Islands of Innovation

Achieving Holistic Grid Resilience

GE Digital Energy

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re·sil·ience
riˈzilyəns/
noun
1. the ability of a substance or object to spring back into shape; elasticity.
2. the capacity to recover quickly from difficulties; toughness.

Grid Resilience...
The degree to which an electrical grid is reliable & efficient
Two ways of looking at resilience...

**Tenacity**

By tenaciously pursuing wise planning you can avoid being forced to rely on your capacity to be resilient.
Our capacity to be resilient is inherent within us...

...collaboration is essential for transformation
Grid Resilient Solutions are Hierarchical and Interconnected

Utility Needs
- Reliability and Stability Improvement
- Reduce System Losses
- Situational Awareness

Monetized interaction are necessary in order to pay for resiliency premium & attract private investment

Optimal balance (supply and demand) of distributed resources to enable reliable and economic operation

Microgrids need to:
Provide solutions and services to plan, forecast, schedule, and dispatch

What
- Load resources – dispatchable consumption
- Distributed generation - Renewable or non-renewable generation
- Integrated resources – load and generation systems

Where
- Local – residential, commercial, and industrial
- Substation /Feeder – distribution system
- Market Operator – electricity and balancing market

Innovative business models at each level will drive market transformation

GE imagination at work
Correctly Design your Energy System
Aligning drivers, challenges, and resources to get to the correct type of system

### End-user & Utility Challenges

<table>
<thead>
<tr>
<th>Security</th>
<th>Regulatory</th>
<th>Financial</th>
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</thead>
<tbody>
<tr>
<td>• Installation-wide energy &amp; H2O security</td>
<td>• Compliance now &amp; future planning</td>
<td>• Reduce cost through efficiency &amp; intelligent system design</td>
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<tr>
<td>• End-user operations resilience, assured fuel, reduced logistics tail, etc.</td>
<td>• Federal/state mandates &amp; regulations, NetZero initiatives, carbon legislation</td>
<td>• Optimize energy-to-investment ratio</td>
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<tr>
<td>• Cyber security</td>
<td></td>
<td>• Utility cost/benefit</td>
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### End-user Drivers

1. **Increased energy independence** … leads to energy efficiency improvement projects
2. **Multiple recent regulations** instituted … forces planning for current/future regs
3. **Growing water scarcity** … drive water consumption reduction projects
4. **Strong operational performance** focus … need to optimize full life-cycle costs
5. **Multiple other additional pressures** …

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**End-user & utility energy objectives will drive whether you will have a:**
- Natural gas based microgrid
- Renewables based microgrid
Quantifying Spark Spread

Payback Analysis, Varying the Price of Natural Gas & Electricity
Engines Sizes for Electrical Load

<table>
<thead>
<tr>
<th>Electricity Price, $/kWh</th>
<th>Natural Gas Price, $/MMBtu</th>
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<tbody>
<tr>
<td>$0.06</td>
<td>$5</td>
</tr>
<tr>
<td>9.1</td>
<td>16.2</td>
</tr>
<tr>
<td>5.2</td>
<td>6.9</td>
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<td>3.6</td>
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<td>2.8</td>
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<td>1.3</td>
<td>1.4</td>
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<tr>
<td>$0.05</td>
<td>1.2</td>
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</tbody>
</table>

- Greater than 5-year payback
- Less than 5-year payback
Grid Resilience Solutions

Utility
- Distribution Automation
- VPP
- FDIR
- Line Monitor

Consumer
- Industrial Energy Management
- Microgrid
- Renewable Energy Systems
- Intelligent NG Generation
- Disaster recovery packages

Regulatory
- WAMS
- GIS/Visualization
- VPP
- Market Functions
Examples of Grid Resilient Solutions
Microgrid Solution Overview

Energy Cost, Environmental Impact and Improved Reliability ...

What is it?

A Microgrid is an integrated energy system with –

• **Local DERs** (Loads, Generators and possibly Storage)
• And can operate in **parallel with the grid** or in an intentional island system (off-the grid mode)

What does it do?

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

Value Proposition?

**Reduced Cost** – Reducing the cost of energy and managing price volatility

**Reliability** – Improving Reliability

**Security** – Increasing the resiliency and security of the power delivery system by promoting the dispersal of power resources

**Green Power** – Helping to manage the intermittency of renewables and promoting the deployment and integration of energy-efficient and environmentally friendly technologies

**Power System** – Assisting in optimizing the power delivery system, including the provision of services

**Service Differentiation** – Providing different level of services quality and value to customers segments at different price points
Microgrid Functional Capabilities

Supervisory Controls
- Optimal Dispatch to optimize electrical and thermal performance and cost
- Manage feeder connection to bulk grid
- Manage renewable intermittency
- Demand Optimization
- Integrated Volt / VAR Control

Holistic Energy System
- Supply & demand
- Utility interaction/Cyber Security/IT Infrastructure

Optimal Dispatch
The process of allocating the required load demand between the available resources such that the cost of operation is minimized.
- The optimal dispatch algorithm implements Model Predictive Control using:
  - Load forecasts
  - Renewable generation forecasts (wind, hydro, solar, bio-mass)
  - and Stored Energy

Demand Optimization
- Emergency Load Shedding
- Load as a Resource
  - Building Energy Management
  - Backup Gensets

Grid Optimization & Utility Interaction

Flatten voltage around a desired setting

Energy Balancing w/ peak demand reduction

Power loss minimization
Convergence of environment, energy cost/efficiency, security, and system reliability prove to be the key drivers for Microgrids . . .
Microgrid Project Examples
Pearl Street Microgrid (1882)

- Ten 27 ton 100Kw steam Gensets
- DC Power Microgrid
- Served 59 Customers
- Islanded operation
- HMI enabled
Toronto Airport Microgrid

104MW Microgrid
- 22 MW Net Consumption
- 80MW Bid to open market

GTAA Distribution Project/Network Statistics

Drivers:
- New Airport Terminal Addition
- New Runway Addition
- New Infield Terminal Addition

6 major switchyards with 41 circuit breakers
46 Vista units
Approximately 60 km of 28 kV cable
Approximately 90 power transformers
85 microprocessor based protection relays
Approximately 20 km of Fiber Optic Cable
Electrical demand of over 30 MW
104MVA co-generation to meet electrical demands to 2020

What the Customer Evaluation Team told GE

“...Technologically the most advanced solution combined with service support infrastructure placed GE first among other suppliers!”
Military Base– 29 Palms

- Bulk Grid Connected or Islanded
- CHP, Diesel, Fuel Cell & PV
- Building Loads as a Resource via BEM
- Wireless local area network
- Interfaces to all Microgrid elements
- Load as a Resource
- Utilize Back-Up Gensets
- GE Durathon Energy Storage

Microgrid Features

Bulk Grid

- Existing Protection / Metering Relay

Central Substation

- Microgrid Controller U90+
- EtherCAT

Fiber Network

- Ethernet Switch

Integrated Technologies

- CHP PLC
- BEM / HMI
- Building Loads w/ PV
- Substation Loads

Auxiliary

- Diesel Backup
- Fuel Cell 500 kW
- 1MW PV

32 kV Distribution

Base Housing

- Existing Protection / Metering Relay

Military Base – 29 Palms

GE Confidential & Proprietary
Use Case 1 – Loss of Utility

1. Islanded Operation
2. Dynamic Load Shed
3. Energy Storage with ISO frequency regulation
Other Grid Resilient Solutions
Multilin Recloser Control System enables the efficient recovery of distribution system networks

- Fault isolation, sectionalization and power system restoration schemes
- Intelligent, high speed and reliable DAS solution reduces customer outages
- Secure wireless capability provides peer to peer communications
Rapid Deployment Digital Substations

GE HardFiber System can significantly reduce the time it takes to rebuild substations

- Eliminates miles of expensive copper wires by using fiber optic cables
- Replaces thousands of individual terminations, with pre-terminated connectors
- Reduces labor required to upgrade or construct power substations by up to 50%
- Substations can be built or rebuilt within 4 months vs. 10-12 months with a net project cost benefit of 20% savings
- Integrated with mobile deployable disaster recovery e-Houses
Key elements needed to successfully achieve grid resilient energy objectives

Energy Surety & Renewable Energy Objectives Require Differing Approaches

• **Energy Surety Goal:** Most cost effective method will lean towards natural gas generation microgrids
  • MG functionality: Islanding, fast load-shed, net metering, ancillary services
• **Renewable Energy Goal:** Most cost effective method will learn towards wind / biogas biomass/landfill gas generation Microgrids
  • MG functionality: Optimal dispatch, firming, DSM, ancillary services

Utility Collaboration

• Microgrids need to interact and provide value to host utility
  • As well as supporting communities e.g. first responders, continuity of government, ...
• Provide ancillary benefits (Supply/demand management, frequency regulation, ...)
• Enable facility energy operator to contract with utility these services

Privatized & Monetized Structures

• ESCOs, IPPs, Utilities need to be able monetize the smart-grid features of the microgrid in order to offset cost of energy surety & attract investment
• Capitalization of existing assets can create opportunities for financial support

Unified Standards & Certification

• DOE needs to drive Microgrid/Smart Grid standards, interoperability, utility integration
• Cybersecurity & IT infrastructure standards
• Certification of technology, architecture, & functionality

Develop a long-term energy roadmap with off-ramps for incremental development

• Establish long-term vision with short-term requirements
Adoption, Policy, and Innovation Begins at the Local Level (You!)

"I'll be happy to give you innovative thinking. What are the guidelines?"
Thank you

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