Outline

• What is a Microgrid
• Microgrid Operation
• Project Process
• Costs and Case Study
Microgrid Benefits

- **Resilient**
  - Keep the lights on
  - Power through the storm
  - Grid Independent

- **Sustainable**
  - Integrate renewables
  - Reduce GHG
  - Reduce fossil fuel

- **Cost Effective**
  - Reduce installed cost for back up power and T&D upgrade
  - PPAs

- **Energy Efficient**
  - Combined Heat and Power
  - Integrate with building management system

Microgrid
What is a Microgrid?
Definition of Microgrid

Department of Energy Microgrid Definition

“A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.”
The grid is the keystone infrastructure – central to the web of interconnected systems that support life as we know it.
Traditional Electric Grid and Microgrid

[A] Generation
Power station
Transformer

[B] Transmission
Transmission line
Substation

[C] Distribution
Substation

[D] Consumption
Home
Commercial facility

https://www.copper.org/environment/sustainable-energy/grid-infrastructure/
Microgrid Illustration

Illustration by Michael Schrader / Affiliated Engineers, Inc.  
Microgrid Complexities

Microgrid Architecture
Microgrid Operation

- **Main Transformer(s)**
- **Utility Switchgear**
- **ATS**
- **Emergency Switchgear**
- **Facility(s) Utility Switchgear**
- **Facility(s) Emergency Switchgear**
- **Host Utility Substation**
- **Disconnect (Manual or Automatic)**
- **Transformer**
- **Power Service**
- **4-34 kV Distribution**
- **120-480V Normal**
- **Emergency Generator(s)**

- **Facility(s) Non-Critical Load(s)**
- **Facility(s) Critical Load(s)**

**Utility Power**

**Emergency Power**
Microgrid Operation

Utility Power Outage

- Facility(s) Utility Switchgear
- Main Transformer(s)
- Host Utility Substation
- Facility(s) Emergency Switchgear
- ATS
- Facility(s) Emergency Generator(s)
- Utility Power
- Emergency Power

- Facility(s) Non-Critical Load(s)
- Facility(s) Critical Load(s)
Microgrid Operation

- Main Transformer(s)
- Host Utility Substation
- Facility(s) Utility Switchgear
- Facility(s) Emergency Switchgear
- Utility Power
- Emergency Power
- Back-Up Generator Starts
- Facility(s) Non-Critical Load(s)
- Facility(s) Critical Load(s)
- Emergency Generator(s)
Microgrid Operation

ATS Senses Voltage and Switches Over

Facility(s) Utility Switchgear

Main Transformer(s)

Facility(s) Emergency Switchgear

Utility Power

ATS

Emergency Power

Host Utility Substation

Facility(s) Utility Switchgear

Facility(s) Non-Critical Load(s)

Facility(s) Critical Load(s)

Emergency Generator(s)
Microgrid Operation

- Main Transformer(s)
- Host Utility Substation
- Facility(s) Utility Switchgear
- Facility(s) Emergency Switchgear
- Utility Power
- Emergency Power
- Facility(s) Non-Critical Load(s)
- Facility(s) Critical Load(s)
- Centralized Emergency Generator(s)
- Centralized CHP
- Centralized Renewables
- Centralized Storage
Microgrid Operation

- Facility(s) Utility Switchgear
- Microgrid PCC
- Main Transformer(s)
- Host Utility Substation
- Distributed Energy Resources
- Centralized Energy Resources
- Facility(s) Non-Critical Load(s)
- Facility(s) Critical Load(s)
- Emergency Generator(s)
- Centralized Emergency Generator(s)
- Central CHP
- Centralized Renewables
- Centralized Storage
Microgrid Operation

- Facility(s)
- Utility Switchgear
- ATS
- Microgrid PCC
- Main Transformer(s)
- Host Utility Substation
- Distributed Energy Resources
- Facility(s) Utility Power
- Facility(s) Non-Critical Load(s)
- Facility(s) Critical Load(s)
- Centralized Emergency Generator(s)
- Central CHP
- Centralized Renewables
- Centralized Storage
Microgrid Operation

Facility(s) Utility Switchgear

Utility Power

ATS

Facility(s) Critical Load(s)

Emergency Generator

Centralized Emergency Generator(s)

Central CHP

Centralized Renewables

Centralized Storage

Host Utility Substation

Distributed Energy Resources

Main Transformer(s)

Microgrid PCC

Microgrid PCC

OPEN
Microgrid Major Devices

• **Distributed or Central Electrical Generation**
  • Generators (Diesel, Natural Gas, Propane, Hydrogen, etc.)
  • Renewable Energy (Wind, Solar, Hydro, Geothermal, etc.)
  • Energy Storage (Batteries, Flywheels, Hydrogen, etc.)
  • Fuel Cells

• **Isolation, Switching and Protection**
  • Reclosers
  • Automatic Transfer Switches (Building, 15kV, etc.)
  • Breakers (Manual, Automatic, Shunt Trip)
  • Relays (Configurable)

• **Controls and Communication**
  • Microgrid Controller (Central, De-centralized, etc.)
  • Generation Controller (BMS, Diesel Control, et.)
  • Building Controller (Building Management System, etc.)
  • Communication Medium (Fiber, Copper, Radio, Cell, etc.)

• **OTHER**
  • Balance of Plant (Enclosures, Foundations, Transformers, etc.)
  • Physical Security (Fences, Locks, etc.)
Project Process
Project Conception

1. **Identify Area & Systems of Interest**
   - Inputs:
     - Infrastructure types & locations
     - System topology
     - Critical functions & assets

2. **Establish Resilience Goals and Resilience & Consequence Metrics**
   - Inputs:
     - Resilience objectives
     - Consequence categories

3. **Conduct Threat Assessment**
   - Inputs:
     - Threats for area
     - Hazard magnitude of threats
     - Fragility curves

4. **Assess Baseline Resilience**
   - Inputs:
     - Baseline system configuration
     - Blue sky and emergency load profiles

5. **Design & Analyze Base Case Resilience**
   - Inputs:
     - Traditional resilience technology selections
     - Base case system configuration

6. **Plan & Analyze Alternative Conceptual Design(s)**
   - Inputs:
     - State-of-the-art resilience technology selections
     - Alternative design system configuration(s)
     - Mitigation options

7. **Multi-Criteria Comparison of Conceptual Designs**

8. **Select Design and Develop Implementation Plan**

**Engage Stakeholders**
Construction and Commissioning

Lesson Learned:
Depending on size and complexity, commissioning could take 1 day or 1 month. But it will always take more time than you think.

- Operational monitoring, Warranty, Predictive maintenance

Design

Commissioning Team development - Roles and responsibilities, Application(s) selection, System selection, codes and standards, Specifications, SOO, ES&H requirements, DAS design.

Procurement

Contracts for Independent testing/commissioning agent, Team roles and responsibilities, Factory test (Warranty)

Construction

Design verification. Factory testing, Develop test procedures based on PNNL/SNL Protocol, Inspections

Commissioning/Testing

- Operational (OAT), Start-up, Functional (FAT) - SNL/PNNL Protocol, Shakedown (safety), baseline measurements, training, emergency response

Operation

- Operational monitoring, Warranty, Predictive maintenance
Case Study
**Sandia Energy Surety Microgrid Efforts**

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<th>Conceptual Designs/Assessments</th>
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<th>Operational Prototypes</th>
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<td>- Maxwell AFB – FY09, DoD</td>
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<td>- Soto Cano – FY12 DoD</td>
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Case Studies: California Energy Commission

- 2018 - Navigant performed a review on 9 microgrids within the California Energy Commission
- Microgrids range from 153kW to 13.5MW
- All 9 microgrids consisted of solar plus storage
- Generation mix was 88% Clean Energy and 12% Fossil Fuel

Types of Economic Mechanisms
- Energy Management Services Agreement: Contractor supplies demand response to SCE (cost savings split between owner and contractor) and owner pays monthly maintenance fees
- Power Purchase Agreement
- Service Contract: Contractor provides reduction to demand charges and splits savings with owner
- Arbitrage for residential: Research purposes not economical
- Utility Owned: Peak shaving mitigation
- Lease to Own: 7 year contract which lease is based on monthly electric savings (Freeze monthly electric bill)
- Private Investment: Reduce GHG and resiliency
- Government Investment: Military Construction (MILCON)

Value Proposition

Microgrid Costs

Microgrid Case Study: Blue Lake Rancheria

- **Location:** California
- **Application:** Energy demand reduction, resiliency, reduce GHG
- **Cost:** $6.3M
- **R&D Cost:** 20%
- **Expected Revenue:** $200k
- **NPV:** positive at ~20-25 years

- **Project Timeline:** 24 Months
- **Unplanned Outages:** 4 in 2017
- **Carbon Reduction:** 175 tons CO₂
- **PV:** 15% of load demand

https://schatzcenter.org/blrmicrogrid/
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