Housekeeping

Use the red arrow to open and close your control panel

Join audio:
• Choose Mic & Speakers to use VoIP
• Choose Telephone and dial using the information provided

Submit questions and comments via the Questions panel

This webinar is being recorded. We will email you a webinar recording within 48 hours. Resilient Power Project webinars are archived online at: www.resilient-power.org
Who We Are

www.cleanegroup.org
www.resilient-power.org
Resilient Power Project

- Increase public/private investment in clean, resilient power systems
- Engage city officials to develop resilient power policies/programs
- Protect low-income and vulnerable communities
- Focus on affordable housing and critical public facilities
- Advocate for state and federal supportive policies and programs
- Technical assistance for pre-development costs to help agencies/project developers get deals done
- See [www.resilient-power.org](http://www.resilient-power.org) for reports, newsletters, webinar recordings
The Resilient Power Project, a joint initiative of Clean Energy Group and Meridian Institute, is focused on accelerating market development of resilient, clean energy solutions for affordable housing and critical community facilities in low-income and disadvantaged communities. The Project is targeted to the deployment of solar PV combined with energy storage (solar+storage) – to power essential services during extended power outages and to reduce the economic burden of energy costs in vulnerable communities. The goal is to further clean energy equity by ensuring that all communities have access to the economic, health, and resiliency benefits that solar and energy storage technologies can provide.

Clean Energy Group’s role in this process is to inform, coordinate, and assist in the planning and implementation of resilient power projects in underserved communities, in both rural and urban areas, across the country. In addition to providing program guidance to policy makers and technical assistance to developers and community organizations, we also prepare reports and analysis on resilient power programs and projects, clean energy funding opportunities, and best practices.
Panelists

• **Kate Anderson**, Senior Engineer and Manager, Engineering and Modeling Group, Integrated Applications Center, National Renewable Energy Laboratory

• **Emma Elgqvist**, Engineer, Engineering and Modeling Group, Integrated Applications Center, National Renewable Energy Laboratory

• **Seth Mullendore**, Project Director, Clean Energy Group (Moderator)
REopt Lite: Sizing Solar+Storage for Savings and Resiliency

Kate Anderson, Emma Elgqvist
National Renewable Energy Laboratory
November 2017
REopt: Decision Support Throughout the Energy Planning Process

Optimization • Integration • Automation

Master Planning
- Portfolio prioritization
- Cost to meet goals

Economic Dispatch
- Technology types & sizes
- Optimal operating strategies

Resiliency Analysis
- Microgrid dispatch
- Energy security evaluation

Cost-effective RE at Army bases
Cost-optimal Operating Strategy
Extending Resiliency with RE
**REopt Inputs and Output**

- **Drivers**
  - Goals: Minimize Cost, Net Zero, Resiliency
  - Economics: Financial Parameters, Technology Costs, Incentives
  - Utility Costs: Energy Charges, Demand Charges, Escalation Rate

- **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

- **Energy Planning Platform**
  - Techno-economic Optimization

- **Technology Options**
  - Energy Conservation Measures
  - Energy Storage: Batteries, Thermal storage, Water tanks
  - Conventional Generation: Electric Grid, Fuel Supply, Conventional Generators
  - Renewable Generation: Solar PV, Wind, Biomass, etc.

- **Loads**
  - Thermal Loads
  - Electric Loads
  - Water Demand

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

**Goals**
- Minimize Cost
- Net Zero
- Resiliency

**Economics**
- Financial Parameters
- Technology Costs
- Incentives

**Utility Costs**
- Energy Charges
- Demand Charges
- Escalation Rate

**Technologies**
- Technology Mix
- Technology Size

**Operations**
- Optimal Dispatch

**Project Economics**
- CapEx, OpEx
- Net Present Value
Project Example: Identifying & Prioritizing Projects across a Portfolio

REopt portfolio screening can help:

- Identify & prioritize cost-effective projects to minimize lifecycle cost of energy or achieve net zero
- Estimate cost of meeting renewable energy goals

---

<table>
<thead>
<tr>
<th>Sites Evaluated</th>
<th>696</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-Effective PV</td>
<td>306</td>
</tr>
<tr>
<td>Size</td>
<td>38.79 MW</td>
</tr>
<tr>
<td>NPV</td>
<td>$37 million</td>
</tr>
<tr>
<td>RE Generation</td>
<td>64.7 GWh</td>
</tr>
<tr>
<td>RE Penetration</td>
<td>10.5 %</td>
</tr>
</tbody>
</table>
Project Example: PV + Battery Sizing

- Determine economically optimal PV + storage system size & dispatch using:
  - 15-minute electric load
  - Southern California Edison utility tariff TOU-8

- Results show 12.4 MW PV + 2.4 MW:3.7 MWh storage can provide $19.3 million NPV

- Battery is only economical when paired with PV at this site due to wide peaks

- Optimal battery dispatch strategy reduces all three demand charges
NREL evaluated thousands of random grid outages and durations throughout the year and compared number of hours the site could survive with a diesel generator and fixed fuel supply vs. generator augmented with PV and battery storage.

<table>
<thead>
<tr>
<th></th>
<th>Generator</th>
<th>Solar PV</th>
<th>Storage</th>
<th>Lifecycle Cost</th>
<th>Outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Base case</td>
<td>2.5 MW</td>
<td>-</td>
<td>-</td>
<td>$20 million</td>
<td>5 days</td>
</tr>
<tr>
<td>2. Lowest cost</td>
<td>2.5 MW</td>
<td>625 kW</td>
<td>175 kWh</td>
<td>$19.5 million</td>
<td>6 days</td>
</tr>
<tr>
<td>3. Proposed</td>
<td>2.5 MW</td>
<td>2 MW</td>
<td>500 kWh</td>
<td>$20.1 million</td>
<td>9 days</td>
</tr>
</tbody>
</table>

**Graph:**
- Probability of surviving outage [%] vs. Length of outage [Days]
- Grid outages evaluated throughout the year
- Comparison between diesel generator and generator augmented with PV and battery storage
- Outage duration: 1-14 days
Publicly available beta version of REopt Lite launched September 2017

Evaluates the economics of grid-connected PV and battery storage at a site

Allows building owners to identify the system sizes and battery dispatch strategy that minimize their life cycle cost of energy

https://reopt.nrel.gov/tool
<table>
<thead>
<tr>
<th>Current Platform Capabilities</th>
<th>Phase 1 Web Tool Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technologies Evaluated</strong></td>
<td><strong>PV + Storage</strong></td>
</tr>
<tr>
<td>PV, SHW, SVP, Wind, Biomass,</td>
<td></td>
</tr>
<tr>
<td>LFG, WTE, GSHP, Storage,</td>
<td></td>
</tr>
<tr>
<td>Conventional reciprocating</td>
<td></td>
</tr>
<tr>
<td>and combustion turbine</td>
<td></td>
</tr>
<tr>
<td>generators</td>
<td></td>
</tr>
<tr>
<td><strong>Sites Evaluated</strong></td>
<td><strong>Single site</strong></td>
</tr>
<tr>
<td>Multi-site</td>
<td></td>
</tr>
<tr>
<td><strong>Load Types</strong></td>
<td>Electric only interval data</td>
</tr>
<tr>
<td>Electric, thermal, interval</td>
<td>or simulated from DOE</td>
</tr>
<tr>
<td>data from actual load profiles</td>
<td>commercial reference</td>
</tr>
<tr>
<td>or simulated from DOE commercial reference buildings, others for customized analysis</td>
<td></td>
</tr>
<tr>
<td><strong>Rate Tariffs</strong></td>
<td>Rate tariffs selected from</td>
</tr>
<tr>
<td>Blended rates, simple rate</td>
<td>URDB</td>
</tr>
<tr>
<td>tariffs, and custom rates</td>
<td></td>
</tr>
<tr>
<td>entered by user</td>
<td></td>
</tr>
<tr>
<td><strong>Resiliency Analysis</strong></td>
<td>Simple outage analysis</td>
</tr>
<tr>
<td>Simple outage analysis or</td>
<td></td>
</tr>
<tr>
<td>complex stochastic outage</td>
<td></td>
</tr>
<tr>
<td>modeling</td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>API</td>
<td>Expose API and provide wiki to call model via API</td>
</tr>
</tbody>
</table>
| Resiliency               | Expand resiliency analysis  
  • Design a system to a specified probability of sustaining a critical load  
  • Build up a critical load profile based on equipment components  
  • Model existing diesel and PV systems  
  • Incorporate the costs of microgrid components and the value of lost load |
| User data storage        | Allow user to retrieve and edit stored inputs for future analysis                                                                                                                                          |
| Wind                     | Add wind technology, purchase license for wind dataset                                                                                                                                                      |
| Custom utility rate      | Allow user to enter custom utility rate tariff                                                                                                                                                              |
| Report                   | Downloadable sensitivity analysis report and dispatch strategy                                                                                                                                             |
| User resources           | Training materials and case studies                                                                                                                                                                           |
REopt Lite
Live Demo
Five Required Site Specific Inputs

Step 2: Enter Your Data

Enter information about your site and adjust the default values as needed to see your results.

- **Site and Utility**
  - Site location: Palmdale, CA, United States
  - Load profile: Simulated
  - Type of building: Retail Store
  - Annual energy consumption (kWh): 500000
  - Electricity rate: Southern California Edison Co: Time of Use, GenX

---

-$ Financial

- PV

- Battery

- Resilience

Get Results
**Financial**

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host real discount rate (%)</td>
<td>6.8%</td>
</tr>
<tr>
<td>Electricity escalation rate (%)</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

**Financial**

<table>
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</tr>
<tr>
<td>Electricity escalation rate (%)</td>
<td>0.5%</td>
</tr>
<tr>
<td>Analysis period (years)</td>
<td>20</td>
</tr>
<tr>
<td>Host effective tax rate (%)</td>
<td>40%</td>
</tr>
<tr>
<td>Inflation rate (%)</td>
<td>2.5%</td>
</tr>
</tbody>
</table>
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

218 kW
PV size

Measured in kilowatts (kW) of direct current, this recommended size minimizes the life cycle cost of energy at your site.

Your recommended battery power and capacity

17 kW
battery power

22 kWh
battery capacity

This system size minimizes the life cycle cost of energy at your site. The battery power and capacity are optimized for economic performance.

Your potential annual savings

$50,877

This is the net 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.
The summary table compares the optimal case with the business as usual case.

### Results Comparison

These results show how doing business as usual compares to the optimal case.

<table>
<thead>
<tr>
<th></th>
<th>Business As Usual</th>
<th>Optimal Case</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV Size (kW)</td>
<td>0 kW</td>
<td>218 kW</td>
<td>218 kW</td>
</tr>
<tr>
<td>Annualized PV Energy Production (kWh)</td>
<td>0 kWh</td>
<td>386,871 kWh</td>
<td>386,871 kWh</td>
</tr>
<tr>
<td>Battery Power (kW)</td>
<td>0 kW</td>
<td>17 kW</td>
<td>17 kW</td>
</tr>
<tr>
<td>Battery Capacity (kWh)</td>
<td>0 kWh</td>
<td>22 kWh</td>
<td>22 kWh</td>
</tr>
<tr>
<td>DG System Cost (Net CAPEX + O&amp;M)</td>
<td>$0</td>
<td>$243,223</td>
<td>$243,223</td>
</tr>
<tr>
<td>Year 1 Utility Energy Payments</td>
<td>$84,292</td>
<td>$53,686</td>
<td>$30,606</td>
</tr>
<tr>
<td>Year 1 Utility Demand Payments</td>
<td>$41,513</td>
<td>$30,672</td>
<td>$10,841</td>
</tr>
<tr>
<td>Year 1 Energy Supplied From Grid (kWh)</td>
<td>1,000,000 kWh</td>
<td>652,022 kWh</td>
<td>347,978 kWh</td>
</tr>
<tr>
<td>Total Utility Energy Cost</td>
<td>$946,089</td>
<td>$602,571</td>
<td>$343,518</td>
</tr>
<tr>
<td>Total Utility Demand Cost</td>
<td>$465,937</td>
<td>$344,264</td>
<td>$121,674</td>
</tr>
<tr>
<td>Total Lifecycle Energy Cost</td>
<td>$869,196</td>
<td>$818,319</td>
<td>$50,877</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>$0</td>
<td>$50,877</td>
<td>$50,877</td>
</tr>
</tbody>
</table>
The hourly dispatch graph allows the user to see how the battery and PV systems are operating on an hourly basis. The zoom feature allows the user to look at different time periods (full year, month, week, day etc.)

Results Output – Dispatch Graph

- Hourly dispatch for one day
- Hourly dispatch for one week

System Performance Year One

Click and Drag Right in the Plot Area to Zoom In; Drag Left to Zoom Out
• REopt website: https://reopt.nrel.gov/
• REopt Lite web tool: https://reopt.nrel.gov/tool
• REopt technical report: https://www.nrel.gov/docs/fy17osti/70022.pdf
• REopt fact sheet: http://www.nrel.gov/docs/fy14osti/62320.pdf
Thank you for attending our webinar

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