Developing Economically Viable and Resilient Microgrids

GE Distributed Grid Solutions

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What’s a Microgrid?

- It has to island!
- It should have renewables
- Gotta include batteries
- Net-zero energy!
- It needs to interact with the market
What about Grid Resilience?

re·sil·i·ence
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, recoverable, & efficient.
Two ways of looking at resilience...

**Tenacity**

By wisely planning your energy system you can avoid being forced to rely on your capacity to react.
Trends Disrupting the Power Sector from Generation to T&D

**Decarbonization**

By 2040, renewables will represent 30% of global net electricity

**Impact**
- Generation is becoming difficult to forecast & variable
- Grid stability, Congestion Volatility on electricity markets

**Digitization**

Growing the number of connected devices & smart sensors

**Impact**
- Allowing decision making based on dynamic and nodal prices

**Decentralization**

Growing penetration of distributed resources (renewable, storage, efficient devices)

**Impact**
- End user becomes an active actor of the power system (‘pro-sumer’)
- Growing complexity of distribution grids

**Electrification**

in energy ecosystem

**Electrification of Energy Uses**, transport (EVs) and heating

**Impact**
- Growth of Electricity demand, and an acceleration of decentralization of the power sector
Microgrids In Many Forms

- Provides sufficient and continuous energy to meet internal demand
- Possesses independent digitalization that can island or reconnect with minimal disruption
- Presents itself as a single controlled unit to the bulk power system – revenue opportunities
- Offers flexibility in how the power delivery system is configured and operated
- Enables optimization of a large network of load, local Distributed Energy Resources and the broader power system

[Diagram showing different applications of microgrids: Utility, Campus, Remote Location, Military, Smart City, Industrial]
Key Challenges in Developing Microgrids

**Complexity**
- Integration of DERs
- Multiple stakeholders

**Economics**
- Cost
- Business model
- Financing...particularly with multi-user microgrids

**Utility / Market Interaction**
- Potentially competes with utilities
- Utility business models

**Technical**
- Voltage & Frequency Control...managing stability
- Islanding & grid integration
- Protection & Control

**Regulatory**
- Nascent regulatory environment
- Fragmented regulations
An holistic approach is essential in developing economically viable microgrids

Utility Needs
- Reliability and Stability Improvement
- Reduce System Losses
- Situational Awareness
- 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
Revenue streams outside of the microgrid can help pay for the premium of energy surety.
Convergence of environment, energy cost/efficiency, security, and system reliability prove to be the key drivers for Microgrids...
Correctly Design your Energy System
Aligning drivers, challenges, and resources to get to the correct type of system

End-user & Utility Challenges

Security
- Installation-wide energy & H2O security
- End-user operations resilience, assured fuel, reduced logistics tail, etc.
- Cyber security

Regulatory
- Compliance now & future planning
- Federal/state mandates & regulations, NetZero initiatives, carbon legislation

Financial
- Reduce cost through efficiency & intelligent system design
- Optimize energy-to-investment ratio
- Utility cost/benefit

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 ...

End-user & utility energy objectives will drive whether you will have a:
- Natural gas based microgrid
- Renewables based microgrid
GE 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

Power, Frequency, Voltage, VARs

Additional optimization constraints include:
- Unit Commitment, Start/Stop
- Min/max power/thermal output
- Generator Efficiency, Storage Efficiency
- Speed to ramp up/down output
- Electricity–to-thermal ratio in Combined-Heat-Power (CHP) source
- Market price of electricity (if connected to the utility grid) and fuel for DER Assets
Leveraging microgrids as a foundation for economic development

Examples
Pearl Street Microgrid (1882)

- Primary driver was selling lightbulbs
- Ten 27 ton 100Kw steam generators
- DC Power Microgrid
- Served 59 Customers
- Islanded operation
- HMI enabled
Modern day example

*Urban vertical farming*

- Eastern Japan 2013, **25000 Sq. Ft.**
- 18 racks each 15 levels, **17000 LED fixtures**
- **10000** heads of Lettuce per day (100 fold density increase from outside)
- Grows **2.5X** faster than outside
- Waste from **50% to 10%** compared to outside
- **1%** of water usage compared to outside
- LED **40%** less power than florescent light
The Philadelphia Navy Yard
Location: The Navy Yard

- Centralized location
- Access to:
  - Major highway
  - Intermodal freight system
  - International Airport
  - Center City, University City, 30th Street
  - Sports Complex
The Navy Yard Then & Now...

Philadelphia Navy Yard 1999, source PIDC

- 3,000 employees
- 10 Companies
- Limited private investment
- 20+ years deferred infrastructure

Philadelphia Navy Yard Today, source PIDC

- 12,500 employees
- 150+ companies; 3 Navy activities
- 7.5 million SF occupied real estate
- $750+ mil of private investment
- $150+ mil of publicly funded infrastructure upgrades
A New Model: The Smart City, Digital Urban Campus
The Challenge

THE SOLUTIONS

- Navy Yard Energy Master Plan
- GE Microgrid Controller & Solutions Team
- System that can acquire data & process with concluding actions
- A scalable platform for customer integration
  - 20% EE
  - 30% On-site DERs
  - PJM market participation
The Navy Yard Energy Master Plan “Constitution”

The Five Point Action Plan

✓ **Infrastructure**: Capacity, Generation/Supply, Technology Microgrid

✓ **Business Model**: Forecasts, Tariffs, Procurement, O & M, Capital

✓ **Building Owner Opportunities**: DG, EE, DR – Programs & Partnership

✓ **Test Bedding Outreach and R&D**: Energy Innovation Campus

✓ **Carbon Reduction and Sustainability**: Reduce Carbon Intensity
Reducing Demand & Usage  Adding Supply  Independence

Business as Usual – 100% Utility Fed
- All PECO supply
- No On-site generation (DG)
- No proactive EE or DR effort
Utility Demand - 82 MW

On-Site DG
Grid Programs:
- Natural gas DG
  - 6 MW Peak Reduction
  - 3 MW CHP (data center)
- 1 MW Solar PV
- 600 KW Fuel Cell
Utility Demand - 72 MW

Demand Response & Energy Efficiency
Customer programs:
- 20% EE goal by 2022
- Navy DOD mandates
- B-T-M Demand Reduction
Utility Demand - 60 MW

Cumulative usage decrease – over 61,000 MWh
Key elements needed to successfully achieve economically viable microgrids

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?”"