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Incorporating On-Site Generation Design Using a Comprehensive Energy Strategy

Techno-Economic Energy Modeling of Distributed Energy Technologies
Presentation Overview

- PV + storage considerations
- Comprehensive analysis using REopt
- REopt Lite web tool
PV + Storage Considerations
Federal agencies have long history of implementing grid-connected solar PV projects for cost savings
- Value stream is well understood: Electricity is generated when the sun is shining, and lowers utility electricity purchases

Opportunities for grid-connected battery storage are emerging, and more complicated
- Value stream is more complicated: there are multiple ways to provide savings, but they depend on how the battery is operated

When configured to do so, PV + storage can provide back-up power in the event on an outage
- This requires additional equipment at added cost

Quiz tip: A typical solar PV system requires modification to provide backup generation during an extend outage
Microgrid-Ready PV

- If there are future microgrid plans at a site, consider microgrid ready PV

- Microgrid ready PV: the practice of including low- or no-cost measures when installing a PV system that will facilitate the integration of that PV system into a microgrid at a later point

- Microgrid ready PV includes:
  - Inverters capable of operating in both grid-interactive and microgrid modes
  - Inverters capable of responding to commands from a microgrid controller
  - Reserved space near the PV system for microgrid and equipment expansions

## Range of PV + Storage Use Cases

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Off Grid PV + Storage</th>
<th>Grid Connected PV + Storage</th>
<th>Grid Connected PV + Storage with Microgrid</th>
<th>PV + Storage for Large-Scale Power Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Providing continuous power in lieu of utility</td>
<td>Lowering cost of utility purchases</td>
<td>Lowering cost of utility purchases Providing power during grid outage</td>
<td>Large-scale generation for off-site sale</td>
</tr>
</tbody>
</table>
| Why/Where it works | • Remote sites with high fuel costs  
  • Low grid reliability | • High demand charges  
  • Time of use (TOU) rates  
  • Ancillary service markets | • High demand charges  
  • TOU rates  
  • Ancillary service markets  
  • Resilience requirements | • Deregulated market  
  • Interested offtaker  
  • large land-availability |
| Primary Power Supply | Distributed energy resources (DERs) (typically including generators) | Grid + DERs | Grid + DERs | Grid only |
| Back-up | None | None | DERs | Typically none, but could be possible |

*Quiz tip: Solar PV plus batteries can be cost-competitive when compared to back-up diesel generators, but it depends on the location and application*
## RE + Storage Value Streams by Use Case

<table>
<thead>
<tr>
<th>Value Stream</th>
<th>Description</th>
<th>Off Grid</th>
<th>Grid Connected</th>
<th>Large Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Offset</td>
<td>Offset fuel cost in off-grid remote locations</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand charge reduction</td>
<td>Use stored energy to reduce demand charges on utility bills</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Arbitrage</td>
<td>Energy time-of-use shift (from on-peak to off-peak hours or selling during high cost and charging during low cost)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Demand response</td>
<td>Utility programs that pay customers to lower demand during system peaks</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency regulation and capacity markets</td>
<td>Stabilize frequency on moment-to-moment basis or supply spinning, non-spinning reserves</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Voltage support</td>
<td>Insert or absorb reactive power to maintain voltage ranges on distribution or transmission system</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Transmission &amp; Distribution Upgrade Deferral</td>
<td>Deferring the need for transmission or distribution system upgrades, e.g. via system peak shaving</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Resiliency / Back-up power</td>
<td>Using battery to sustain a critical load during grid outages</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Quiz tip:** During normal grid connected operations, battery storage has the potential to provide demand charge reduction and time-of-use energy arbitrage, and enable participation in demand response programs.
Drivers for On-Site Project Economics

- Resource
- Technology Costs & Incentives
- Utility Cost & Consumption
- Financial Parameters
- Space Available
Comprehensive Analysis Using REopt
REopt Inputs and Outputs

Resources
- Renewable Generation
  - Solar PV
  - Wind
  - Biomass, etc.
- Conventional Generation
  - Electric Grid
  - Fuel Supply
  - Conventional Generators
- Energy Storage
  - Batteries
  - Thermal storage
  - Water tanks
- Dispatchable Technologies
  - Heating and Cooling
  - Water Treatment
- Energy Conservation Measures

Goals
- Minimize Cost
- Net Zero
- Resilience

Drivers
- Economics
  - Technology Costs
  - Incentives
  - Financial Parameters
- Utility Costs
  - Energy Charges
  - Demand Charges
  - Escalation Rate

REopt
Energy Planning Platform
Techno-economic Optimization*

Optimized Minimum Cost Solution
- Technologies
  - Technology Mix
  - Technology Size
- Operations
  - Optimal Dispatch
- Project Economics
  - CapEx, OpEx
  - Net Present Value

*Formulated as a mixed integer linear program (MILP)
PV + Storage for Demand Reduction & Energy Arbitrage

- REopt considers trade-off between capital costs and optimal cost savings under complex utility tariff

- Results show 12.4MW PV + 2.4 MW:3.7 MWh storage can provide $19.3 million net present value (NPV)

- Battery is only economical when paired with PV at this site due to wide peaks
Surviving Outage vs. Cost Savings

- REopt evaluates grid outages and durations to compared number of hours the site could survive with a diesel generator and fixed fuel supply vs. generator augmented with PV and battery.

- Found that lowest cost solution could lower lifecycle cost of electricity and provide 1 extra day of outage survivability.
Market Revenues for Back-Up Generators

- **Description:** Back-up generators are not typically utilized for economic dispatch, what value can they provide

- **Technologies:** Natural gas and diesel generators

- **Impact:** The overall cost of back-up generation can be lowered, but opportunities vary across US

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https://www.nrel.gov/docs/fy19osti/72509.pdf
Aligning Generation & Load with Storage & Demand Response

- **Description:** Evaluating controllable load (smart A/C and water heater) and storage options to improve customer economics of solar under post-net metering utility tariffs

- **Technologies:** Solar, storage, buildings

- **Impact:** Flexible loads increase the value of solar by aligning generation to load to maximize value

Evaluating Impacts of EV Load in Conjunction with Building Load

- **Description**: How can the impacts of electric vehicles (EV) charging stations loads be mitigated?

- **Technologies**: EV charging stations, solar PV, stationary storage

- **Impact**: The cost of EV loads can be mitigated through co-location with building load, PV and stationary storage deployment, and optimizing EV charging times
Integrating Loads and Diverse DER Technologies

- **Description:** Electrification of transportation fleets provide an opportunity for optimizing multiple DER technologies.

- **Technologies:** Mobility, storage, buildings, solar, advanced system integration controls

- **Impact:** Develop and validate an integrated framework to optimize mobility with solar, buildings and storage to maximize value
REopt Lite

Free Web Tool
New system decisions are complex...

- Utility Rates
- Wind & Solar Generation
- Site Location & Generation Assets
- Annual Load
- Technology Costs, Financing & Incentives
... REopt Lite is here to help
REopt Lite Web Tool

- **REopt Lite** is a web tool that offers a no-cost subset of NREL's more comprehensive REopt model.

- **Financial mode** optimizes PV, wind, and battery system sizes and battery dispatch strategy to minimize life cycle cost of energy.

- **Resilience mode** optimizes PV, wind, and storage systems along with exiting back-up generators to sustain critical load during grid outages.

- To access REopt Lite: [https://reopt.nrel.gov/tool](https://reopt.nrel.gov/tool)
Summary Results Include System Sizes & Savings

Results for Your Site

These results from REopt Lite summarize the economic viability of PV and battery storage at your site. You can edit your inputs to see how changes to your energy strategies affect the results.

Your recommended solar installation size

781 kW

PV size

Your recommended battery power and capacity

131 kW battery power

556 kWh battery capacity

Measured in kilowatt-hours (kWh) of direct current, this recommended size minimizes the life cycle cost of energy at your site.

Your potential life cycle savings (20 years)

$439,275

This is the present value of the savings (or costs if negative) realized by the project based on the difference between the life cycle energy cost of doing business as usual compared to the optimal case.

Outage occurring June 6–7

Critical load 50% of typical load
Conclusion

- RE + storage can provide revenue streams and savings while grid connected
  - Savings may allow for the incorporation of additional microgrid components

- When integrated into a microgrid, RE + storage can increase survival time during a grid outage when fuel supplies are limited

- Techno-economic modeling can quantify economic and resilience benefits
Thank you!

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