NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Energy Storage Analysis with REopt

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reopt.nrel.gov

REopt Integration and Optimization

Will DERs Work for Your Site?

RE Resource

Technology Costs & Incentives

Site Goals
Cost Savings
Resilience
Emissions Reduction

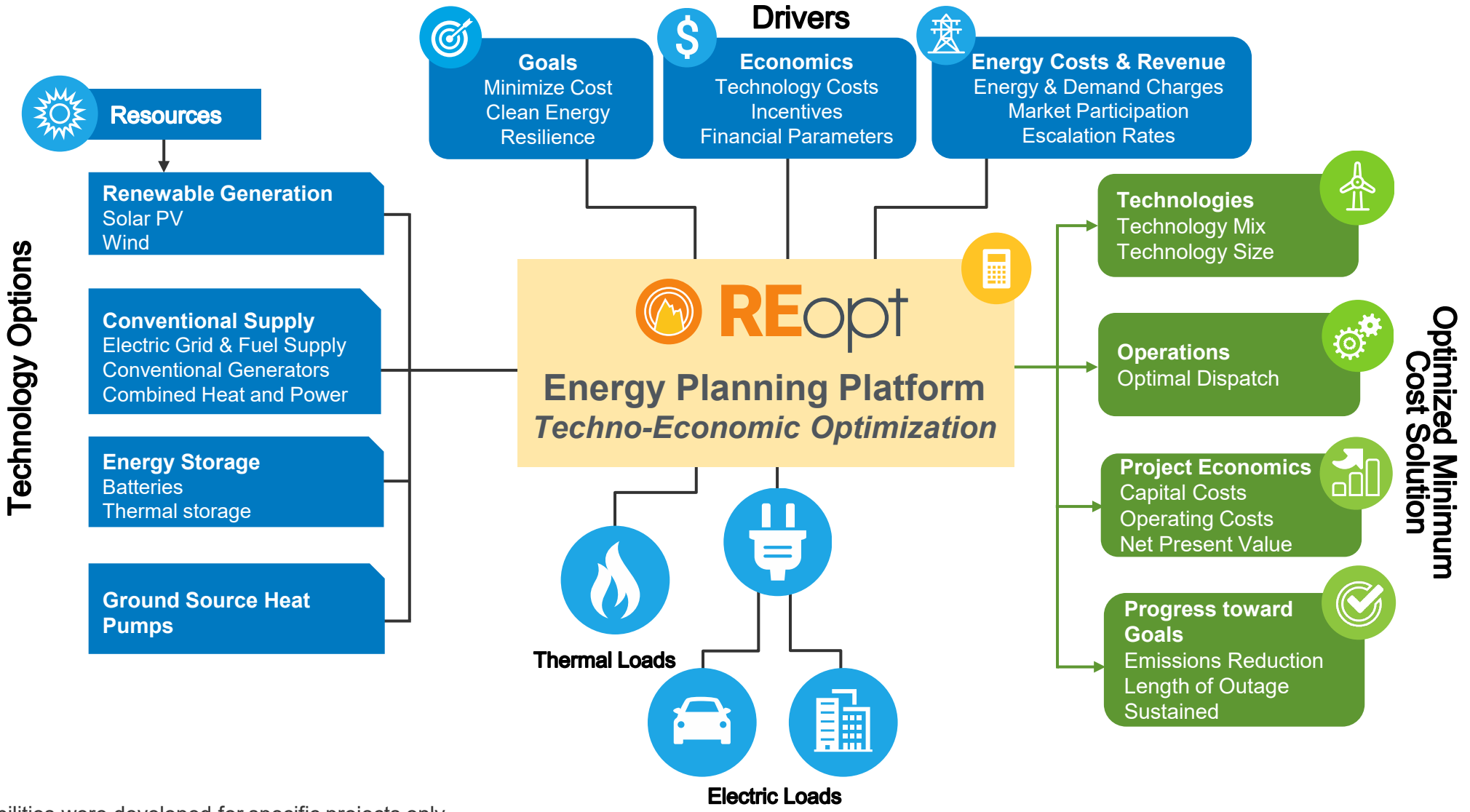
Utility Cost & Consumption

Financial Parameters

Many factors affect whether distributed energy technologies can provide cost savings and resilience to your site, and they must be evaluated concurrently.

REopt Energy Planning Platform

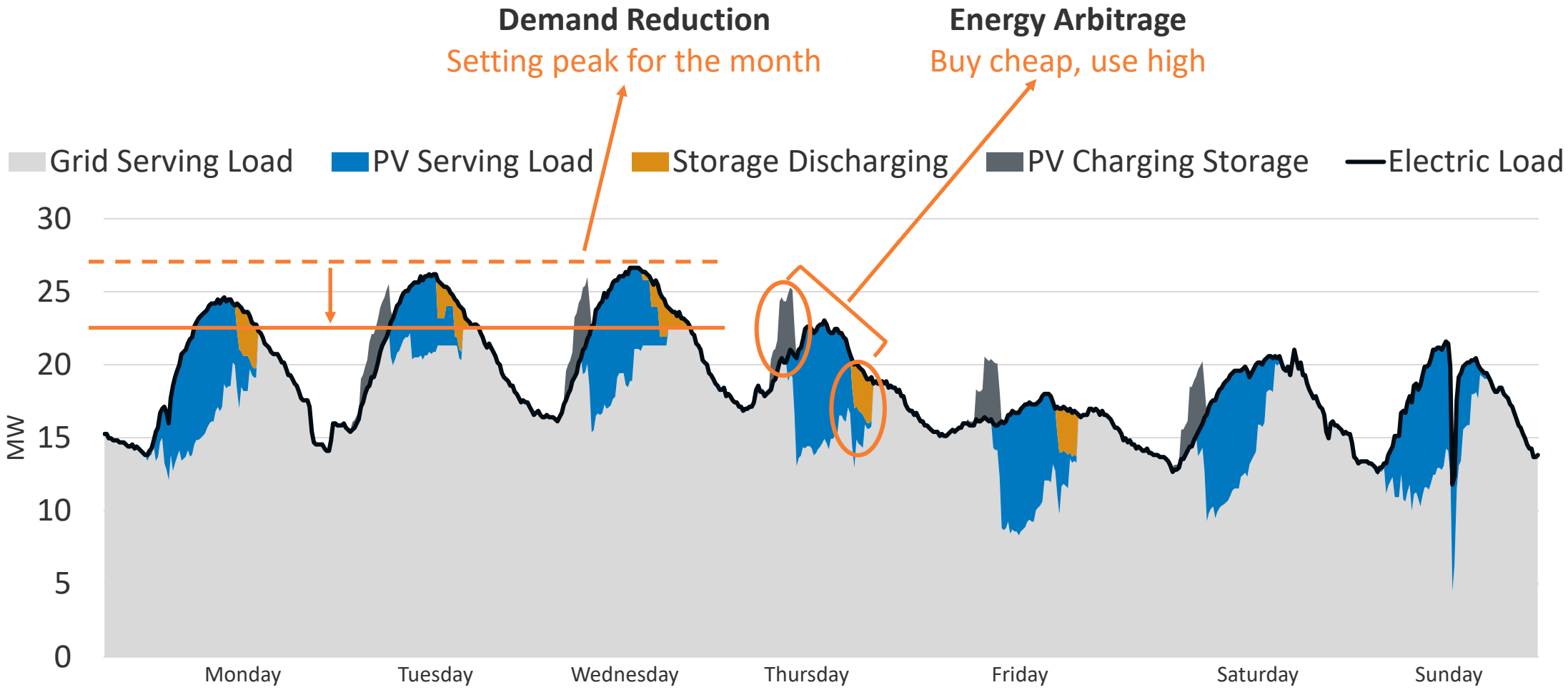
Formulated as a mixed integer linear program, REopt provides an integrated, cost-optimal energy solution.



Note some capabilities were developed for specific projects only.

How Does REopt Work?

REopt considers the trade-off between ownership costs and savings across multiple value streams to recommend optimal size and dispatch.



Example of optimal dispatch of PV and BESS

Value of Behind-the-Meter Storage at Fort Carson

Description: NREL used REopt to independently verify the predicted utility savings estimated by the project developer from battery peak shaving.

Technology: Li-ion battery storage

Impact: 4.2 M; 8.5-MWh battery installed at Ft. Carson under an ESPC. Largest battery in the Army at time of installation, saving Ft. Carson $500,000 per year in utility costs.

Partner: Army, AECOM

NREL. "Energy Systems Integration Newsletter: July 2019." Accessed April 22, 2020. https://www.nrel.gov/esif/esi-news-201907.html.
NREL. "NREL's REopt Helps Fort Carson Save Big." Accessed April 22, 2020. https://reopt.nrel.gov/projects/case-study-ft-carson.html.

Design Tradeoffs between Economics and Resilience

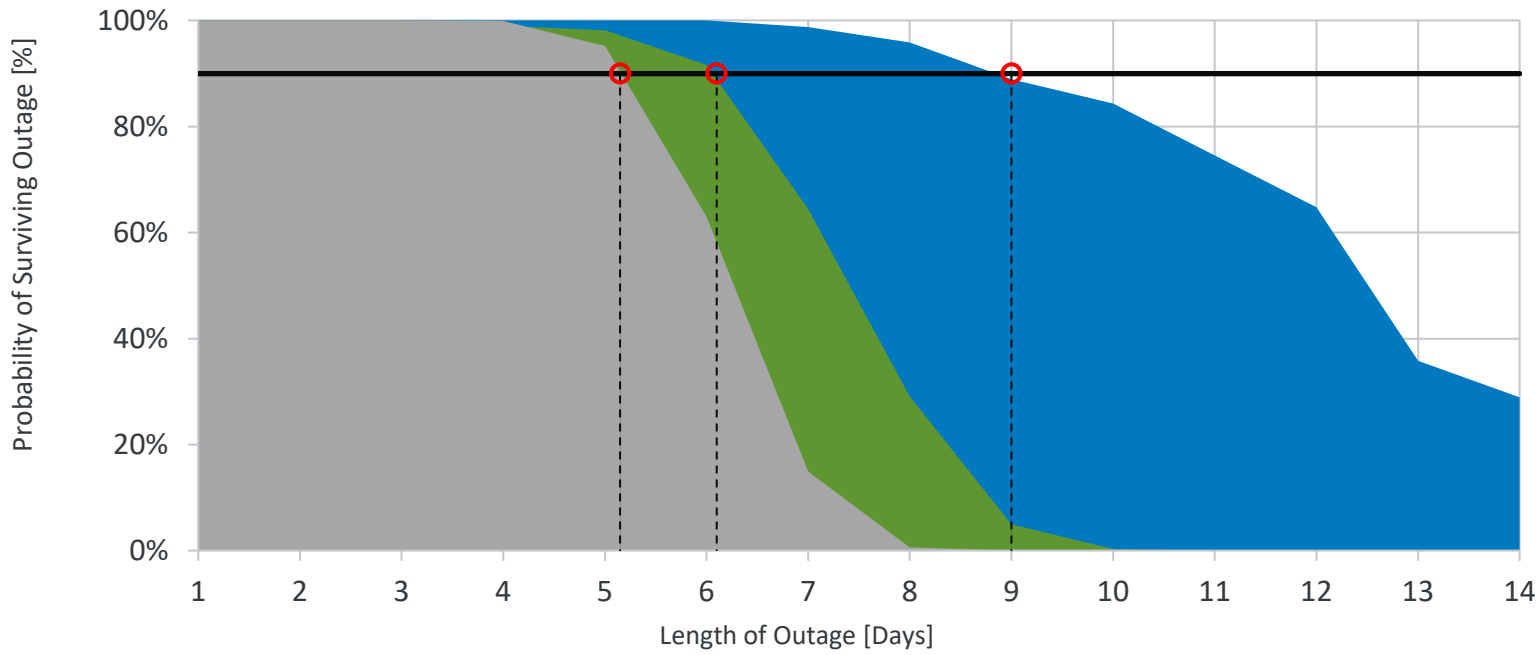
Description: NREL used REopt to evaluate how long existing and proposed backup energy systems could sustain the critical load during an outage at an Army National Guard base. REopt evaluated thousands of random grid outage occurrences and durations and compared hours survived with diesel gensets vs. gensets augmented with PV and battery.

Technology: Solar, storage, diesel generation

Impact: PV and battery can provide savings and resilience. Site can achieve 4 extra days of resilience with no added cost.

Partner: Army National Guard

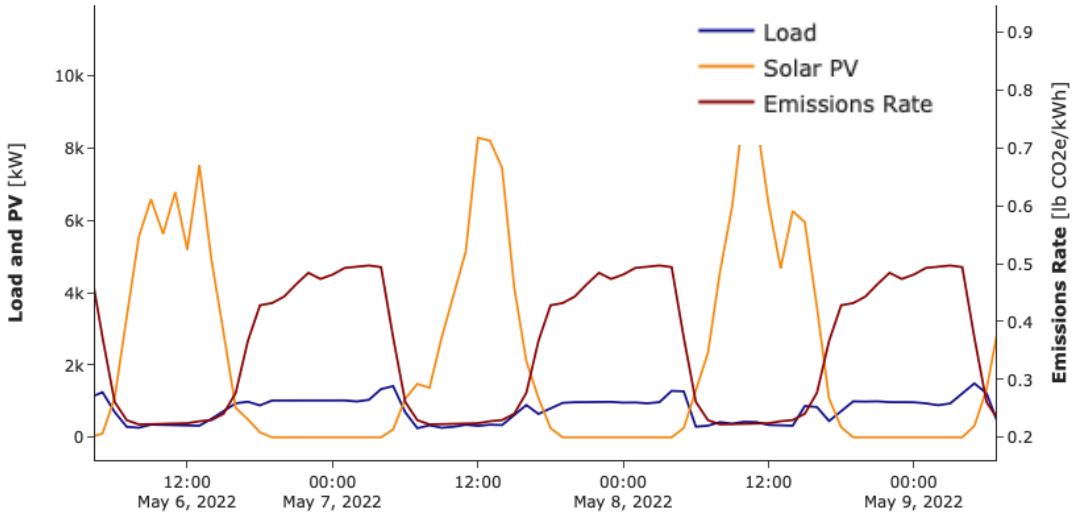
	Generator	Solar PV	Storage	Lifecycle Cost	Outage
1. Base case	2.5 MW	-	-	$20 million	5 days
2. Lowest cost	2.5 MW	625 kW	175 kWh	$19.5 million	6 days
3. Proposed system	2.5 MW	2 MW	500 kWh	$20 million	9 days



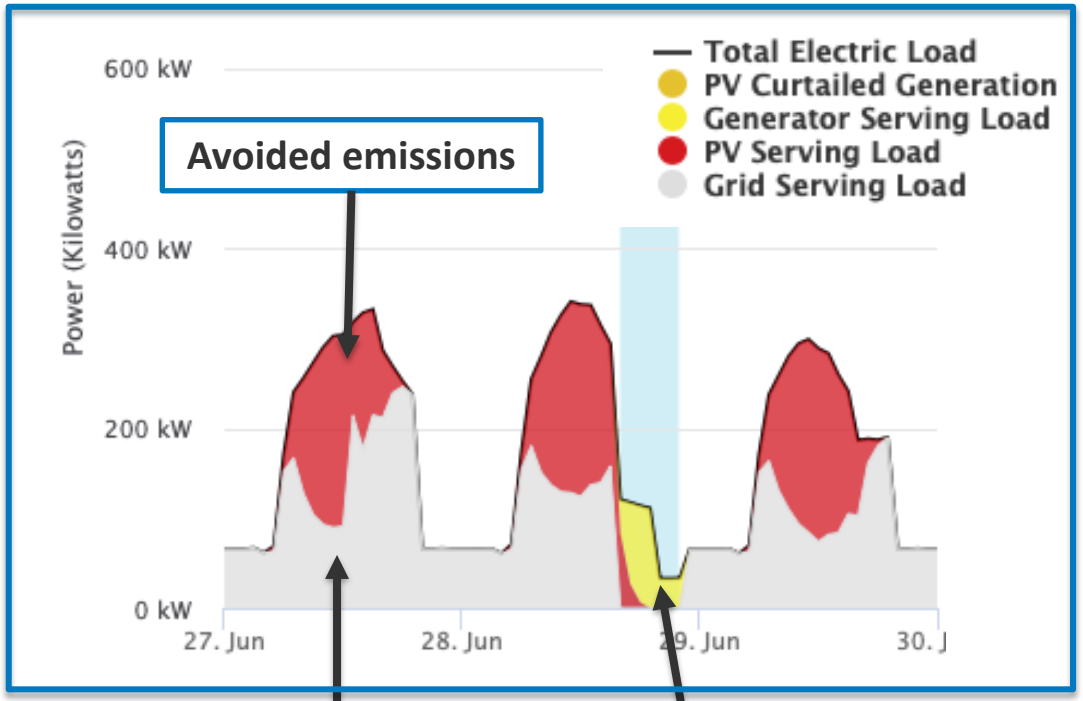
Kate Anderson et al. *Increasing Resiliency Through Renewable Energy Microgrids*. Exton, PA: Journal of Energy Management. August 2017. https://www.nrel.gov/docs/fy17osti/69034.pdf.

Health and Climate Emissions

REopt determines the emissions and emissions cost impacts of a DER investment, accounting for the hourly emissions intensity of grid electricity and on-site fuel consumption.



Use of hourly emissions rates (as opposed to annual averages) captures time-varying nature of emissions intensity, PV generation, and facility load.

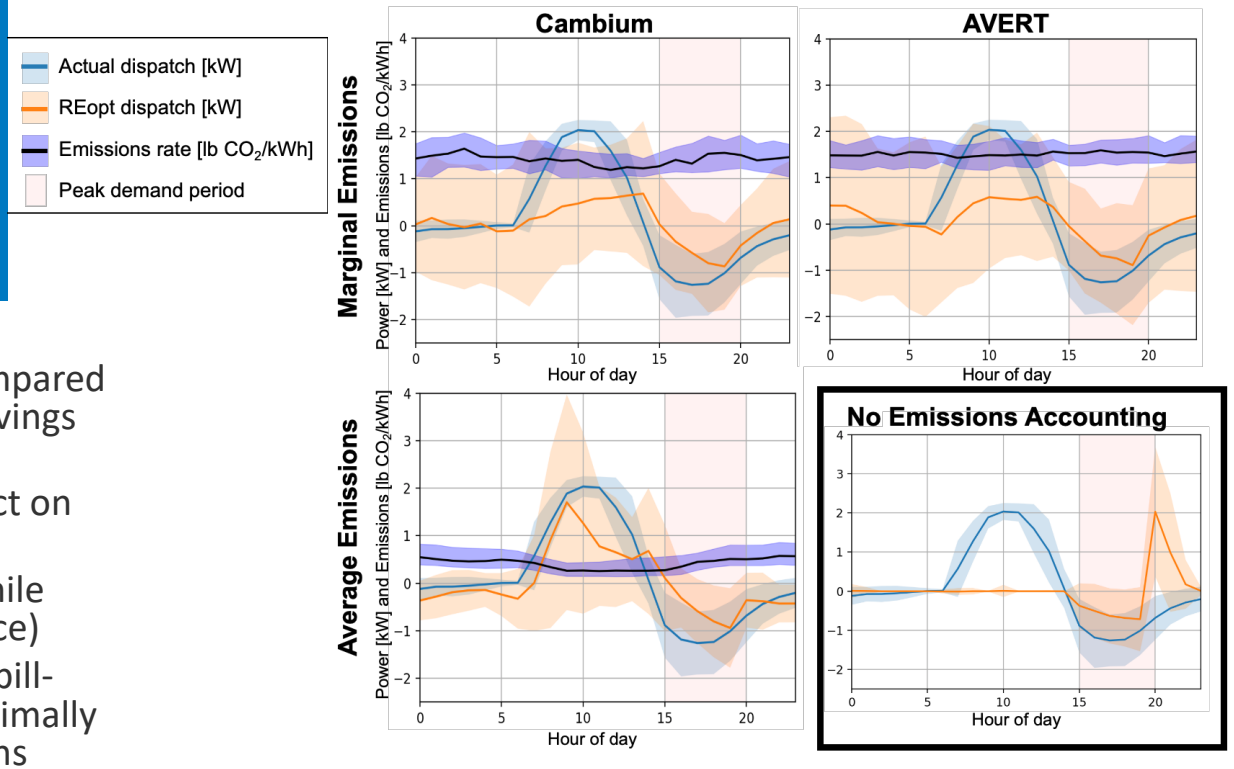


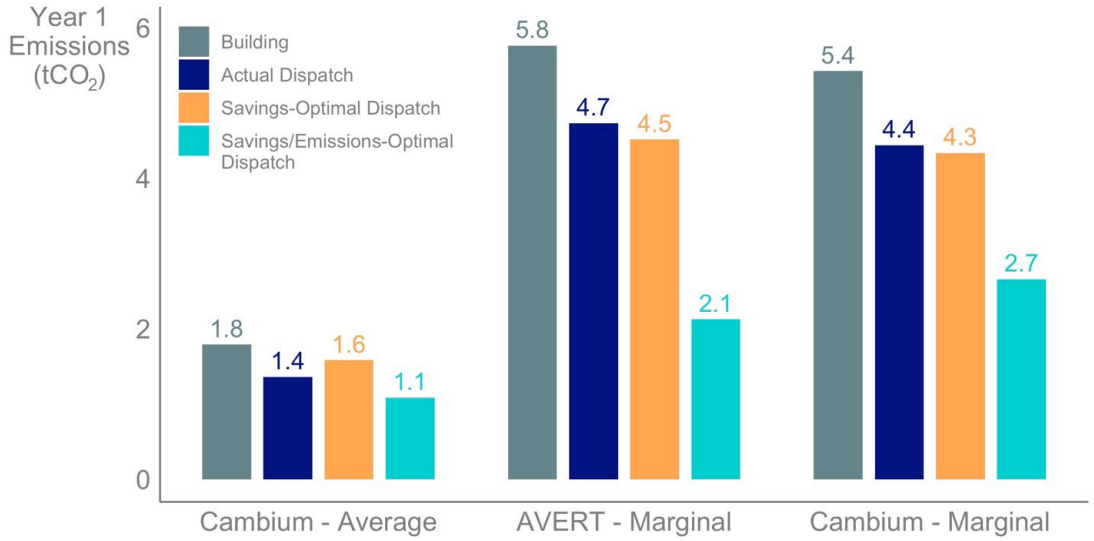
Grid emissions [tons] =
Electric grid purchases [kWh]
x
Marginal emissions intensity [ton/kWh] of the grid (location-specific) in each hour

Fuel emissions [tons] =
Fuel burned on-site [gal]
x
Fuel emissions intensity [ton/ gal]

Battery Dispatch Impact on Emissions

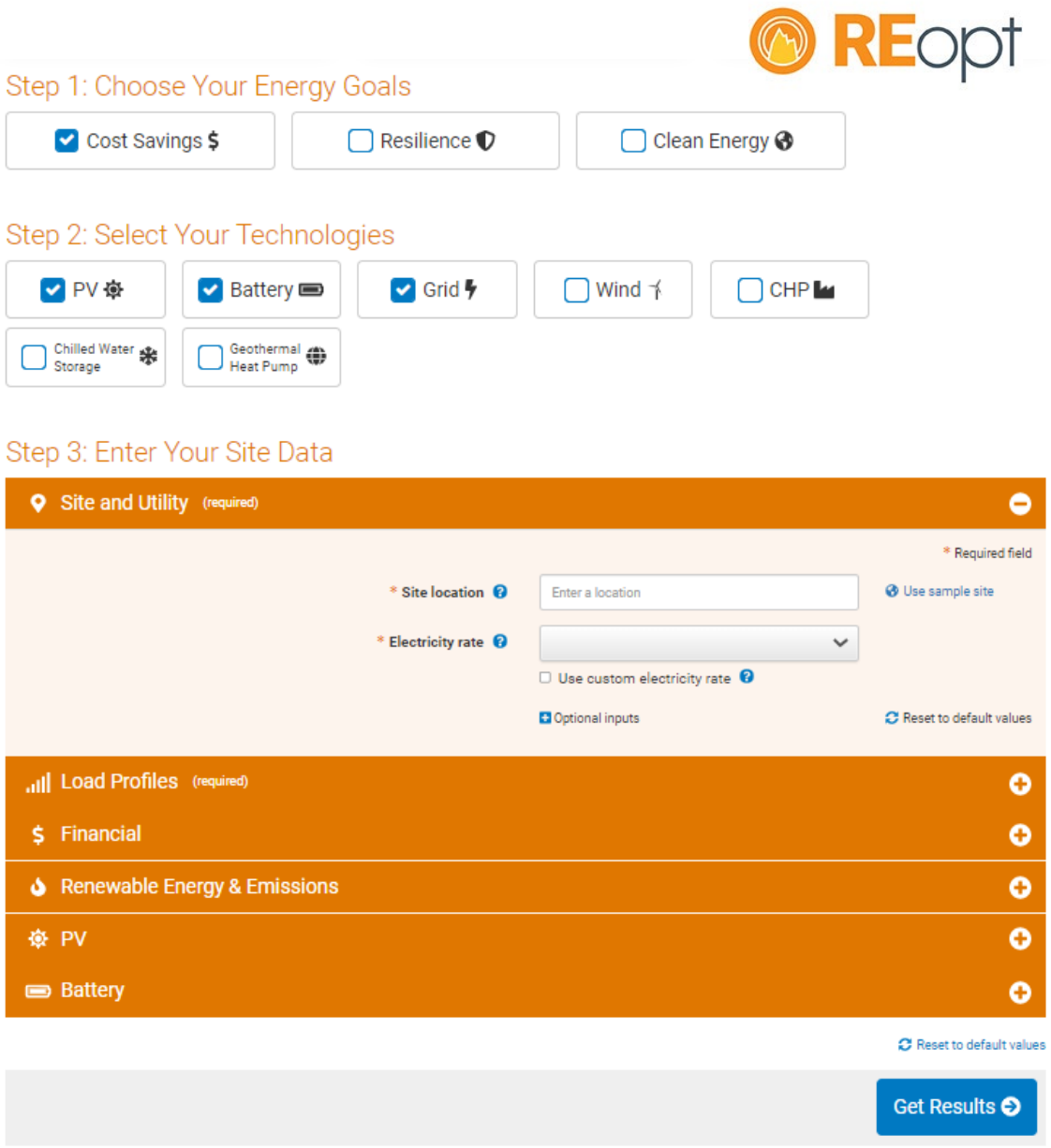
- Evaluated actual dispatch strategy in residential homes and compared to optimal dispatch under different scenarios to quantify bill savings and emissions reduction opportunities
- Optimal dispatch can reduce grid emissions with minimal impact on bill savings
  - Actual dispatch strategy charges batteries during day, while bill-savings optimal charges at night (to increase resilience)
  - When considering social cost of carbon (emissions- and bill-savings optimal), the times at which battery charges minimally impacts economics, but can significantly impact emissions reduction
  - The emissions- and bill-savings optimal dispatch entails more midday charging, but also significant variability in hourly charging—a strategy that requires real-time emissions information from the grid
  - Emissions reductions vary based on dataset (source and emissions type)
- Policymakers and rate designers could implement measures to incentivize dispatch of demand-side resources to simultaneously reduce grid emissions and maximize customer savings.





REopt Web Tool User Interface

- **REopt Web Tool** offers a free, publicly available, user-friendly web tool that offers a subset of NREL's more comprehensive REopt™ model
- Optimizes **PV, wind, CHP, GHP, and energy storage** system sizes and dispatch strategies to **minimize life cycle cost of energy**
- **Resilience mode** optimizes PV, wind, and storage systems, along with backup generators, to sustain critical load during grid outages.
- **Clean energy goals** allow users to consider renewable energy targets, emissions reductions targets, and emissions costs in optimization
- Access REopt web tool at reopt.nrel.gov/tool.



Thank You

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https://reopt.nrel.gov/