DER Planning with Resilience Analysis Using REopt Lite: A Behind-the-Meter Techno-Economic Analysis Tool

Energy Systems Integration Group - Webinar

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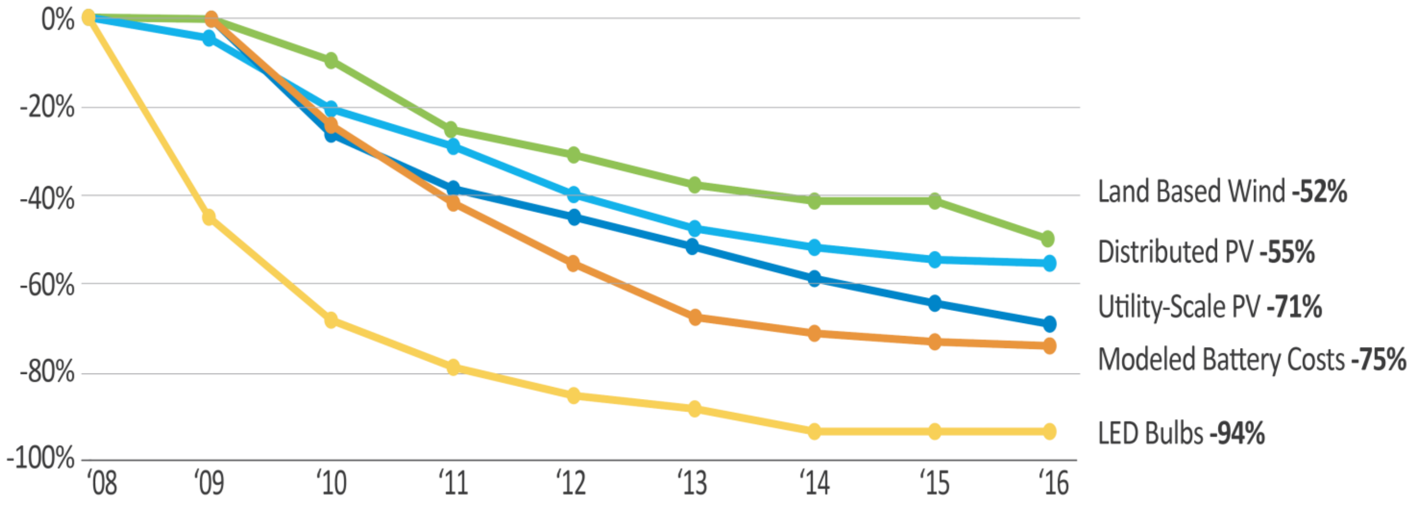
Agenda

1. Need for Renewable Energy Optimization Tool
2. Case Study – Industrial site DER planning with Resilience
3. Formulation - Mixed Integer Linear Programming
4. REopt Toolkit – methodology and ways of accessing
5. Q&A

Why Renewable Energy Optimization?

Various drivers: Including falling technology Costs…

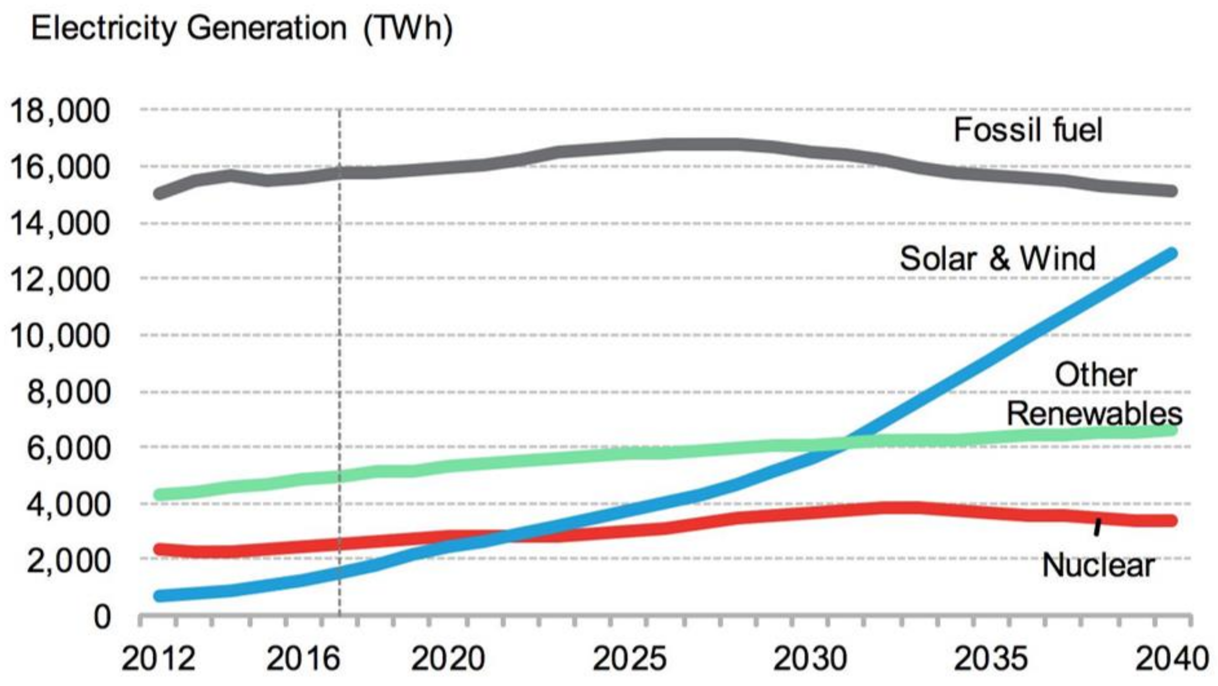


Source: *DOE Revolution Now* (2016)

Advanced energy technologies are **providing real-world solutions**

- Distributed solar costs fallen over 50% since 2008
- State RPS driving increased adoption of RE
- Increasing EV adoption posing V2G opportunities

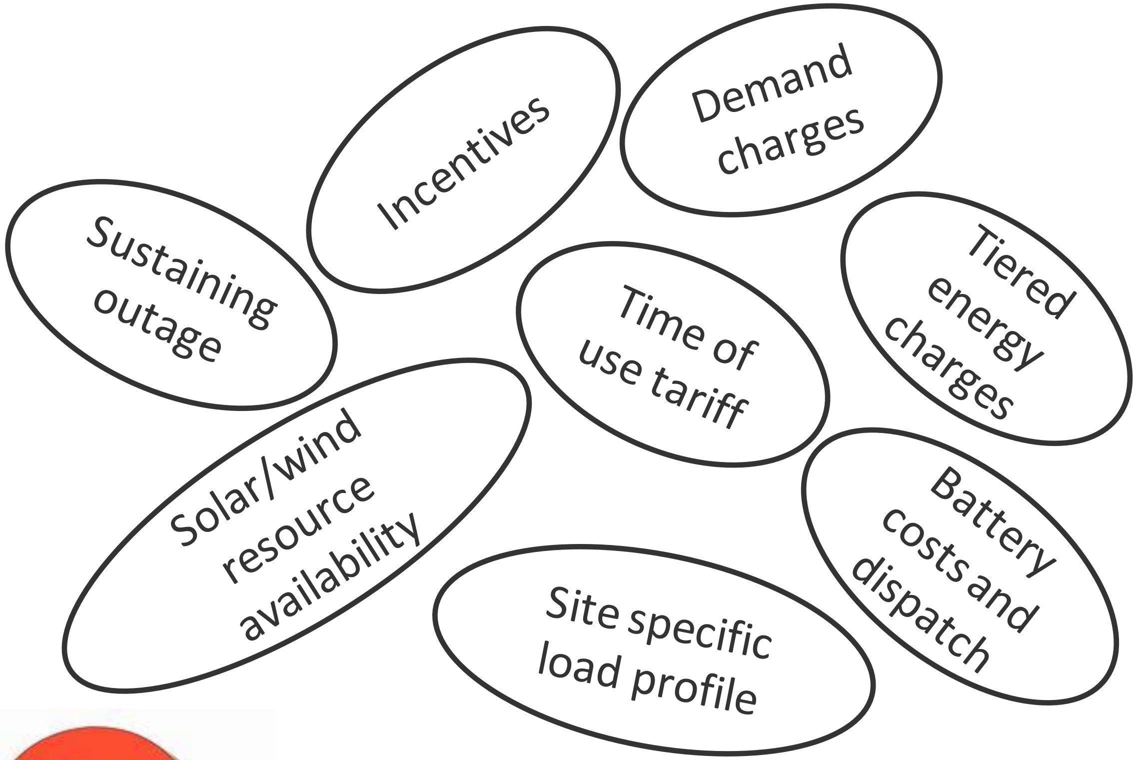
…Are Leading to Increased Deployment



Global Electricity Generation Mix to 2040
Source: Bloomberg New Energy Finance, New Energy Outlook 2017

- As costs decrease, RE deployment is growing
- Worldwide, 25% of power comes from RE
  - Need to reach 85% to avoid worst impacts of climate change
- Generation will be increasingly distributed, with 31% of new capacity behind-the-meter
- Achieving this transformation will require increasingly integrated and complex solutions

What's the Optimal Energy System?



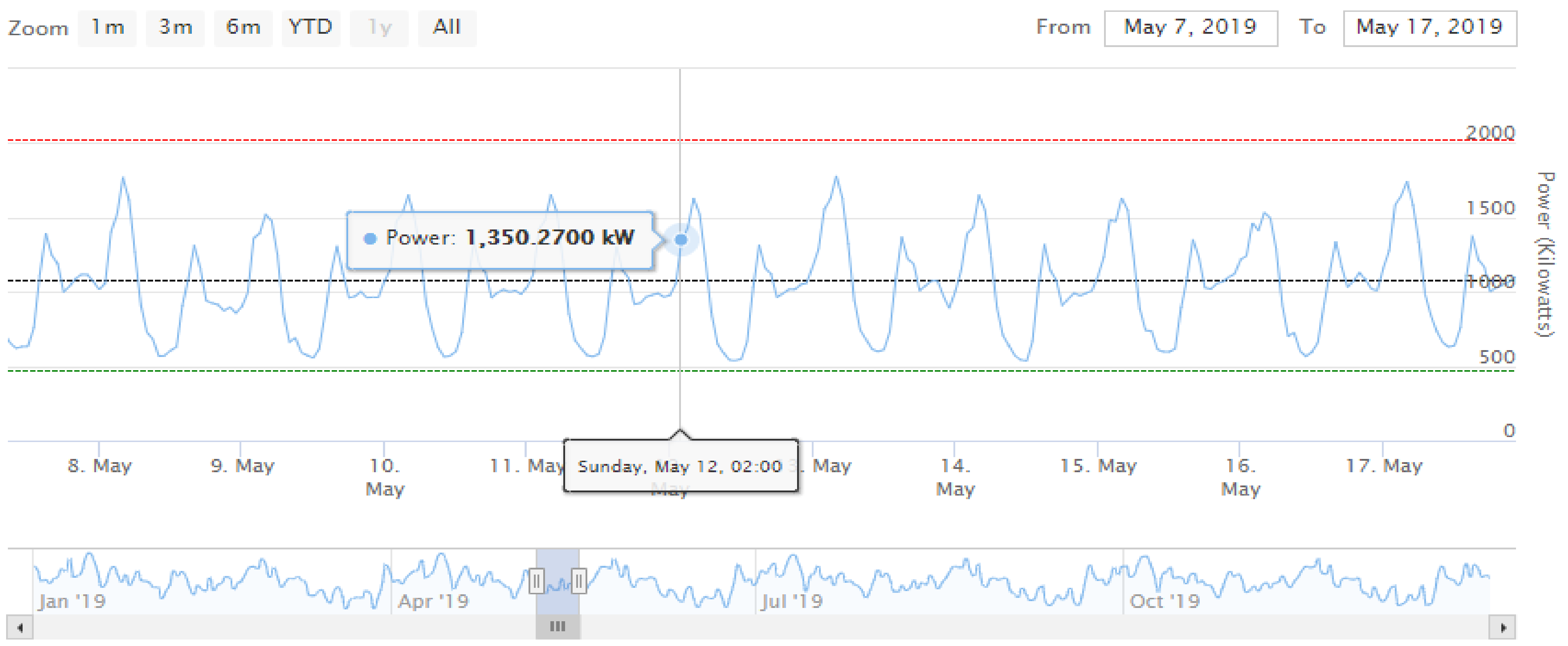
- With increasingly complex systems, traditional metrics (i.e., LCOE) are no longer sufficient to determine project economics
- Need a more powerful methodology to extract information from technical *and* economic aspects of behind-the-meter energy systems to find the optimal deployment and operations strategy
- When this analysis is coupled with ***resilience*** requirements, the problem's complexity increases

Case study – determine optimal DER size with the capability to sustain predefined outage

Site Specifications

- A mask manufacturing plant in Denver area
- Yearly energy consumption: 9,437,485.685 kWh
- Existing PV system: 500 kW
- DER options to assess: additional new PV and battery
- Analysis focus: resilience to sustain 48-hour long outage using on-site DERs
- Critical load: 65%

Manufacturing Plant's Load Profile



Average Load: 1077.34 kW **Min Load:** 475.98 kW (Mar 20) **Max Load:** 2022.43 kW (Jan 8)

Utility tariff

https://openei.org/apps/USURDB/rate/view/5e612c5c5457a32343019406#1__Basic_Information

Utility Name	Public Service Co of Colorado
EIA Id	15466
Rate Name	Secondary Photovoltaic Time Of Use Schedule (SPVTOU) Section A
Expert Has Verified	Yes
Is Default	
Effective Date	01/01/2020
End Date	
Supersedes	Secondary Photovoltaic Time Of Use Schedule (SPVTOU) Section A
Sector	Industrial
Service Type	Bundled

Weekday Schedule

	12 am	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
Jul	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
Aug	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
Sep	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Tiered Energy Usage Charge Structure

Period	Tier	Max Usage	Max Usage Units	Rate $/kWh	Adjustments $/kWh
1	1		kWh	0.02378	0.029072
2	1		kWh	0.1344	0.037311

Seasonal/Monthly Demand Charge Structure

Period	Tier	Max kW Usage	Rate $/kW	Adjustments $/kW
1	1		5.63	3.3

Results

Your recommended solar installation size

3,225 kW
PV size
(2,725 kW new + 500 kW existing)

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

This optimized size may not be commercially available. The user is responsible for finding a commercial product that is closest in size to this optimized size.

Your recommended battery power and capacity

1,129 kW
battery power

14,636 kWh
battery capacity

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

This optimized size may not be commercially available. The user is responsible for finding a commercial product that is closest in size to this optimized size.

Your potential life cycle savings (25 years)

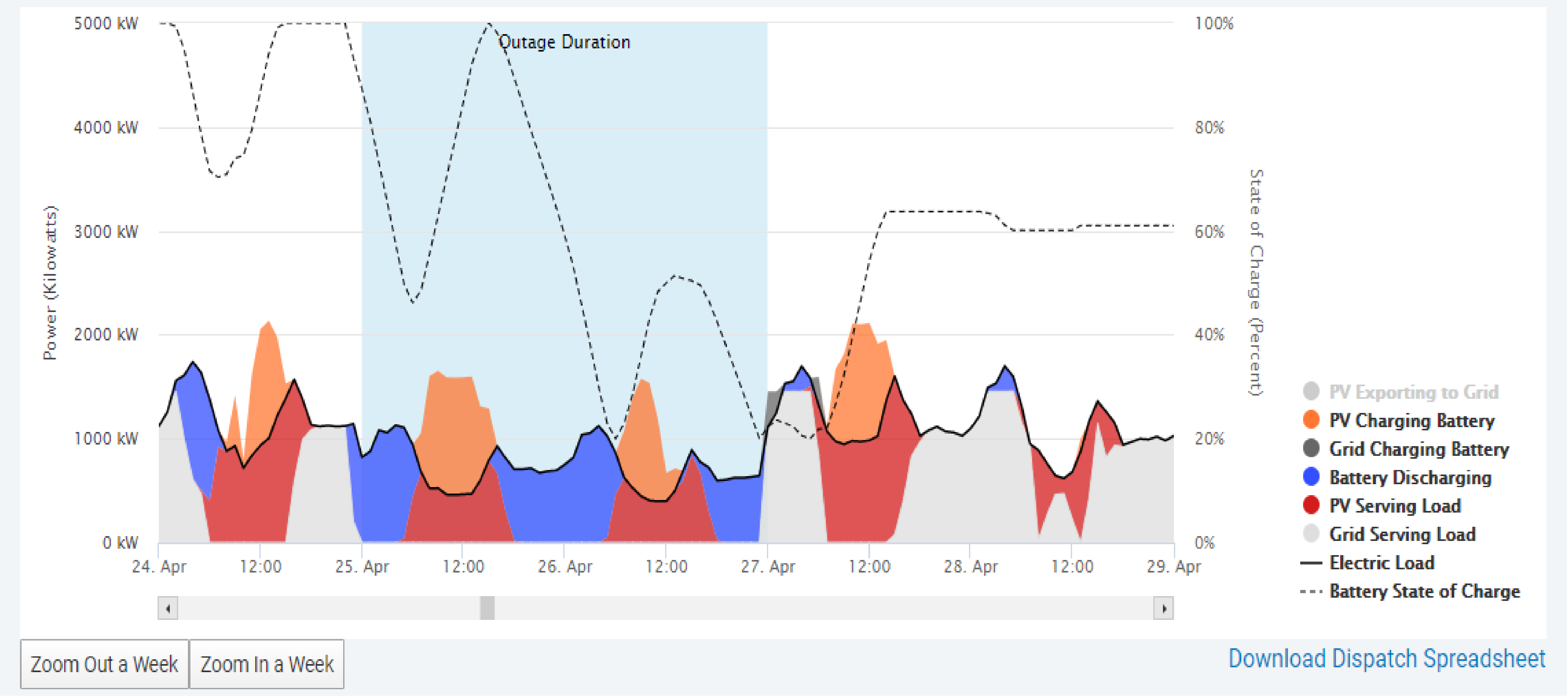
This is the net present value of the savings (or costs if negative) realized by the project based on the difference between the total life cycle costs of doing business as usual compared to the optimal case.

-$5,719,960

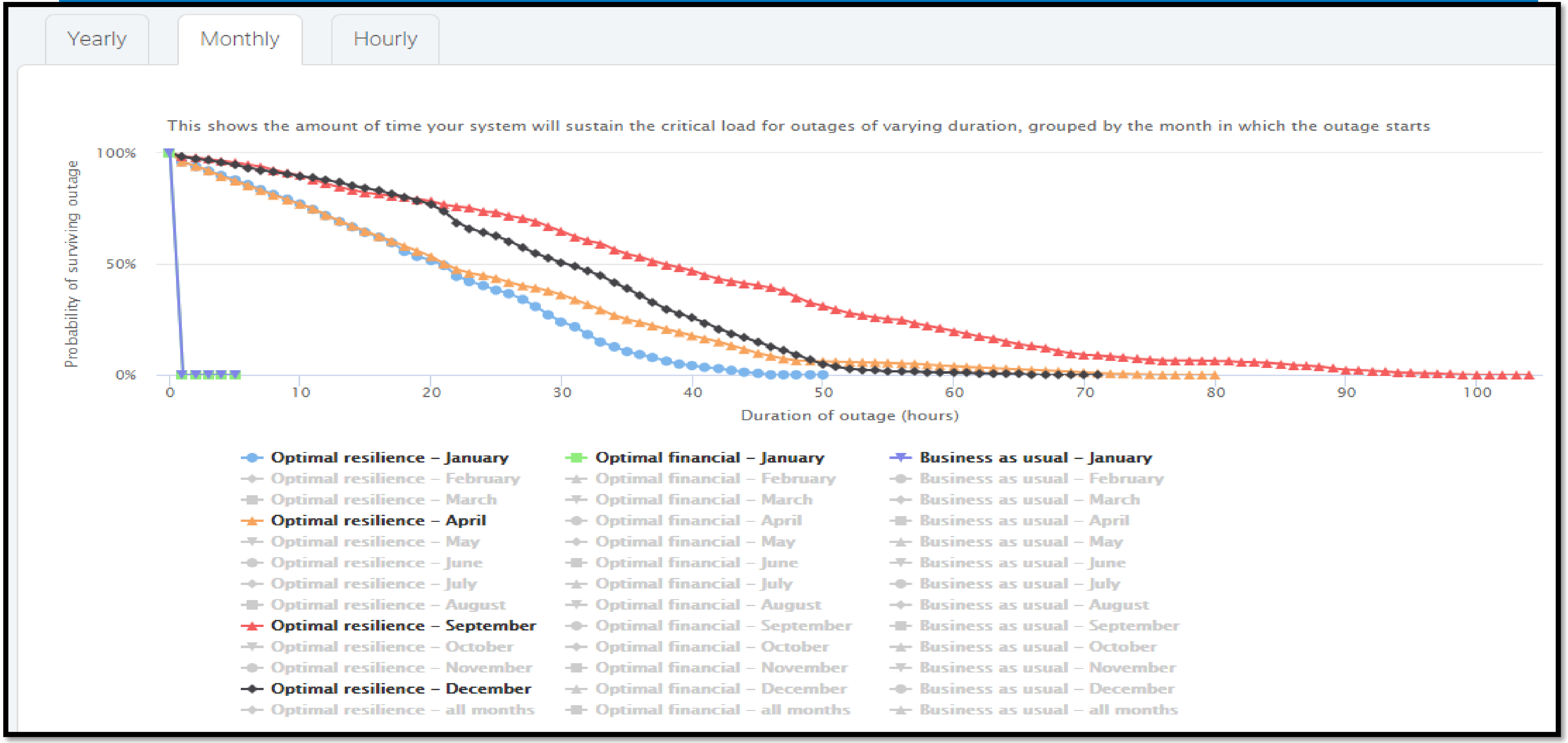
Resilience-focused vs financial-focused

	Business As Usual	Resilience	Financial
System	500 kW PV	2,725 kW PV 1,129 kW Battery 14,636 kWh Battery	0 kW PV 0 kW Battery 0 kWh Battery
NPV	$0	-$5,719,960	$0
Survives Specified Outage	No	Yes	No
Average	1 hrs	29 hrs	1 hrs
Minimum	0 hrs	0 hrs	0 hrs
Maximum	3 hrs	166 hrs	5 hrs

System Performance – year one



Outage Simulation – system performance insights



Case study results available here: https://reopt.nrel.gov/tool/results/d3851794-a2ff-41f0-9ba4-14ff54c92886

Mixed Integer Linear Programming

REopt’s Formulation

REopt Lite MILP Overview

Objective: Minimize life cycle cost of energy

- Uses one year of resource and cost data with present worth factors to account for life-time costs
- Assumes that one year repeats, with degradation and escalation factors

Energy balance at every time step for entire year

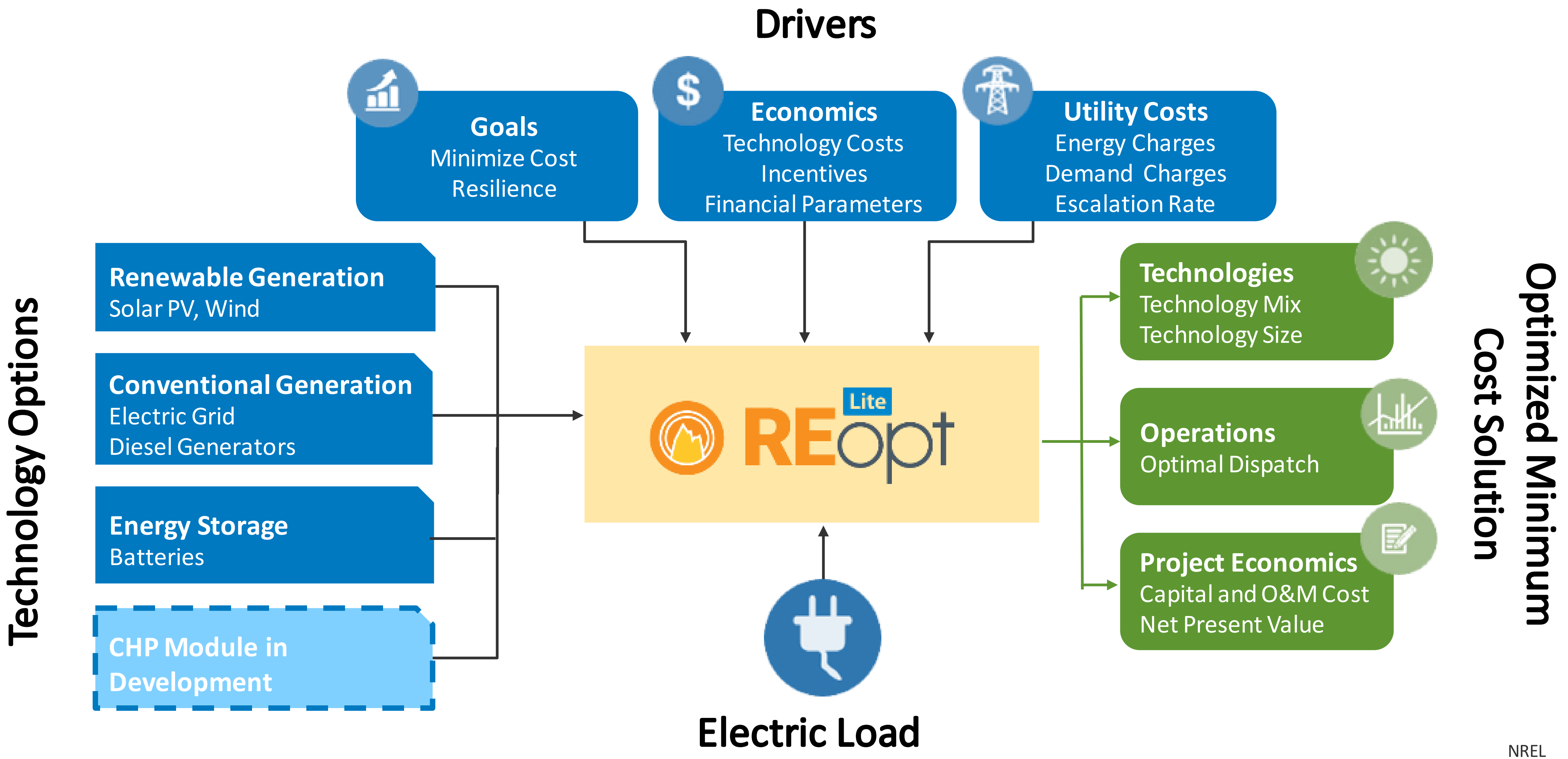
- Load must be met from some combination of grid purchases, on-site generation, or discharge from storage
- Does not consider power flow or transient effects

Technology modules based on empirical operating data

- Finds optimal technology sizes (can be zero) and optimal dispatch strategy subject to resource, operating, and market constraints

REopt Lite: Free Tool to Optimize Economic and Resilience Benefits of DERs

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



Ways to work with REopt

REopt – Internal

REopt Lite – Webtool

REopt API – Programmatic access

REopt OS – recently released!

In Summary

- An optimization model facilitates answering complex questions about system design and dispatch
- Results are driven by economic objective: minimize costs
- Model determines which technologies to add and how to operate them to satisfy the objective
  - **Size, technology mix, and dispatch is not a user input but a model output**
- The user can force in a technology type and size by setting constraints

Other resources

- **REopt Lite:** https://reopt.nrel.gov/tool
  - Tool
  - Help manual
  - Accessing REopt API with python
- **REopt Open Source:** GitHub Repository
  - Wiki with more information
- **REopt Website:** https://reopt.nrel.gov
  - Analysis services
  - Case studies
- **Send tool feedback & ask a question:** reopt@nrel.gov
- **My contact information:** Sakshi.Mishra@nrel.gov