Developing Microgrids and Integrating with Energy Master Planning
Microgrid 101

One Definition
Two Types of Microgrids
Three Key Components
Four Major Benefits
One Definition

- A **microgrid** is an integrated energy system consisting of both energy generating and consuming systems.

- Capable of operating with or without the main utility grid and is intelligently controlled.
What is a Microgrid?

**Two Types of Microgrids:**

- **Full Isolation (Island)**
  - Uses local energy generation resources and controls to meet the full energy demand of all connected loads and is capable of isolating from the utility grid at any time.
  - Useful when the electrical utility is unreliable, there are major utility cost fluctuations, or when downtime is not an option.

- **Partial Isolation (Emergency)**
  - Uses local energy generation resources and demand reduction controls to isolate from the grid during outages.
  - Controls isolate non-critical facilities and manage connected loads to reduce overall demand on local generation capacity.
  - This arrangement is for a microgrid that has mission critical loads but the cost to provide a full isolation system is not warranted.
What is a Microgrid?

Three **Key Components**

- **Distributed Generation**
  - Improves reliability by utilizing multiple generation sources to remove the single point of failure arrangement
  - Improves overall efficiency and economics through the diversification of energy sources and the ability to better deploy renewable energy.

- **Sectionalizing Switches and Relay Protection**
  - Designed to isolate and recover from disturbances and keep the grid operational.

- **System Intelligence**
  - Centralized SCADA system to monitor and control grid.
  - Enterprise level integrated supply and demand control (SCADA and Building Automation Systems).
What is a Microgrid?

Four Major Benefits

• **Resiliency**
  » In order to meet the mission, an extended power outage is no longer acceptable. A microgrid enhances utility systems to achieve nearly 100% uptime operation.

• **Increased use of renewables and improved efficiency**
  » Use of cogeneration, and renewables can provide alternative fuel options and reduce GHG.

• **Energy Security**
  » Reduce exposure to outside threats (natural disasters, cyber attacks, physical attacks, etc..) by limiting the reliance on outside utility systems and improving the infrastructure.

• **Future Proofing**
  » A robust infrastructure that is developed and planned as part of a microgrid can accommodate future growth and incorporate new energy technologies.
Microgrid - Distributed Generation

- **Power Generation**
  - Cogeneration
    - Produces heat and power
    - Turbine or reciprocating engine
    - Base for grid isolation
  - Emergency Generators

- **Energy Storage**
  - Thermal Storage
  - Electrical Storage
    - Battery or Flywheel

- **Renewable Energy**
  - Solar Photovoltaic
  - Wind Energy
Microgrid – Reliability & Redundancy

• Grid Isolation
  » Full Isolation/Partial Isolation and load shedding

• Self Healing Grid
  » Utilize intelligent control system, relays and sectionalizing switches to automatically detect and isolate faults

• Robust Infrastructure
  » Looped distribution system to allow for multiple feeds
  » N+1 redundancy on key pieces of equipment

• Diversified Generation
  » Multiple generation sources prevents a single point of failure
  » Utility/Generation/Cogeneration/Solar/Energy Storage/Wind
Nanogrids Anyone?

District Energy for Electricity

A robust infrastructure that can prevent power outages in critical facilities by providing continuous power with the reliability of having multiple generators/UPS systems interconnected.
Nanogrid Concept
<table>
<thead>
<tr>
<th>Individual Generators</th>
<th>Nanogrid</th>
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<tbody>
<tr>
<td><strong>Period of Full Blackout During an Outage</strong></td>
<td>10 Seconds</td>
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<tr>
<td><strong>Supports Additional Non-Critical Loads</strong></td>
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A Smart Campus: Stepping Beyond a Microgrid

Intelligent, two way communications and control between energy producing and consuming equipment.

- Distributed Generation
  - Solar PV and thermal
  - Wind and steam turbine
  - Generators

- Energy Storage
  - Flywheel
  - Battery storage
  - Thermal storage

- Central Utility Plant
  - Boilers and chillers
  - Cogeneration
  - Optimized control load

- Electrical Infrastructure
  - High-speed switching
  - Fault indicators
  - Substation integration

- Exterior Variables
  - Utility company
  - Weather forecast

- Microgrid
  - Resiliency
  - Integrated supply and demand
  - Efficiency

- Buildings
  - Building automation system integrated with smart grid
  - Energy optimization
  - Continuous commissioning
  - Demand response
A Smart Campus: Stepping Beyond a Microgrid

- Implement enterprise level control system to integrate central utility plants and buildings to create a holistic energy system
- Campus wide implementation increases savings ability
- Required capital is lowered by utilizing existing systems
- Projected to save approximately 5-15% of campus energy costs with a payback of less than 3 years

- Some features of a smart campus:
  » Smart Metering
  » Demand Response
  » Continuous Commissioning
  » Complete System Energy Optimization
  » Automated Set Point Control

5-15% REDUCTION IN CAMPUS ENERGY
Case Study:
Centennial Campus Smart Grid Master Plan
Centennial Campus Smart Grid Master Plan – Project Overview

• Project/Site Overview
  » Campus is approximately 1,000 acres and has approximately 2 million sf of building space

• Project Goals
  » Improve electrical infrastructure resiliency
  » Plan for incorporating smart grid research on campus
  » High level demand response
Centennial Campus Smart Grid Master Plan – Projects

- **Distributed Generation**
  - 5.7 MW Cogeneration
  - 4 million gallon Thermal Storage Tank
  - Solar PV

- **Resiliency**
  - Sectionalized Self-Healing Grid
  - Emergency Grid Isolation

- **Efficiency**
  - Intelligent Microgrid Control System
    - Projected to save over $1 million annually with a payback of approximately 3 years
Centennial Campus Smart Grid Master Plan – Project Implementation

- **Tier I**
  - Smart Campus
  - Redundant and Automated Substation
  - Self-Healing Grid

- **Tier II**
  - Cogeneration
  - Thermal Storage
  - Load Shed Generator
  - Smart Grid Proving Grounds

- **Tier III**
  - Fuel Cell
  - Micro Steam Turbine
  - Grid Isolation
  - Self – Regulating Grid
  - Solar PV

<table>
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<th>Payback</th>
<th>Annual Savings</th>
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<td>2.2 Year</td>
<td>$3,600,000</td>
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<tr>
<td>20 Year</td>
<td>$1,560,000</td>
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<tr>
<td>90 Year</td>
<td>$340,000</td>
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Smart Campus Control System

- Orchestrates the various smart grid components to work as one
- Provides a centralized location to view all the energy components on campus
- Develops an energy strategy for the campus

Diagram:
- Monitoring
- Modeling
- Optimizing
Smart Campus Control System

- Integrates with the existing control systems
- Provides one fluid system to analyze energy on numerous levels
- Cost and savings estimates are based on the full implementation

2.5 Year Payback

$970,000 Annual Savings

$2,450,000 Investment
Case Study:
NJ ANG Sea Girt Microgrid Feasibility Study
• **Project Overview**
  » Fully occupied training center with approximately 250,000ft\(^2\) of building space
  » Hit hard by Super Storm Sandy

• **Project Goals**
  » Evaluate the existing and future conditions
  » Identify system weaknesses and requirements for implementing a microgrid
  » Develop a prioritized list of projects and an implementation plan for a full microgrid
Sea Girt Microgrid Considerations

- **Electric Distribution System Upgrade** – SCADA controls and monitoring
- **Improve resiliency** by adding looped circuits and self-healing grid capabilities
- **Islanding capability** - disconnection from utility grid with additional distributed generation.
- **Battery Storage** – Extend generation capabilities and reduce peak demand
- **Smart Campus Integration** – integrate grid SCADA with building controls
Sea Girt Microgrid Study – Value Added

- Resiliency
- Reliability
- Energy Efficiency
- Currently developing funding through ECIP
- If funding is approved, the site will become the first DoD microgrid that can fully isolate
Microgrid Considerations During Energy Master Planning
Microgrid Considerations – Holistic Approach

- Identify Smart Campus Efficiency Options and impact on demand load
- Electrical vs. thermal loading
- Identify level of renewables
- Grid Stabilization
- Self-Generation/Fuel Diversity
Utility Master Planning Considerations

- Condition Assessment
- System Modeling
- Load Growth Projections
- Infrastructure Renewal
- Energy Efficiency Upgrades
- Self-Generation/Fuel Diversity
- Microgrid & power resiliency
- Environmental Strategies
- Plant Siting
- Reliability Improvements
- Economic Analysis
- Cost Estimating
- Funding/Phasing/Scheduling
Benefits of Energy and Utility Master Plans?

- Ensure Energy Systems Meet Mission Needs and Addresses Deferred Maintenance
- Improve Energy Reliability & Redundancy
- Strategic Approach to Reduce GHG Emissions & Operating Costs (Meeting Federal Energy Policy)
- Provides a Road Map that Optimizes Energy Efficiency and Defines Capital Requirements
Energy Master Plan Results

Road Map and Long Term Planning Tool

» Just in time delivery
  • Meet the utility demands as required to optimize capital expenditures

» Align with goals and strategies
  • Pathway to meeting energy reduction or GHG neutrality goals

» Respond to Planning Flux
  • Maintain relevance
  • Dynamic & Adaptive

» Sensitivity Tool
  • Understand the financial and energy impact of the decisions being made

» Fund future improvements through savings
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