Toward Understanding MicroGrid Costs and Making a Project Pencil Practical Considerations
What Problems are the MicroGrids Attempting to Solve?

- Resiliency
- Utility Disruptions
- Energy Savings
- Power Quality
- Energy Supply Diversity
- Demand Management
- Hedging
- Daily Arbitrage

The Capability to Solve Multiple Problems is a Core Value Proposition of the Microgrid

Customer’s Infrastructure:

“How Much Resiliency Do I Have?”
“How Vulnerable is My Core Mission?”
“Define the Resiliency Criteria”
   ex. outage duration
Form – the Components of the Microgrid

**Distributed Resources – Lowest to Highest Cost**

- IC Engine / CHP
- PV Solar
- Battery Energy Storage
- All of the above in one system

**Island Microgrid Transition – Highest to Lowest Cost**

- Fast / Seamless (seconds or cycles?)
- Load Shedding
- Administrative / Manual

**Microgrid Controllers**

- Scalable Solutions
  - Cloud Based
  - Local
- Distributed
- Relay Based
- Bespoke / PLC / DCS

Function of the Microgrid often dictates the equipment used and cost for transition into and out of Microgrid

Value of controller to Microgrid may be hard to quantify … multi-DER Microgrids don’t function without controller
Development & Modelling ..... Understanding the Function ..... Designing to the Form ..... Speed to Execution

- MicroGrid Concept Development & Modelling
- Commercial Offering / Model
- Validation of model aids in financial closing
Island Microgrid Cost Structure … Cost Following Function Following Form

Project Cost - Administrative Microgrid

- Development Modelling: 53%
- Project Engineering: 29%
- DER: 2%
- Electrical Infrastructure: 3%
- Microgrid Switching & Transition: 10%
- Microgrid Controller: 10%
- Construction: 2%

Project Cost: $ 1,700 / kWe

Project Cost - Fast Transition Microgrid

- Development Modelling: 44%
- Project Engineering: 8%
- DER: 10%
- Electrical Infrastructure: 32%
- Microgrid Switching & Transition: 10%
- Microgrid Controller: 2%
- Construction: 1%

Project Cost: $ 2,100 / kWe

Incremental Cost for Fast Microgrid Transition: $ 400 / kWe …. ROI on incremental cost?

Both Microgrids Provide the Same Basic Function – but the Form of the Microgrid is driving the relative cost
Depicting and Assessing Project Revenue – The Road to Financing

Secured or Warrantable Revenue Stream

- Combined Heat and Power ESA
- Solar PPA
- Resiliency or “Micro-Grid as Service”

Revenue or Benefit at the Margin

- Renewable Energy Credits
- Dispatch of Distributed Generation as Arbitrage
- Onsite Generation as a Capacity Resource
- Onsite Generation as a Demand Management Hedge
- Unbundled Electric Supply
- Frequency Regulation / Ancillary Markets

Does the Financer Have a Contract to Match the Function of the Micro-Grid
EXAMPLE PROJECT – PRIVATE UNIVERSITY

Project Overview

Major Private University located in urban area and served by load challenged local electrical distribution system. Recent disruption in electrical service impacted critical research activities and damaged relations with students, faculty and donors.

**Electricity Delivery:**
- 7 MW – Dual Feeders
- Project supports 2 MW CHP with steam and hot water heat recovery. 4 MW simple cycle economic dispatch

**DER Potential**
- Limited distributed On-Site Diesel Gen with limited fuel storage

**Emergency Gen**
- University is fed by 2 utility feeders. Local distribution system is capacity and demand constrained.

**Electrical Infrastructure**
- Students and funded research projects at risk in the event of prolonged loss of utility service

**Customer Vulnerability**
- Susceptible to weather based utility disruptions

**Weather**
- No redundancy, single point failure, limited backup power fuel storage

**Equipment**
- Loss of utility service longer than 1 hour requires contingency plans for students and loss of funded research activities

**Event Length**
- Insurance premium for loss of operations is expected to escalate

**Insurance**
- High demand and distribution charges

**Utility Tariff**
- Unbundled wholesale electricity and gas

Resiliency Impact

Loss of energy delivery severely impacts central missions of University: student health and safety and ongoing funded research

MicroGrid Function

Resiliency #1 .... Energy Savings, Demand Management follow
Combination of administrative microgrid and design+build allowed project to pencil and come on line to secure reduction in summer peak demand.

<table>
<thead>
<tr>
<th>Function</th>
<th>Form</th>
<th>Finance</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Resiliency</td>
<td>✓ Simple administrative transition into island microgrid</td>
<td>✓ 3rd Party Financed through SPE</td>
</tr>
<tr>
<td>✓ Energy Savings</td>
<td>✓ Design+Build reduced project schedule and costs</td>
<td></td>
</tr>
<tr>
<td>✓ 2 MW CHP + 4 MW Demand Management</td>
<td>✓ Modular packaged engines and outdoor substation to reduce capital cost</td>
<td>✓ Resiliency as a Service + Energy Savings through Reduction in Capacity &amp; Transmission Expenses</td>
</tr>
<tr>
<td>✓ Integration of CHP into existing boiler plant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### EXAMPLE PROJECT – PRIVATE REAL ESTATE DEVELOPMENT

#### Project Overview

Client is private real estate developer owning a multi-building property attempting to attract tenants with building level microgrids that optimizes use of limited onsite PV solar and offers resiliency.

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electricity Delivery:</strong></td>
<td>Buildings range from 600 kWe to 2 Mwe – Grid Only</td>
</tr>
<tr>
<td><strong>DER Potential</strong></td>
<td>PV Solar + Simple Cycle IC engine + BESS</td>
</tr>
<tr>
<td><strong>Electrical Infrastructure</strong></td>
<td>Utility supply at local substation. Individual buildings have dedicated load centers dedicated.</td>
</tr>
<tr>
<td><strong>Customer Vulnerability</strong></td>
<td>Tenants range from professional services with sensitive IT needs to light manufacturing requiring reliable power</td>
</tr>
<tr>
<td><strong>Weather</strong></td>
<td>Historic data describes loss of grid due to severe winter and weather events</td>
</tr>
<tr>
<td><strong>CHP Potential</strong></td>
<td>Existing tenants – limited / Future tenants may desire CHP</td>
</tr>
<tr>
<td><strong>Event Length</strong></td>
<td>Tenants are sensitive to loss of power – depending on tenant 5 minutes to 1 hour of disruption can negatively impact business operations</td>
</tr>
<tr>
<td><strong>Insurance</strong></td>
<td>Business risk insurance premium is expected to escalate</td>
</tr>
<tr>
<td><strong>Utility Tariff</strong></td>
<td>High demand and distribution charges</td>
</tr>
<tr>
<td><strong>Supply Contract</strong></td>
<td>Unbundled wholesale gas and electric supply contracts</td>
</tr>
</tbody>
</table>

#### Resiliency Impact

Interruption of electrical service affects tenant operations and confidence.

#### Client Goals

**Technical & Economic**

Maximize renewable energy, Manage and reduce demand, lower energy expenses, recruit and retain tenants.
### OUTCOME / SOLUTION

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<tr>
<td>Incorporate Renewables</td>
<td>Multi-DER</td>
<td>3rd Party Financed through SPE</td>
</tr>
<tr>
<td>Energy Savings</td>
<td>Scalable cloud based microgrid controller</td>
<td>Owner Equity + ITC</td>
</tr>
<tr>
<td>Demand Management</td>
<td>Battery energy storage</td>
<td></td>
</tr>
</tbody>
</table>

Modelling of multiple DER options provided client with technical and finance options.
Questions?

Thank You