Case Studies in Distributed Energy Systems
Future of Energy & Resilient Cities

Presented By: Graham Morin
Workshop Summary

- Changing Energy Landscape
- Success Stories: Economic, Resilience, and Renewable Energy
- Q&A
The Changing Energy Landscape: Traditional Grid to Distributed Energy
Energy Market Mega Trends

- Energy grids in the United States continue to decarbonize driven largely by economics rather than federal policy.
- Coal usage continues to drop as the fuel becomes increasingly uncompetitive with cheap natural gas.
- Renewable generation technologies like wind and solar are nearing or exceeding the economics of other forms of generation.
- Cheap natural gas and renewables are keeping energy prices low for the foreseeable future.
- Increasing renewables penetration is creating grid balancing challenges that grid operators have not faced previously.
- Aging energy delivery infrastructure is making the cost of delivering energy more expensive and is projected to increase significantly in years to come.
- **End-users are increasing expected to become active prosumers of electricity to ensure power reliability and optimize energy spend.**
- Aging workforce is creating challenges for utilities and end-users in managing a more complex energy infrastructure.
From centralized, unidirectional grid …
... to distributed energy and bidirectional energy balancing

- Increased Reliability
- Reduced Energy Costs
- Improved Grid Resilience
- Lower Emissions
- Enhanced Control
- Financed Solutions
New technologies becoming cost competitive

Price development of storage facilities worldwide ($ / kWh)

Power generation costs worldwide ($ / MWh)

Forecasts for 2015-35

- **Storage** - 40% (2015-20)
  → Primarily through scaling

- **Photovoltaic**: - 45% → Even small roof-top installations will be universally competitive

- **Offshore wind**: - 43% → Industrialization of production and simplification of value creation

- **Onshore wind**: - 22% → Improvement via more full-load hours and new locations (weak-wind turbines)

- **Fossil fuels** with increasing costs:
  + 32% coal, + 12% gas

It's less "solar & wind" or "shale" and more "highly-distributed, high-learning rate, highly-iterable, cost-discoverable technology."

*(Vox, August 2017)*

Sources: IHS (2015), Bloomberg (2016)
Defining DES: Solutions that deliver value to campus, industrial and commercial environments

Cogeneration / Combined Heat & Power

Description
Combined generation of electricity behind the meter and heat near the point of use

Value
- Delivers lower cost electricity and thermal energy, independently from utilities
- Increased energy efficiency

Small-scale power generation

Description
Generation assets <100MW connected to the MV/HV grid for flexibility of supply delivery

Value
- Power supply where grid may be unreliable unavailable or expensive
- Reduced cost of electricity

Microgrids

Description
Grid operating independently or in conjunction with the main utility grid

Value
- Integrates various generation components; manages energy demand
- Enables low cost, independent supply

Energy Storage

Description
Storage of energy, producing electricity on demand, connected to grid, microgrid or generation source

Value
- Reduces peak generation needs, enables load shifting
- Reduces cost and increases reliability of electricity supply
New technologies are versatile.
What is energy storage? Large-scale batteries for industrial applications.

Modular, scalable arrays of proven technologies integrated at utility and industrial scale.

- Battery cabinets and battery management system
- Power Control Electronics
- BATTERY CELLS
- BATTERY PACKS
- BATTERY MODULES
- BATTERY CABINET
- Low voltage and medium voltage components
- Fire detection and extinguishing system
- Intelligence: Array Controls & Application Software
- HVAC
Energy Storage is Not:

- Energy Storage is not energy efficiency
- Energy Storage is used to shift electrical demand in response to rates and or other programs that incentivize demand reduction, off-peak power usage, etc.
- Due to efficiency losses in these systems installation of a Energy Storage will generally cause a customer to use more kWh. However, depending on when and how the demand for electricity is controlled, total energy spend should go down from Energy Storage.
- Energy Storage is not generation.
- Energy Storage can help optimize renewable generation like solar by smoothing the output of a solar system or extending the output of the solar power into the evening.
- Energy Storage can provide short-term bridge power while back-up or peak-shaving fossil fuel generators start-up and synch in to provide longer-term power.
- Energy Storage systems do not generate their own power nor do they provide economical power for more than 4-6 hours.
## Comparative Benefits of Solar, Storage & Solar + Storage

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Solar Only</th>
<th>Storage Only</th>
<th>Solar + Storage Microgrid</th>
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<tbody>
<tr>
<td>Green Energy (Reduced kWh from Grid)</td>
<td>+</td>
<td>x</td>
<td>+</td>
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<tr>
<td>Emergency Back-Up</td>
<td>x</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Power Quality (kVar, freq and voltage response)</td>
<td>x</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Load Following (Dispatchable Energy)</td>
<td>x</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Demand Management / Critical Peaks Mgmt</td>
<td>Nominal (~10% reduction)</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Energy Arbitrage / Demand Response</td>
<td>x</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Grid Balancing Revenue (Ancillary Services)</td>
<td>x</td>
<td>++</td>
<td>+</td>
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<tr>
<td>Investment Tax Credit Eligible</td>
<td>+</td>
<td>x</td>
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Changing Energy & Infrastructure Landscape

**Desired Outcomes:**

- Enhanced Resiliency
- Lower Energy Costs
- Localized Control
- Enhanced Sustainability

**Challenges:**

- Aging Infrastructure
Microgrid capabilities and components

- Monitor and control all local power generation and usage
- Balance supply and demand
- Manage sufficient and safe voltage
- Schedule power production and storage
- Switch between islanded and grid-connected operation
- Restore from a black out
- Respond to utility’s demand response request
- Optimize the microgrid for maximum power utilization
The cost reduction for new technology happened overnight.
New business models are cropping up because of reduced risk in financing.
Increasingly, hybrid power applications are feasible for on-site energy.
Digitalization (software and data mining) enables and expands the energy world.
Ultimately we are solving human problems, not technical ones.
Success Stories: Economic, Resilience and Renewable Energy
Blue Lake Rancheria Deploys Low-Carbon Microgrid to Manage and Control Energy Sources

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverse renewable energy sources - .5MW solar PV, 950 kWh battery</td>
<td>Microgrid management software for managing numerous energy sources and balancing with energy loads</td>
</tr>
<tr>
<td>storage syst., a biomass fuel cell and diesel generators need to be</td>
<td></td>
</tr>
<tr>
<td>optimally managed and controlled to achieve energy effic., cost savings</td>
<td></td>
</tr>
<tr>
<td>and emission goals</td>
<td></td>
</tr>
<tr>
<td>Operations need to be automated to allow limited staff to manage the</td>
<td>Microgrid defined sequence of operations programmed to coordinate with the local utility</td>
</tr>
<tr>
<td>system in event of a grid outage to ensure energy security for the on-site</td>
<td></td>
</tr>
<tr>
<td>emergency shelter</td>
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</table>

7 days

Duration of available on-site power independent from the utility
Algonquin College – CHP Optimization (Today); Microgrid (Tomorrow)

### Challenge

- Optimize campus energy costs through lowest cost generation mix
- Integrate both electrical (CHP, grid) & thermal (CHP, gas boiler) objectives within a single system
- Interface to existing building automation system for electric price forecasts & load data
- Interface with additional assets:
  - Solar PV
  - Battery storage
  - EV car chargers

### Solution

Microgrid management system installed to forecast, optimize & dispatch 4 MW of cogeneration. This is accomplished by:

- Forecasting electrical & thermal loads of campus
- Modeling economic characteristics of CHP units and electrical & gas utility prices
- Optimizing when to dispatch each CHP unit based on minimizing energy costs while respecting equipment operational constraints
- Ability to add additional assets at a low cost

### Benefits

- Leverages all available data (CHP economic curves, gas prices, electric prices) to minimize both thermal & electrical energy costs
- Software enables potential savings* of $100K+ per year for 20 years

*Note: Based on Siemens value estimation tool

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**Project Profile**

- Algonquin College, Ottawa, Ontario, Canada
- Educational Institution
- Peak Demand: 4,656 kW
- Total CHP Capacity: 4 MW (2 x 2 MW units)
- Installed July 2017
Atwater, CA, Water Treatment Plant Buys a Solar Power Purchase Agreement (PPA)

Challenge | Solution
--- | ---
New WWT plant to see increased energy demand on community resources—PPA to manage increased expense | Solar system to save city $5,000 per month
Renewable energy source to improve sustainability efforts and provide clean environmental impact | Significant greenhouse gas emissions savings

2,177,387 kWh clean renewable energy annually

$0 capital expenditure

$>1,000,000 savings over 20 years with PPA
City of Thousand Oaks Hill Canyon Wastewater Treatment Plant Achieves Energy Self-Sufficiency

100% Energy Self-Sufficient
All of the energy needs are generated on-site

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<td>To contribute to the city-wide Energy Management plan focused on energy</td>
<td>A cogeneration project to create energy by burning methane gas created in facility’s anaerobic digesters</td>
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<tr>
<td>conservation and process and energy optimization</td>
<td>Reduction of carbon emission by more than 1600 metric tons</td>
</tr>
<tr>
<td>Reduce carbon footprint</td>
<td>Reduction of carbon emission by more than 1600 metric tons</td>
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Fort Hunter Liggett – US Army

Project Size: 1,260kVA / 1,250kW / 1MWh
Location: Fort Hunter Liggett, California
Commissioning Date: May 2014

Highlights
- The Fort Hunter Liggett is one of the pilot sites of the DOD net zero energy initiative
- The fort has installed two 1 MW solar PhotoVoltaic (PV) systems with a third being planned in 2014

Description of Application
- Demand Charge Management
- Renewable Integration
- Energy Time shifting
- Islanding Operation

Solution
- Battery units are connected to the grid through two smart 630 kW inverters.
- These inverters decouple the generating sources from the grid ensuring that the energy sources can always be kept operating at the optimum level.
- The built-in droop control functionality helps maintain power balance during islanded operation.
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