GE Digital Energy

The Future of Energy: Smart Grid and Beyond

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IEEE PES Tallahassee Chapter
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Agenda

- Key Industry/Societal Trends
- Integration of Renewables
- Holistic Solutions
- Big Data, Analytics and Enterprise Data Management
- Industry Standards Vision
- Incentive-Based Regulation

Key Industry/Societal Trends

Key Industry/Societal Trends

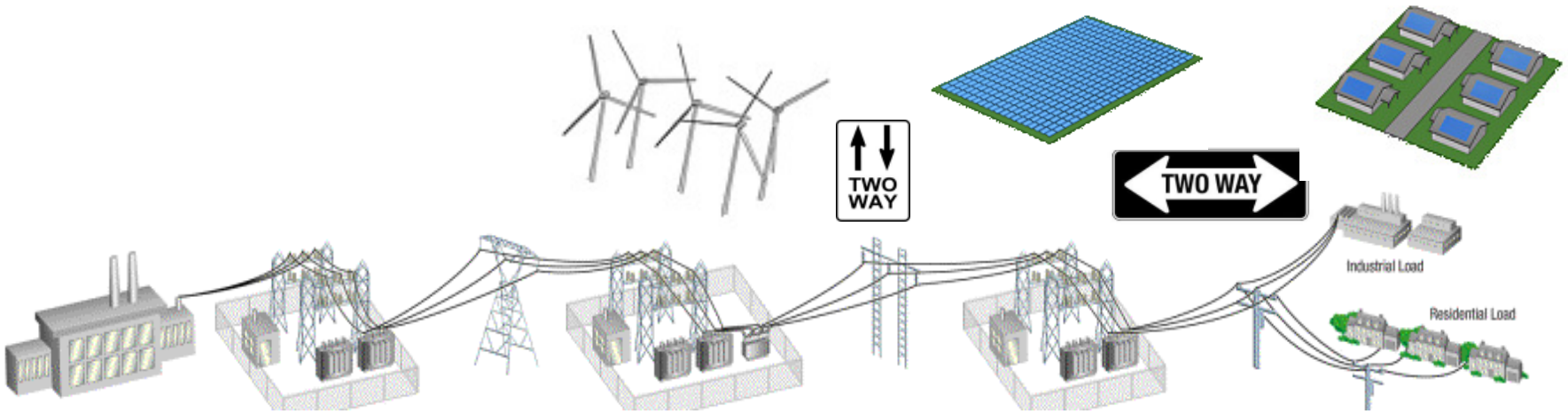
- ✓ Transitioning from Devices/Systems to Holistic Solutions
- ✓ Success = Technology, Standards, Policy
- ✓ Grid Flexibility + Self Healing + Reconfigurable
- ✓ Electrical Power Distribution Infrastructures Resiliency
- ✓ Big Data, the Cloud and Use of Social Media
- ✓ Convergence of IT and OT to Support Enterprise Data Management

Integration of Renewables

Distributed Generation

Industry Challenge

A wide array of DG is creating unique challenges in the grid: two-way power flow, voltage regulation concerns.



Distribution controls and protection traditionally take advantage of and are designed only for uni-directional power flow

Distributed Generation

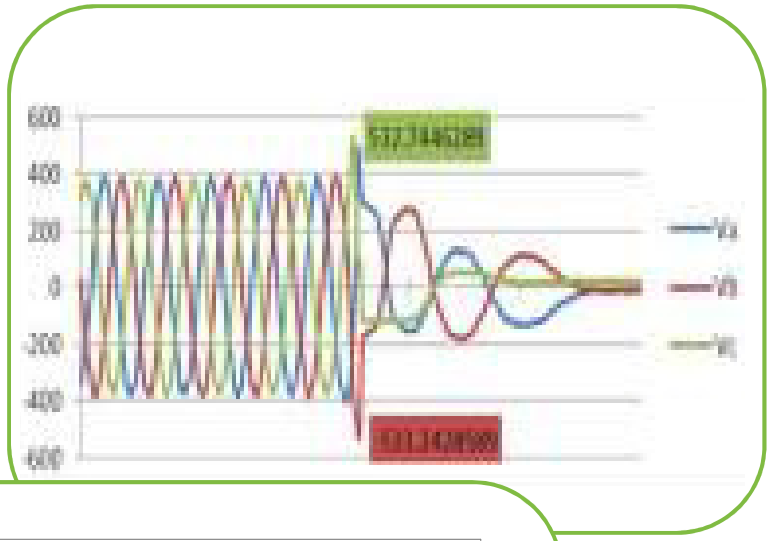
Industry Challenge

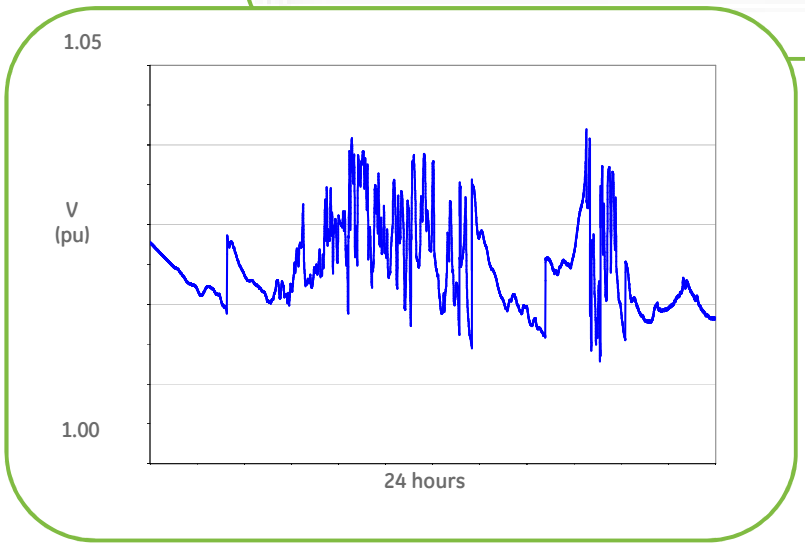
Open circuit over-voltage due to unintentional islanding

Protection ratings not matched to fault currents

Varying Fault Currents due to DG

Stress on Voltage Regulation equipment





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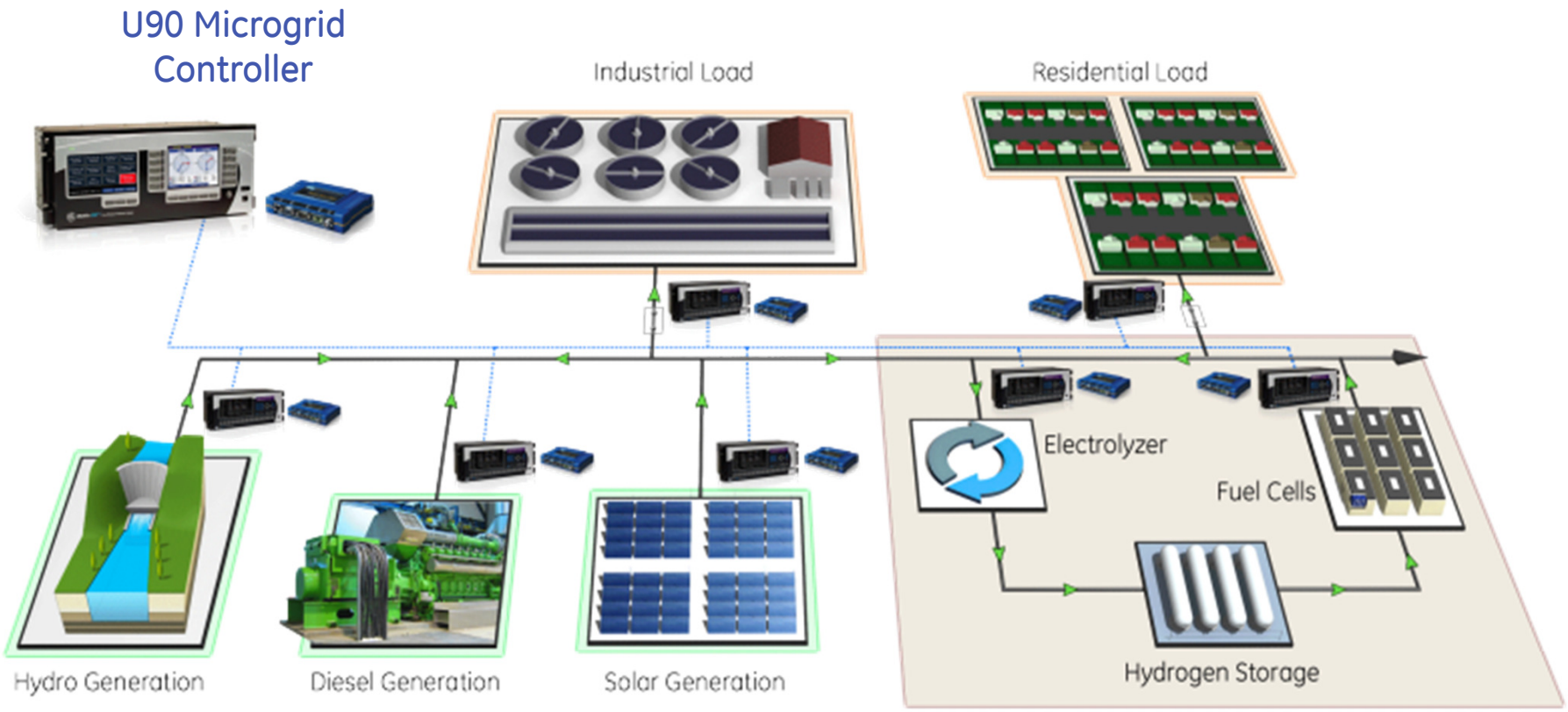
Distributed Generation Integration

Technology Solution

Optimal dispatch of complex energy resources



Smart control system to optimize and manage generators, energy storage and loads featuring:

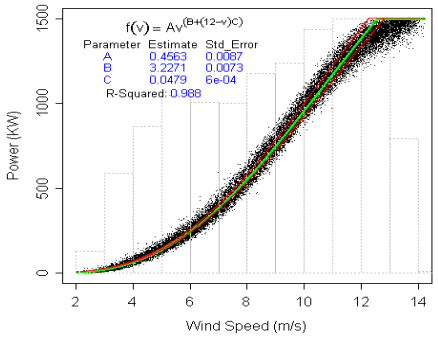
- Optimal Dispatch
- Supervisory Controls
- Islanding/Tie-Line Controls

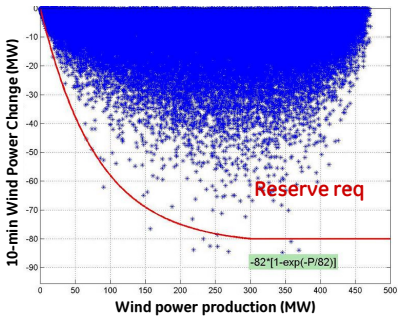
Distributed Generation Integration

Technology Solutions

Optimize conventional generation dispatch

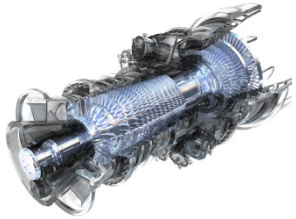
- Leverage production forecasting in optimal dispatch
- Intelligent unit commitment and use of reserves



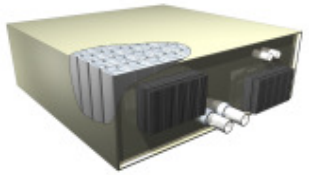


Compensate for variability when needed

- Use of fast-start thermal generation
- *Bridging* storage (if needed)
- Demand response



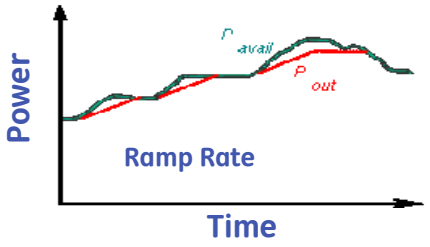
FlexEfficiency 60

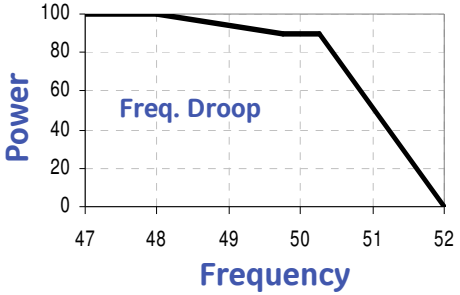


GEMx Battery

Leverage full capabilities of the renewables

- Fault ride-through
- Volt/VAr regulation
- Ramp-rate controls
- Curtailment
- Inertial response





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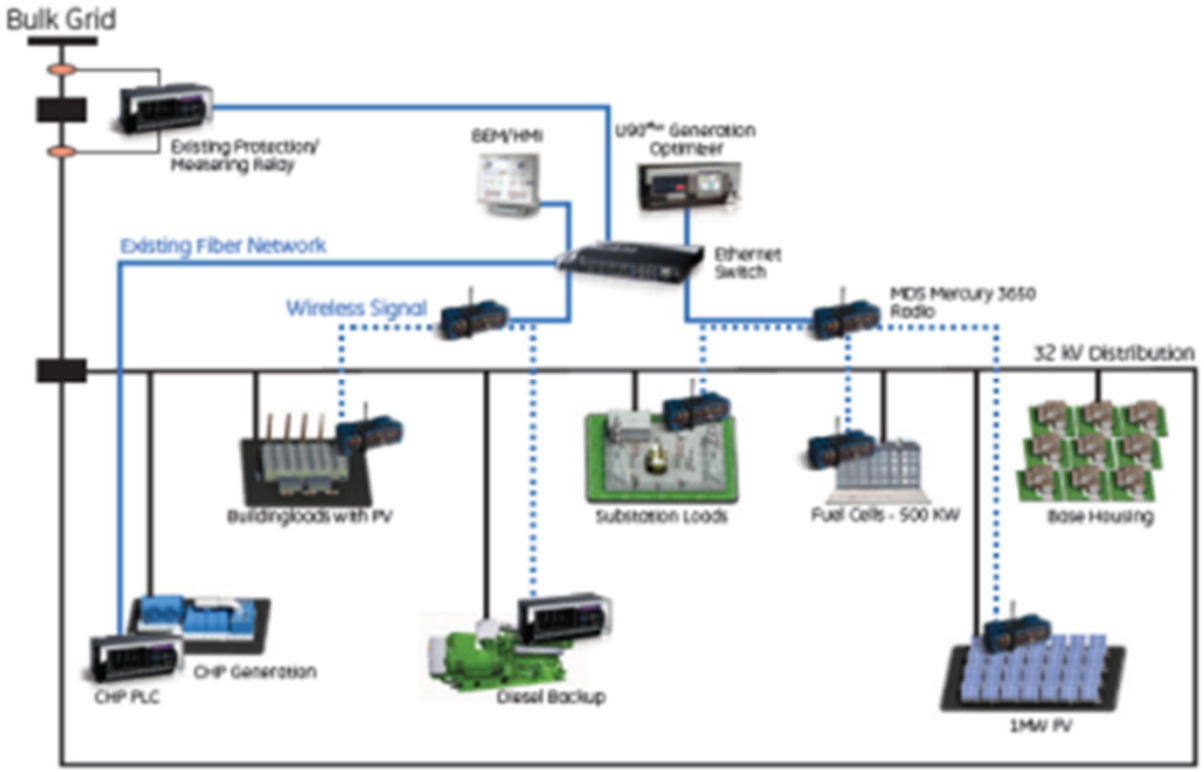
Grid Edge Controllers and Microgrids

Edge of grid transforming into Microgrids



Impact of High Penetration of Rooftop Solar PV on the Distribution System

New Applications of Power Electronics (my Power Electronics magazine article – August 22, 2013 issue)

- Substation Transformer On-line Tap Changer
- Low Voltage Network Dynamic Grid Edge Controllers
- Increased capability from Inverters

The Death Spiral (Intelligent Utility magazine article – November /December 2013 issue)

- Impact of High Penetration of Rooftop Solar PV in the State of Queensland, Australia

Holistic Solutions

A "Smarter" Grid

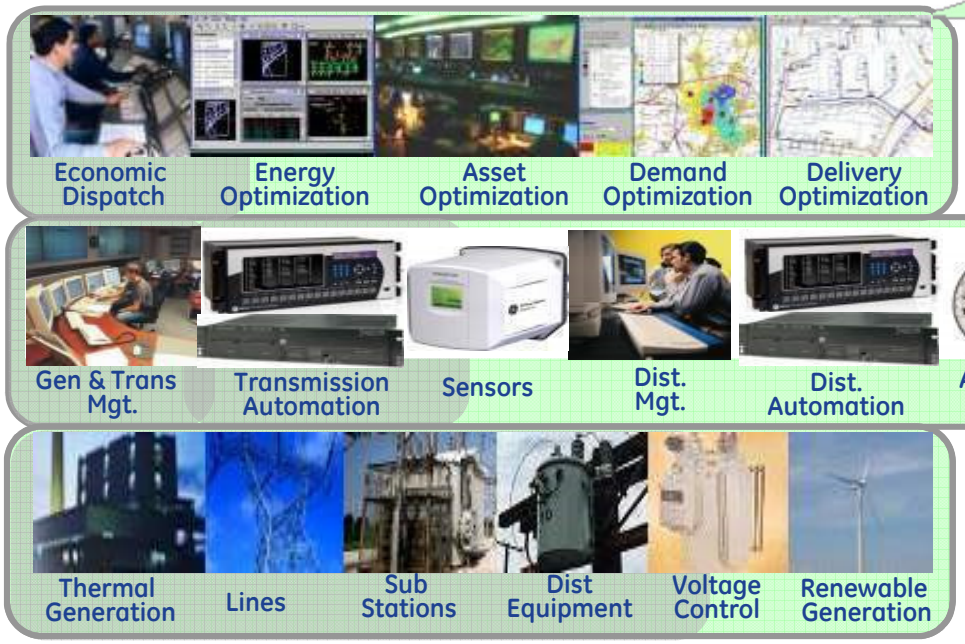
Enabled
Utility Managers

'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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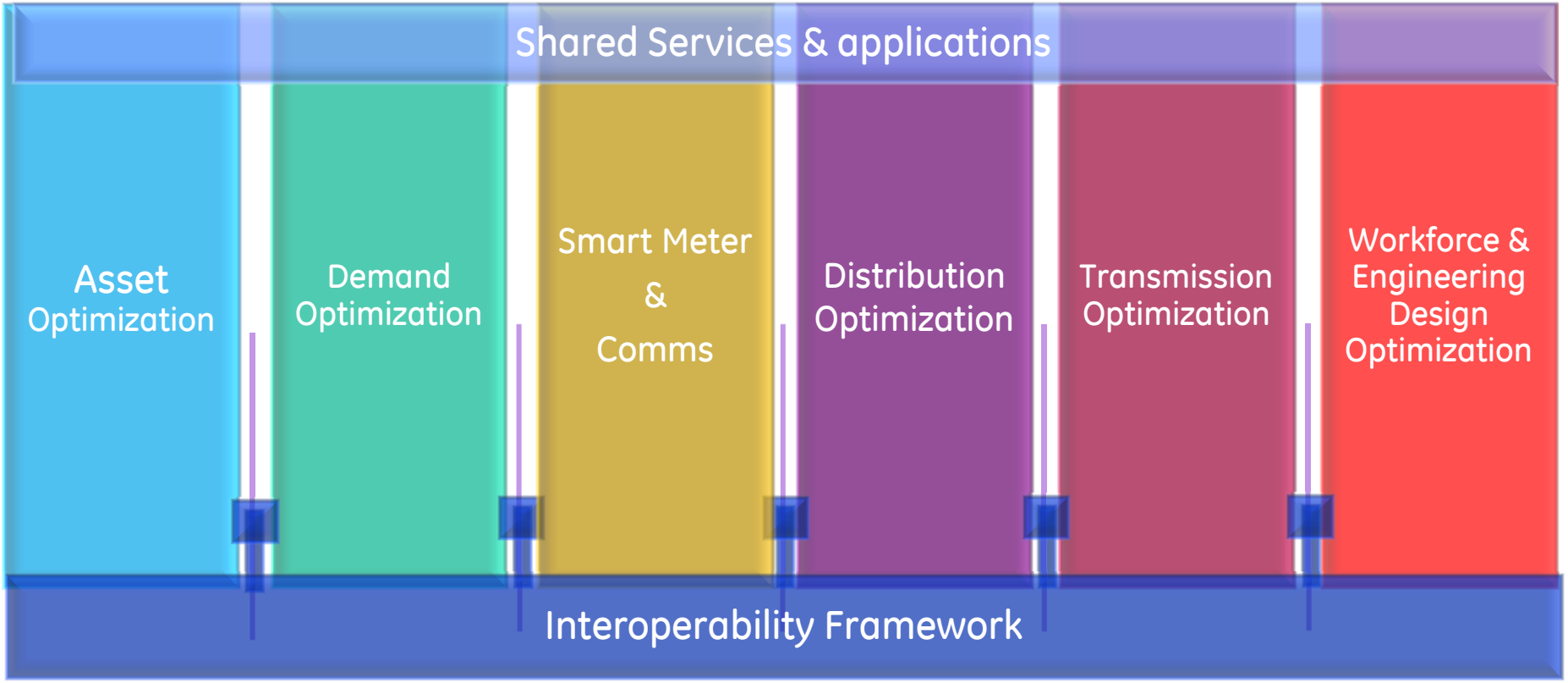
Smart Grid Holistic Solutions



Transitioning from products/systems to holistic solutions

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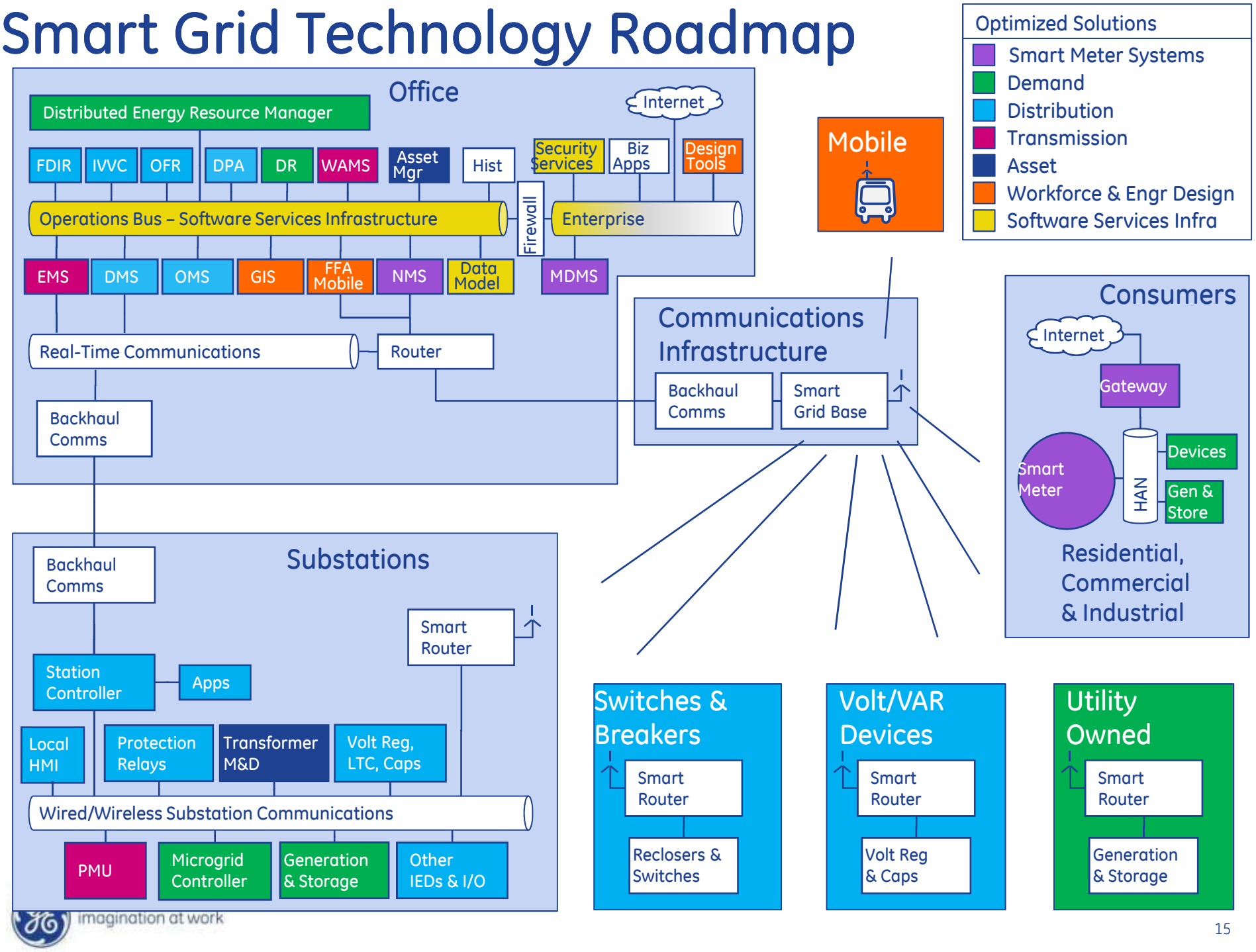
Smart Grid Technology Roadmap



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

Big Data, Analytics and Enterprise Data Management

Internet of Things (IoT)

Drive the next productivity revolution by connecting intelligent machines with people at work

The "II" Connects…

1. Intelligent Machines

Leverage technology & communication to cost-effectively connect machines

+2. Big Data & Analytics

Combine the power of big data, big analytics, and industry physics

+ 3. People at Work

Connecting people any place, any way, and any time for intelligent operations

= A world that works better, faster, safer, cleaner and cheaper

Energy Value: **Global Energy Capex $1.9T/year** → **The first 1% annual savings equals $300B over 15 years**

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Analytics

Meter Insight
(in development)

- Revenue Protection
- Power Quality and Reliability
- Load Forecasting and Research

Outage Insight
(in development)

- Automated KPI data validation
- Dynamic KPI dashboards
- Outage Event Recorder
- Planned outage optimization
- Predictive Outage Analytics
- Accurate ETR

Reliability Insight
(in development)

- Predictive vegetation management
- Asset health analysis
- System health analysis
- Lifecycle analysis and portfolio optimization

Renewables Insight
(in design)

- PV load (dis)aggregation/ hotspot analysis
- Wind load (dis)aggregation and hotspot analysis
- EV penetration/ impact analysis
- DER load orchestration

Consumer Insight
(in design)

- Social media integration
- Customer Segmentation
- Customer Engagement
- Sentiment Analysis

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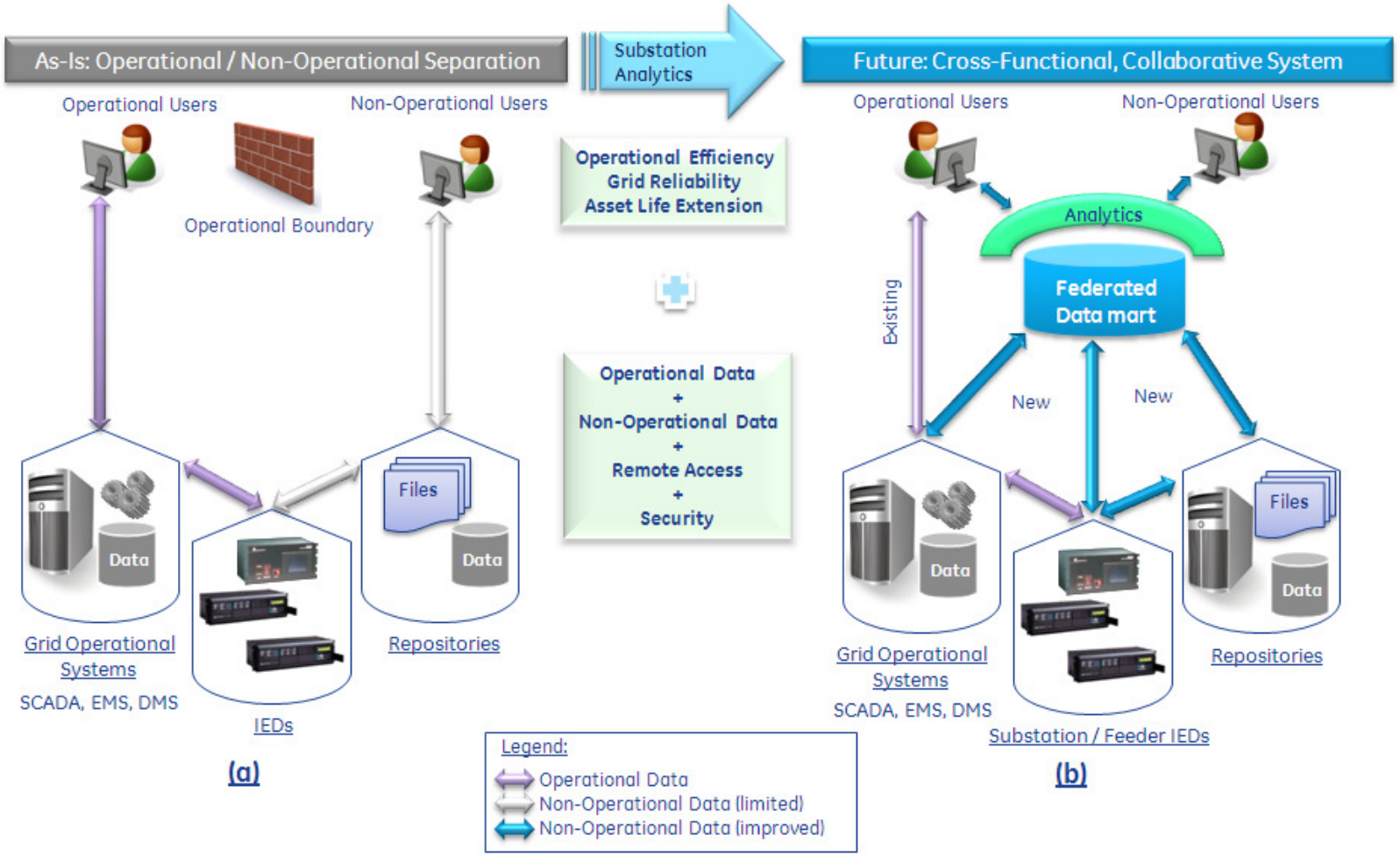
Enterprise Data Management

Collecting data for Data Analytics

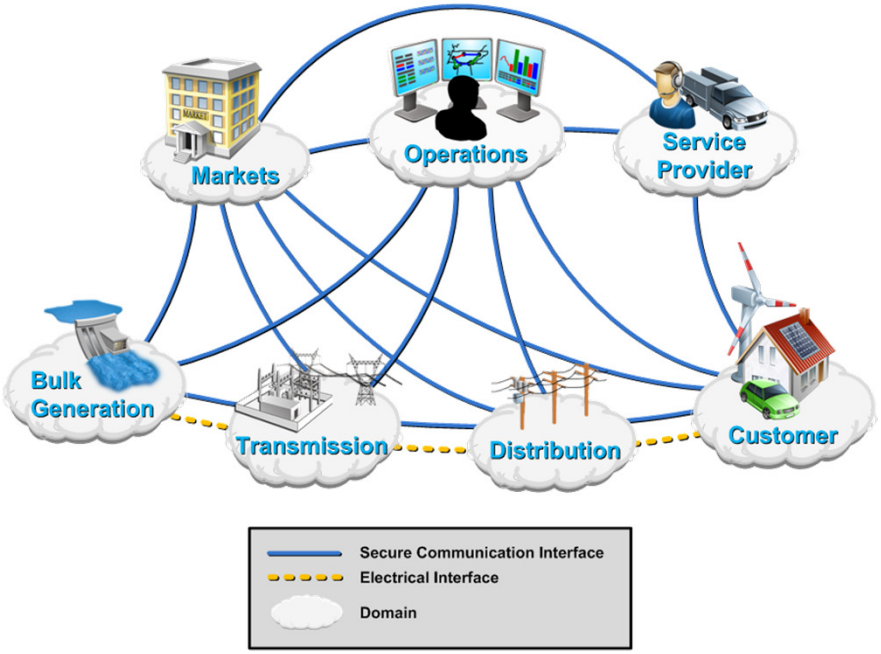


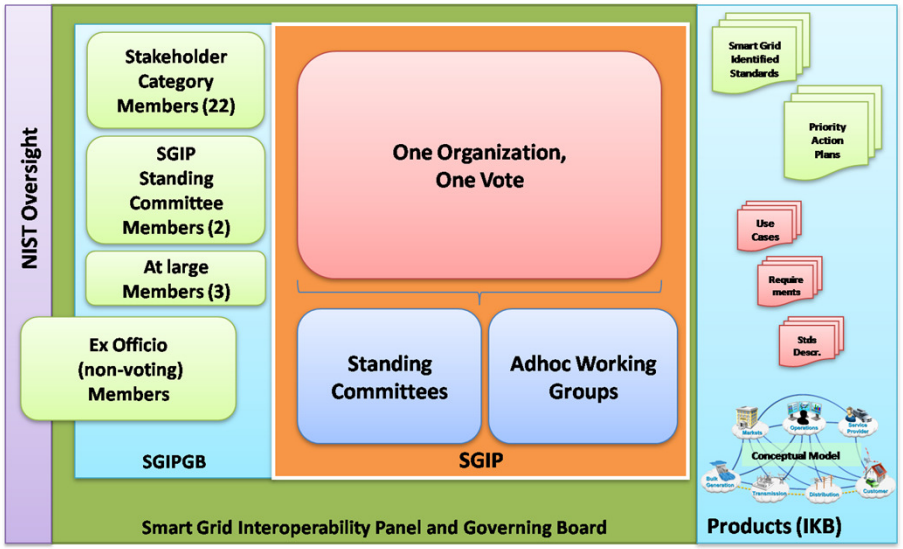
Industry Standards Vision

Example: Standards Framework

National Institute of Standards and Technology (NIST)

... Smart Grid Conceptual Reference Model
... Smart Grid Interoperability Panel (SGIP) Organizational Structure





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Smart Grid Foundational Standards

SmartGrid

NIST National Institute of Standards and Technology

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

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

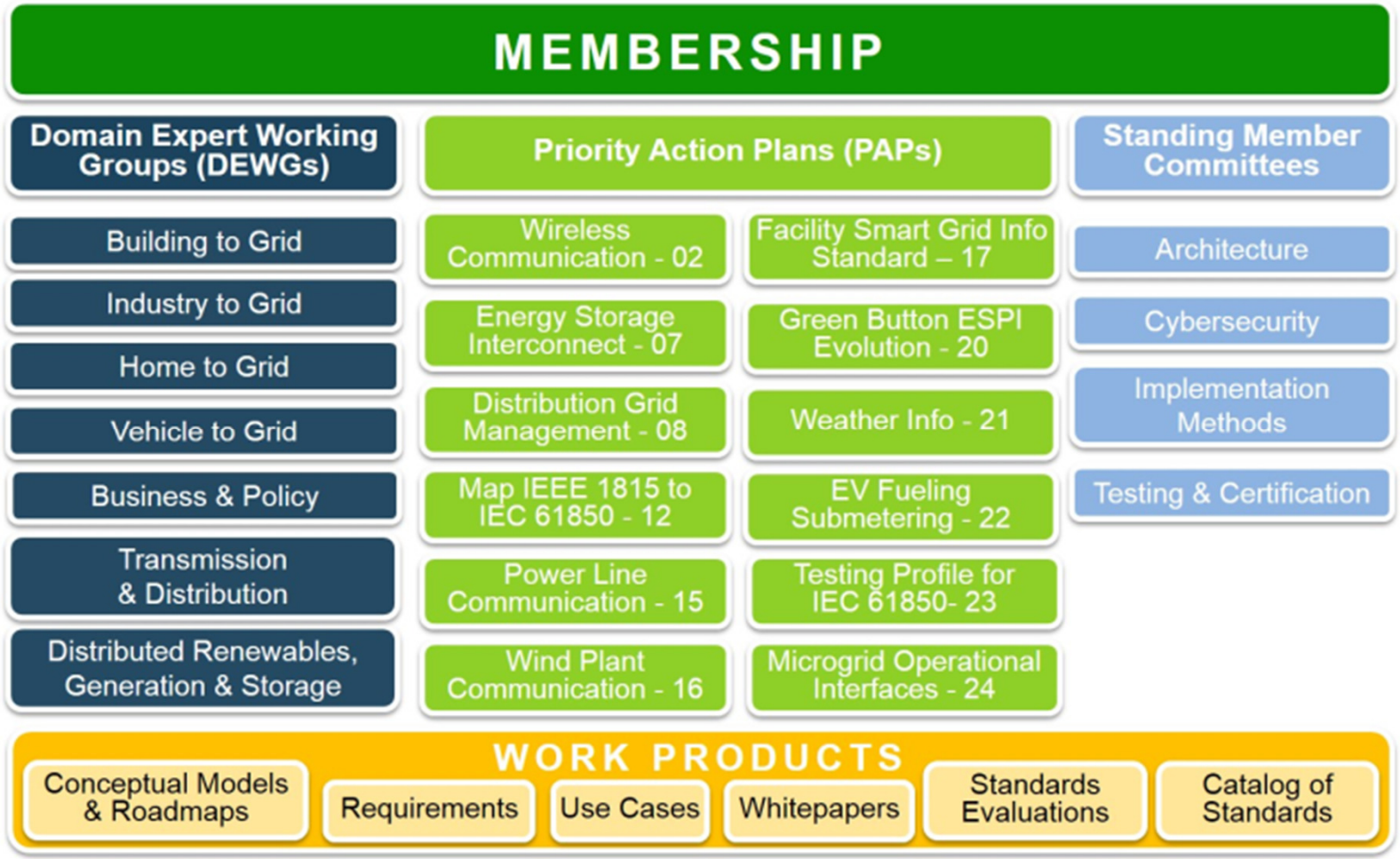
Oversee the performance of these activities & continue momentum

Inform and educate Smart Grid industry stakeholders on interoperability

Conduct outreach to establish global interoperability alignment

SGIP Activity Areas

Standards – More needed than ever



Communication Protocols

Control Center to Control Center

- IEC 60870-6/TASE.2 – Inter-control Center Communications Protocol (ICCP)

Control Center to Field Equipment

- IEEE 1815 (DNP3) – North American Suppliers
- IEC 60870-5 – European Suppliers
  - 101 – serial communications
  - 103 – protection devices
  - 104 – TCP/IP (network communications)

Field Equipment

- IEC 61850 – substation automation and protection
- IEEE 1815 (DNP3) – substation and feeder device automation

SGIP

Accelerating Grid Modernization

www.sgip.org

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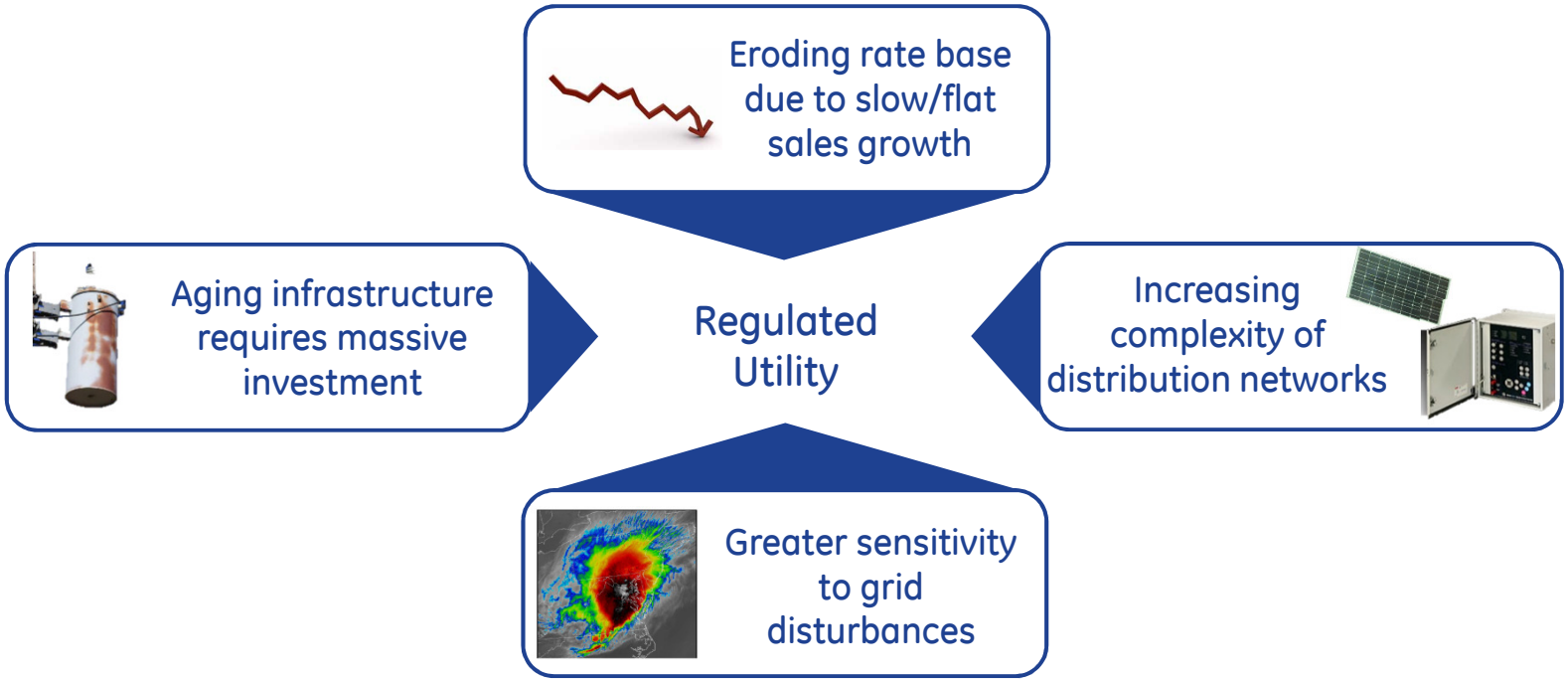
Incentive-Based Regulation

Velocity of Change

Industry Trends Force Regulatory Rethink



Challenges associated with traditional COS regulation

- "Least cost" approach to ratemaking often fails to provide utilities with consistent/adequate incentives to improve system performance
- Threat of disallowance discourages investment in new/innovative technologies
- Narrow focus on cost/benefit fails to provide utilities with adequate investment guidelines

Velocity of Change

Incentive Regulation… an Alt. Approach

Key attributes

- ✓ Ties utility profits to performance
  - Reliability
  - Efficiency
  - Power Factor
  - Consumer satisfaction
  - Safety
  - Other output-based metrics…
- ✓ Balances shareholder risk with performance rewards
- ✓ Combines certainty with accountability to protect ratepayers

Recent examples

Illinois

Energy Infrastructure Modernization Act

- Authorizes $3.2 B in grid modernization investment
- Establishes mandatory performance targets
- Contains spending/rate cap to protect consumers

Maryland

Grid Resiliency Task Force recommendations

- PSC implementation of performance-based ratemaking structure to align customer, utility incentives
- Establishment of reliability-based metrics with associated rewards/penalties
- Targeted cost recovery tracker to promote investment

United Kingdom

Revenue = Incentives + Innovation + Outputs (RIIO)

- Extends review cycle to 8 years to increase certainty
- Establishes incentives for performance against reliability and environmental metrics
- Rewards utilities for executing projects under budget

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IEEE Potentials Article

November/December 2011

Go West Young Man – My First Job

Lessons Learned

Don't let a disappointing work situation affect your attitude and work, because it will change

No one is indispensable and continue to do more than expected and provide value to the company

Practice "precision without accuracy" in all engineering work

Get an MBA and know how to build the business case for a technical project

Get a PE license as soon as you have the required work experience (assuming you have passed the FE exam)

Serve as a mentor for young engineers

Get involved in outside activities (IEEE PES) giving talks, teaching courses and developing industry standards

John at work at Bechtel in 1975

Thank You!