PV+ES for Resilience


Chris Lotspeich
Celtic Energy Inc.
NESEA Building Energy 16
March 9th, 2016
PV+ES planning considerations

• What are your mission critical loads?

• How long do you want to operate off grid?

• Location and capacity of onsite systems?

• What role for backup generation (if any)?

• What procurement “business model”? 
What is your design basis threat?
Salt Lake City Public Safety building

The first net zero energy public safety building in the U.S.

320,000 SF, $80 million facility completed in 2013

Image by Jeff Goldberg/Esto. From EDC magazine, 12/16/13.
Salt Lake City Public Safety building
Contains PD & FD HQ, EOC, 911 dispatch, City data center

- Designed to withstand 7.5 Richter scale seismic event
- Critical facility sustained operations during power outages
- 350 kW rooftop solar power array, solar thermal hot water
- 35 kW PV canopy is public device charging station

Image by Jeff Goldberg/Esto. From EDC magazine, 12/16/13.
Need to plug in? Tap into a renewable energy source using the outlet defined to power your laptop, mobile phone, or other electronic devices responsibly and share with others in the place.
FL SunSmart Schools E-Shelters program

- FL Energy Office, FL Solar Energy Center, DOE
  - 2009 ARRA funds to expand shelter program
  - Goals: save energy costs, shelter, educational tool

- 115 schools totaling ~1 MW PV
  - Goals: save energy costs, shelter, educational tool
  - Total shelter capacity of 10,000–50,000 people

- Teachers, school facilities staff training
FL SunSmart Schools E-Shelter program

- 10 kW PV, 48 kW / 25 kWh lead acid batteries
  - 150 mph wind loading requirement
  - $74,000–$90,000 installed, savings $1,500+/yr

- 1 kW critical loads defined by local committee
  - American Red Cross, Emergency Management, school facility personnel and FSEC

- Lighting, outlets for device charging; no HVAC
  - Enhanced Hurricane Protected Area in each school
  - Typically gyms, cafeterias, classrooms
Potential Service Restoration Timeframes (M7.9 Earthquake)

- Gas:
  - 1 DAY: 5
  - 2 DAYS: 25
  - 3 DAYS: 60
  - 1 WEEK: 95
  - 2 WEEKS: 97
  - 3 WEEKS: 98.5
  - 1 MONTH: 100
  - 2 MONTHS: 100
  - 3 MONTHS: 100
  - 6 MONTHS: 100

- Electricity:
  - 1 DAY: 0
  - 2 DAYS: 0
  - 3 DAYS: 0
  - 1 WEEK: 0
  - 2 WEEKS: 2.5
  - 3 WEEKS: 5
  - 1 MONTH: 10
  - 2 MONTHS: 30
  - 3 MONTHS: 65
  - 6 MONTHS: 100

Data Credit: Lifelines Council

Slide courtesy of Arup
PV+ES Technologies
PV+ES ... + Generators

[Image of solar panel, inverters, Tesla Powerwall, batteries, and a generator]

Adapted from slide courtesy of Arup
Design Decision Tree

Building Load Assessment
Critical Loads / Efficiency Improvements

Motor Loads?

Can you meet with S+ES onsite?

Can you meet with S+ES offsite?

Diesel Generator (Null Case)

Rotating Equipment + Solar+Energy Storage (S+ES)

Microgrid

Compare system type on:
- O&M
- CapEx
- Insurance

*Evaluate each additional unit of generation of storage vs. load reduction potential

Facility Scale System

Slide courtesy of Arup
SF Critical Facilities
Potential Microgrids
Potential “West Side” Microgrid
Microgrid Considerations

End of the same feed branch

12 KV 480 V 12 KV

1 2 3
Critical Critical Non-Critical

Transformer
Microgrid Considerations

Same feed, different feed branch

12 KV transformer

12 KV

480 V

Non-Critical

2

Non-Critical

2

Non-Critical

2

Critical

3

Critical

1

Slide courtesy of Arup
Microgrid Considerations

On a different feed

12 KV

480 V

transformer

Non-Critical 2

Non-Critical 2

Critical 3

Critical 1

Slide courtesy of Arup
Microgrid Demonstration Project for the City of Fremont Fire Department Stations 6, 7 and 11

CEC PON-14-301
Demonstration of Low Carbon-Based Microgrids for Critical Facilities

Slide courtesy of Gridscape
CEC Microgrid Award

- **Total Award**
  - $2.4M

- **Proposed Sites**
  - Three Critical Facilities – Fire Stations in the City of Fremont

- **Benefits to State and City**
  - 3 hour Renewable Energy Islanding in case of disasters
  - 25%-50% of Net Energy Cost Savings
  - Clean & Sustainable Energy

- **Partners:**
  - Gridscape
  - Fremont
  - Samsung
  - Ideal Power

- **Project Details**
  - 25-60KW Solar Canopy System
  - 50-80 kWhr Energy Storage System
  - Microgrid Controller
  - Cloud-based Predictive Energy Management Software

*Gridscape Proprietary & Confidential*

October 15, 2015

Slide courtesy of Gridscape
## Project Design

### Equipment to be Installed:

<table>
<thead>
<tr>
<th>Location</th>
<th>Solar</th>
<th>Energy Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Station #11:</td>
<td>22.3 kW parking canopy</td>
<td>Samsung Lithium-ion battery (~80 kWhr)</td>
</tr>
<tr>
<td>47200 Lakeview Blvd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Station #6:</td>
<td>37.1 kW parking canopy</td>
<td>Samsung Lithium-ion battery (~80 kWhr)</td>
</tr>
<tr>
<td>4355 Central Ave</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Station #7:</td>
<td>43.4 kW parking canopy</td>
<td>Samsung Lithium-ion battery or IMERGY vanadium based flow battery (~80 kWhr)</td>
</tr>
<tr>
<td>43600 S. Grimmer Ave</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project Design (cont.)
Project Design (cont.)

Fire Station #6

Fire Station #7

Fire Station #8

Slide courtesy of Gridscape
Project References
Duke Energy McAlpine Substation & Fire Station

Abb solution
- Implement microgrid control system to manage transition from grid to island mode
- Manage solar PV and battery while islanded

System Specifications
- 1 x 50kW Solar PV Farm
- 1 x 200kW/250kWh Battery System
- 1 x back up diesel generator in fire station

Key objectives
- Test and prove seamless ‘islanding’ capabilities
- Validate battery and PV power to provide reliable power upon main grid loss of power
### McAlpine Site Layout

<table>
<thead>
<tr>
<th>Number</th>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Substation</td>
<td>McAlpine Creek Retail Substation</td>
</tr>
<tr>
<td></td>
<td><strong>Microgrid Controls</strong></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Islanding Switch</td>
<td>Electronic switch to disconnect from grid</td>
</tr>
<tr>
<td>3</td>
<td>DER Recloser</td>
<td>Electronic switch with interconnection protection</td>
</tr>
<tr>
<td>4</td>
<td>DER Transformer</td>
<td>500kVA 24kV/480V three-phase transformer</td>
</tr>
<tr>
<td></td>
<td><strong>Distributed Energy Resources</strong></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Solar Inverter</td>
<td>50kW three-phase 480V inverter</td>
</tr>
<tr>
<td>6</td>
<td>Battery, Inverter &amp; Control House</td>
<td>200kW/500kW Lithium-Iron-Phosphate</td>
</tr>
<tr>
<td>7</td>
<td>Solar Array</td>
<td>50kW array; 207 monocrystalline panels (230 W/panel)</td>
</tr>
<tr>
<td></td>
<td><strong>Customer Application</strong></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Customer Transformer</td>
<td>75kVA; 120/208V transformer</td>
</tr>
<tr>
<td>9</td>
<td>Customer Generator</td>
<td>50kVA generator with open transition transfer switch</td>
</tr>
</tbody>
</table>

McAlpine Substation | 7132 South Pineville-Mathews Road | Charlotte, NC  28226

Scripps Ranch, CA
Scripps Ranch Community Rec Center

- Support from CPUC, DOE, CA Solar Initiative
- Existing 30 kW PV, added ES to empower EOC
  - Grid-tied 100 kW inverter
- Add 100-kW/100-kWh lithium-ion battery
  - 2 grid-tied 100 kW inverters
  - Island via Princeton Power Systems Site Controller
- Energy bill fell from $2,000/mo to nearly zero
  - Shave peak for demand charge reductions
  - Revenue for grid support
Stafford Hill, Rutland, VT

- Green Mountain Power with Dynapower, GroSolar, DOE, ESTAP, State of VT

- 1\textsuperscript{st} 100% solar microgrid, 1\textsuperscript{st} on brownfield
  - ES provides ancillary services to the grid
  - Island mode energy support for HS shelter

- 2.5 MW PV panels, 4 MW ES
  - 2 MW / 1 MWh Lithium ion
  - 2 MW / 2.4 MWh lead acid batteries

- $\sim$10.8 million cost, $\sim$ 10 year payback
Community Clean Energy Resiliency Initiative
Project Implementation and Technical Assistance

**Map: Massachusetts**
- **Greenfield (Award and TA)**
- **Northampton (Award and TA)**
- **Holyoke (Award and TA)**
- **Springfield**
- **Greater Lawrence Sanitary District**
- **Chelmsford**
- **Sterling**
- **Andover**
- **South Essex Sewerage District**
- **MAPC 1 - Beverly (Award and TA)**
- **MAPC 2 - Wayland (Award and TA)**
- **Berkley & Taunton**
- **Cambridge, Medford (Award and TA)**
- **Boston (Award and TA)**
- **Cape & Vineyard Electric Cooperative**
- **Sandwich**
- **New Bedford**
- **Falmouth**
- **Barnstable (Award and TA)**

**Table: Project Implementation Award and TA**

<table>
<thead>
<tr>
<th>Applicant</th>
<th>Project Title</th>
<th>Grant Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnstable</td>
<td>Cogeneration Plant at Barnstable Intermediate School</td>
<td>$406,000</td>
</tr>
<tr>
<td>Berkley and Taunton</td>
<td>Berkley/Taunton Community Migratory</td>
<td>$1,455,000</td>
</tr>
<tr>
<td>Boston</td>
<td>Solar PV with Battery Storage for select Boston Community Centers</td>
<td>$1,570,000</td>
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<tr>
<td></td>
<td>BMC Merrim Campus CHP Plant</td>
<td>$3,180,000</td>
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<tr>
<td>Cambridge</td>
<td>Cambridge Water Supply Resilience</td>
<td>$85,196</td>
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<tr>
<td>Chelmsford</td>
<td>McCarthy Middle School, Emergency Power Generation</td>
<td>$74,941</td>
</tr>
<tr>
<td>Cape &amp; Vineyard Electric Cooperative</td>
<td>Dennis-Yarmouth High School Regional Solar</td>
<td>$1,479,291</td>
</tr>
<tr>
<td>Greater Lawrence Sanitary District</td>
<td>Organcs to Energy Upgrade Project</td>
<td>$5,000,000</td>
</tr>
<tr>
<td>Greenfield</td>
<td>Greenfield Resiliency Plan for High School</td>
<td>$367,310</td>
</tr>
<tr>
<td></td>
<td>Resiliency at Holyoke Facilities - Fire HQ, Mt. Tom Tower, Ocean School</td>
<td>$1,013,794</td>
</tr>
<tr>
<td></td>
<td>Energy Resilience at Beverly Regional Cache Site</td>
<td>$526,380</td>
</tr>
<tr>
<td></td>
<td>The MAPC Solar Resiliency Project</td>
<td>$254,527</td>
</tr>
<tr>
<td></td>
<td>Medford Resilience Project</td>
<td>$833,366</td>
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<tr>
<td></td>
<td>Batteries and PV Islanding Capability for Fire HQ</td>
<td>$525,401</td>
</tr>
<tr>
<td></td>
<td>Microgrid with Solar-PV at Smith Vocational and Agricultural High School, Northampton DPW and Cooley Dickinson Hospital</td>
<td>$3,075,960</td>
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<tr>
<td></td>
<td>Combined Heat and Power Facility</td>
<td>$700,000</td>
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<tr>
<td></td>
<td>Baystate Health Cogeneration Project</td>
<td>$2,990,099</td>
</tr>
<tr>
<td></td>
<td>Implementing a Resiliency Plan through Cogeneration Project</td>
<td>$1,463,198</td>
</tr>
</tbody>
</table>

**Total** $26,829,308

Cape & Vineyard Electric Cooperative received Award and Technical Assistance (Includes all Barnstable and Dukes County towns)

Graphic: MA DOER
MA DOER Community Clean Energy Resilience Initiative grant awards

• Technical assistance by Cadmus Group, HOMER Energy, MCFA

• Seven projects serve individual facilities
  • Boston (4 community shelters)
  • Northampton Fire Headquarters
  • Cape and Vineyard Electric Cooperative
  • Cambridge
  • Medford
  • Greenfield
  • Holyoke

• Four projects seek to install battery storage in microgrids
  • Metropolitan Area Planning Council – Beverly
  • Berkley
  • Sterling
  • Northhampton
| Applicant                  | Project Title                                    | Grant Amount | Brief Description                                                                 | Facility(ies)                                                                                                    | Technology(ies)                                                                 |
|---------------------------|--------------------------------------------------|--------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Berkley and Taunton       | Taunton/Berkley Community Microgrid              | $1,453,000   | Community microgrid                                                                | (1) Middle School - shelter  
(2) Emergency Services Building - Police and Fire  
(3) Community School - shelter  
(4) Municipal fueling station/pump  
(5) Police/fire radio repeater | - Energy management system  
- Lithium ion battery  
- Solar PV (existing)  
- Diesel generators (existing) |
| Boston                    | Solar PV with Battery Storage for select Boston Community Centers | $1,320,000   | Solar and storage based islandable community shelters                               | (1) Shelburne Community Center - shelter  
(2) Roslindale Community Center - shelter  
(3) Tobin Community Center - shelter  
(4) Curtis Hall Community Center - shelter | - Solar PV  
- Battery storage |
| Greater Lawrence Sanitary District | Organics to Energy Upgrade Project            | $611,000     | Islandable and black start capable self-sustaining wastewater treatment facility       | (1) Wastewater treatment facility | - Biogas storage  
- Combined heat and power system  
- Anaerobic digestion (existing) |
| Northampton               | Batteries and PV Islanding Capability for Fire HQ | $523,401     | Solar and storage based islandable fire station, that incorporates existing backup generation for further resiliency | (1) Northampton Fire Department | - Solar PV  
- Battery storage  
- Diesel generators (existing) |
| South Essex Sewerage District | Combined Heat and Power Facility              | $700,000     | Islandable and black start capable combined heat and power facility at wastewater treatment facility | (1) Wastewater treatment facility | - Combined heat and power system |
| Springfield               | Baystate Health Cogeneration Project            | $2,790,099   | Islandable and black start capable combined heat and power facility at regional hospital | (1) Baystate Health - hospital | - Combined heat and power system |
| **Total**                 |                                                  | **$7,401,500**|                                                     |                                                                     |                                                                     |
## Microgrids and Single facilities

### Massachusetts Department of Energy Resources - Community Clean Energy Resiliency Initiative: Round 2 Project Implementation Awards

<table>
<thead>
<tr>
<th>Applicant</th>
<th>Project Title</th>
<th>Grant Amount</th>
<th>Brief Description</th>
<th>Facility(ies)</th>
<th>Technology(ies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnstable</td>
<td>Cogeneration Plant at Barnstable Intermediate School</td>
<td>$406,000</td>
<td>Islanding equipment for a 60kW CHP system to support town's emergency shelter with both electric and thermal power.</td>
<td>Barnstable Intermediate School</td>
<td>Islandable CHP</td>
</tr>
<tr>
<td>Boston</td>
<td>BMC Menino Campus CHP Plant Project</td>
<td>$3,680,000</td>
<td>Engineering, controls, electrical switchgear and wiring required for a 2MW CHP system black start at BMC and interconnection of city emergency communications infrastructure system</td>
<td>BMC, Emergency communications</td>
<td>Islandable CHP</td>
</tr>
<tr>
<td>Cambridge</td>
<td>Cambridge Water Supply Resilience</td>
<td>$851,868</td>
<td>Battery storage to complement the planned 170kW solar PV system and other equipment to enable the system to island during an outage event.</td>
<td>Sullivan WTP</td>
<td>Islandable PV + Storage</td>
</tr>
<tr>
<td>Chelmsford</td>
<td>McCarthy Middle School, Emergency Power Generation</td>
<td>$74,941</td>
<td>Retrofit existing solar PV to provide emergency generation in island mode. Provide automated controls for grid and island mode.</td>
<td>McCarthy Middle School</td>
<td>Islandable PV + NG generator</td>
</tr>
<tr>
<td>Cape &amp; Vineyard Electric Cooperative</td>
<td>Dennis-Yarmouth High School Regional Shelter</td>
<td>$1,479,193</td>
<td>Incorporation of two PV systems (641kW and 715kW, both VNM) with battery back-up, an energy management system and islanding equipment.</td>
<td>Dennis-Yarmouth High School</td>
<td>Islandable PV + storage</td>
</tr>
</tbody>
</table>
City of Northampton, MA

• FD HQ
  – 100 kW PV, 640 kWh battery (dispatch 1\textsuperscript{st})
  – Diesel emergency generator (dispatch 2\textsuperscript{nd})

• Cooley-Dickinson hospital microgrid
  – Hospital with CHP
  – School with PV+ES
  – Department of Public Works garage
City of Holyoke, MA

- **FD HQ**
  - 53 kW PV + 300 kWh battery bank
  - Islandable, 3 day duration

- **Mt. Tom emergency communication tower**
  - Small PV, small wind turbine, 200 kWh battery
  - Islandable, 3 day duration

- **City of Holyoke school shelter**
  - Islandable PV+ES
Thank you for your time...

QUESTIONS?

Chris Lotspeich, MBA, MES, CEM (pending)

Director of Sustainability Services
Celtic Energy, Inc.

437 Naubuc Avenue, Suite 106
Glastonbury, CT 06033
(860) 882-1515
chrislot@celticenergy.com
www.celticenergy.com