GE Energy
Digital Energy

Smart Grid: Definition, Concepts, Standards, Deployments and Lessons Learned

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Smart Grid Definition and Concepts

Smart Grid View

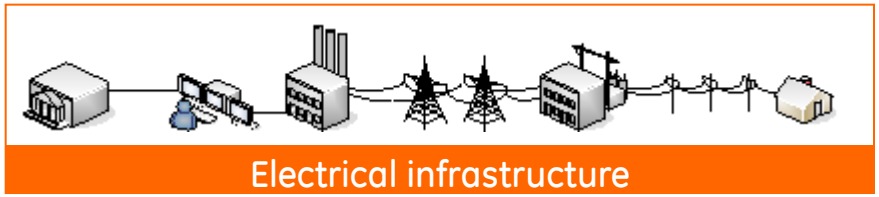
The integration of electrical and information infrastructures, and the incorporation of automation and information technologies with our existing electrical network.

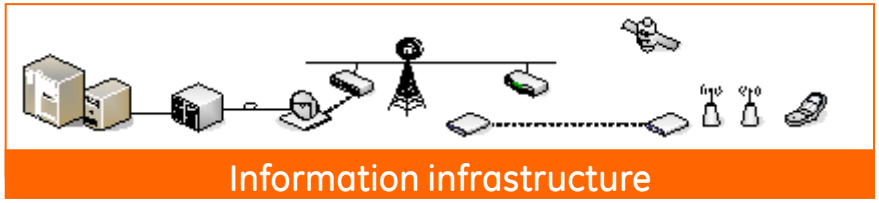
Comprehensive solutions that:

- ✓ 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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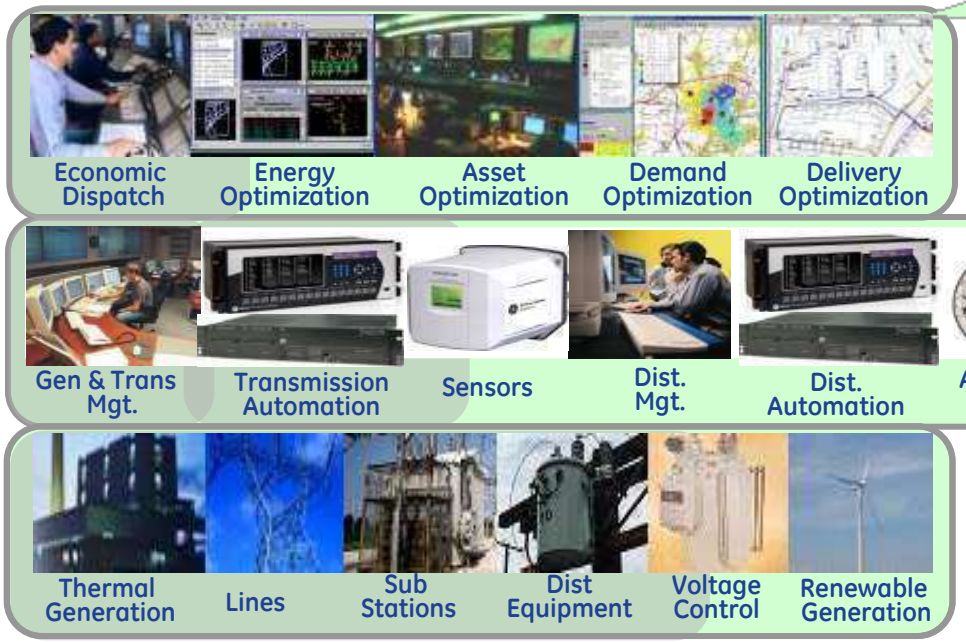
A "Smarter" Grid

Enabled
Utility Managers

'New Applications enabled by Additional Infrastructure'



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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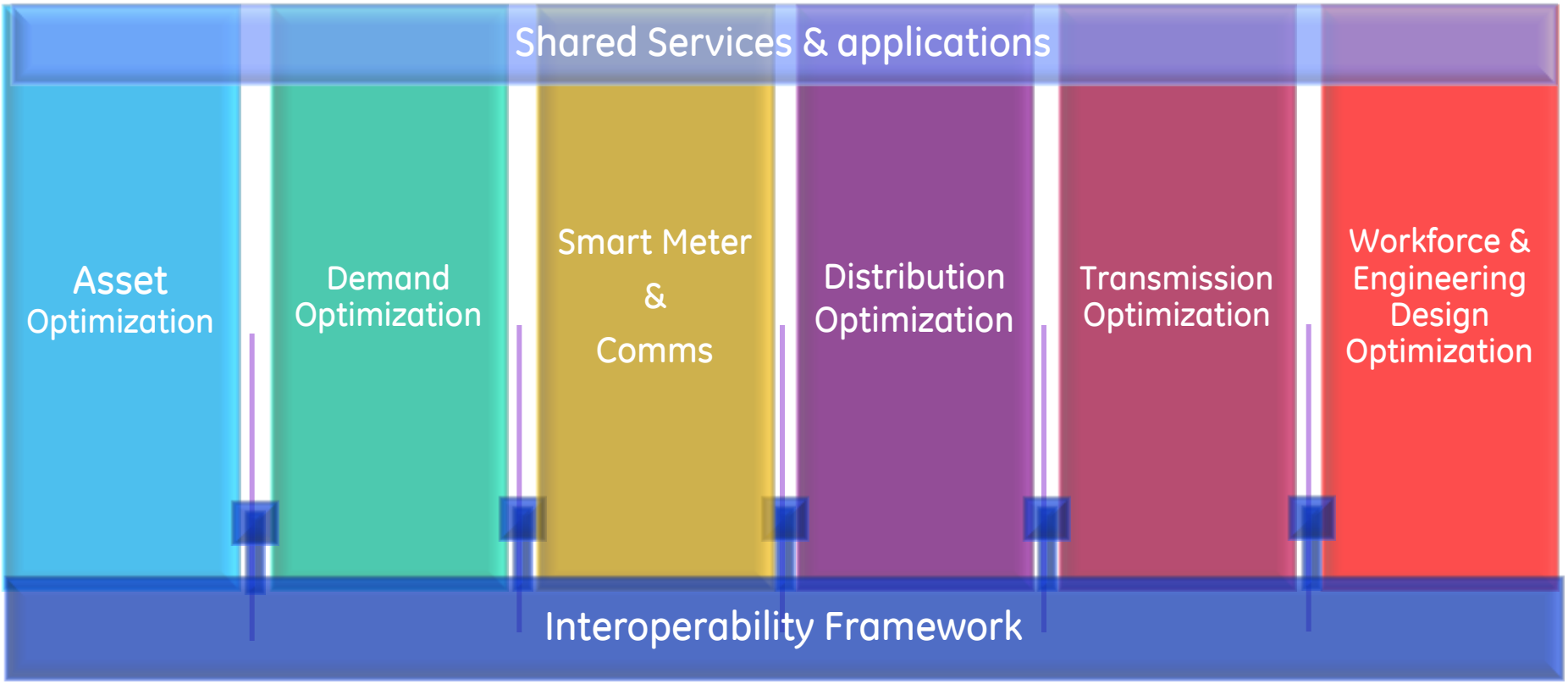
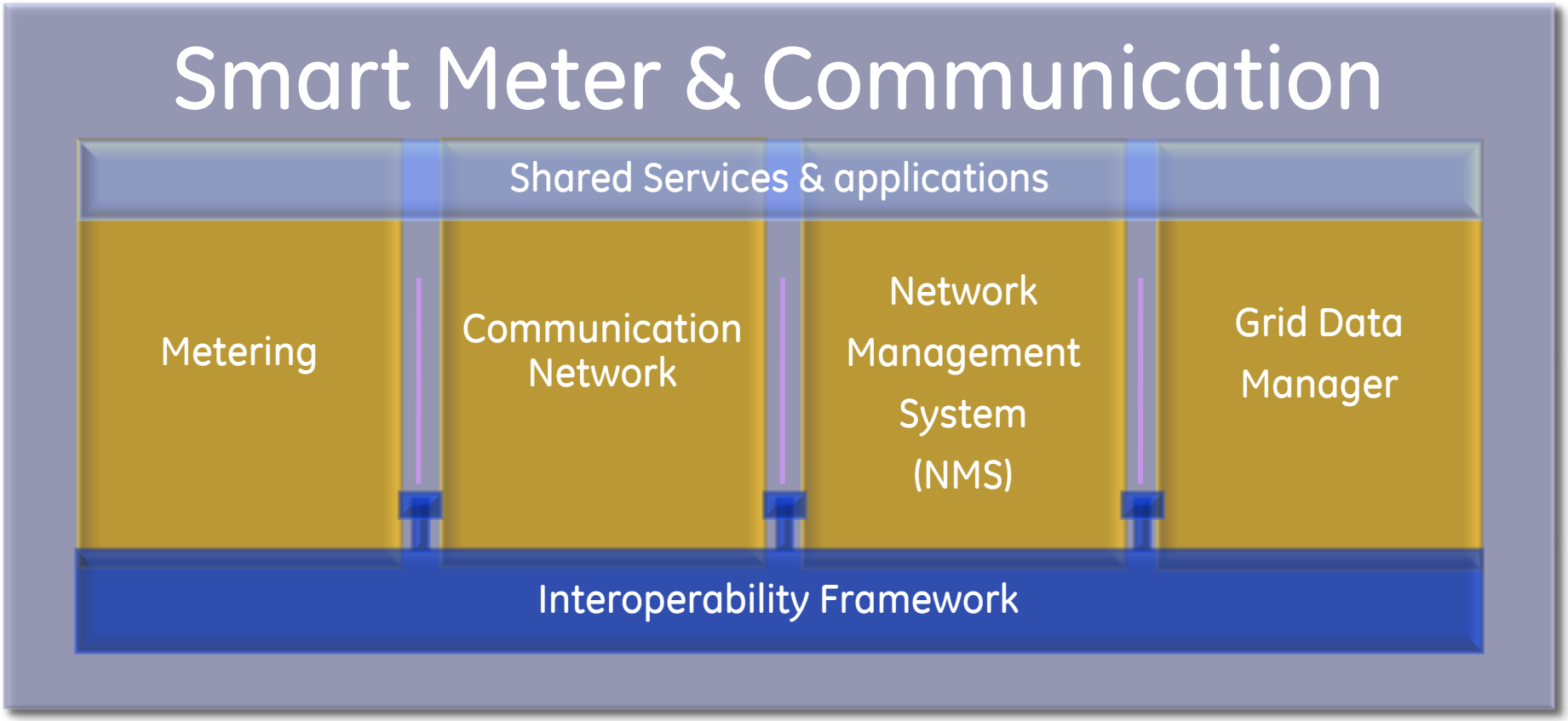
Smart Grid Solutions

Smart Grid Holistic Solutions



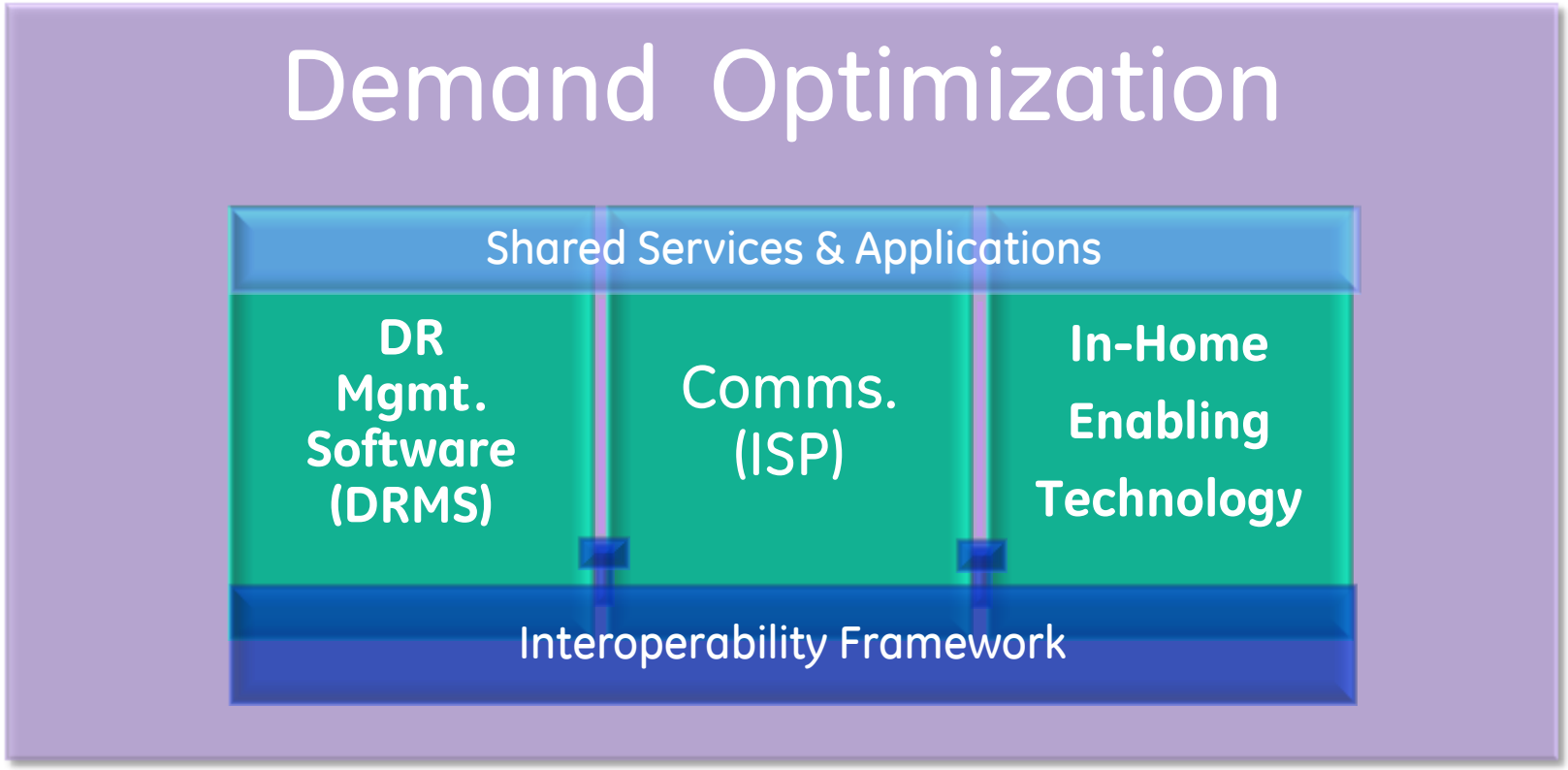
Transitioning from products/systems to holistic solutions

Smart Meter System



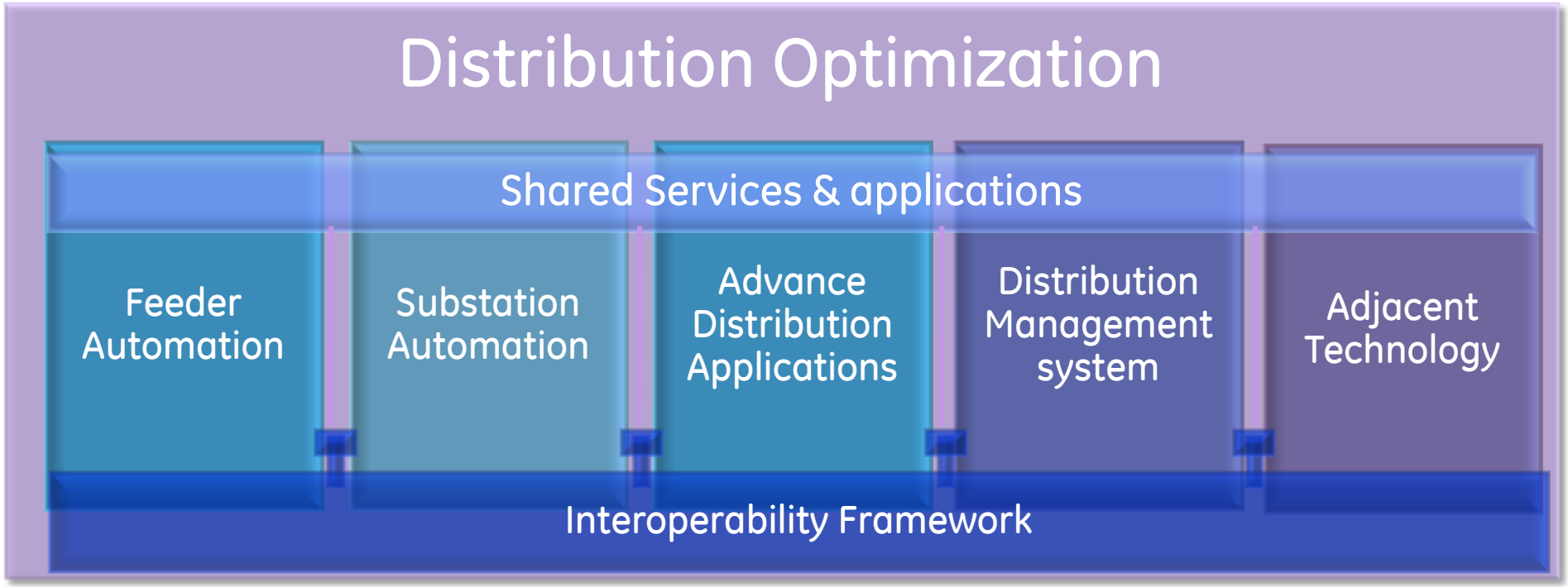
Enabling technology for network connectivity, consumer enablement, demand optimization, and improved grid operations

Demand Optimization



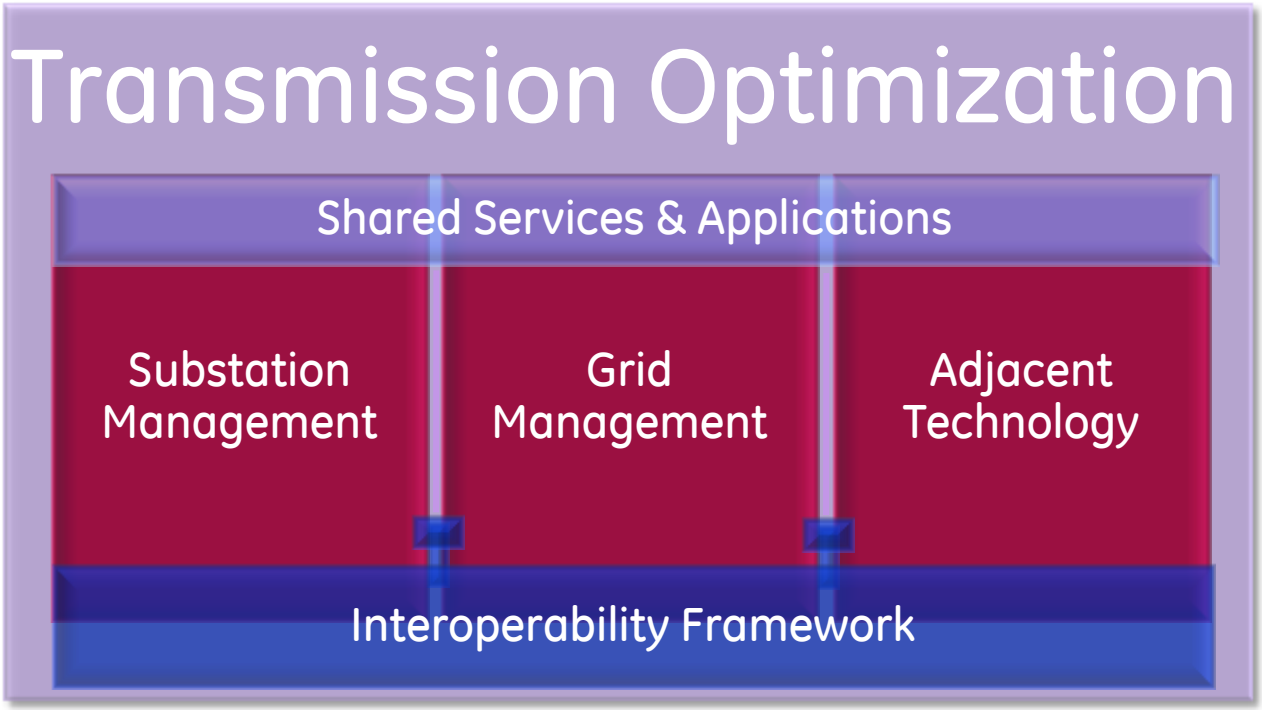
Defer grid upgrades, optimize generation by managing peak via control of power consumption

Distribution Optimization



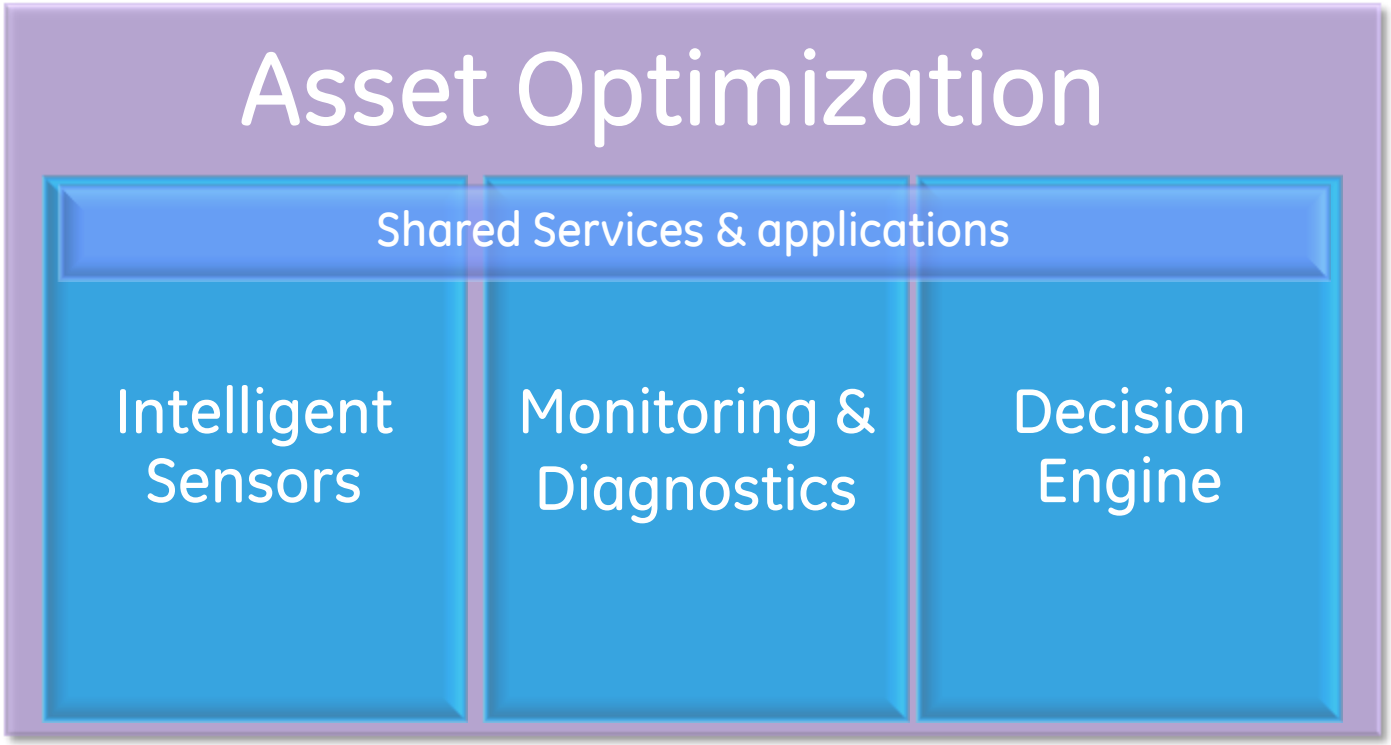
Less energy waste and higher profit margin by reducing delivery losses in distribution system

Transmission Optimization



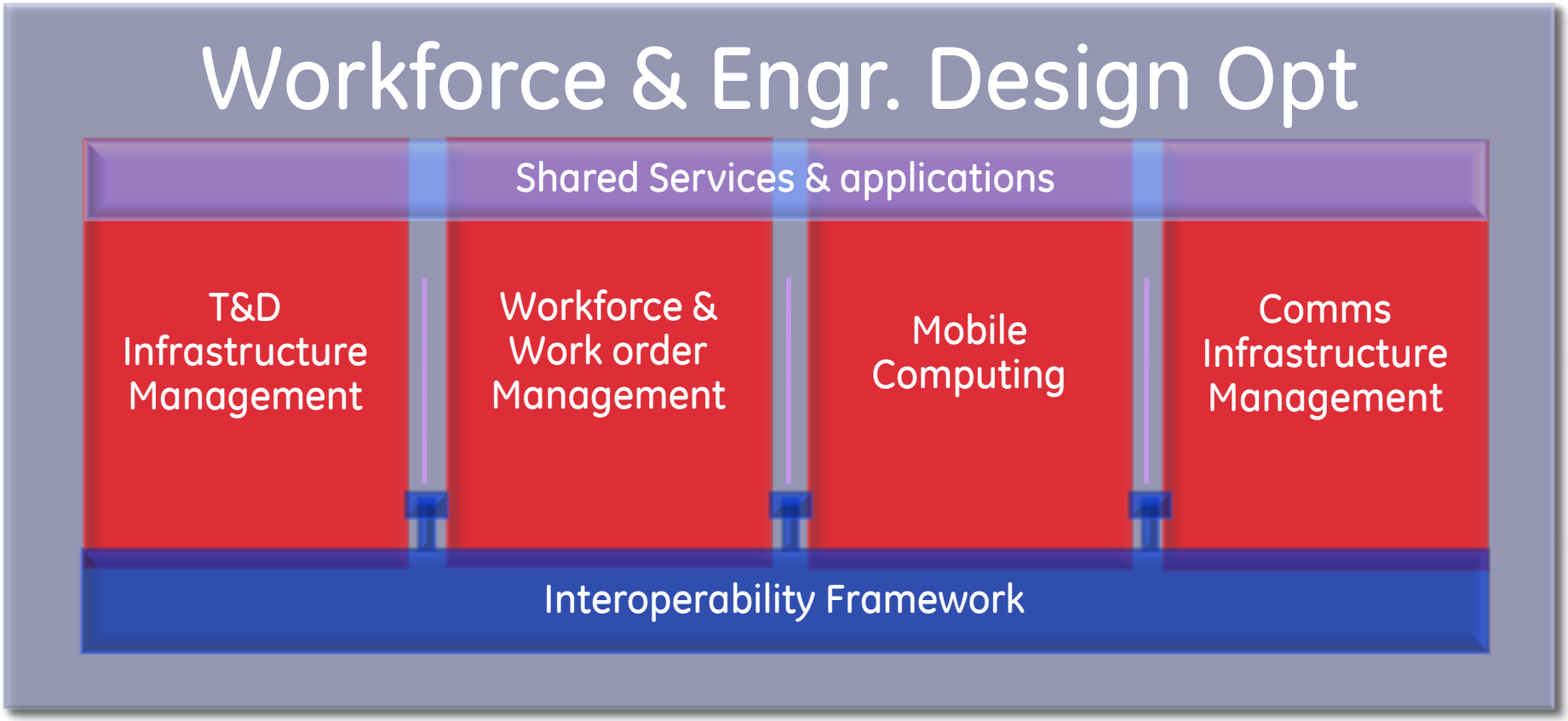
Improve return on assets, enhance electric reliability and raise situational awareness

Asset Optimization



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

WEDO



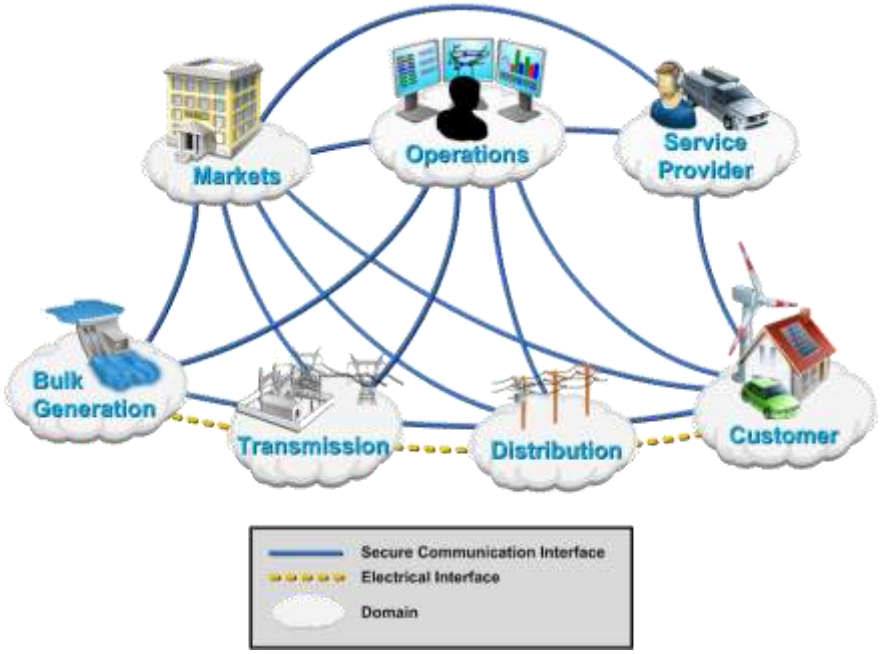
Increase productivity and reduce planning and design costs.
Reduce miles driven and increase field crew productivity.

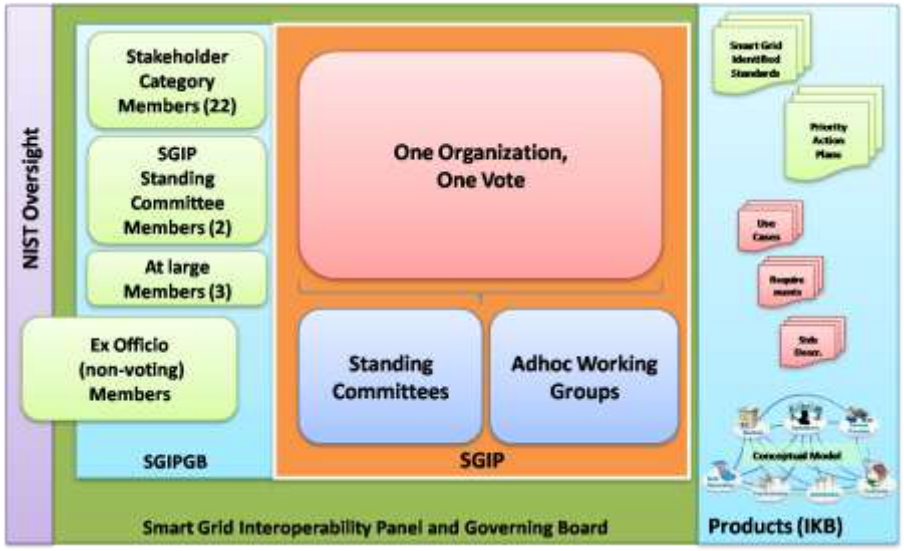
Smart Grid Standards Development and Interoperability

Example: Standards Framework

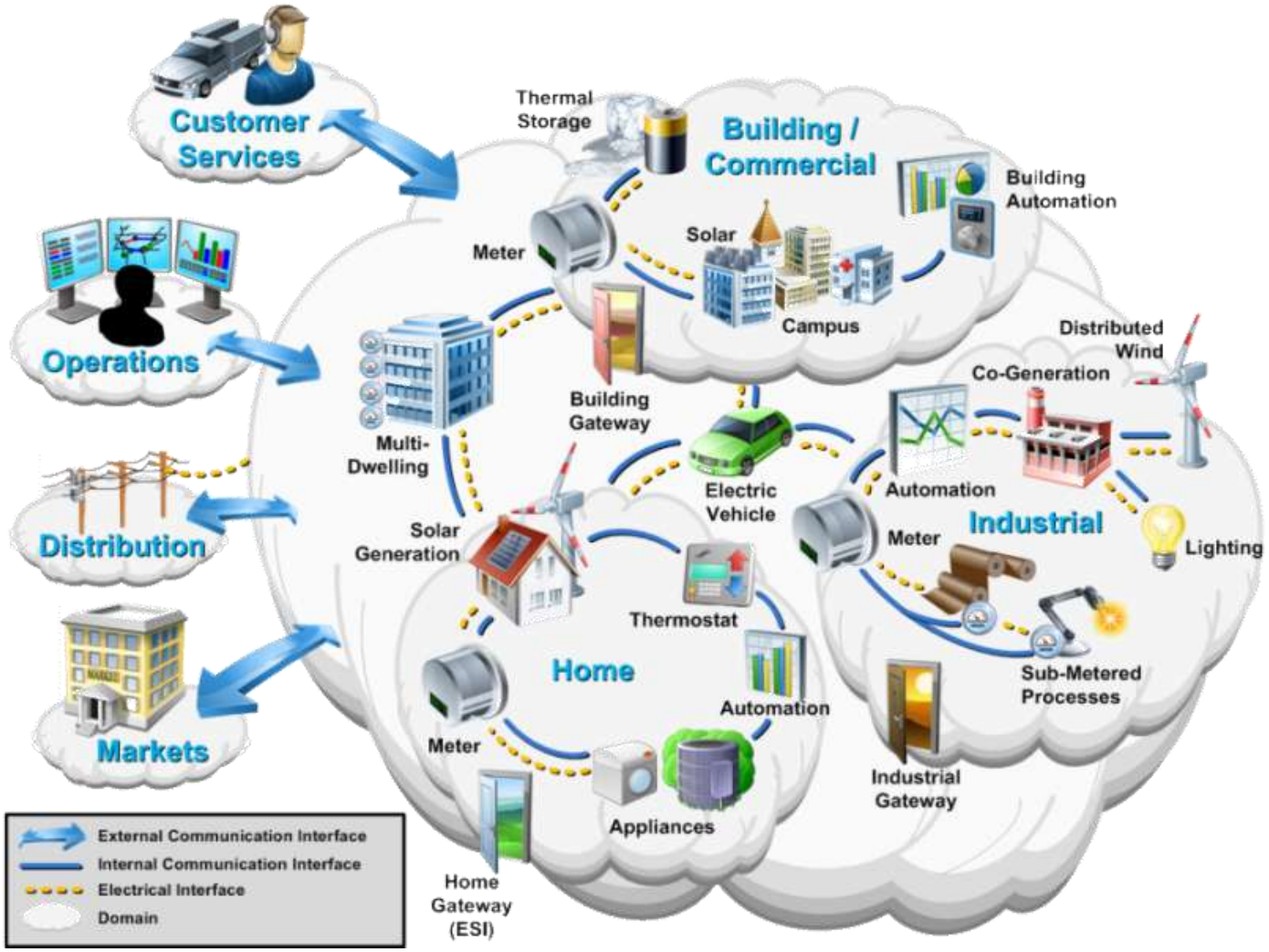
National Institute of Standards and Technology (NIST)

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



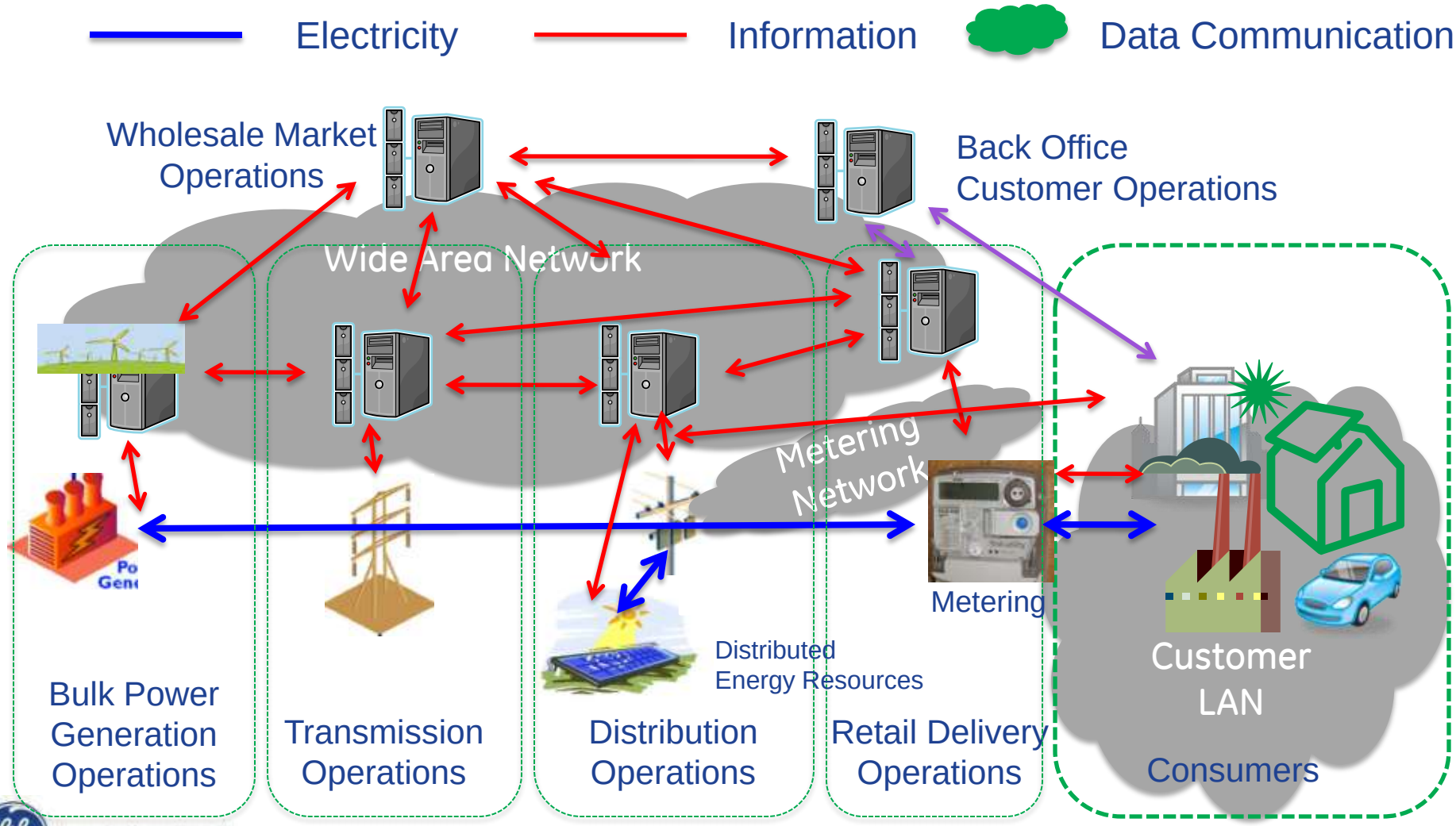


Model Build-out for the Customer



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.



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A Clear Plan to Mobilize and Accelerate

Priority Action Plan	Schedule	Deliverables	Resources
PAP 02 - Wireless Communications for the Smart Grid			
PAP 05 - Standard Meter Data Profiles			
PAP 06 - Common Semantic Model for Meter Data Tables			
PAP 07 - Electric Storage Interconnection Guidelines			
PAP 08 - CIM for Distribution Grid Management			
PAP 09 - Standard DR and DER Signals			
PAP 10 - Standard Energy Usage Information (TASKING COMPLETE)			
PAP 12 - IEC 61850 Objects/DNP3 Mapping			
PAP 13 - Time Synchronization, IEC 61850 Objects/IEEE C37.118 Harmonization			
PAP 14 - Transmission and Distribution Power Systems Model Mapping			
PAP 15 - Harmonize Power Line Carrier Standards for Appliance Communications in the Home			
PAP 16 - Wind Plant Communications			
PAP 17 - Facility Smart Grid Information Standard			
PAP 19 – Wholesale Demand Response Communication Protocol			
PAP 20 – Green Button ESPI Evolution			

=Completed PAPs have been removed from table

=On Target

=Late

=Tasking Complete

=Caution

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Collaboration is critical

Customers/ Vendors	Academic Institutions	Trade Associations	Technical Standards

Global Standards Collaboration

cen CENELEC ETSI

ena energy networks association

STATE GRID CORPORATION OF CHINA

KSGA Korea Smart Grid Association

NEDO

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Smart Grid Recent Deployments and Lessons Learned

Micro Grid Operation: Bella Coola Example

Microgrid Features:

- Centralized Supervisory control to optimize the use of renewables and minimize the use of diesel
- Wireless local area network
- Hydrogen based energy storage system
- Capability to connect, monitor and control the system remotely
- Interfaces to all Microgrid elements

Ah Sin Heek Diesel / Energy Storage Site

Local HMI

Microgrid Controller

Remote Monitoring

Ethernet Switch

Wireless Radio

25 kV Distribution

modem

Bella Coola 2.1/1.5MW

Hagensborg 2.6/1.7 MW

Hydro Generator Interface

Storage 3.3 MW-hr

Electrolyzer 300 kW

Fuel Cell 125 kW

Battery Support 125 kW / 400 kW-hr

Clayton Falls 2.12 MW Hydro

Utility Service Vehicle

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

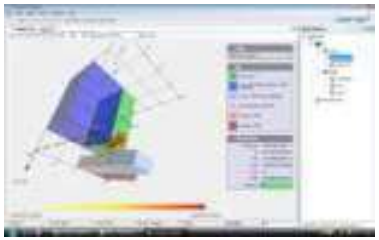
AEP Project – Solutions Delivered

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



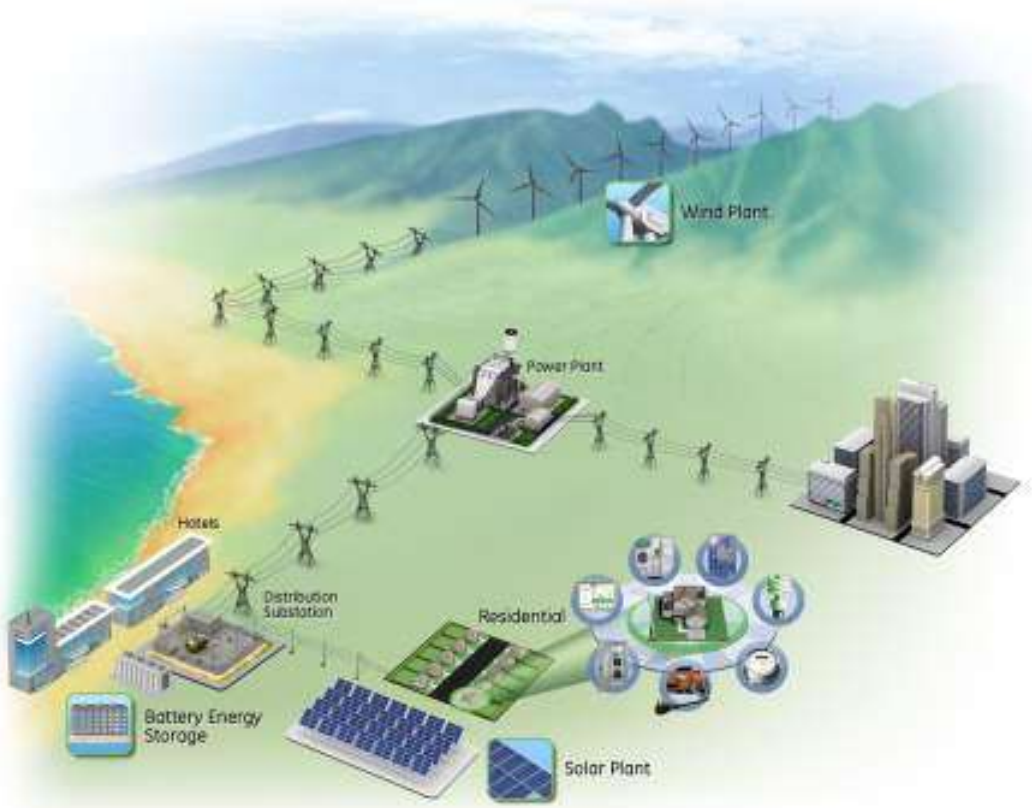
Asset Optimization

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

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**



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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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

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.)

Questions ?