MICROGRIDS

2017 Southeastern Tri Regional SAME Training Symposium
Microgrids – What are they, lessons learned
8/30/2017
Dan Dorn Eaton Corp
Eaton: One brand with solutions for the entire power system and expertise spanning seven core competencies
The microgrid energy system concept

Local “Grid Within a Grid”
- Delivers Power Resilience, Reliability and Uptime

Distributed Energy Sources
- Backup Generation
- In-House Co-Gen
- CHP (Combined Heat and Power)
- On-Site Renewables and Fuel Cells
- Energy Storage (Batteries)

Microgrid Applications
- Islanding & Synchronization
- Black Start
- Generation/Load Balance Control
- Battery Energy Storage & Frequency Regulation

A group of generating assets and defined loads that can operate within the utility grid or islanded from the grid, as a self-sufficient stand alone application

Requires Control System “Glue” to Achieve System Performance
Market segments differ on their goals for microgrids and energy storage

**Segment Goals**

Utilities East: Coast: Disaster Response

Utilities West Coast Renewables and Reduced Emissions

Government & Institution Segment Focus: Savings

**Microgrid/ES Business Cases**

<table>
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<tr>
<th>Driver</th>
<th>Description</th>
<th>Detail</th>
<th>Business Focus</th>
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<tbody>
<tr>
<td>Energy Storage Regulations</td>
<td>Fills need for grid storage to complement intermittent renewables</td>
<td>California AB 2514- IOUs to install 1400 MW by 2020 to mate with 33% RPS reg. 400 MW in 2015</td>
<td>California- Battery installations</td>
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<tr>
<td>Resiliency Regulations</td>
<td>Limits outages due to natural events (weather)</td>
<td>NY REV, numerous state programs &amp; regs to implement microgrids</td>
<td>East Coast Sandy States- CT, Mass., NJ, NY, MD</td>
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<tr>
<td>Frequency Regulation</td>
<td>Supplants loss of coal-fired base load power plants</td>
<td>PJM- Wholesale price creates viable business case for short duration ES. ERCOT emerging</td>
<td>PJM territory- OH, PA, KY WV, VA, NJ; Ontario; ERCOT- TX</td>
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<td>Dependency on imported fossil fuels</td>
<td>Need to embrace renewables to offset high fossil cost &amp; environmental impact</td>
<td>Impacts remote and island grid environments using renewables and ES to minimize diesel use</td>
<td>HI, PR, AK, Canada</td>
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<tr>
<td>Need for energy surety and independence</td>
<td>Military and government drive for energy surety at key bases and facilities</td>
<td>Military bases and mission-critical facilities critical to national defense</td>
<td>DOD bases and key facilities</td>
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Energy and Grid Transformation
Eaton’s Microgrid Energy System (MES)

System Design

Seamless islanding

Black Start

Frequency & voltage control

System Balance

Renewable optimization

Lowest cost

To Upstream Grid

IEC-61850

Local Controller - Fuel Cell

Fuel Cell

Local Controller - Engine Generator

Engine Generator

Local Controller - Energy Storage

Energy Storage

Local Controller - PV

Photovoltaic

Local Controller - Load

Controllable Loads

System Controller

HMI

PCC Breaker/Recloser

To Upstream Control
Microgrid Design and Use Cases
- Key Features

System Design
- Open Comm standards
- SCADA & enterprise interface
- Modular, Pre-engineered templates
- Legacy asset compatible
- Adaptable to future asset changes

Seamless islanding
- Unintentional (Seamless) islanding
- Fast grid-fault detection, isolation and safety interlocks
- Load shedding
- Source management
- Grid reconnection

Black Start
- Safety interlock for grid isolation
- Gen and renewable source start-up
- Paralleling sources
- Power Quality stabilization
- Load sequencing & management

Frequency & voltage control
- Islanded generator Freq. control
- Generation-demand balancing
- Supporting renewable dynamics
- Ramp rate control
- Ancillary services
- Energy storage

System Balance
- Generation and demand priority management
- Fast load shedding
- Dynamic demand response
- Dynamic energy storage management
- Protection and fault

Renewable optimization
- Smart inverter controls
- Energy storage integration
- Adaptive system to weather and price forecast
- Renewables maximization option to save fossil fuel

Lowest cost
- Utility Demand Response functionality
- Energy arbitrage
- TCO optimization
- Fossil fuel conservation
- Peak shaving
- Load shifting
- Conservative voltage regulation
Utility storage / microgrid demonstration project

Eaton helps Portland General Electric make tomorrow’s smart grid a reality

Project goals
- Investigate energy storage and islanding to supply energy to customers during an outage
- Coordinate utility feed with distributed generators, battery storage, solar PV and wind power

Primarily two methods of operation
- **Grid connected** - for load support, peak shifting, spinning reserve, wind firming, solar firming, kVAR supply
- **Islanded / disconnected from grid** – disconnect from grid and pick up load and regulate frequency and voltage and reconnect back to the grid
5 MW utility battery storage system components

**Batteries**
- 1 MW / 1.25 MWh EnerDel Lithium-Ion battery blocks and battery management system (x 5 for total of 5 MW)

**Inverters**
- 20 Eaton PowerXpert 250 kW inverters, adapted for battery storage application

**Associated AC Power System**
- Low-Voltage switchboards
- Step-up transformers
- Medium-voltage switchgear, metering, protection
- UPS (for control)

**Storage Master Control System**
- Integration services to coordinate and regulate operation of multiple inverters and battery banks and interface with utility control system

One of the first Li ion projects of this size, active since 2012
Portland General Electric MicroGrid

PGE Salem High Reliability Zone

The Yellow line is a 2.5 mile 12kV over head line
Portland General Electric MicroGrid

Un-intentional Islanding and Return to Grid

1. SI connects to grid and charges battery

2. A grid-loss event occurs and MISS opens. SI maintains frequency and voltage

3. Utility returns and ISO controller provides frequency and voltage correction signals to SI

4. SI with ISO synch to grid and close MISS

5. SI charges battery

SI: Storage Inverter
MISS: Microgrid Interconnection Static Switch
ISO: Intelligent Switchgear Organization
Portland General Electric MicroGrid

Supporting Grid Connected Renewables

Twenty inverters in current mode, grid connected and discharging batteries to follow the setpoint from the utility.
Portland General Electric MicroGrid

Frequency Support in Microgrids

**Without support**
- Frequency drop: 4.41 Hz
- Frequency overshoot: 2.02 Hz

**With Support**
- Frequency drop: 1.84 Hz
- Frequency overshoot: 0.8 Hz
Utility storage / microgrid: increases reliability of electricity for business and residential customers

**Pioneering solutions**
- Seamless transition from utility to battery storage system power
- Dynamic load sharing and transitioning from utility feeder to island mode
- Coordination between generators, battery storage, solar PV, wind power

**Outstanding results**
- Using lithium ion batteries with rapid charge discharge cycles
- Demonstrating reliable, safe management of batteries and inverters
- Help stabilize grid frequency during power sags

Image credit: Portland General Electric Co.
Key lessons learned

- PLC and PC based communications are not easily repeatable
- Energy storage / microgrid controls should be modular and scalable
- Need to communicate to multiple vendor’s equipment
- Utility-proven hardware addressing cybersecurity and NERC* requirements is an advantage
- Larger MW inverters simplify the AC grid connection

*NERC = North America Electric Reliability Corporation

Image credit: Portland General Electric Co.
Project Focus: Energy Surety / Resiliency for a military campus

Solution developments:

1. Manage multiple generation sources – natural gas generators, solar pv, wind, battery storage
2. Optimized capital and operating costs via microgrid system design
3. Seamless islanding and reconnection to the grid

Eaton provides the “glue” to seamlessly connect and island the microgrid.
How do you deal with variable energy sources?

Addressing variable energy sources if they make up the bulk of available DERs?

Variable Renewable Sources - Storage

- G1_KW
- SI_KW
- Ren_KW
- Util_KW

Static Switch Opens
Generator Output “mirrors” Solar Variations
Energy Storage Supports Bus During Solar Variations
Static Switch Closes: (Utility Recovers)
Thank you

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