MICROGRID OUTLOOK
UTILITY DILEMMA OR OPPORTUNITY

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MICROWHAT? DEFINING MICROGRIDS

Key Characteristics
• Contains interconnected loads and distributed energy resources
  ✓ DG (renewable or fossil), storage, DR controls
• Operates in either islanded or grid-connected mode
• Can move seamlessly between grid-connected and islanded mode
• Single point of grid connection
• Advanced controls and metering

Source: DOE
CUSTOMER PERSPECTIVES

Disadvantages:
- Capital and O&M costs (vs purchase of energy)
- Additional responsibility in a non-core mission

Advantages:
- Increased reliability
  ✓ Enables coordinated and multiple generation sources
  ✓ Critical operations still possible even when grid is down (islanding)
- Increased efficiency
- Increased flexibility
  ✓ Enables participation in DR programs
  ✓ Ability to use renewable resources
UTILITY PERSPECTIVES

Disadvantages:
- Potential loss of revenue
- Will they really provide power when needed?
- Do not fit existing utility business models

Advantages:
- Ability to provide service during critical events
  - A number of microgrids continued operations during Hurricane Sandy
  - Critical operations still possible even when grid is down
- Financial and economic aspects
  - Options to T&D capital outlay
- Increased operational flexibility
  - Can provide additional resources
  - Ability to harness renewable resources that otherwise may pose challenges

Source: Edison Electric Institute
Market forces and policies are providing forward momentum

- **Interconnection of Intermittent Renewables**
  - 29 states have adopted RPS; others adopting net metering
  - Within CA, 50% of all new generation will be from renewable resources (20 GW by 2020)
  - 50% of RPS generation interconnected by 2013; 65% by 2016; and 75% thereafter

- **Significant Reductions in GHG Emissions**
  - 2009 federal goal: 17% by 2020
  - Increasing pressure to adopt 40% reduction by 2020
  - Leading to new clean energy policies

- **Market Growth of DG and CHP**
  - 2012 worldwide investment in renewables at $244 billion U.S. at $36 billion (Bloomberg)
  - 65% of worldwide investment in solar in small scale systems
  - 30% of U.S. generation from DG and renewables by 2020
MICROGRIDS: STATUS AND PROSPECTS

Current Status:
Microgrids have been steadily developing
- By the start of 2011, global installed microgrid capacity was nearly 1.5 GW
- By mid-2013, installed capacity was nearly 2 GW
- 2012 global revenue over $5 billion

Projected Growth:
Expect rapid and sustained growth
- Growth to over 5 GW by 2020
  - Some estimates as high as 15 GW
- 2020 European and Asian revenue expected to exceed $19 billion
- 2020 U.S. revenues to approach $6 billion

Source: Pike Research
THREAT OR OPPORTUNITY?

**Threat:**
- Disruptive market force driving change
- Outside utility control
- Continuing financial pressure going forward as DER/DG costs drop

**Opportunity:**
- May stimulate positive changes in utility business models
- Could enable utilities to provide expanded level of services to customers

Utility Role in Tomorrow’s Grid?

[Diagram showing changes from unidirectional power distribution to a grid with self-managing, demand-responsive smart buildings, generation from renewable sources, secure, self-healing, self-optimizing grid, clean transportation, energy-efficient homes driven by consumer choice.]
MOVING MICROGRIDS FORWARD

**Regulations and Policies**
- Encourage upfront utility support for microgrid development that benefits utilities and utility customers
- Promote transparency of T&D information to help identify optimal locations for microgrids

**New Business Models**
- Reward utilities for supporting cost-effective microgrid development
- Enable effective partnerships for grid development

**Forums for Open Exchange**
- Fostering open discussion of issues and opportunities facing utilities and project developers
THANK YOU
Microgrid Research and Demos

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Microgrid Characteristics

- Combination of conventional and/or renewable on/off the grid energy sources
- Energy storage system to compensate for renewable intermittency
- Communication networking of all Microgrid elements including load clusters
- Integration with Protection Controls to ensure reliable operation

A smart control system to optimize and manage generators, energy storage and loads within the microgrid
Technical Approach: Optimal Dispatch

Microgrid Optimization Model

- **Pre-processing Unit**
  - Device Status
  - Storage State of Charge

- **Processing Unit**
  - System Topology, Fuel Cost, Start-up/Shut-down Costs, Isoch Margin, ...

- **Post-processing Unit**
  - Setpoints of Dispatchables
  - Setpoints of Storage Devices

**Forecasts**
- Load
- Renewables
- Electricity Price

**Settings**
Microgrid Optimization

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**

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
Bella Coola Microgrid

Features:
- Centralized supervisory control to optimize the use of renewables and minimize the use of diesel
- Wireless local area network, interfaces to all Microgrid elements
- Hydrogen based energy storage system
- Capability to connect, monitor and control the system remotely

Electrification of Remote Communities
Twentynine Palms Microgrid

Ref: Load Flow Report: P-807 Aircraft Surveillance Radar Contract# N68711-01-D-6231; Task Order #0001

Dept. of Defense Program: Energy Surety in Addition to Energy Efficiency
Screen Shots from Twentynine Palms

Selective Control: U90+

Visibility: Cimplicity
Distinctive Features

• Support of low-intermittent renewable power sources operating in isoch mode

• Support of both electricity and thermal systems in a single optimization framework
Support Capabilities of the Controller

- U90Plus is capable of supporting a maximum of:
  - 16 dispatchables
  - 16 storage devices
  - 16 renewables
  - 16 loads
  - 1 grid
  - 8 CHPs
  - 8 boilers
  - 8 heat storage devices
  - 16 heat loads
  - Total number of assets: 32

- U90Plus has industrial standard (operating under harsh weather conditions)
Volt/VAr Control – Function Objective

The objective functions analyzed for application to military bases are:

- Minimize peak load (through conservation voltage reduction)
- Minimize line power losses
- Minimize number of cap bank operations
- Voltage flattening
Implementation Plan

Telemetered Data every 10-15s

Decide Mode of Operation

Decide control objective

D400

Cap-bank Control
Phase III – Battery Energy Storage System

Plan: a Durathon equipped BESS

- 1000 kVA apparent inverter power rating
- 240kW/480 kWh energy storage
- Option for a total of 1.2MWh energy storage
- Volt/VAR, phase imbalance, and real power injection capable
- Grid-Tie

**Primary Technical Objectives:**

- Increase Power Factor of Co-Generation facility
- Increase overall Solar Power Plant capacity factor, specifically during islanded operation
- Provide peak-shaving during high demand periods and reduce peak demand charges
HMI main screen
Simulated PV smoothing
Summary

• Microgrid can better utilize local renewables in remote areas without utility grid

• In military bases, they can help the operators in energy efficiency in addition to energy surety

• Efficient use and asset optimization of reactive power devices are possible – both in microgrid and bulk grid

• Energy storage (if available) can help in certain functions within the microgrid working with a site controller which is capable to accept utility signals.
THANK YOU