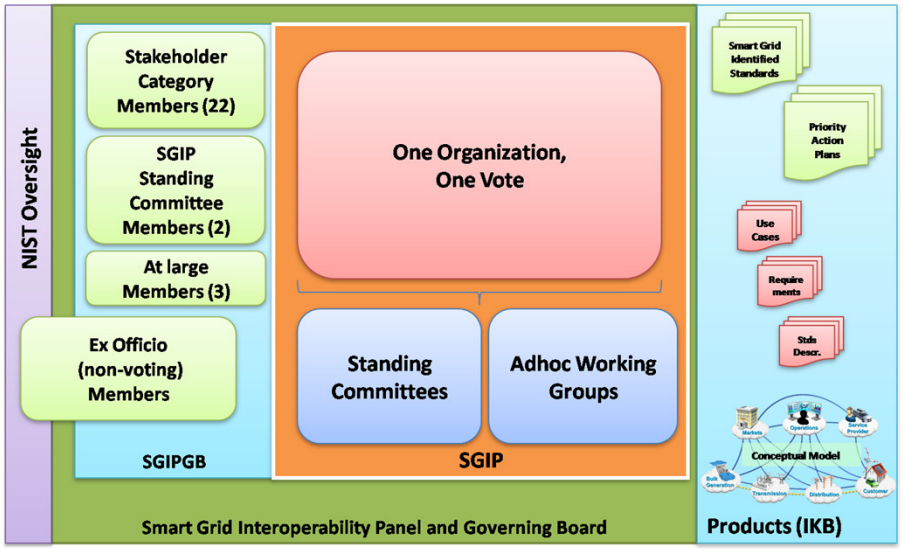
Jul. 2012 – Business Sustainment Plan Finalized, SGIP 2.0 incorporated

Example: Standards Framework

National Institute of Standards and Technology (NIST)

… Smart Grid Conceptual Reference Model
… Smart Grid Interoperability Panel Organizational Structure





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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

SGIP Accomplishments

Nearly 800 companies and organizations are members of SGIP

Catalog of Standards

- Hundreds of standards considered
- 42 Included in the catalog
- 14 currently being voted on
- 82 in the review/evaluation queue

International letters of intent have been signed with countries in Europe, Asia, and the Americas with many more to come

Global Standards Collaboration

cen CENELEC ETSI

ena energy networks association

KSGA Korea Smart Grid Association

NEDO

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Global Standards Collaboration - Ecuador

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Global Standards Collaboration - Colombia

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Smart Grid Standards Vision


SGIP
provides a framework for orchestrating all Smart Grid stakeholders to accelerate standards harmonization and interoperability

What Does SGIP Do?

Identify user requirements and gaps in standards

Accelerate standards development and harmonization for interoperability of Smart Grid devices & systems

Identify necessary testing and certification requirements

Oversee the performance of these activities & continue momentum

Inform and educate Smart Grid industry stakeholders on interoperability

Conduct outreach to establish global interoperability alignment

SGIP Member Groups

Membership

Domain Expert Working Groups (DEWGs)

- Building to Grid
- Industry to Grid
- Home to Grid
- Vehicle to Grid
- Transmission & Distribution
- Business & Policy
- Distributed Renewables Generation & Storage

Priority Action Plans (PAPs)

- Wireless Comm - 02
- Energy Storage Interconnect - 07
- Distribution Grid Mgmt - 08
- Standard DR & DER Signals - 09
- Map IEEE 1815 to IEC 61850 - 12
- Power Line Comm - 15
- Wind Plant Comm - 16
- Facility Smart Grid Info Std - 17
- Wholesale Demand Response - 19
- Green Button ESPI Evolution - 20
- Weather Info - 21
- EV Fueling Submetering - 22

Standing Member Committees

- Architecture
- Cybersecurity
- Implementation
- Testing & Certification

Work Products

- Conceptual Models & Roadmaps
- Requirements
- Use Cases
- Whitepapers
- Stds Evaluation
- Catalog of Stds

SGIP

Accelerating Grid Modernization

www.sgip.org

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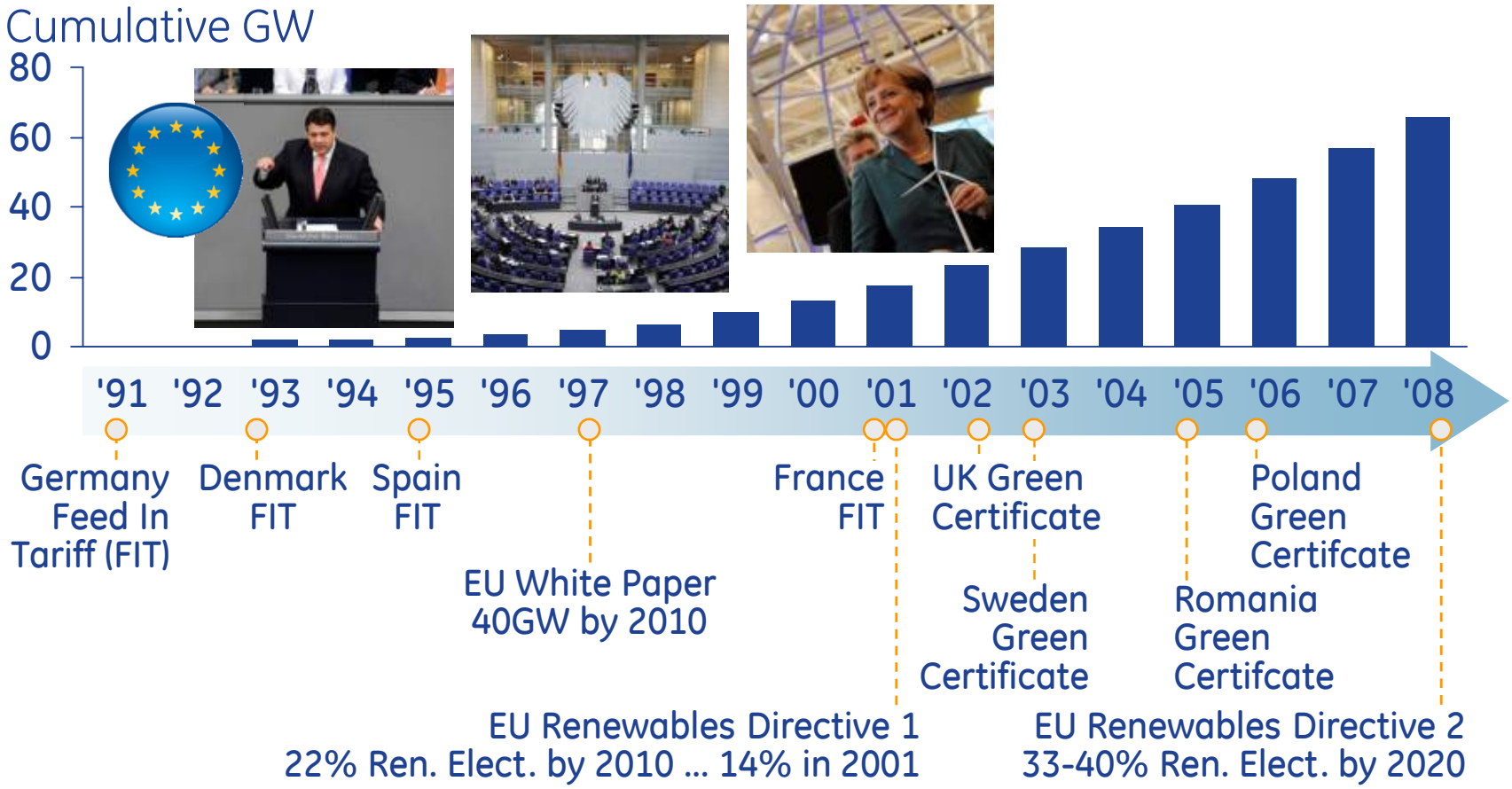
Smart Grid Policy

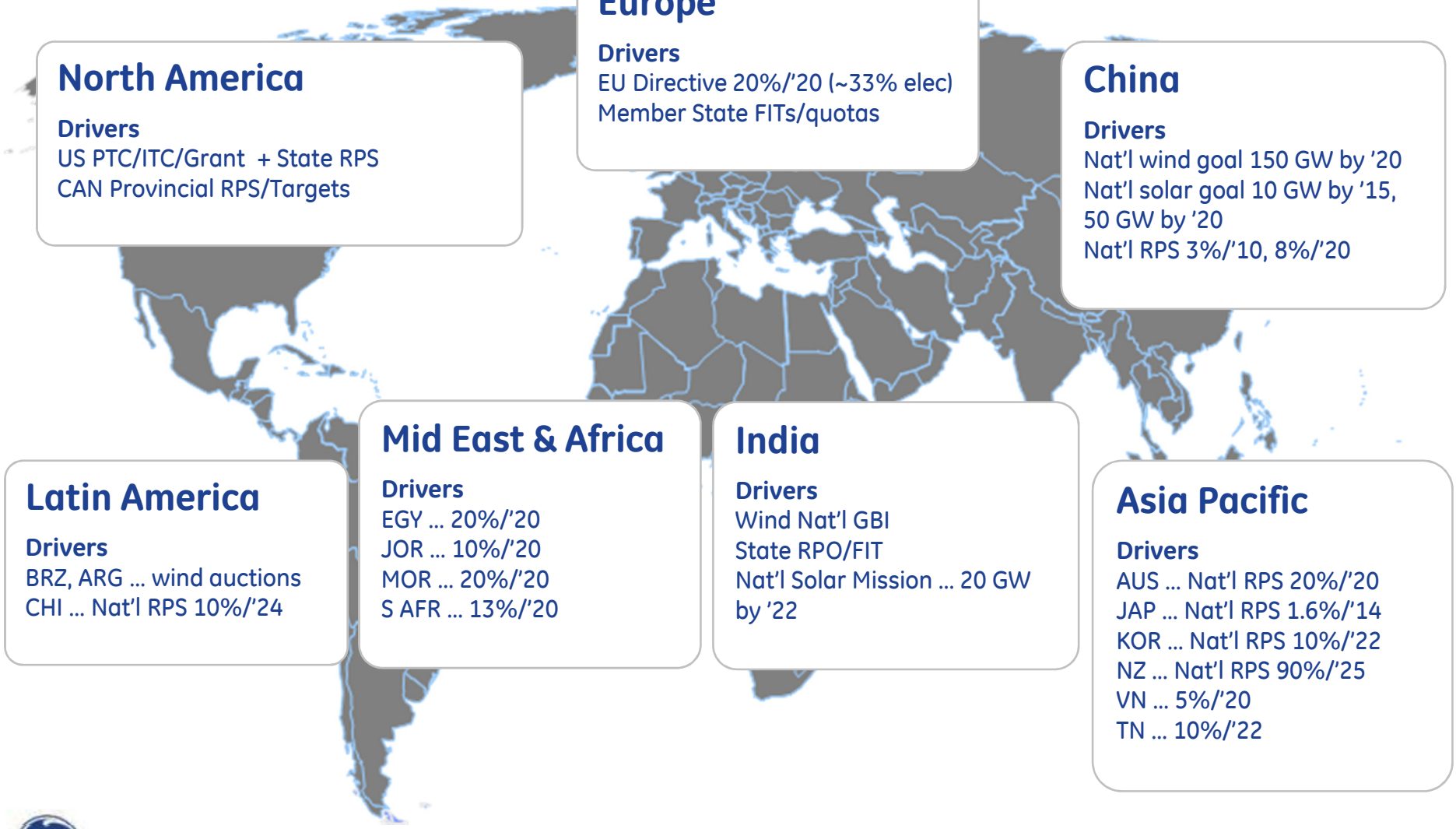
Lessons from Renewables

The powerful role of policy

Consistent European policy created the wind industry



Europe and China lead policy-driven growth



Europe

Drivers
EU Directive 20%/'20 (~33% elec)
Member State FITs/quotas

North America

Drivers
US PTC/ITC/Grant + State RPS
CAN Provincial RPS/Targets

China

Drivers
Nat'l wind goal 150 GW by '20
Nat'l solar goal 10 GW by '15, 50 GW by '20
Nat'l RPS 3%/'10, 8%/'20

Latin America

Drivers
BRZ, ARG … wind auctions
CHI … Nat'l RPS 10%/'24

Mid East & Africa

Drivers
EGY … 20%/'20
JOR … 10%/'20
MOR … 20%/'20
S AFR … 13%/'20

India

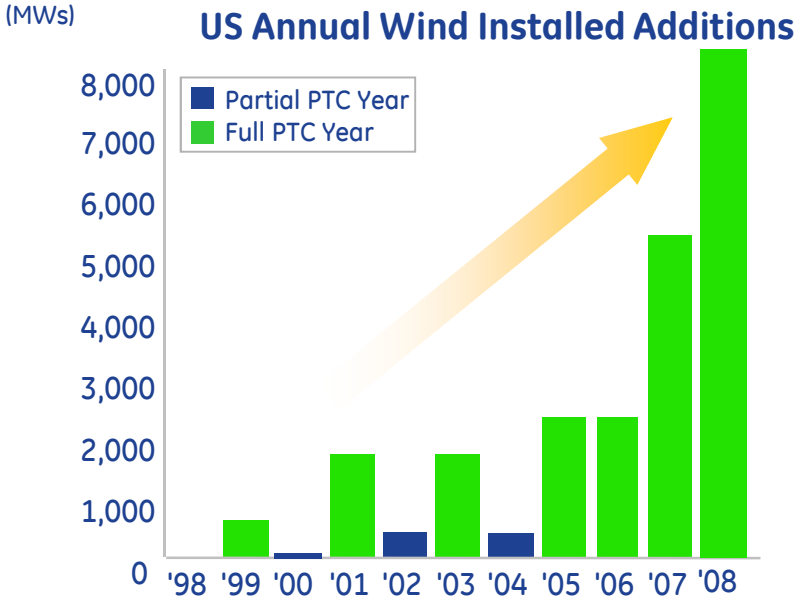
Drivers
Wind Nat'l GBI
State RPO/FIT
Nat'l Solar Mission … 20 GW by '22

Asia Pacific

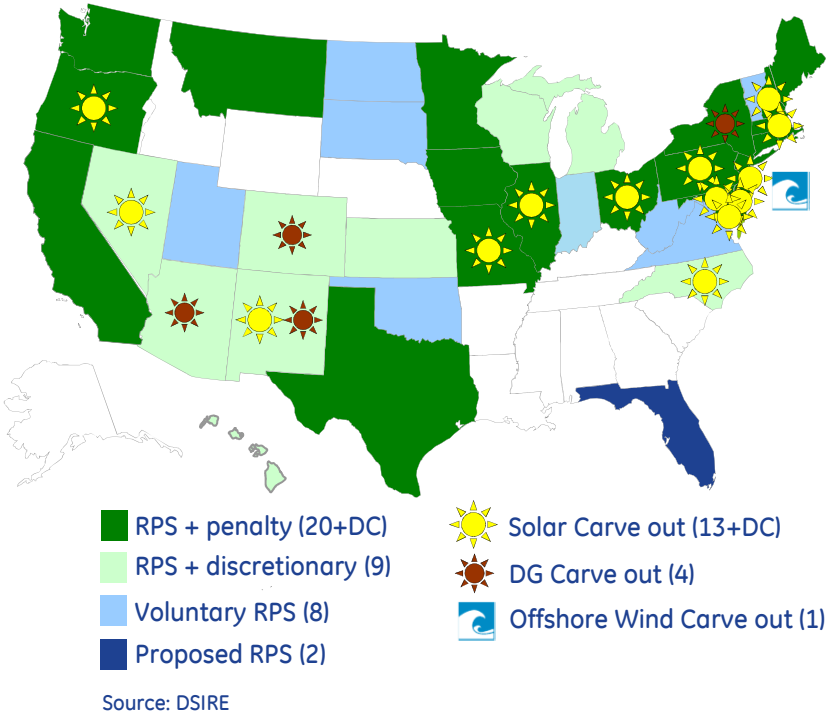
Drivers
AUS … Nat'l RPS 20%/'20
JAP … Nat'l RPS 1.6%/'14
KOR … Nat'l RPS 10%/'22
NZ … Nat'l RPS 90%/'25
VN … 5%/'20
TN … 10%/'22

Progress in the United States

Federal production tax credit



Renewable portfolio standards



Source: DSIRE

- National incentives
  - PTC … $.021/kWh, 10y
  - ITC … 30%
  - Cash grant in lieu of tax credits (~ITC value)
  - DOE Loan Guarantee Program

- State RPS
  - Jan '07: 22 states … ~44 GW wind '07-25
  - Jan '10: 35 states … ~50 GW wind '10-25

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Global lessons learned

No "one size fits all" … focus on outcomes

- Feed-in tariff
- Quota/RPS
- Tax incentive
- Auction/Tender

Attributes of an effective policy

- Stable, long-term commitment
- Rewards performance
- Supports project financial viability
- Non-compliance "teeth"
- Tied to enabling policies (transmission, siting)
- Reasonable cost containment measures

Application to Smart Grid

Setting the stage

DRIVERS

Economic competitiveness

Energy security

Consumer empowerment

Environmental sustainability

ISSUES

Frameworks & funding

Interoperability

R&D support

Cyber security

Cost recovery

Customer protection & engagement

GOALS

Create, shape <u>and</u> sustain the market

… Policymakers – establish the targets

… Regulators – provide the incentives

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Stimulus to kick-start

$70B

- Expand power grid by 26,000 km, incl. new equipment by 2009 and 2010

$19B

- $14.5 billion of guarantees for T&D and renewables
- $4.5 billion for Smart Grid, including federal matching funds

$10B

- Additional funding for India's '07-'12 power development program in order to reduce T&D energy losses by 15%
- Part A-$2B, SW/Auto
- Part B-$8B, Hardware

$7B

- Support trans-European infrastructure
- Energy Package, 80% smart meter coverage by 2020
- EU 20/20/20

$3B

- Ofgem - £500MM, four (4) Smart Towns
- Olympic village
- Regulation to reward grid efficiency and reliability

$1B

- Govt $100MM, two (2) Smart Cities
- Victoria required to achieve full smart meter coverage by 2013

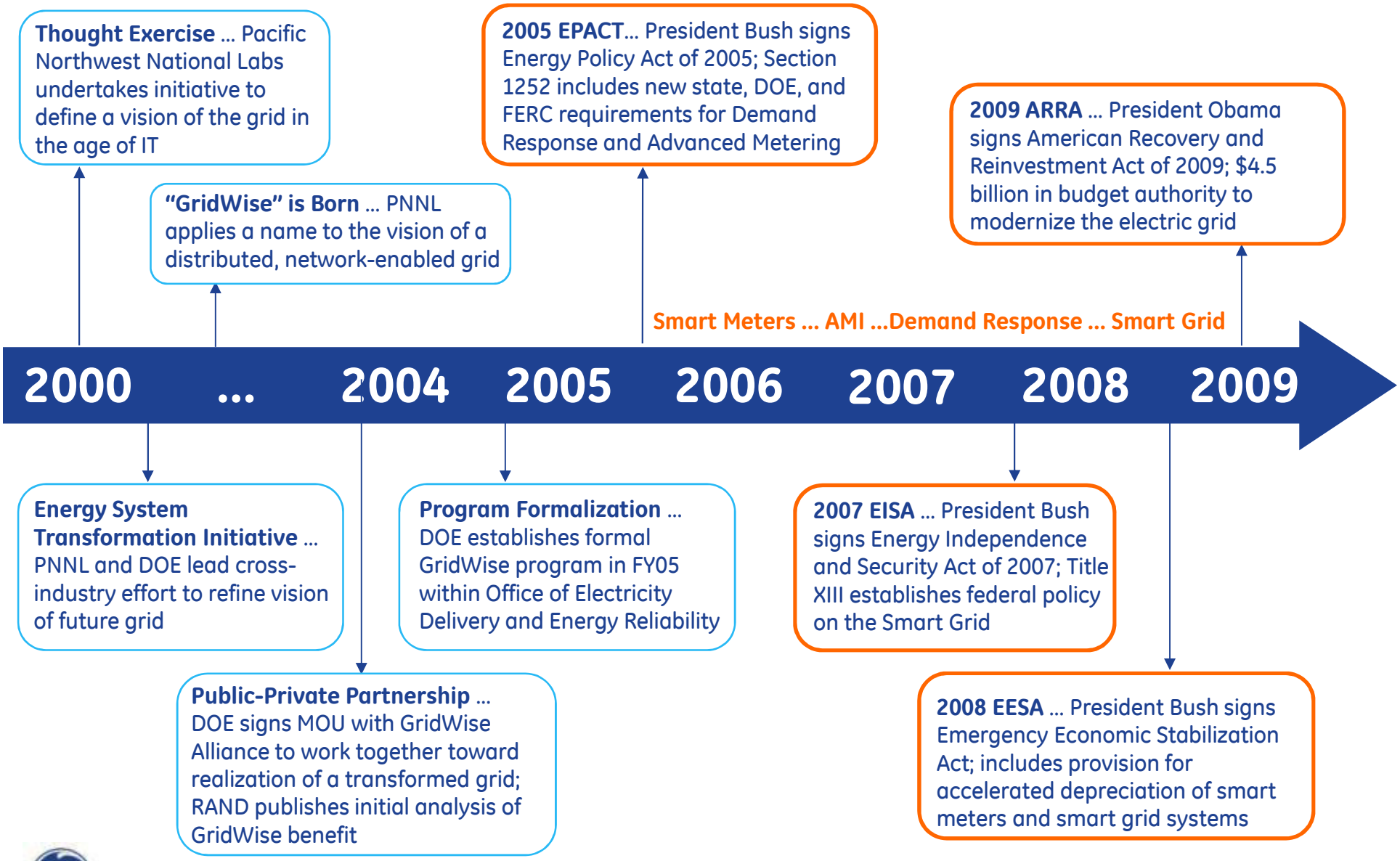
$0.5B

- Infrastructure: Smart Grids, Renewable integrations
- Demonstration programs, matching funds

$0.3B

- Jeju island test bed
- Development oppty's
- MKE directing Smart Meter roll-out

A historical review for the United States



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Example: state legislation

Characteristics of effective policy

Relevant

- Target a particular smart grid technology or benefit;
- Disincentivize alternative means of compliance

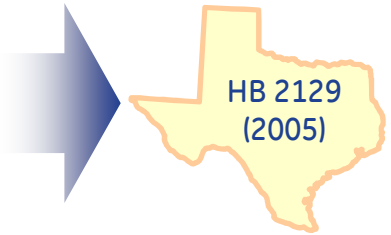
Specific

- Identify required functionalities
- Include timelines for implementation

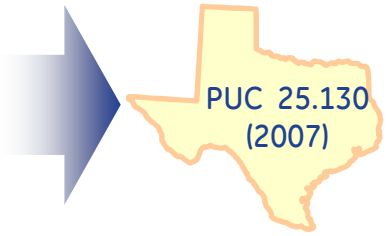
Proactive

- Establish cost recovery parameters
- Anticipate and address implementation challenges

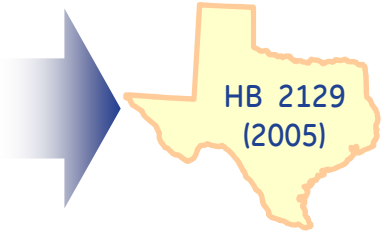
Ex) Texas smart meter experiences



- "Encouraged" utility adoption of smart meters and AMI
- Subsequent linkage to energy efficiency (HB 3693, 2007)



- Identified minimum technical capabilities for smart meters

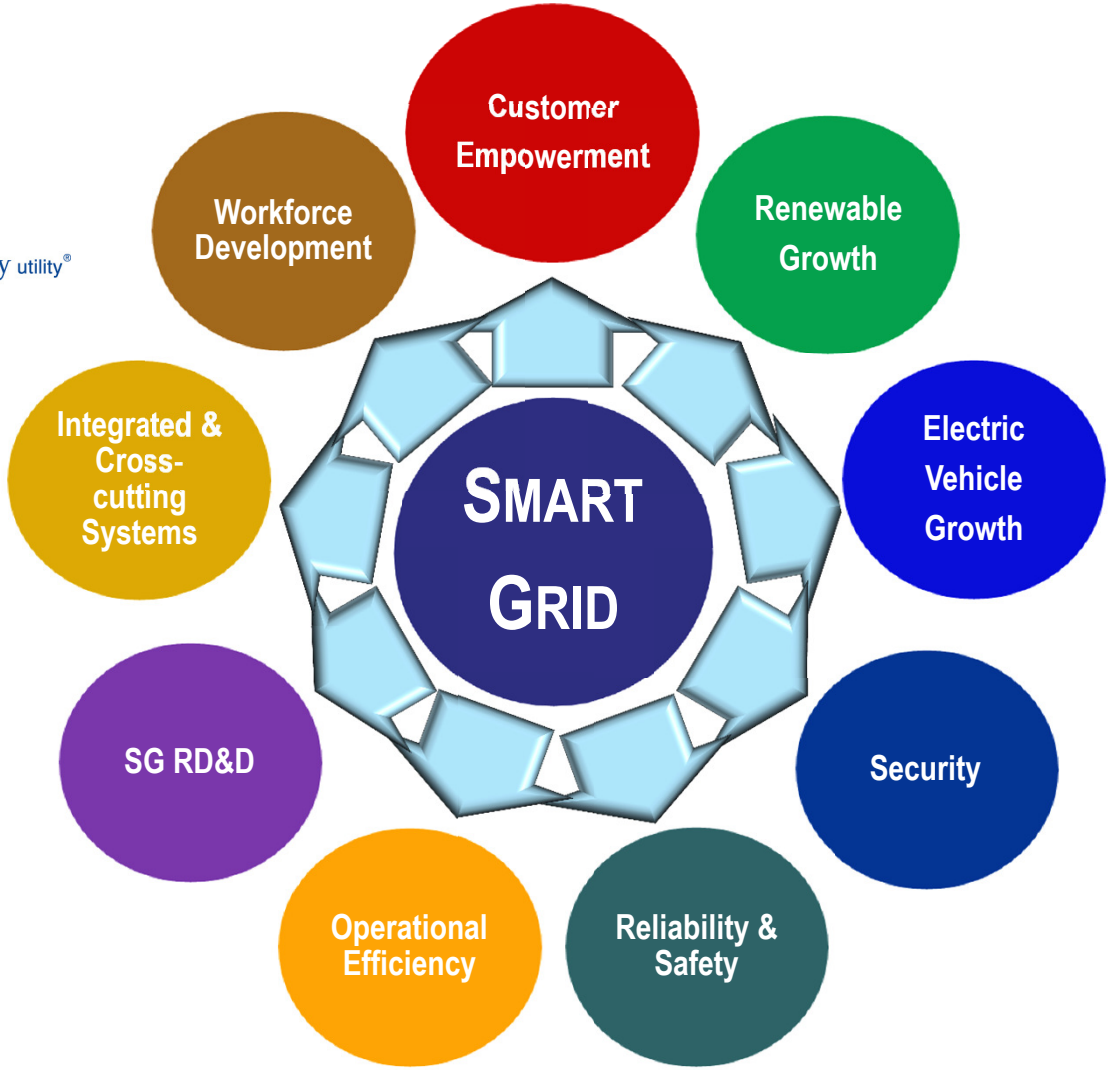


- Directed PUC to establish a surcharge for cost recovery

Example: utility deployment plan

Estimated $3.5B in investment in 9 programs through 2020

SDGE
A Sempra Energy utility®



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Policy and standards are closely linked

Competing standards can inhibit markets

By default…

- Disparate standards bodies give rise to competing standards
- Firms face higher transaction costs, diseconomies of scale

By design…

- Technical standards as industrial policy…non-tariff trade barriers
- "Prescriptive" standards development undermines "market-based" approach

Leading to calls for harmonization

- Country-to-country MOUs
  - ✓Joint R&D
  - ✓Standards working groups
- Foreign participation in national/regional standards bodies
- Government support for development of international standards
- Internationally-recognized conformance testing procedures
- Funding for standards development in emerging markets
- Other…

Smart Grid Recent Deployments and Lessons Learned

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

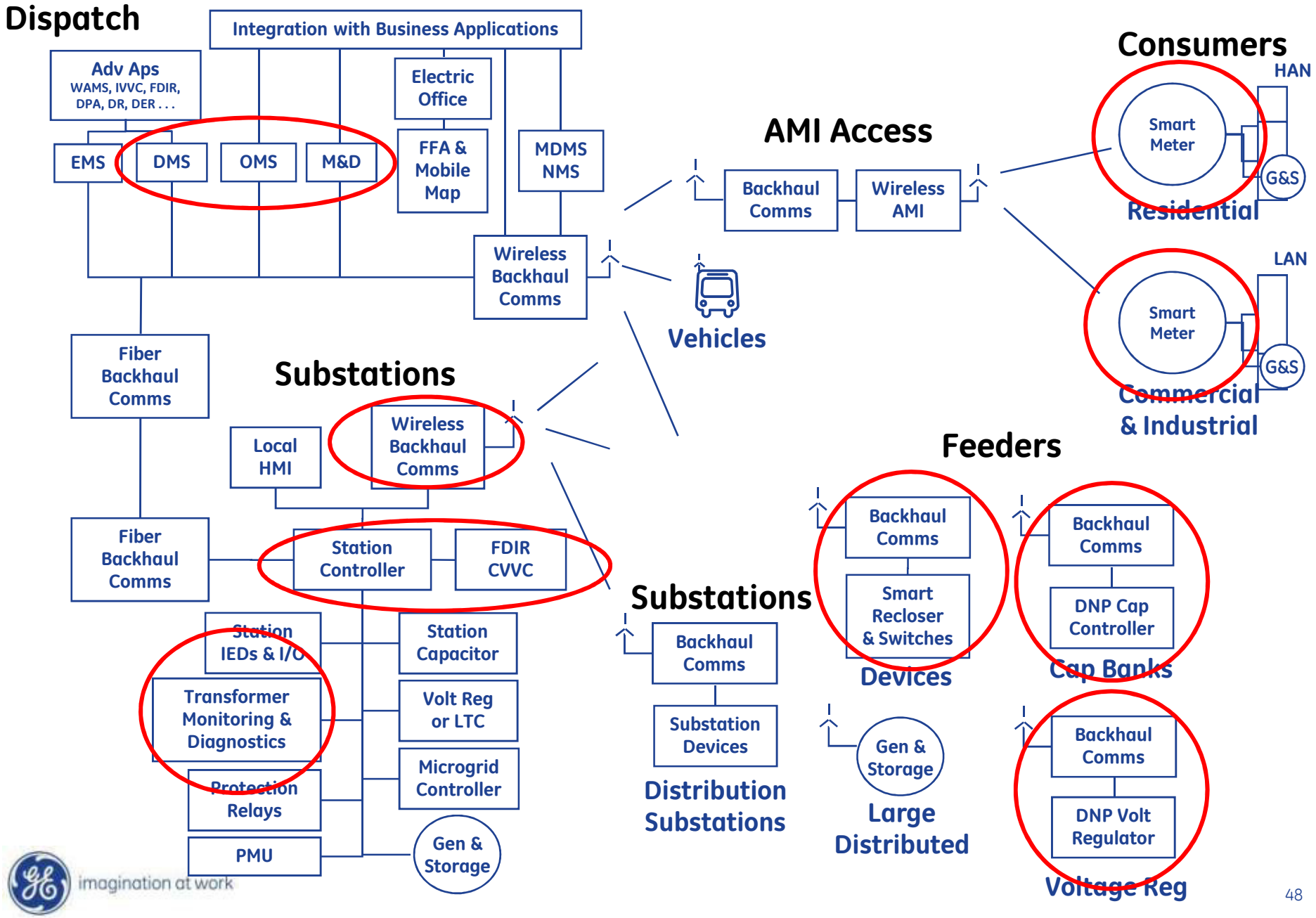
Drivers

- 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

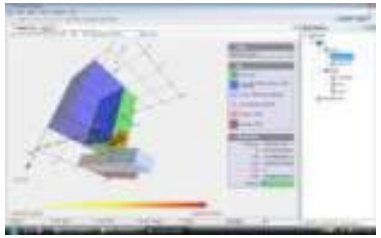
AEP Project – Integrated System View



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)
- GENe 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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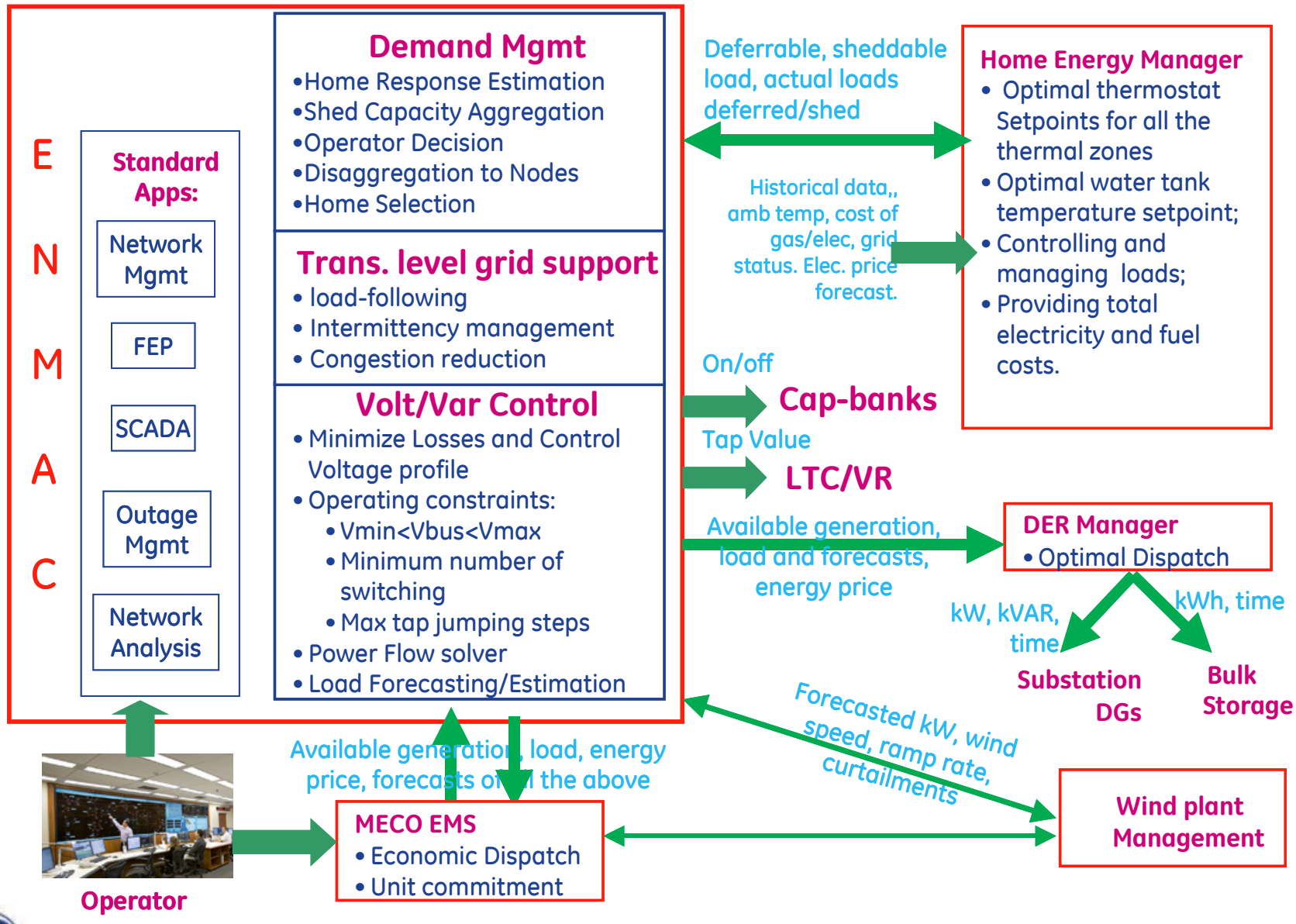
Maui Smart Grid Project

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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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

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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 | Recommend (0) | share | email | print | comment | reprint

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

imagination at work

Smart Grid Lessons Learned

Technology:

- Challenge: “Hype” versus “Reality”
  - Utility expectations were that basic SG solutions were “shovel–ready”
  - Reality - Component technology was not as mature as advertised when combined to create a Smart Grid Solution
  - In many cases components were field re-engineered or upgraded to meet objectives and expectations
- Challenge: Integration / Interoperability
  - Integrating multiple supplier products to create a SG solution
  - Lesson Learned: adopt and insist on standards and open architecture methodology – drive for plug and play solutions
- Test, Test, Test
  - Lesson Learned: Extensive lab testing for “SG Solutions” is mandatory prior to implementation – understand the capabilities
  - Re-do’s are expensive and time consuming!

Smart Grid Lessons Learned

Implementation & Deployment:

- Challenge: Coordinating multiple suppliers
  - Managing equipment, shipments & delivery – pieces and parts along with assembly required for implementation (e.g., radio, controller, AMI network, substation equipment with software)
  - Coordinating software functionality with multi-supplier hardware and AMI
  - Lesson Learned: Minimize niche suppliers – prefer alliance suppliers with strong engineering and solution teams
- Challenge: Coordinating multiple internal departments
  - Managing Substation and Distribution Engineering, Protection and Control, Communications and Construction
  - Lesson Learned: Engage 1 Project Manager for each Smart Grid solution with multi-discipline authority
- Prefer packaged solutions from fewer suppliers – minimize the finger-pointing

Smart Grid Lessons Learned

Project Management:

- Establish Program Management Office
  - Multiple Project Managers reporting to the Program Manager
  - Adhere to PM guidelines such as Communication, Status Reporting, Risk Management, etc.
  - Build an “A” team with project and technical members – there will be challenges to collectively solve
- Establish Corporate Steering Committee
  - Key status meetings with Utility Executives and Alliance Suppliers
  - Escalation and Risk Mitigation in timely manner is critical
- Build Strategic Alliances with Key Suppliers
  - Define, Engineer and Build the Smart Grid solutions collectively
  - Alliance Supplier provides “On-site” management and technical support

Smart Grid Lessons Learned

Change Management:

- Smart Grid solutions involve multiple stakeholders (actors)
  - Residential / Commercial customers are now a “Major Stakeholder”
  - For example: PCT’s, In-home devices, utility incentivized customer programs, 2-way communication with the Utility
- Define and develop “Use-Cases” for each component of Smart Grid
  - Use-Cases provide – a scenario description, defines the benefits, actors, functional requirements, and business rules and assumptions
  - Lesson Learned: Use-cases form the basis for the benefits achieved, functional requirements, development, and training
  - Smart Grid actors require “Significant Training” on the operation and maintenance of the deployed system (i.e., Operations Center, Communications, Customer Call Center, Engineering, Field Crews, etc.)

Thank You!