Approaches to a Resilient, Reliable and Efficient Electric Grid

Partnership Forum: Innovation for Resilient and Smart Communities

Asian Development Bank
Manila, Philippines
19-20 May 2015

Imagination at work

GE Energy Management

is one of GE's 8 business units

Employees: ~29,000 • Revenue: $7.3B • Operating in 80+ countries

Digital Energy

- Grid modernization
- Metering solutions
- Automation systems
- T&D projects
- UPS Power Quality
- Voltage Regulation
- Transformers
- Utility Software Solutions

Industrial Solutions

- Electrical control and distribution
- Mechanical Consultations
- Power Electronics
- DC Power Systems
- Circuit breakers
- Parts and repair services

Power Conversion

- Motors and generators
- LV and MV Drives
- Variable Speed Drives
- Automation systems
- Power conversion solutions
- Power management systems

Intelligent Platforms

- Industrial Internet: Enhancing industrial systems with advanced computing, analytics, low-cost sensing and connectivity
- SCADA, hardware, software

Energy Consulting

Consulting services to help serve electric power system challenges across generation, delivery, utilization

Digital Energy Product Lines & Project Execution

Grid Automation

- Protection & Control
- Industrial Communication
- Smart Metering
- Monitoring & Diagnostic

Power Delivery

- Transformer & Capacitors
- XD HV Primary Equipment
- Power Sensing
- Series compensation
- Synchronous condenser

Software Solutions

- Asset Management
- Asset Control
- Solution as a service
- Analytics

Projects & System Solutions

- Cross P&L system solutions & services
- Enhancing multi-P&L system capabilities
- Channels and partners

2014 Revenue: $1.4B

Markets & End Customers

Oil & Gas

Chevron, ExxonMobil, BP, Petrobrass, Petronas, Saudi Aramco, Oneok

Energy: Generation, Transmission & Distribution

PG&E, Calpine, Dominion, EDF, KMS Energy, National Power, Southern, TECO, National Grid, Con Edison, Tampa Electric, CenterPoint Energy, Hydro One, TXU, Red Electrica, CFE, Colbon, T-Mobile, Credit Suisse

Critical Infra.

Texas Heart Institute, Xiamen Chang Gung Hospital, T-Mobile

Heavy Industrial

BHP Billiton, AK Steel, Falconbridge, Inco, SIDOR, Newmont, Cemex,

Transportation

Metra, Toronto Transit Commission, Trans Link, GTAA

Water

American Water, Orange County, Puerto Rico Water Authority

Telecom

American Water, Telstra, Telkom South Africa, Swisscom

3 broad approaches to a Resilient, Reliable and Efficient Electric Grid

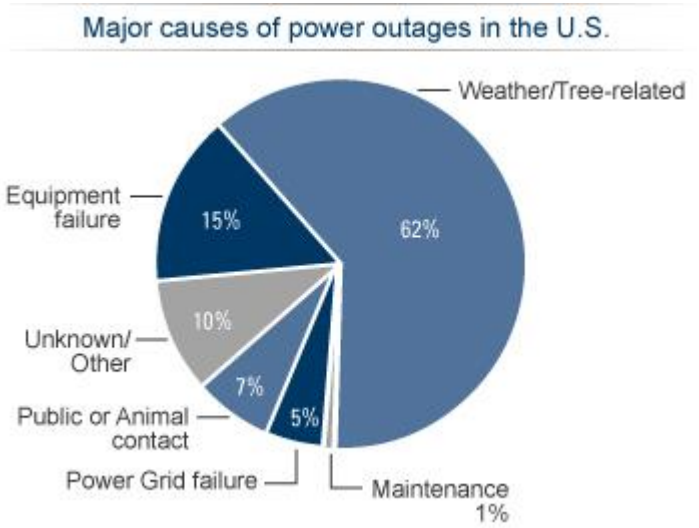
1. **Risk prioritized strengthening of grid infrastructure**
   i. Better vegetation management
   ii. Undergrounding
   iii. Protecting transformers and substations

2. **Improving the end users ability to withstand outages**
   i. Microgrids
   ii. Behind the meter energy storage and distributed energy resources

3. **Smart Grid – incremental approach to improving resiliency, reliability and operational efficiency**
   i. Distribution automation and Substation automation
   ii. AMI and communications
   iii. Software Applications (OMS, DMS, EMS, GIS)

Vegetation management and undergrounding can help

http://www.nj.com/news/index.ssf/2012/10/nj_out_of_power_238_million_st.html

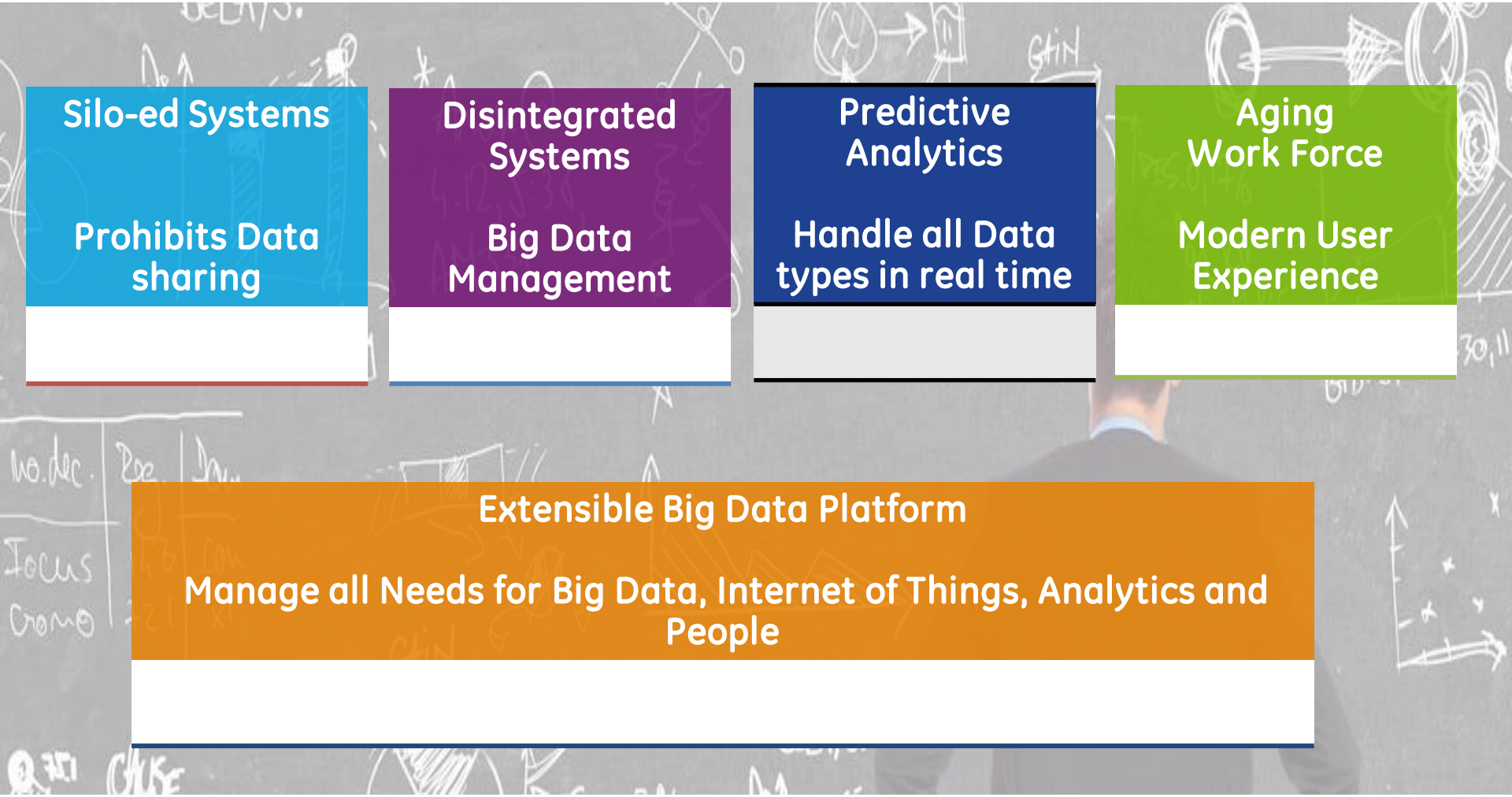


Edison Electric Institute

https://www.youtube.com/watch?feature=player_detailpage&v=Eazksqc6QO8

http://www.nj.com/news/index.ssf/2012/11/power_restored_to_1_million_si.html

Common Challenges Facing Utilities



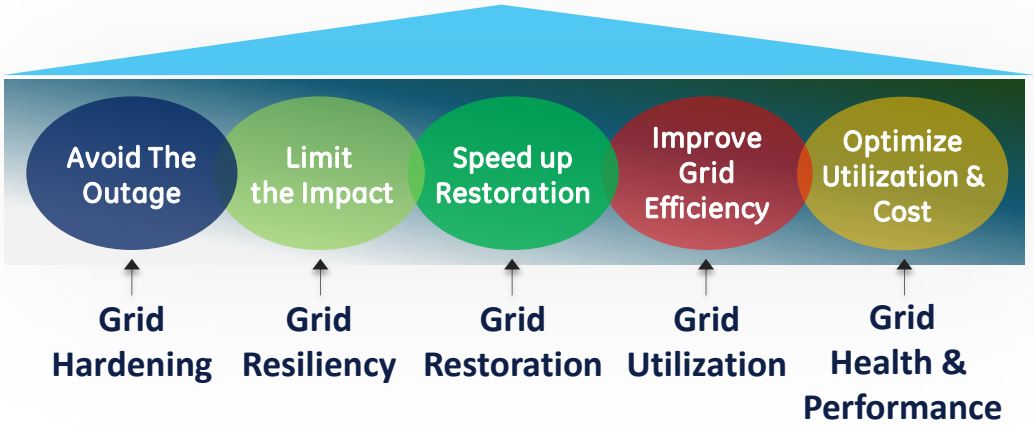
Industrial Internet of the Grid

Implementing an industrial collaboration software platform that combines clouds, applications and devices into a single architecture … ***Enabling the delivery of an integrated E2E Solutions and Services offering, utilizing DE portfolio of Intelligent devices, Sensors, Comms, Apps, Systems and Services***

… Yielding results far greater than the sum of their parts … faster, leaner and more secure.

Outcome

… Improving Grid Reliability and Resiliency



Microgrid Solution Overview

Energy Cost , Environmental Impact and Improved Reliability …

What is it?

A Microgrid is an integrated energy system that:

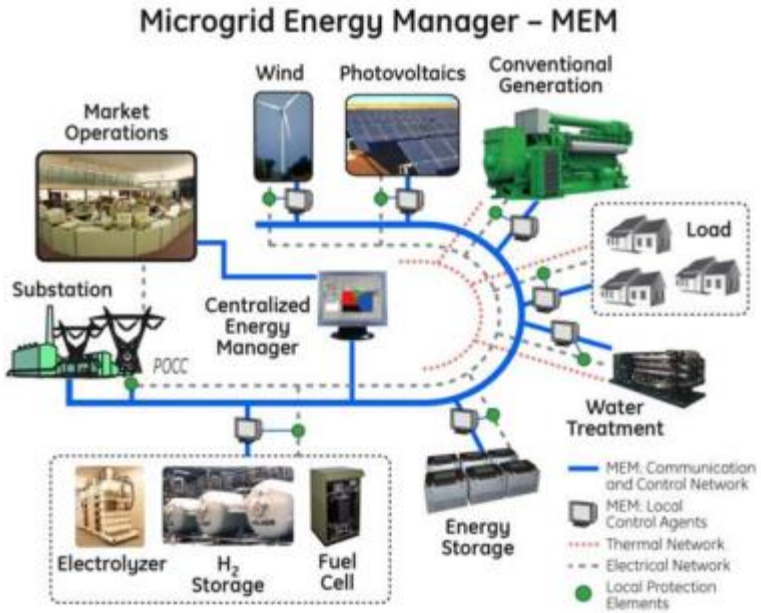
- Has local DERs (Loads, Generators, Storage)
- Operates grid connected or islanded (off grid)

What does it do?

- Integrations of Renewables
- Optimal Dispatch (thermal & electrical)
- Load management and balancing
- Islanding and grid synchronization
- Secure communications
- Integrated Demand Response system
- Advanced protection and dynamic stability
- Seamless integration into the bulk grid

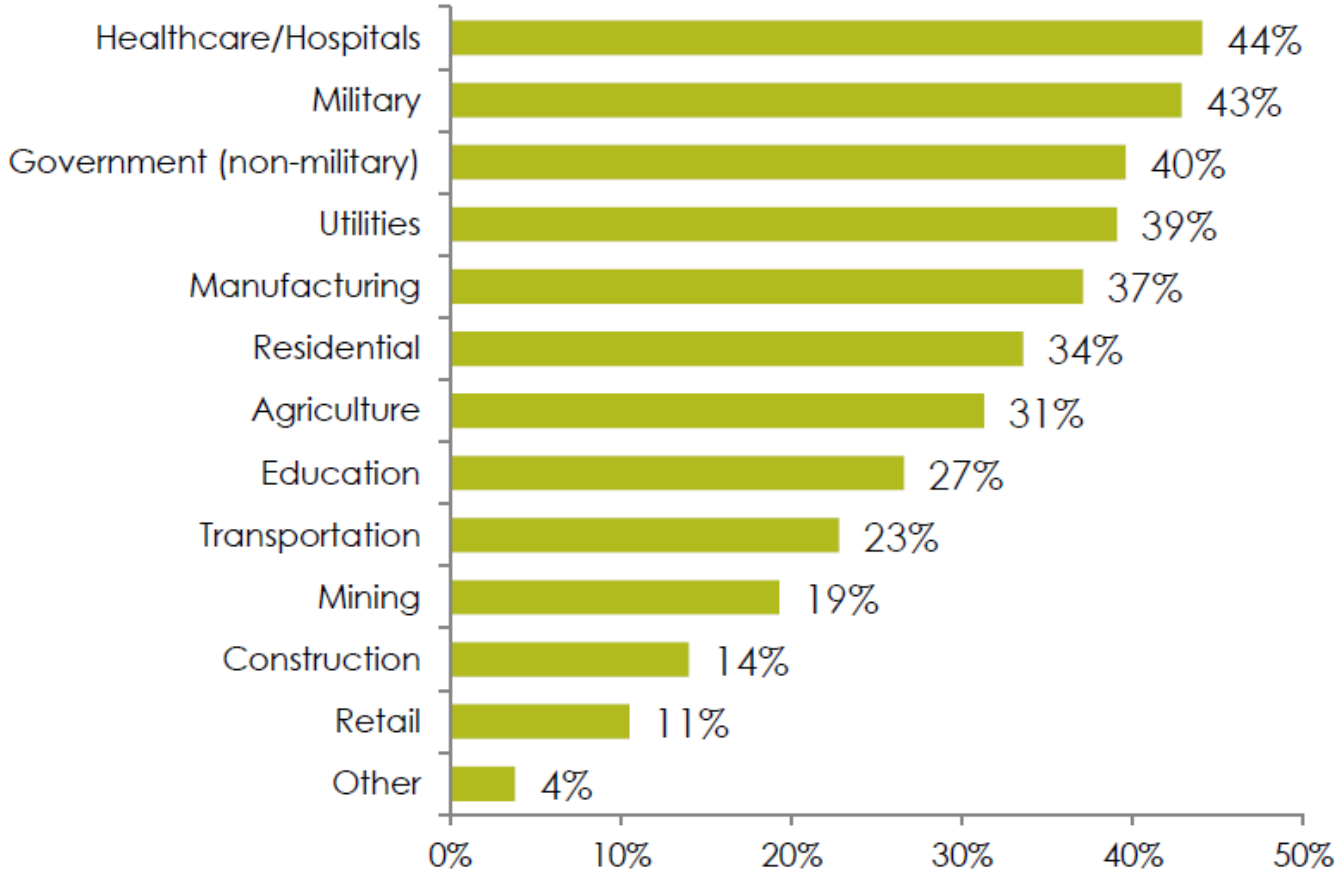
Value Proposition

- **Reducing cost of energy** + managing price volatility
- **Improve Reliability**
- **Increase resiliency and security** of power delivery
- **Green Power** – Manage renewables intermittency
- **Optimize power delivery** and the provision of services
- **Service Differentiation** – Providing different level of services quality and value to customers (if applicable)



Which industries are most likely to deploy microgrids over the next 5 years?

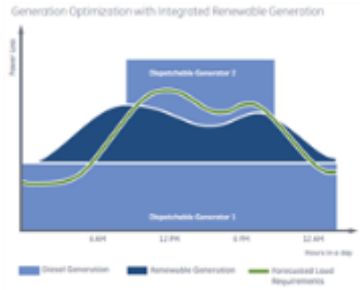
(figure 22, source: Zpryme & IEEE)

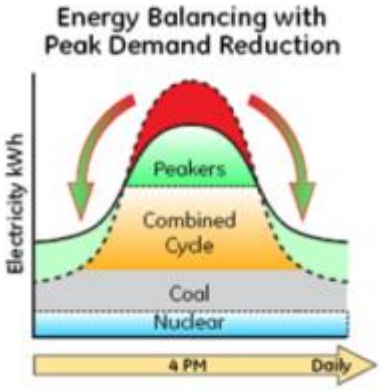


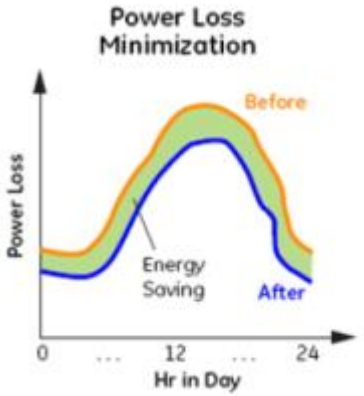
3 top benefits of microgrids: energy security/surety, renewable energy integration and supply/load optimization

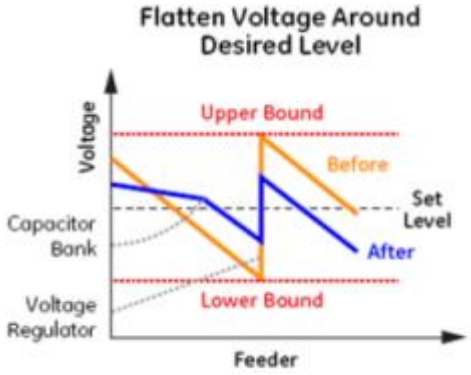
Microgrid Technology Solution

Functions deliverered

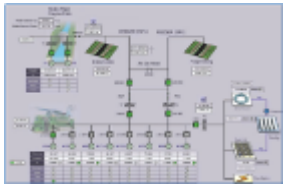








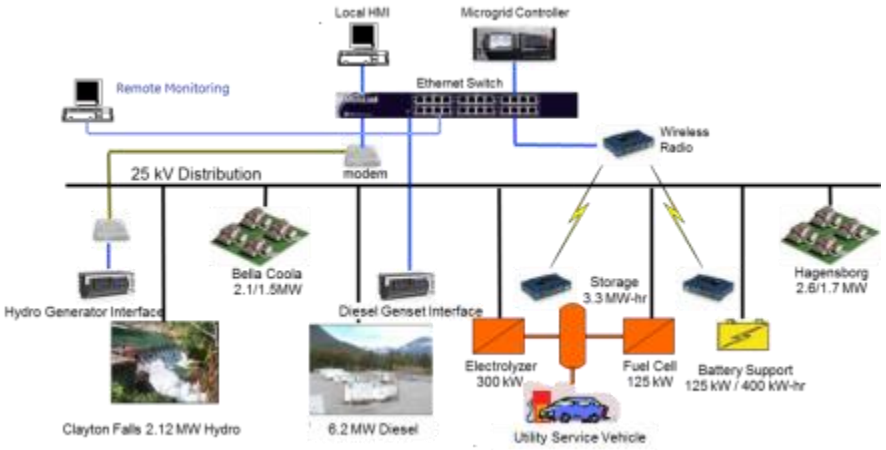
Components



GE Microgrid Implementations

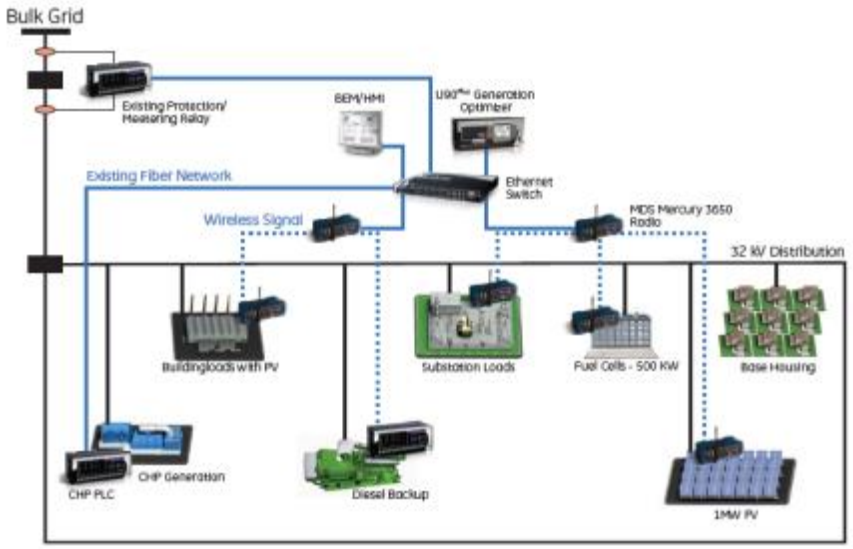
1. Remote community – Bella Coola (Canada)

- Objective – Reduction of GHG emissions and cost of diesel transportation
- Assets:
  - 2.1 MW hydro (run of river)
  - 6.2 MW diesel
  - Storage
    - H2 system – 3.3 MWh
    - Battery – 125/400 kWh
- 2 communities served



2. Military base (grid connected) – 29 Palms (US)

- Objective – - increase energy conservation, reduce energy and water demand, increase the use of renewable energy, reduce emissions
- Prove Microgrid operation for a military base (to be replicated in others) integrating:
  - Solar PV
  - Combined Heat & Power (CHP)
  - Building Energy Management (BEM)
- It should also interface with Existing Base Control Systems
- And be capable of Bulk Grid Connected or Islanded operations



Demand-Side Resources

Automated management of energy use:

- Automated demand response
- Voluntary load control
- Dynamic pricing

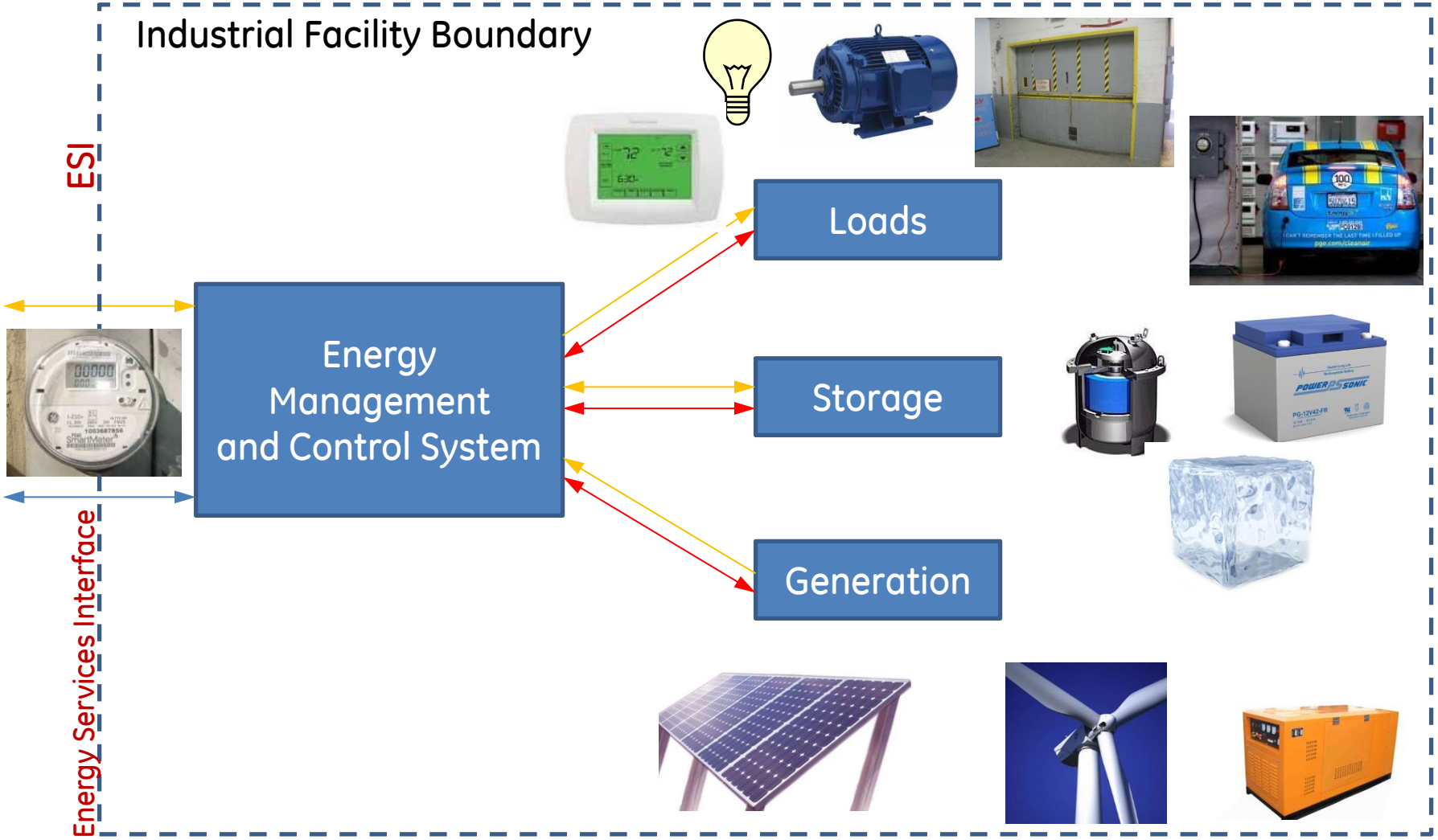
On-site generation and storage

Smart charging for electric vehicles

Industrial plants

Advanced Metering Infrastructure (AMI)

Smart Grid Extending into Industrial Facility



Secure External Communications

Intra-Facility Communications

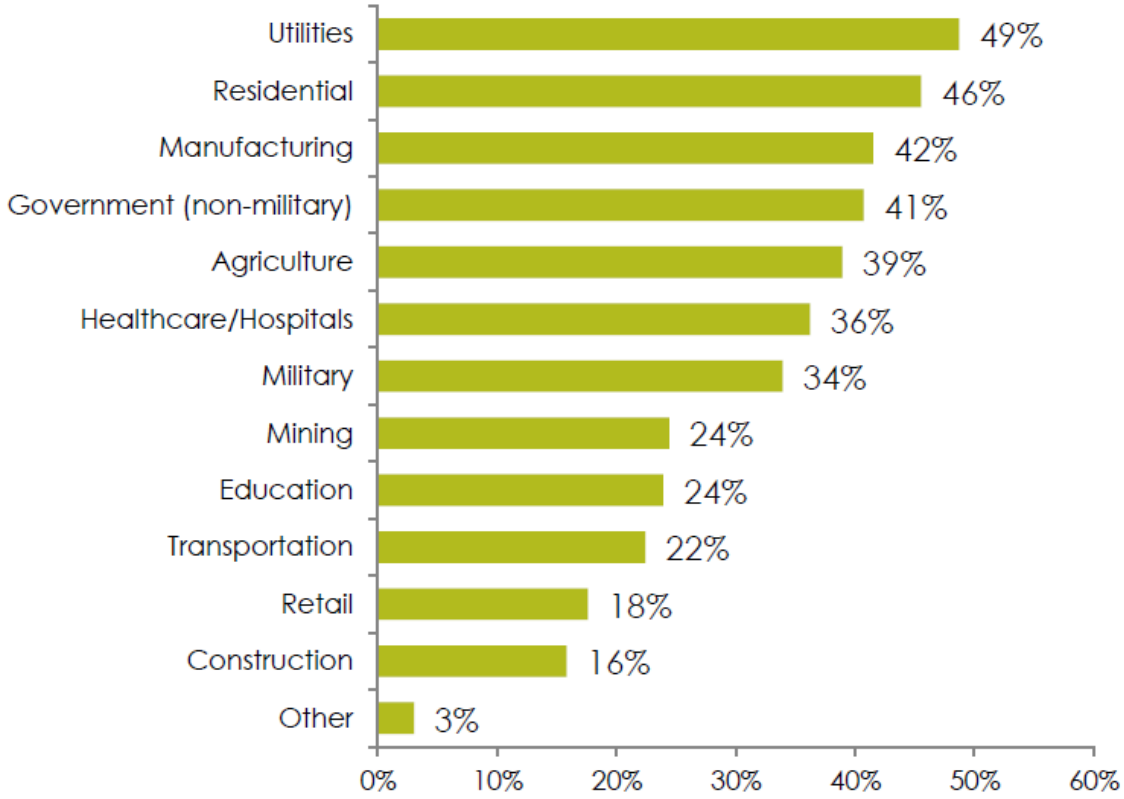
Electrical Flows

Costs of Disruption

Interruption Cost	Interruption Duration				
	Momentary	30 minutes	1 hour	4 hours	8 hours
Medium and Large C&I					
Cost Per Event	$6,558	$9,217	$12,487	$42,506	$69,284
Cost Per Average kW	$8.0	$11.3	$15.3	$52.1	$85.0
Cost Per Un-served kWh	$96.5	$22.6	$15.3	$13.0	$10.6
Cost Per Annual kWh	9.18E-04	1.29E-03	1.75E-03	5.95E-03	9.70E-03
Small C&I					
Cost Per Event	$293	$435	$619	$2,623	$5,195
Cost Per Average kW	$133.7	$198.1	$282.0	$1,195.8	$2,368.6
Cost Per Un-served kWh	$1,604.1	$396.3	$282.0	$298.9	$296.1
Cost Per Annual kWh	1.53E-02	2.26E-02	3.22E-02	$0.137	$0.270
Residential					
Cost Per Event	$2.1	$2.7	$3.3	$7.4	$10.6
Cost Per Average kW	$1.4	$1.8	$2.2	$4.9	$6.9
Cost Per Un-served kWh	$16.8	$3.5	$2.2	$1.2	$0.9
Cost Per Annual kWh	1.60E-04	2.01E-04	2.46E-04	5.58E-04	7.92E-04

Source: Lawrence Berkeley National Laboratory/ DOE

Which industries are most likely to deploy distributed generation over the next 5 years?
(figure 15, source: Zpryme & IEEE)



- 3 main drivers for DG implementations: **policy**, **power reliability** and the **business case**
- The strongest case for power reliability in the form of DG is when "energy surety" is mission-critical
- Corporate campuses and residences are turning to DG, short-term storage and microgrids to prevent loss of productivity and comfort in face of high frequency and duration of local outages

Traditional Grid And Smart Grid

Overlay with automation and analysis

Sense

Communicate

Compute

Control

Power Plants

Transmission Networks

Substations

Distribution Networks

Consumers

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

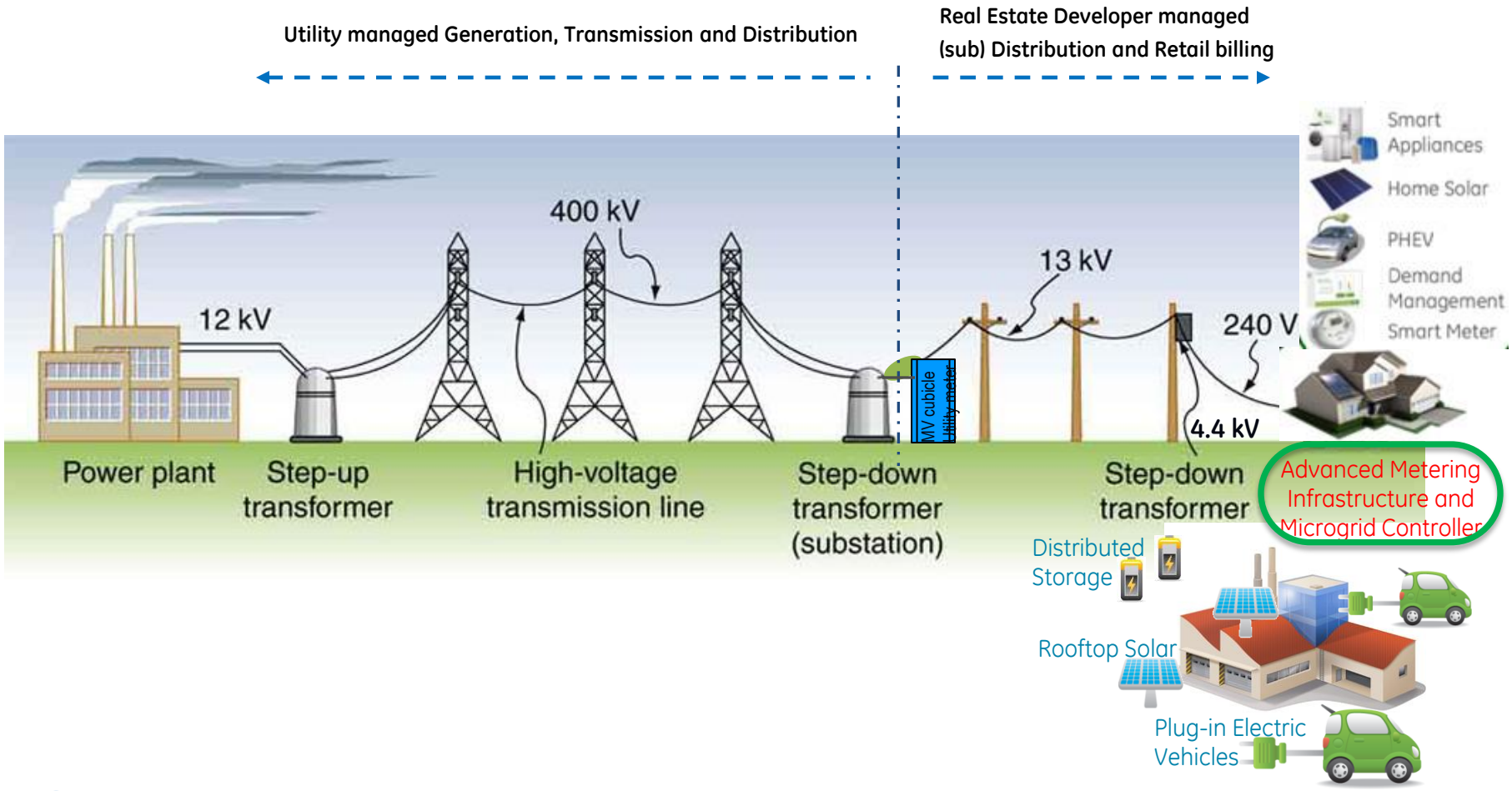
Maui Smart Grid Project

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

Operational Scope – Utility and Developer



GE Digital Energy product portfolio

http://www.gedigitalenergy.com/OurCompany.htm

Solution engagement model

Optimize solutions to meet objectives

Questions?

sasank.goli@ge.com

A "Smarter" Grid

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.

Key insights from implementations

- Focus, focus, focus on interoperability
- Realize that compliance to standards does not in itself guarantee interoperability
- Share information among stakeholders to ensure success
- Build a collaborative team with technical and project management expertise

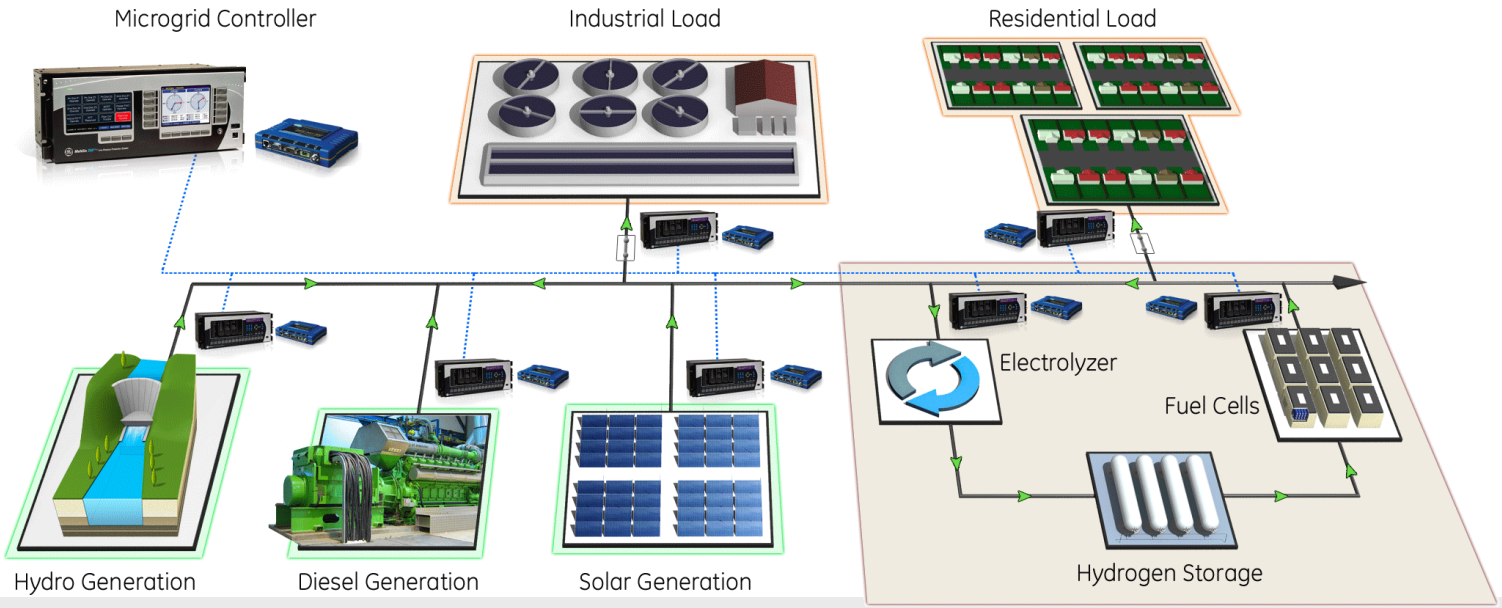
Outage Management: PowerOn Advantage ADMS

https://www.youtube.com/watch?v=x73mUwFuCPA

Microgrid Control

Microgrid Control System optimizes site generation

- Selects the most cost effective generation available to support the load
- Optimizes green power by dispatching power storage when excess generation is available
- Minimizes use of diesel generation, reducing CO2 impact and fuel costs



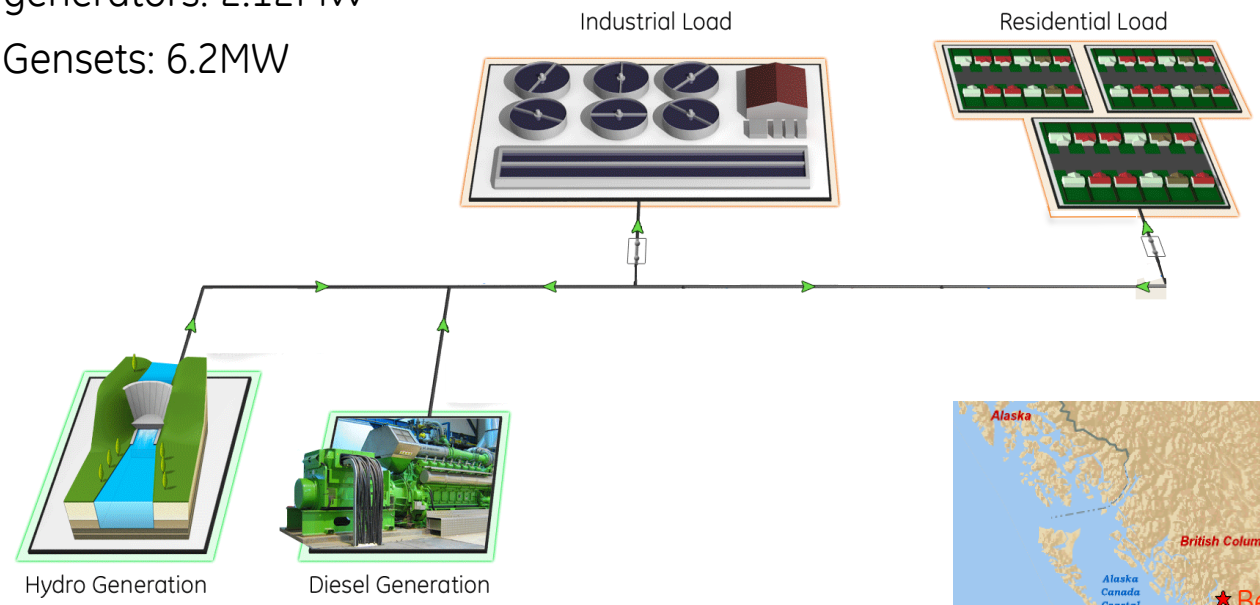
Microgird Features

- 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

Microgrid Control

Application Example: Remote Community in Northern Canada

- Remote community of 1,900 people in the 440 km North of Vancouver, BC, off-grid community
- Currently running on Diesel gensets and Hydro generators at Clayton falls
- Load profile: 4.7/3.2MW, Mostly residential loads
- 2 Hydro generators: 2.12MW
- 8 Diesel Gensets: 6.2MW



Biggest Challenges

- Fuel and transportation costs of diesel
- GHG emissions from diesel generation

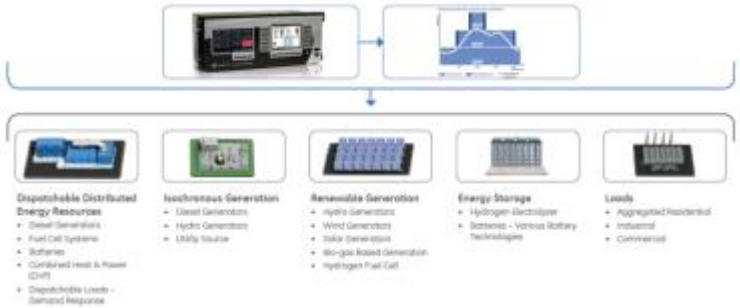
GE's Microgrid Delivery Process

- Main objectives:
  - Business outcomes
  - Technical outcomes
- Business case
  - Funding arrangements

Preliminary

- Overall program budget
- Components of the solution
- Brownfield assets (if applicable)
- Load profiling requirements (high level)
- Pre-assessment of desired mix (high level)

High level assessment



- Detailed assessment of any brownfield conditions
- Modelling of energy technologies mixes
- System stability and reliability studies
- Technology options according to outcomes and constraints
- BoM for HW and SW

Developing a value proposition

- Order
- Procurement of energy technologies
- Customization of objective functions into algorithms
- Testing of control and fine tune
- Deployment of HW and SW
- Commissioning

Order + delivery