StorageVET 2.0 Task Force

ESIC Working Group 1: Grid Services and Analysis

Miles Evans | EPRI
Halley Nathwani | EPRI
Giovanni Damato | EPRI

March 5, 2020

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Agenda

- Last Month: Post-Facto Reliability
- DER-VET Public Safety Power Shutoff Use Case

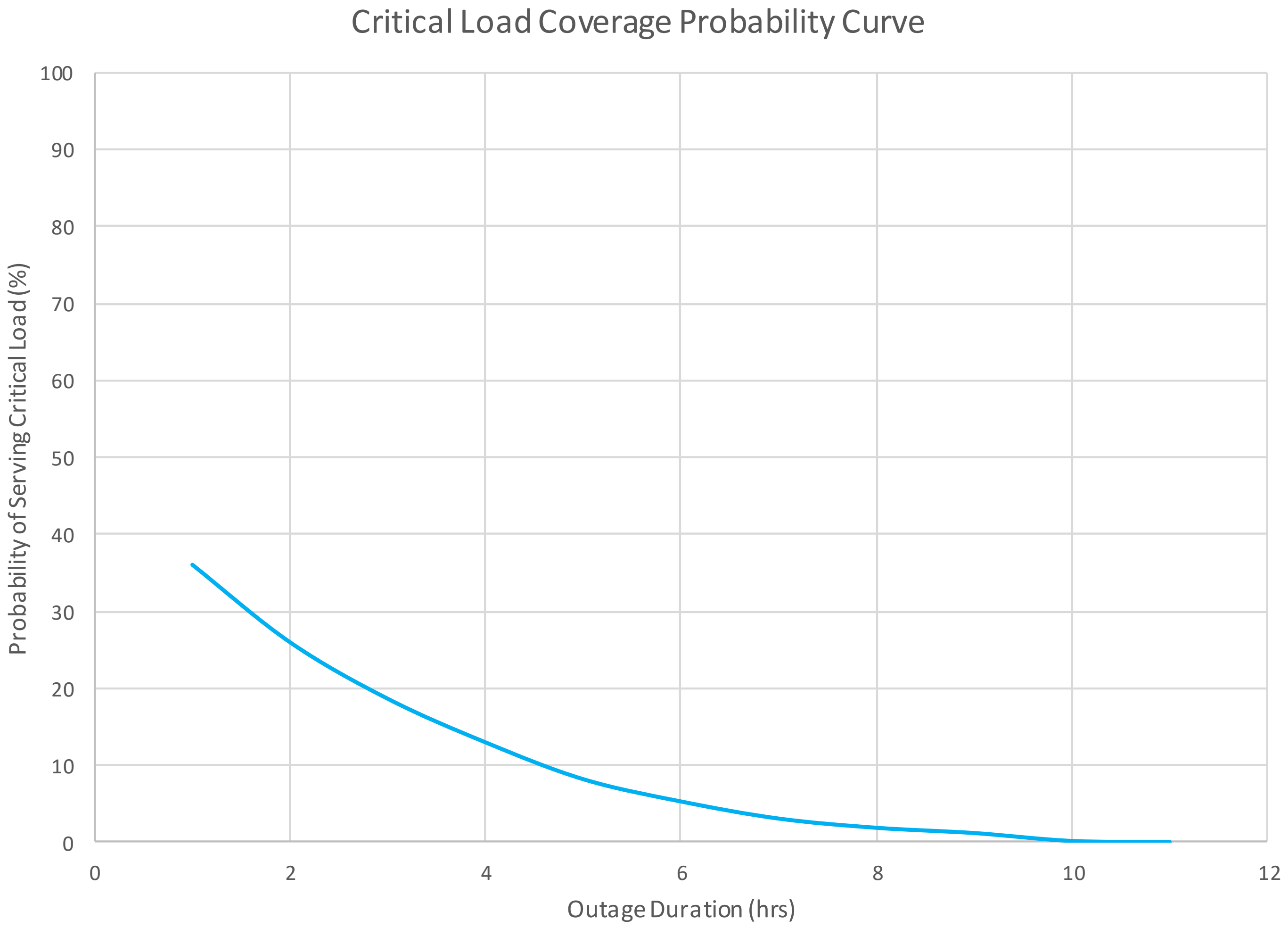
Post-Facto Reliability Review

Review Post Facto Reliability Process

Optimize Size for Demand Charge Reduction → Calculate Outage Coverage Probability

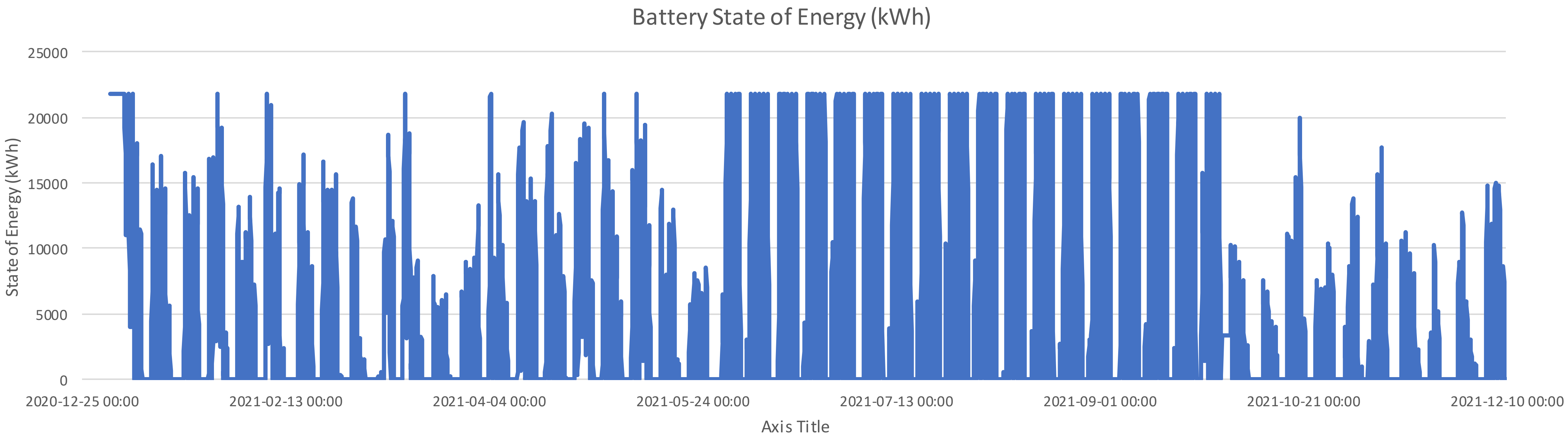
Conclusions - Reliability

- Battery is unlikely to cover a random outage.
  - Size not constrained or optimized for reliability
  - Operated to minimize SOC most of the time



Conclusions – Should be Operated Differently for Reliability

- Next time
  - Set a minimum SOC
  - Optimize for reliability
  - Penalize low SOC

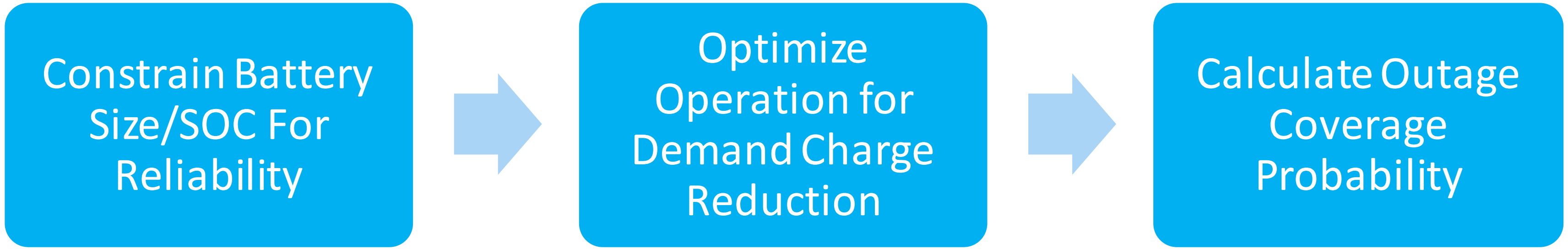


Optimize for Reliability: PSPS Adaptation

Public Safety Power Shutoffs

- Long-duration power shutoffs when fire risk is high
  - Can last several days
  - 24-48 hours is typical
- DER-VET Input: Critical loads need to be covered for all 48-hr outages

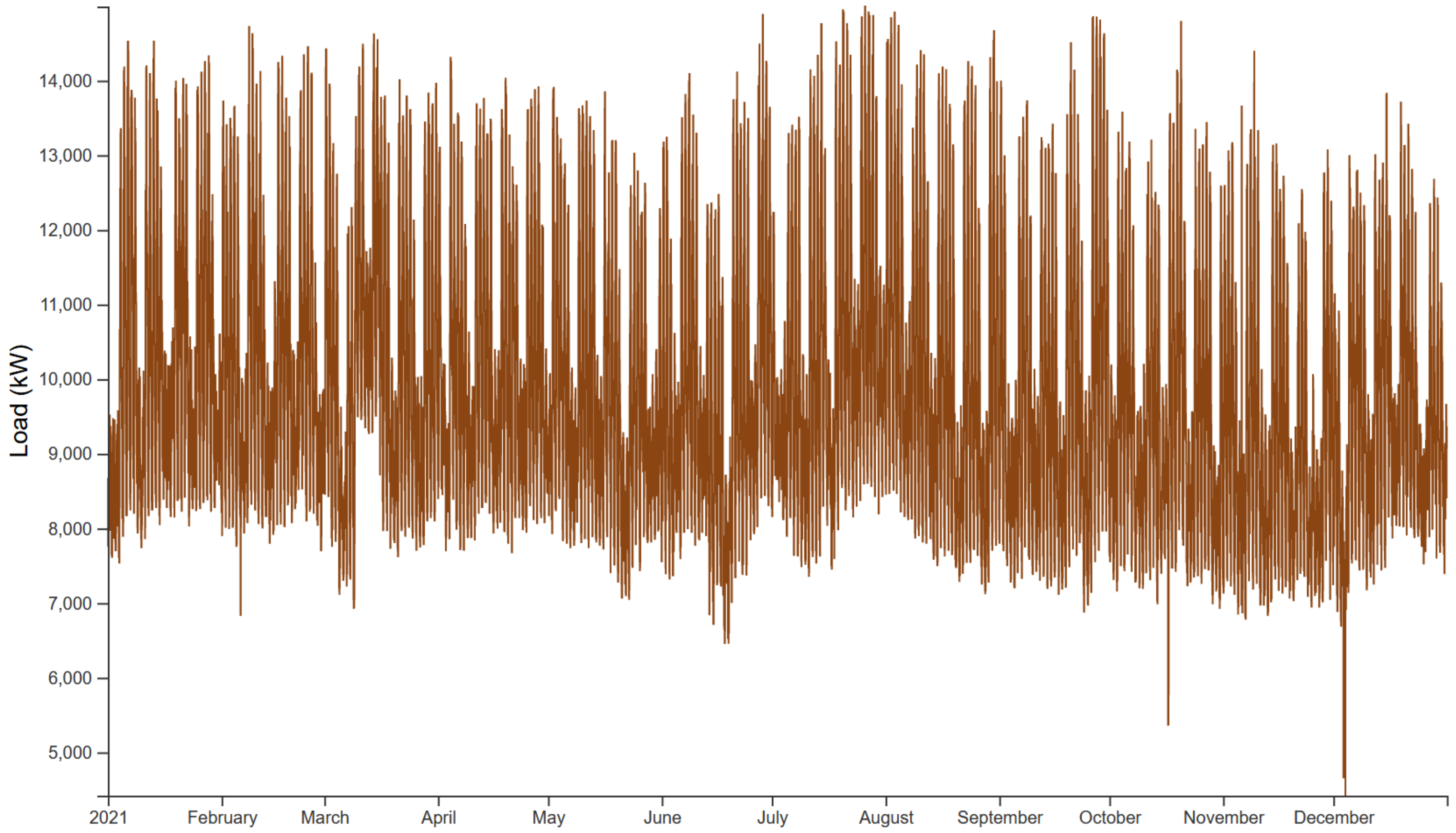
Optimize for Reliability Approach



- If demand charges are high, potential for more storage than reliability requires

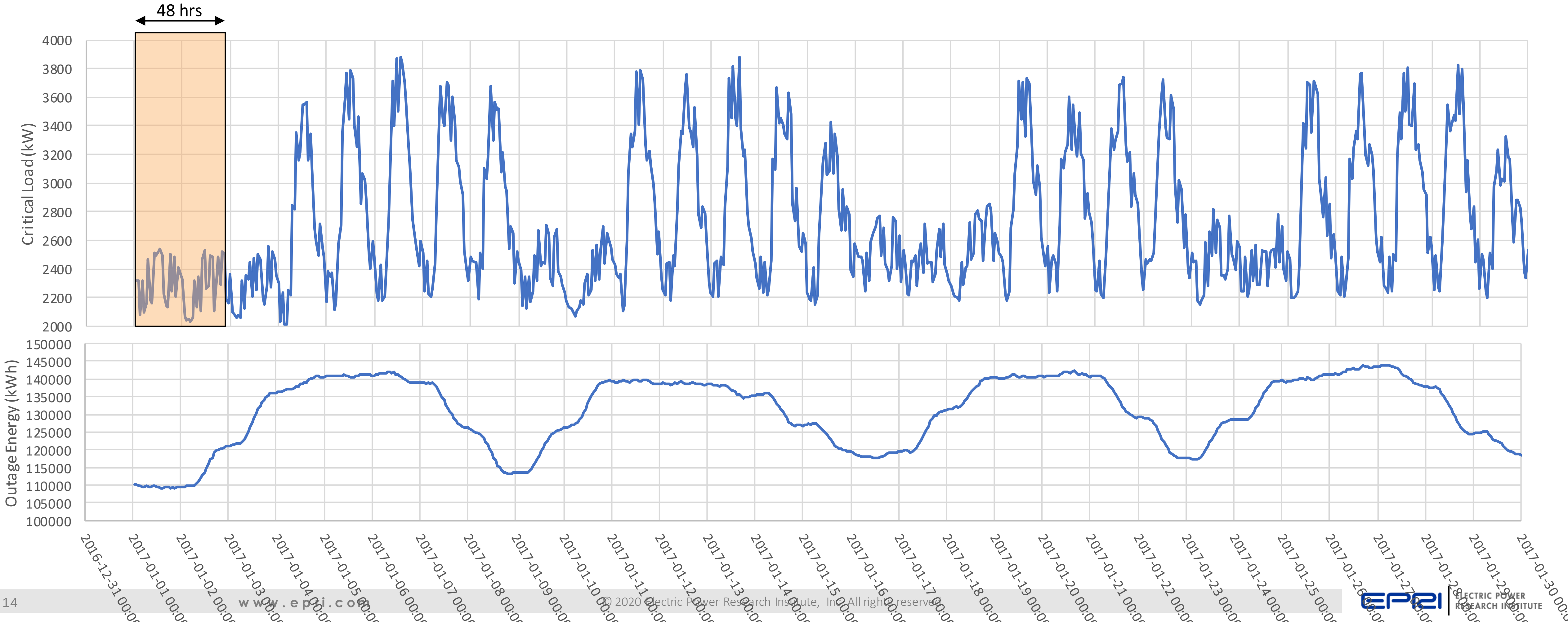
Use Case Description (Review)

- Large military base in California wants to build a battery microgrid
  - Back up critical loads
  - Reduce electricity costs
- ~15 MW load
- ~4 MW Critical Load
- $**8.77**/kW Demand Charges
- TOD Energy Charges



Reliability Optimization

- Minimize DER costs while meeting reliability objectives
- Our objective: 100% coverage of all 48-hr outages



Results

- Minimum Power Capacity Required to meet reliability objective: **4 MW**
- Minimum Energy Capacity Required to meet reliability objective: **155 MWh** (almost 39hr duration)

- Compare to the economically-optimal results of **3.6 MW**, **22 MWh** (6 hr)

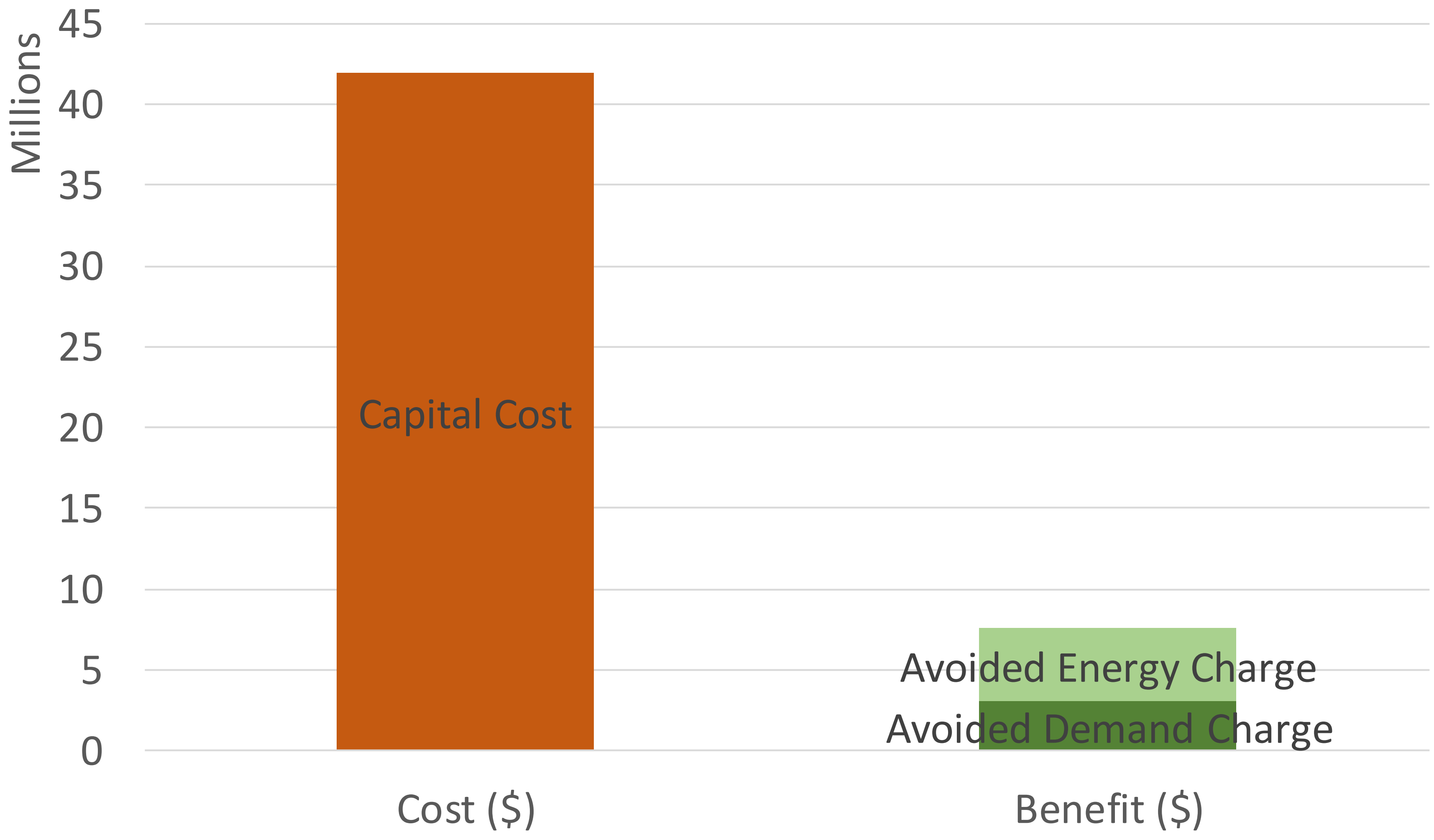
Economic Results

- Demand Charge Reduction of $288,226 per year
- Energy Charge Reduction of $429,744 per year

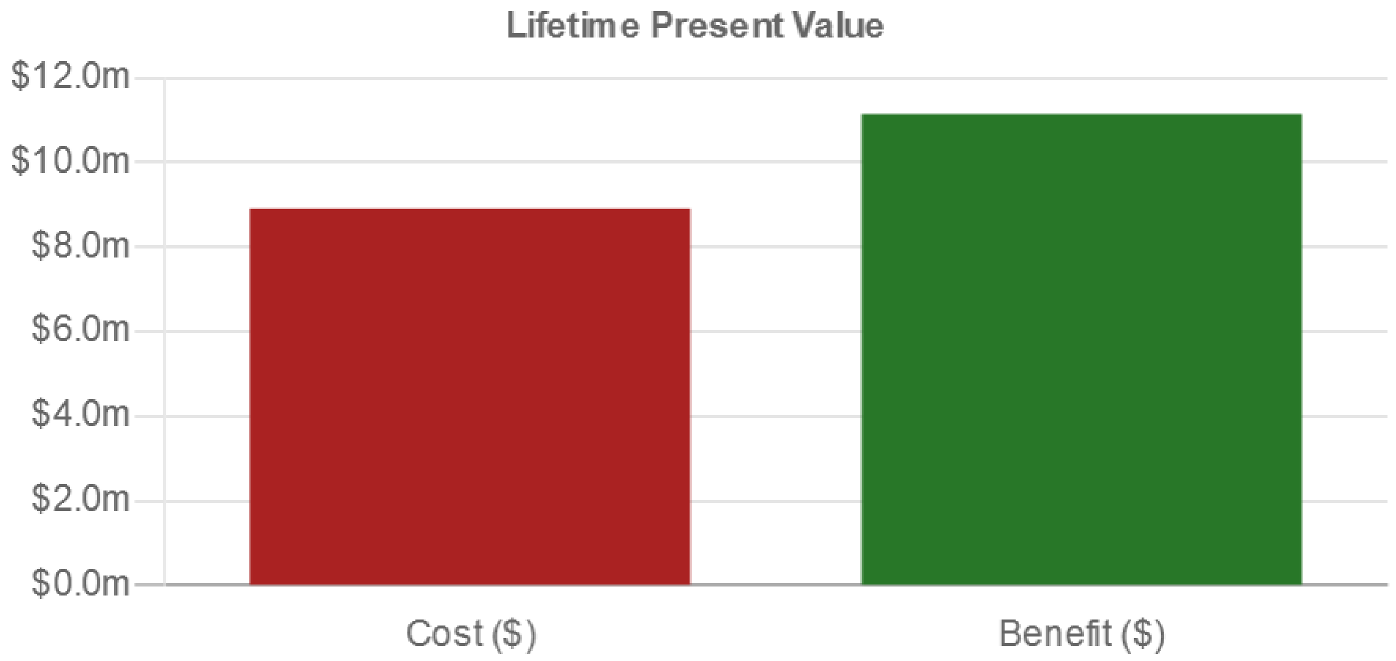
- Compare to the economically-optimal results of:
  Demand Charge Reduction: $315,548 per year
  Energy Charge Reduction: $474,998

- Electric bill savings are lower despite larger storage system size due to SOC restrictions to maintain readiness.
  – In PSPS cases, these restrictions could be removed most months!

Cost-Benefit

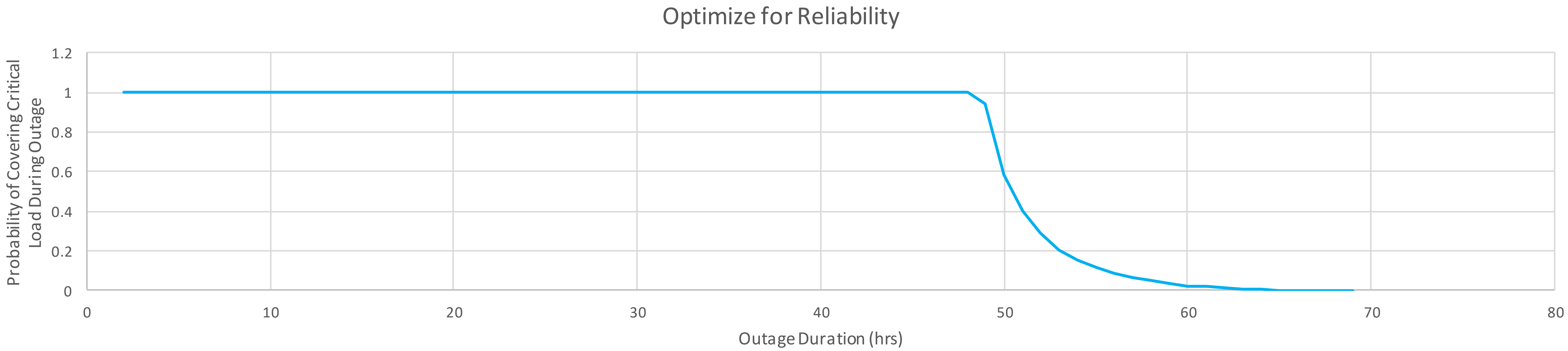


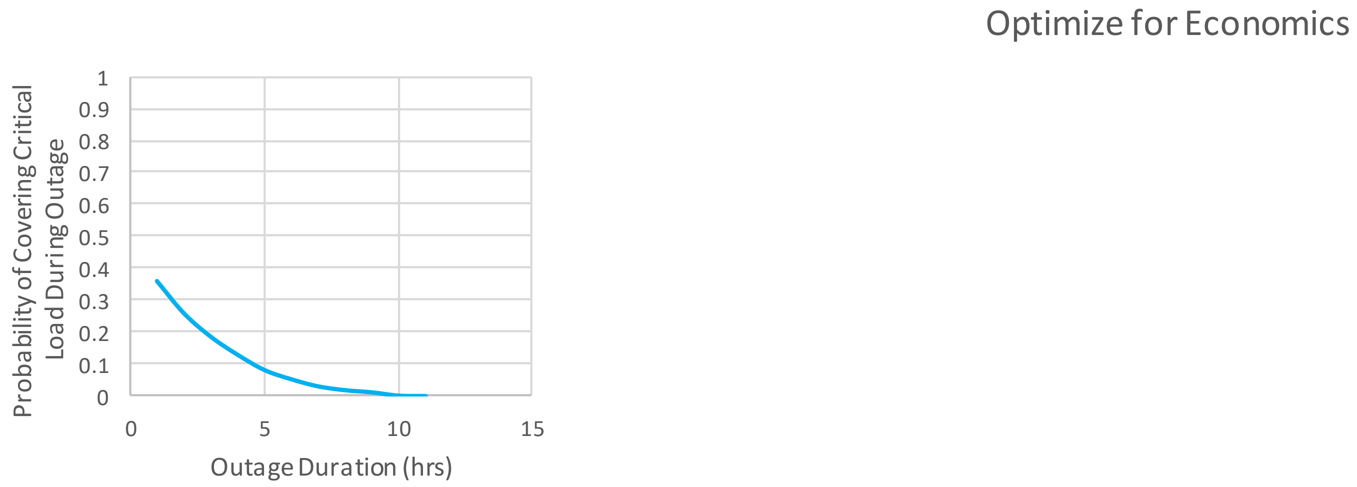
Compare to Economically-Optimal Results



View Detailed Financials Results...

Reliability Results Comparison





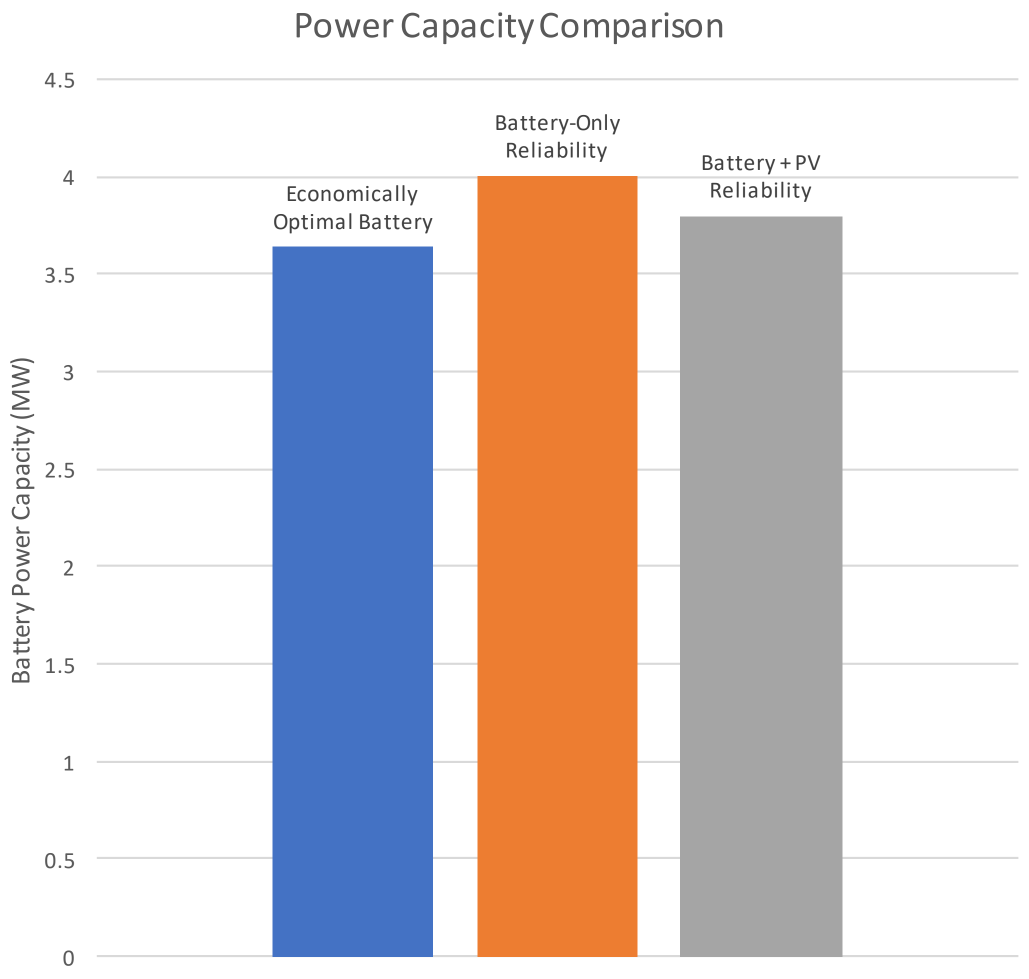
What about distributed generation?

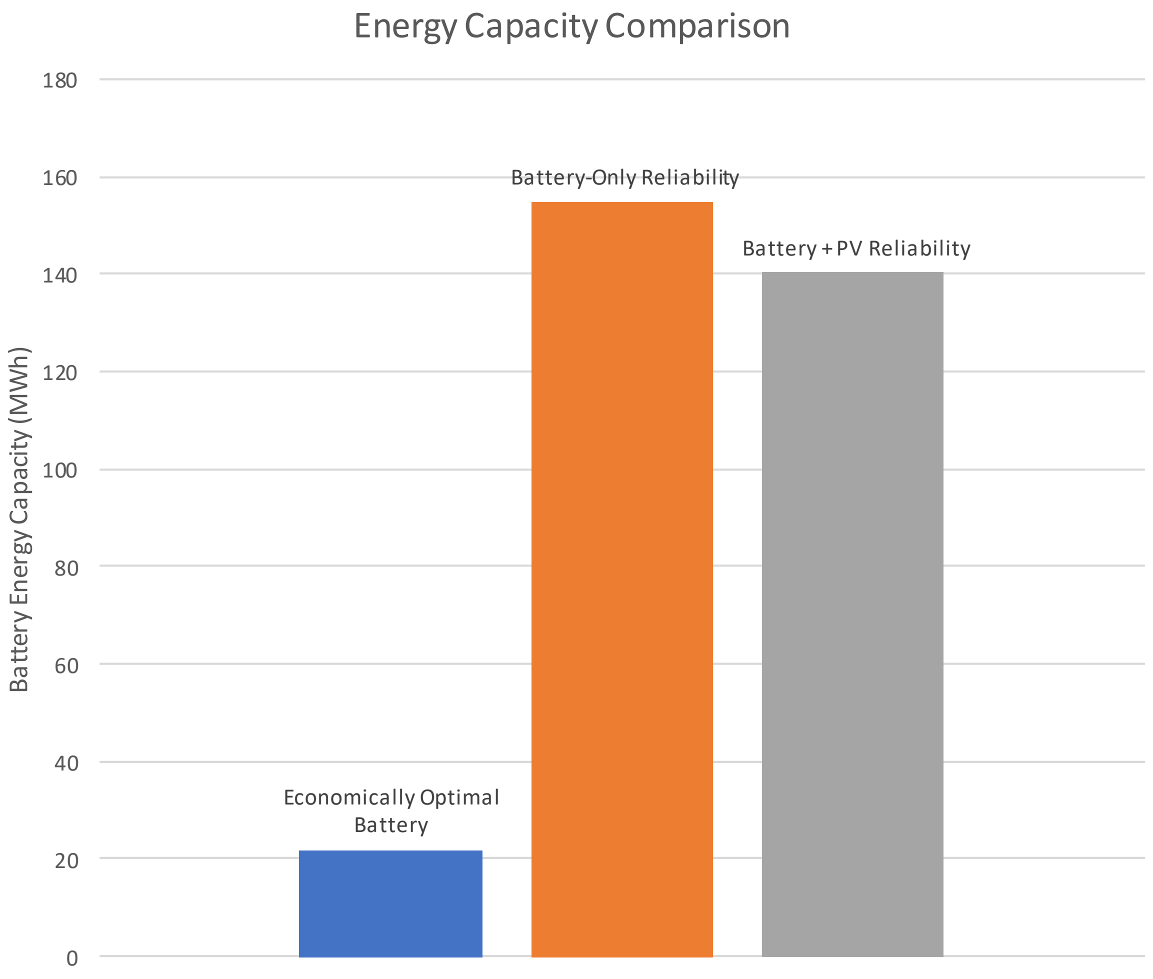
Include PV in Size Optimization

- PV Assumptions
  - 1 MWAC
  - $1500/kW
- Battery Cost Assumption = $800/kW + $250/kWh

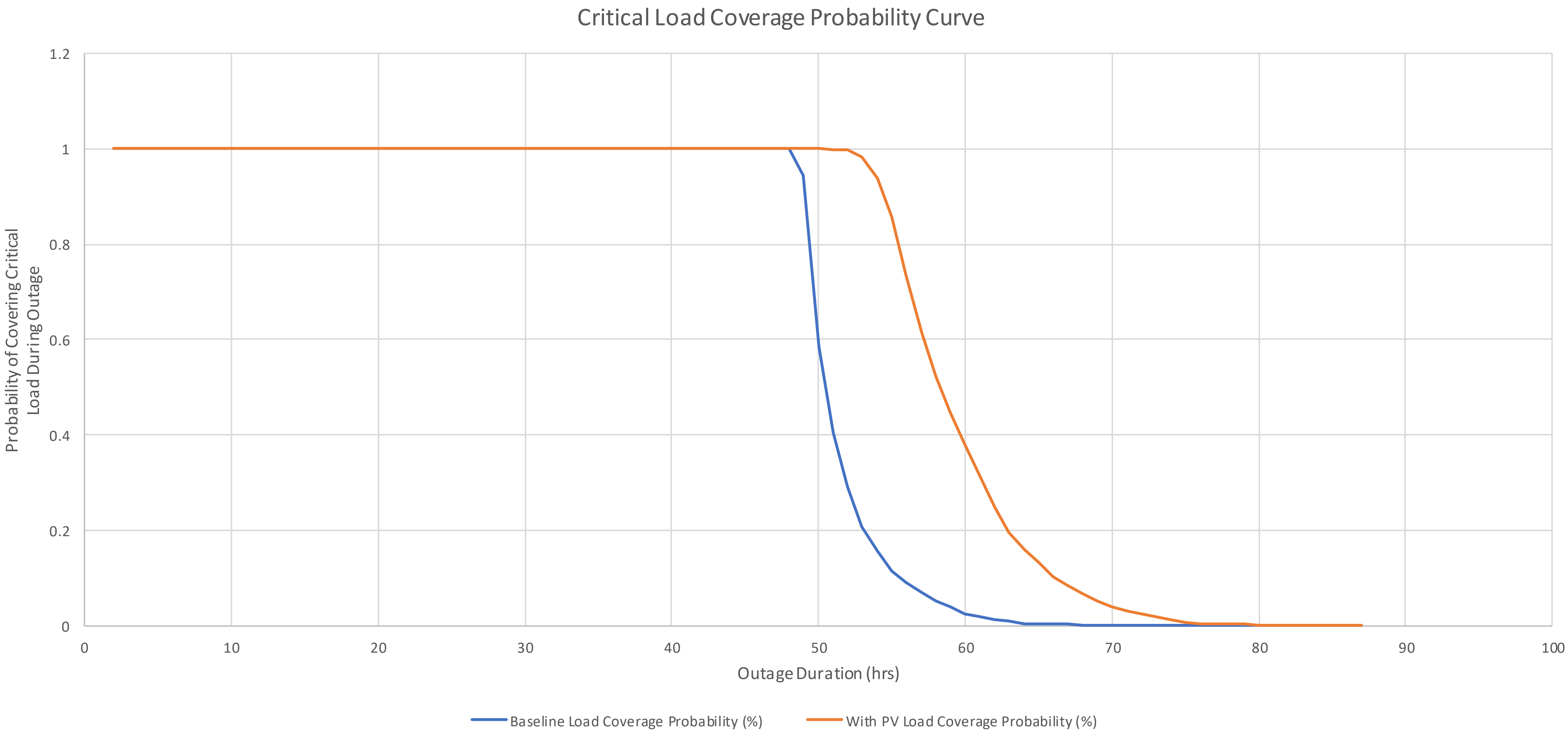
- PV Will:
  - Reduce the size of battery required to cover 48-hr outages
    - Storage can charge from PV when PV > critical load during outages
  - Offset some of the electricity bill

Optimal Battery Size Comparison



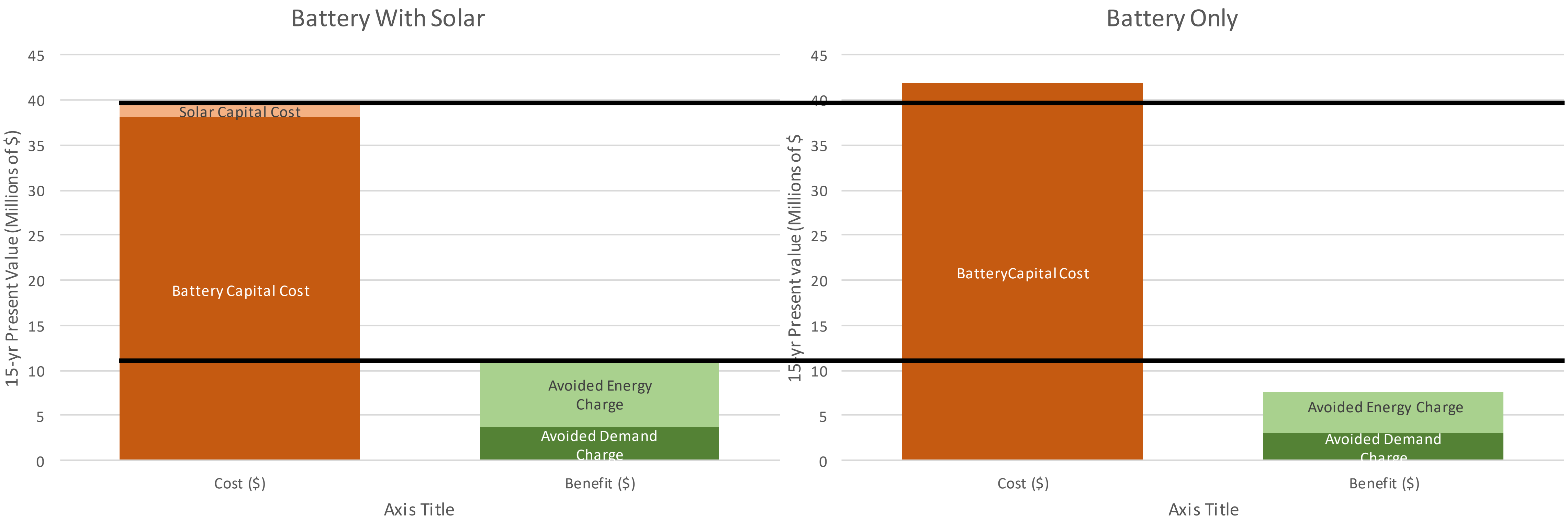


New Reliability Outcomes



Change in Economic Results

- Higher Benefits and Lower Cost With Solar



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Possible Future Work

- Could extend results to PV + Battery + Genset
  - …or any other DER
- Optimize PV size too if footprint restrictions, etc. not in play
- Scenario analysis with different combinations of PV, Storage, Generator sizes
- **Realistic storage duration!**
  - Constrain duration to a maximum of 8 hrs, for example
  - Redo analysis with optimal energy capacity and a larger power capacity

Note on Perspective

- This case is customer-centric but can be adapted to a utility-owned microgrid scenario.
- Avoided costs can be included instead of electric bill reduction as the economic objective
- Or, reliability can be the only objective

Next Meeting

Regularly-Scheduled Meetings

- Next Meeting – **Thursday April 2, 11:00 am Pacific Time**
  - **DER-VET Beta**

Together...Shaping the Future of Electricity

Use Case Description

- Large military base in California wants to build a battery microgrid
  - Back up critical loads
  - Reduce electricity costs
- ~15 MW load
- ~4 MW Critical Load
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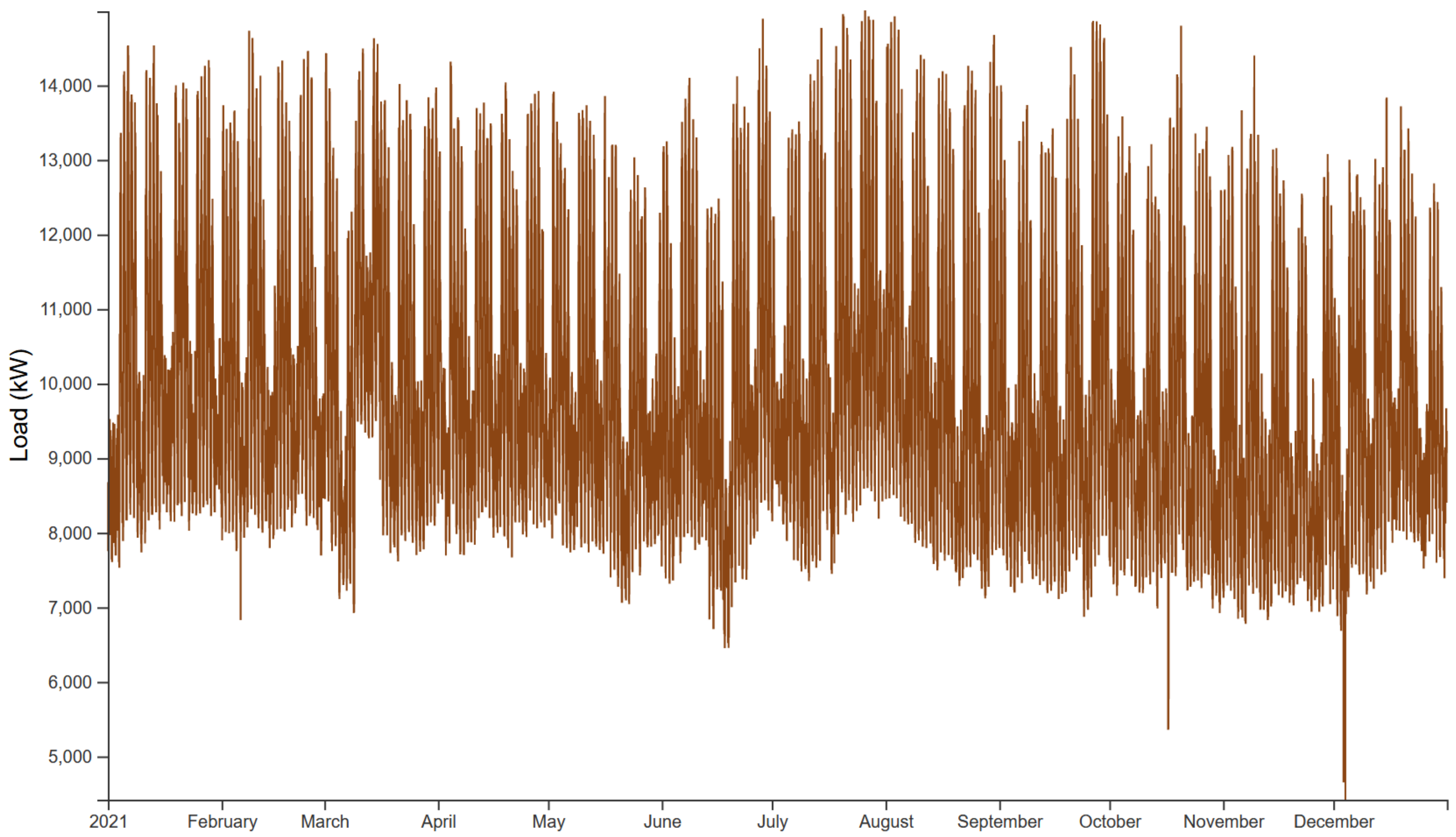
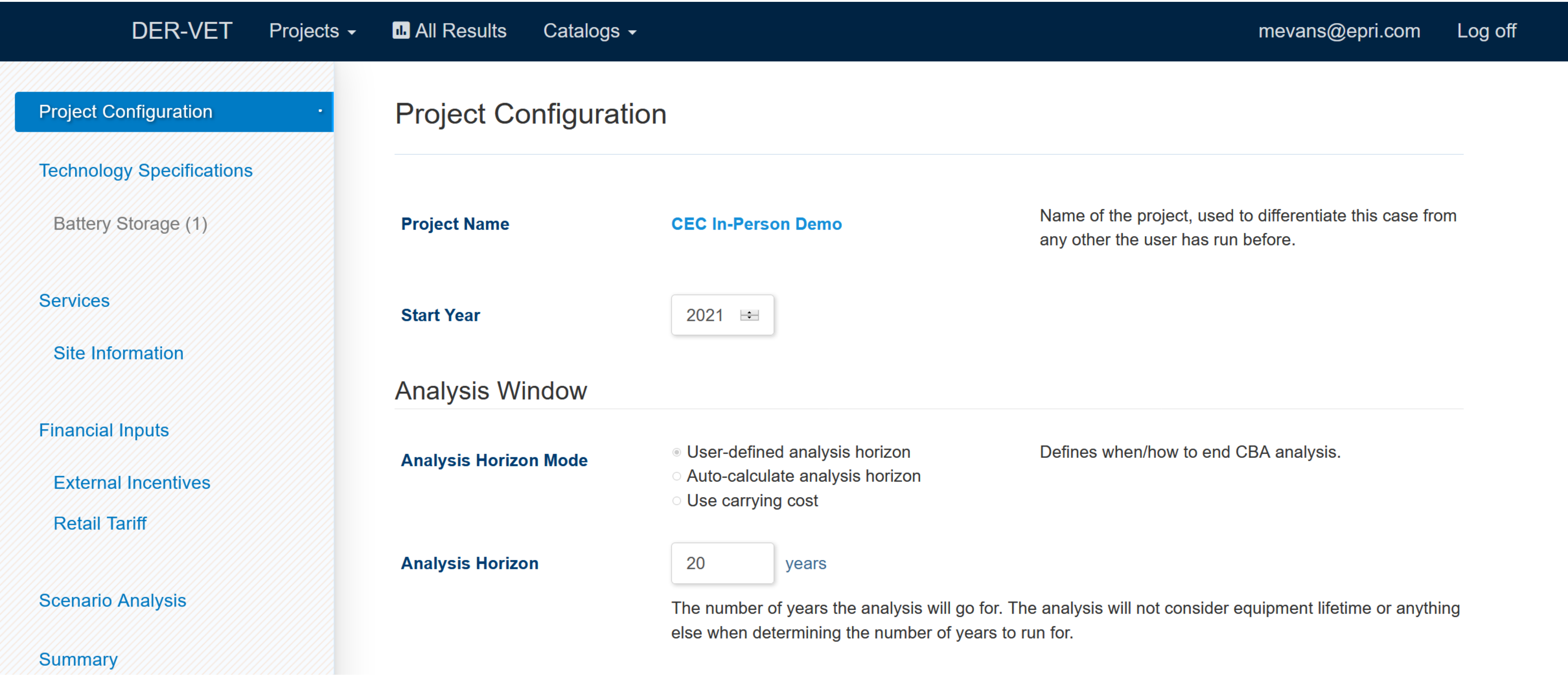
- TOD Energy Charges



Analysis Objectives

- What is the economic optimum battery size?
  - Power capacity
  - Energy capacity
- Given the optimum size/operation, how much critical load could the battery cover?
  - Depends on state of charge and size

Define General Project Parameters



Grid Domain and Ownership Model

Technology Specifications

Battery Storage (1)

Services

Site Information

Financial Inputs

External Incentives

Retail Tariff

Scenario Analysis

Data Year

2021

** Note: Analysis for a scenario where the data year comes before the start year has not yet been implemented. You must enter a data year that is the same or after the project start year.*

DER-VET uses exactly one year of data. If the year this data comes from is different from the year the optimization is run against, it will be escalated from the data year to the optimization year.

Grid Domain

- ◉ Customer
- ○ Distribution
- ○ Transmission
- ○ Generation

Which grid domain the project will be connected to. This limits which services are available.

Ownership

- ◉ Customer
- ○ Utility
- ○ 3rd Party

Who owns the assets.

Physical Location for Tariff and Solar Data

Technology Specifications

Battery Storage (1)

Services

Site Information

Financial Inputs

External Incentives

Retail Tariff

Scenario Analysis

Summary

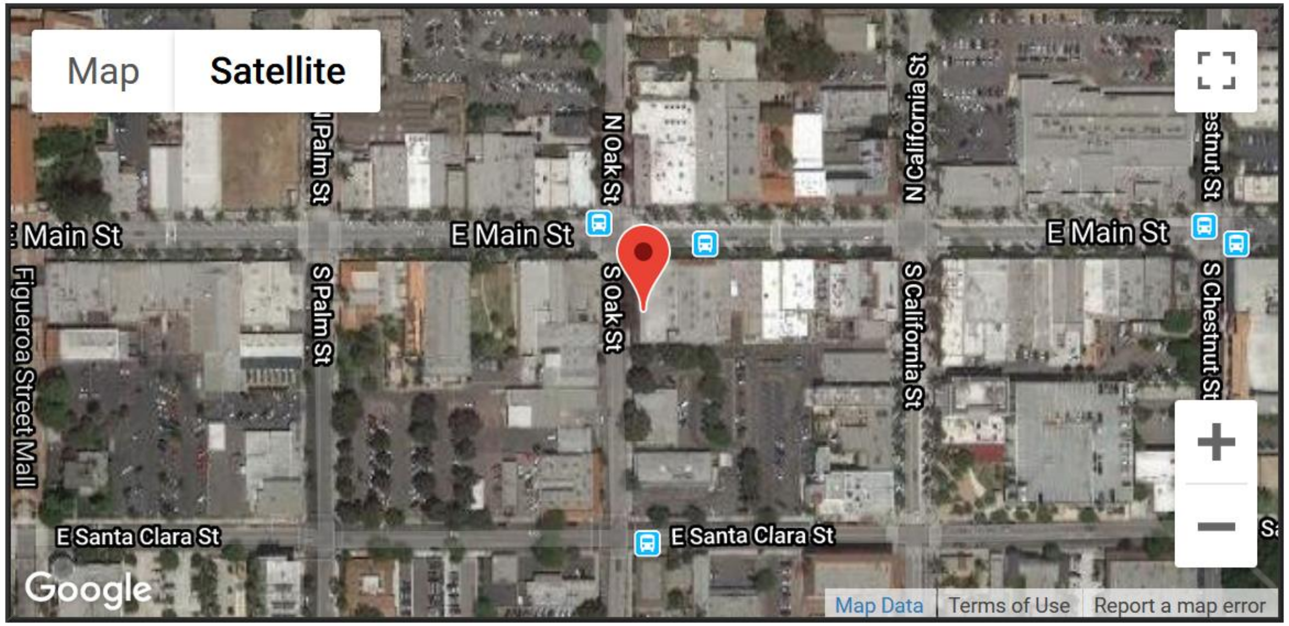
Physical Location: Address for this project [Go]

Enter the address for this project.

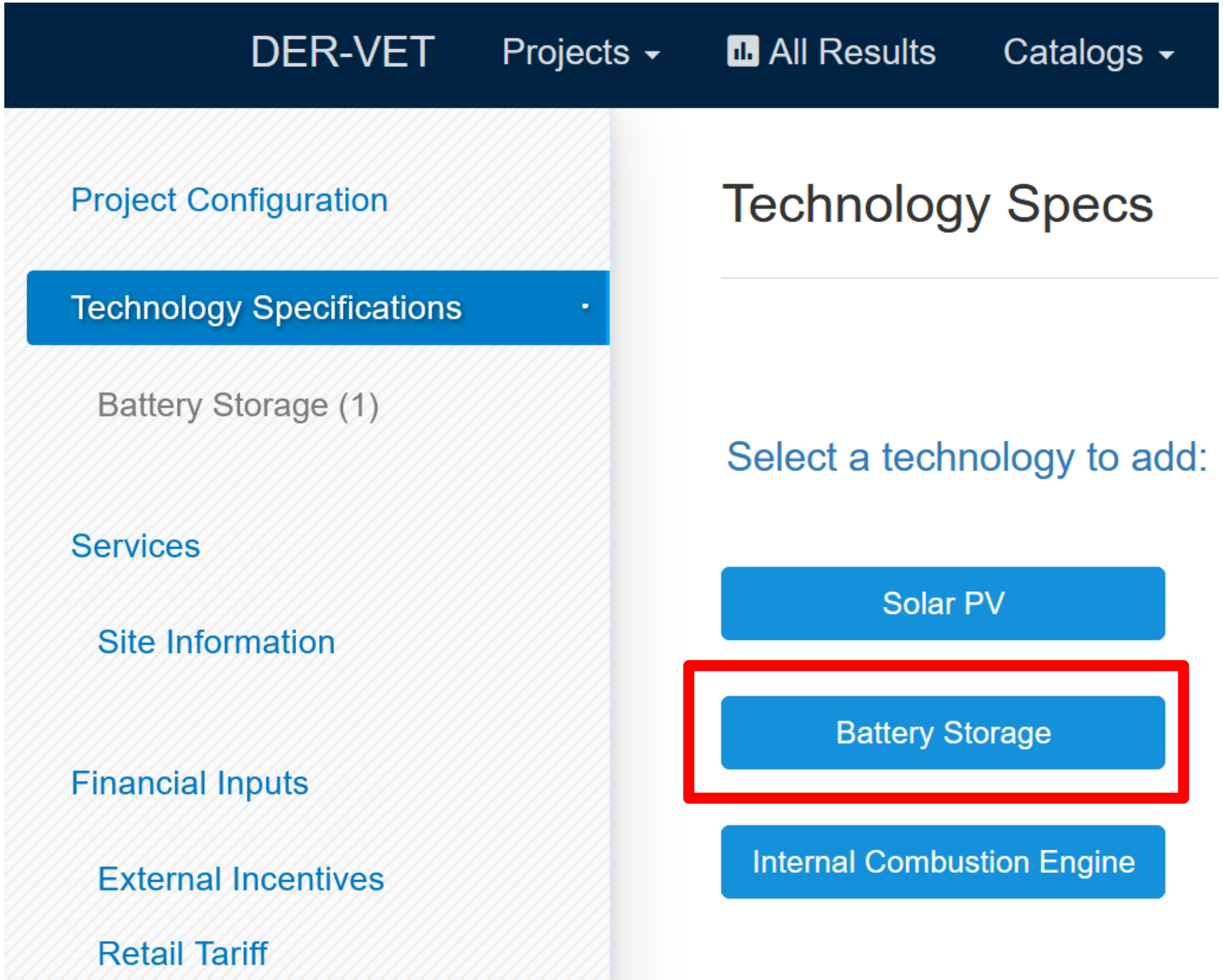
Latitude: 34.280492

Longitude: -119.294520

Locate Current Address



Add a Battery System



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Project Configuration

Technology Specifications

Battery Storage (1)

Services

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Retail Tariff

Scenario Analysis

Summary

Technology Specs: Battery Storage

Battery Catalog

Name Battery

Energy Capacity Sizing ◉ **Have DER-VET size the Energy Capacity** ○ **Known size**

Power Capacity Sizing ◉ **Have DER-VET size the Power Capacity** ○ **Known size**

Roundtrip Efficiency 91.0 %

What is the AC roundtrip efficiency of the storage system? Only this single number is considered - no variable efficiency is modeled.

Target SOC 100.0 %

What state of charge should the battery storage system return to at the end of each optimization window?

Self-Discharge Rate

0.0 %/hour

What is the AC roundtrip efficiency of the storage system? Only this single number is considered - no variable efficiency is modeled.

Limit Daily Cycling

○ Yes ◉ No

Constrain the battery storage system's daily discharge energy. When selected, this input limits the amount of discharge energy a battery can do in any 24-hr period to a maximum of its rated energy capacity * daily cycle limit.

Include Housekeeping Calculations

○ Yes ◉ No

"Include Housekeeping Power" – Apply a constant AC power consumption that does not discharge the battery directly. This is usually associated with HVAC requirements and keeping all equipment on."

Include startup cost in the dispatch optimization?

○ Yes ◉ No

Cost Function

Capital Cost

0 $

What is the capital cost for the storage system?

Capital Cost per kW

800 $/kW

What is the capital cost per kW for the storage discharge power capacity?

Capital Cost per kWh

250 $/kWh

What is the capital cost per kW for the storage energy capacity?

Fixed O&M Costs

0 $/kW-year

What is the cost of fixed operations and maintenance for the battery storage system?

End of Life Expenses ($)

0

How much will it cost to decommission the battery at its end of life? This cost is applied at the end of life of the battery system in nominal dollars.

Construction Date

01 / 01 / 2021

Operation Date

01 / 01 / 2021

MACRS Term

- years

Which MACRS GDS category does the battery storage system fall into?

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- Project Configuration
- Technology Specifications
  - Battery Storage (1)
- Services
  - Site Information
- Financial Inputs
  - External Incentives
  - Retail Tariff
- Scenario Analysis
- Summary

Services

Where do energy prices come from?

◉ **Retail tariff, PPA, or other fixed contract (define energy price structure)**

Will the project be reducing energy charges on a retail electricity bill?

Customer Services

☐ **Reliability/Resilience**

Define a number of hours the site must be capable of covering a grid outage for. DER-VET will size and operate the DERs to guarantee coverage for outages of this duration.

☐ **Backup Power**

Reserve a fixed amount of energy capability in case of an outage. Unlike the reliability service, this will not impact DER sizing and the energy reservation will not depend on the load.

☑ **Retail Demand Charge Reduction**

Will the project be reducing demand charges on a retail electricity bill?

Wholesale Services

There are no wholesale services available because your project does not include a battery or because there are technologies that are not explicitly sized.

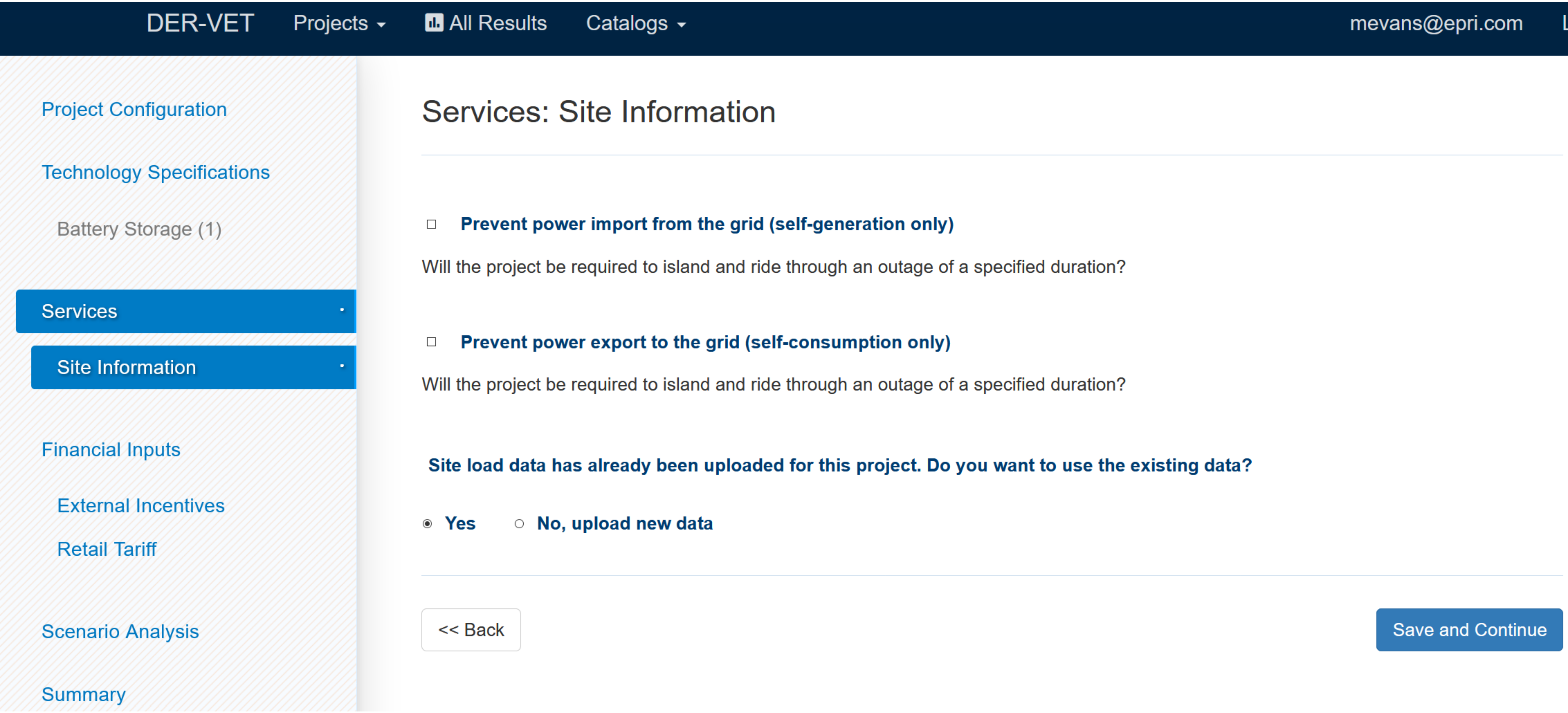
** Note: The Backup Power service has not yet been implemented. You must select at least one objective that is not backup power.*

Other

You cannot define custom storage system settings because your project does not include a battery that is explicitly sized.

<< Back

Save and Continue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Services: Site Information
Prevent power import from the grid (self-generation only)
Will the project be required to island and ride through an outage of a specified duration?
Prevent power export to the grid (self-consumption only)
Will the project be required to island and ride through an outage of a specified duration?
Site load data has already been uploaded for this project. Do you want to use the existing data?
Yes
No, upload new data
<< Back
Save and Continue

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Project Configuration

Technology Specifications

Battery Storage (1)

Services

Site Information

Financial Inputs

External Incentives

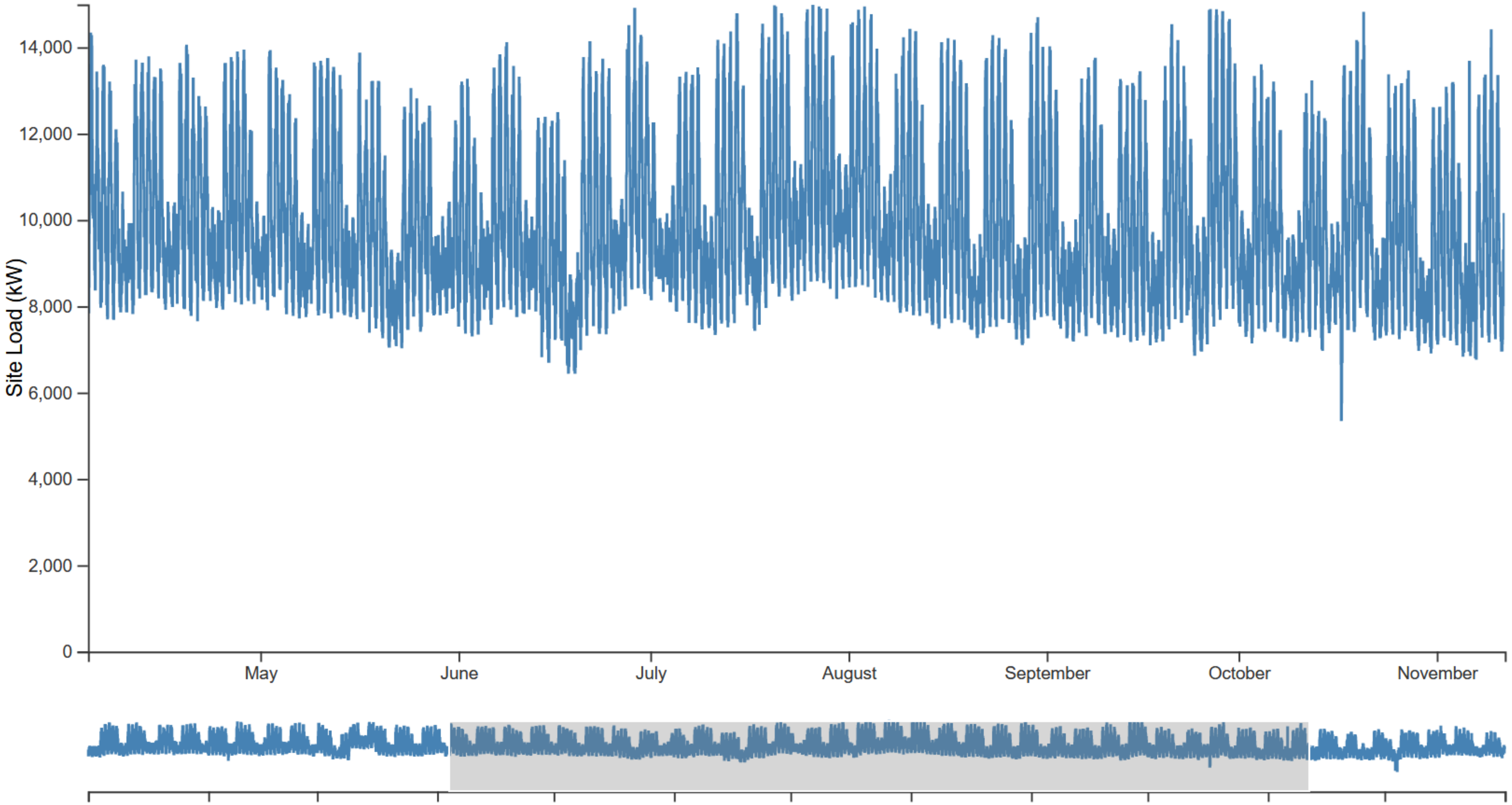
Retail Tariff

Scenario Analysis

Summary

Services: Site Load

Please take a moment to review the Site Load data for your project. Click the **Back** button below to upload different Site Load data, or click **Next** to continue using the below Site Load data.



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Project Configuration

Technology Specifications

Battery Storage (1)

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Retail Tariff

Scenario Analysis

Summary

Financial Inputs

Discount Rate (for discounted cash flow analysis) 6 %

What is the discount rate to be used in the financial analysis? (Note: in the future, we will build calculators for this based on loan terms, return on equity, etc.)

Inflation Rate 2.2 %

What is the inflation rate to be used in the financial analysis?

Federal Tax Rate 0 %

State Tax Rate 0 %

Property Tax Rate 0 %

<< Back

Save and Continue

Project Configuration

Technology Specifications

Battery Storage (1)

Services

Site Information

Financial Inputs

External Incentives

Retail Tariff

Scenario Analysis

Summary

Retail Tariff

Import Tariff Export Tariff OpenEI Tariff

Build a retail tariff definition by: entering the billing periods one at a time; or by importing a tariff file from an export file; or by importing a tariff from OpenEI.

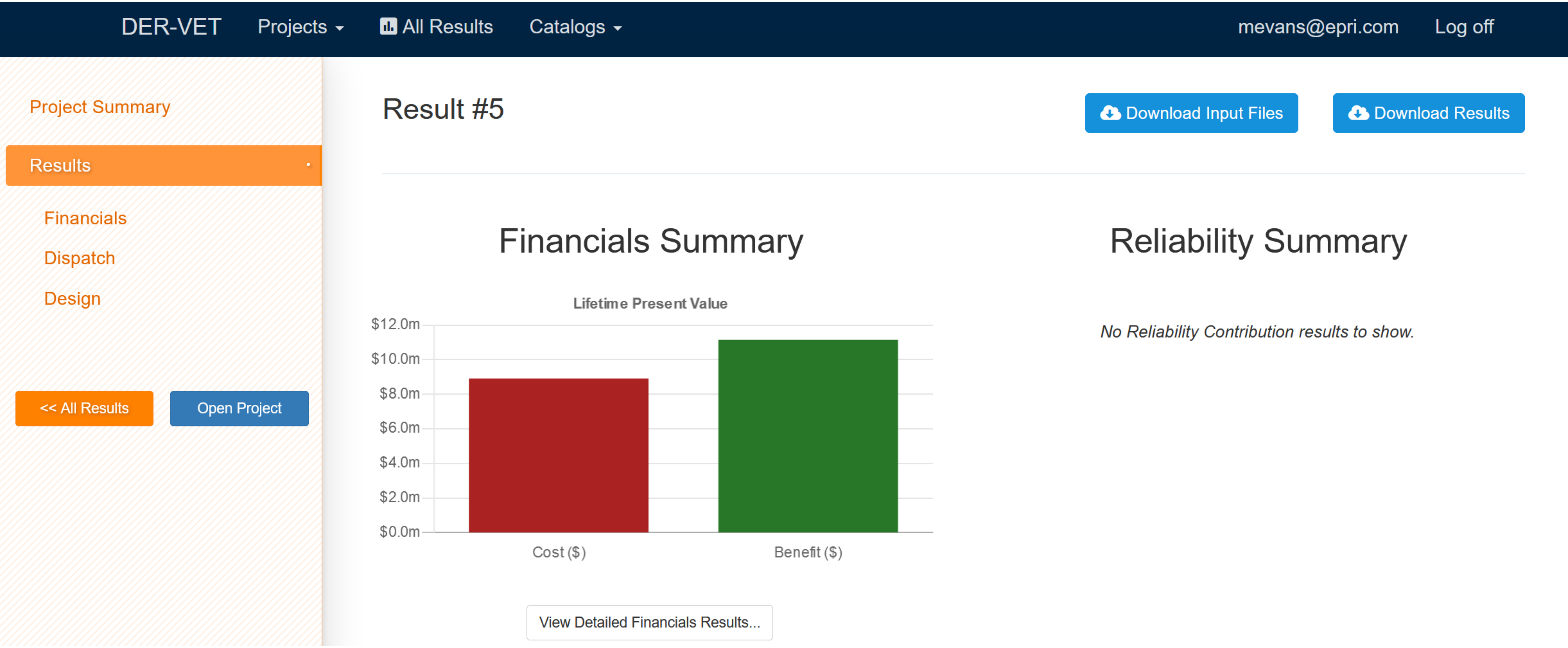
Rate Table | Energy Heatmap | Demand Heatmap

	Name	Period	Coverage	Day of Week	Value	Charge	Remove All
Edit	0 indicates that the period applies to weekends	1	January - May 12:00 AM - 08:00 AM (8 hours)	Weekdays	$0.0676	Energy	Remove
Edit	1 indicates that the period applies to weekdays	2	January - May 08:00 AM - 09:00 PM (13 hours)	Weekdays	$0.0779	Energy	Remove
Edit		3	January - May 09:00 PM - 12:00 AM (3 hours)	Weekdays	$0.0676	Energy	Remove
Edit		4	January - May 12:00 AM - 12:00 AM (24 hours)	Weekends	$0.0676	Energy	Remove
Edit		5	June - September 12:00 AM - 08:00 AM	Weekdays	$0.062	Energy	Remove

Weekdays

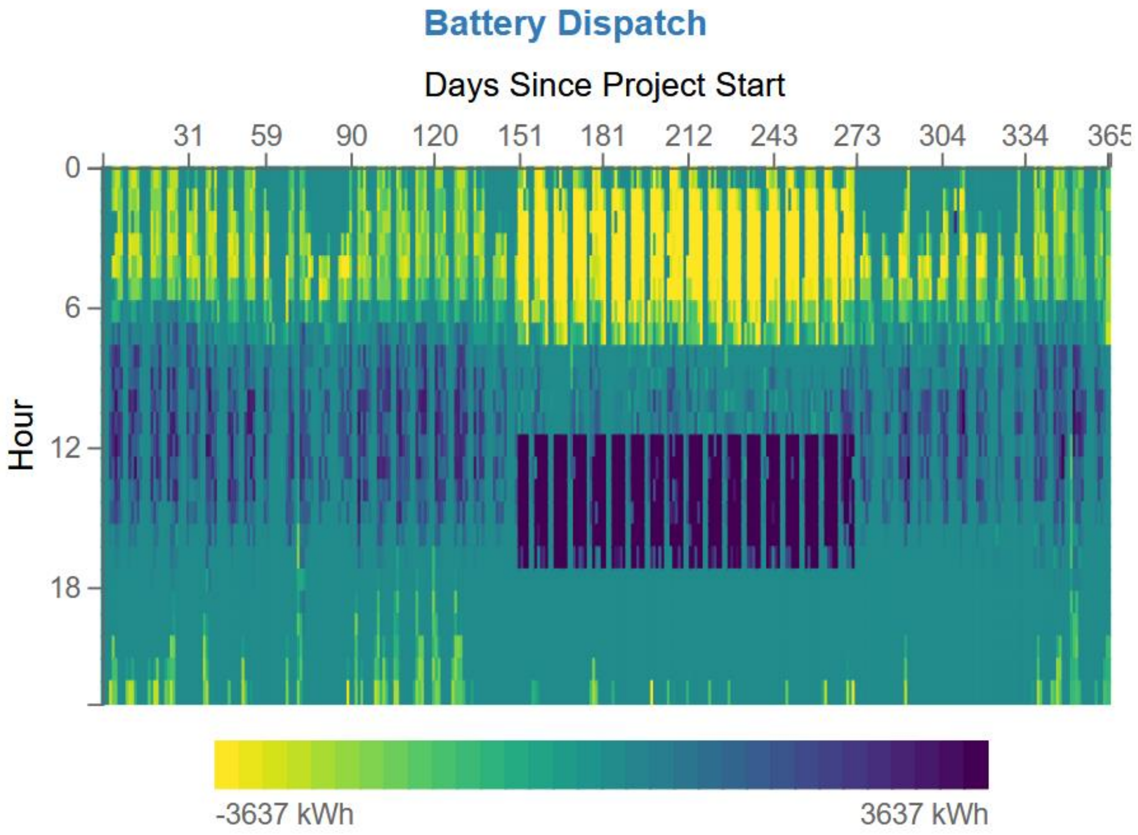
Month	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
January	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
February	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
March	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
April	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
May	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
June	1	1	1	1	1	1	1	1	4	4	4	4	5	5	5	5	5	5	4	4	4	4	4	1
July	1	1	1	1	1	1	1	1	4	4	4	4	5	5	5	5	5	5	4	4	4	4	4	1
August	1	1	1	1	1	1	1	1	4	4	4	4	5	5	5	5	5	5	4	4	4	4	4	1
September	1	1	1	1	1	1	1	1	4	4	4	4	5	5	5	5	5	5	4	4	4	4	4	1
October	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
November	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
December	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2

Results Summary Page

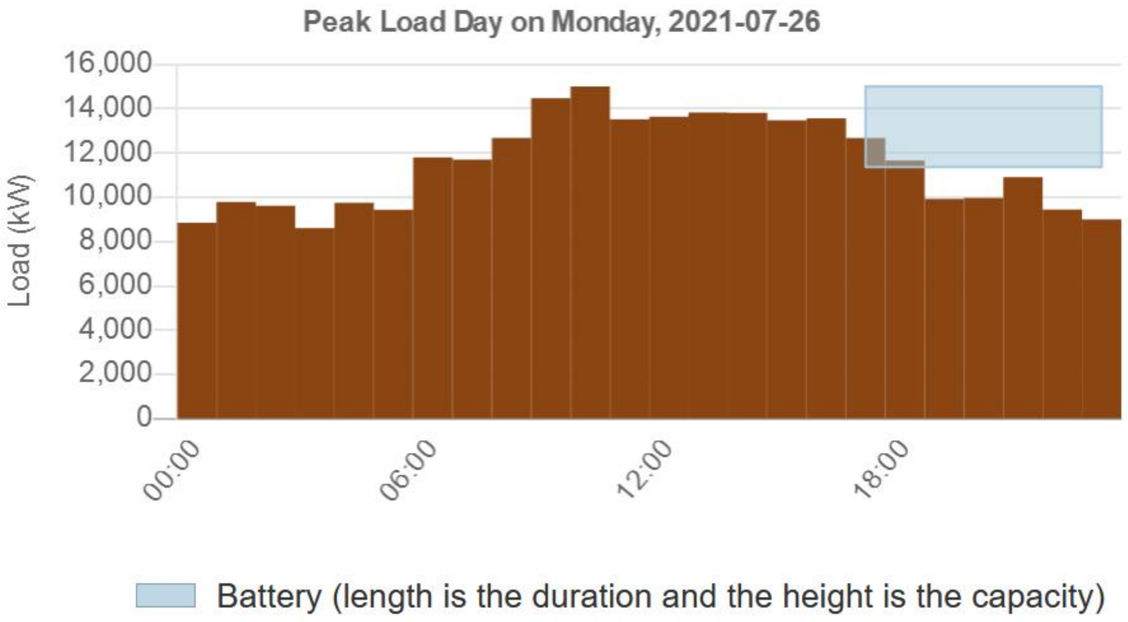


Results Summary Page (Cont)

Dispatch Summary

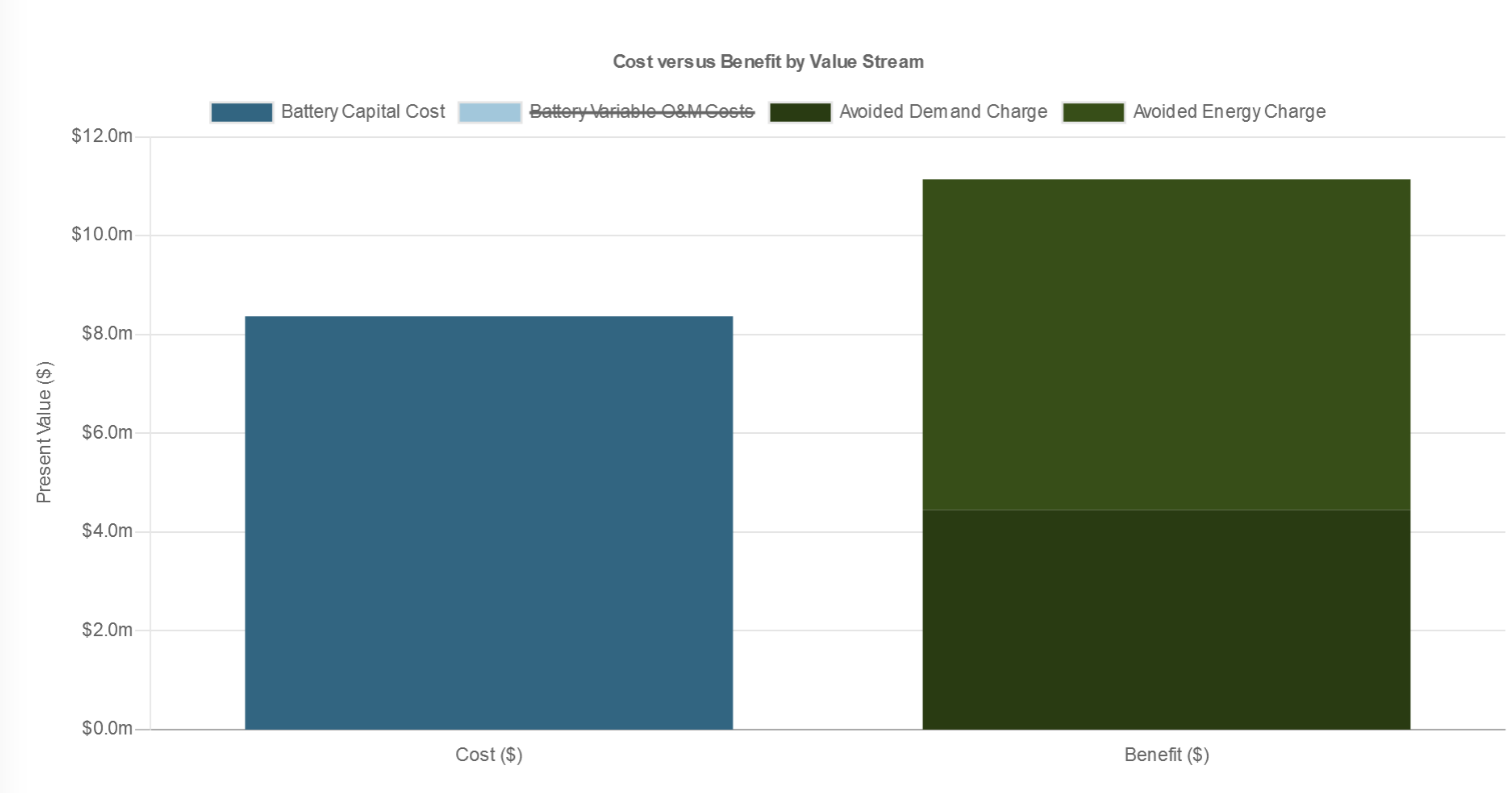


Design Summary



View Detailed Design Results...

Financial Results



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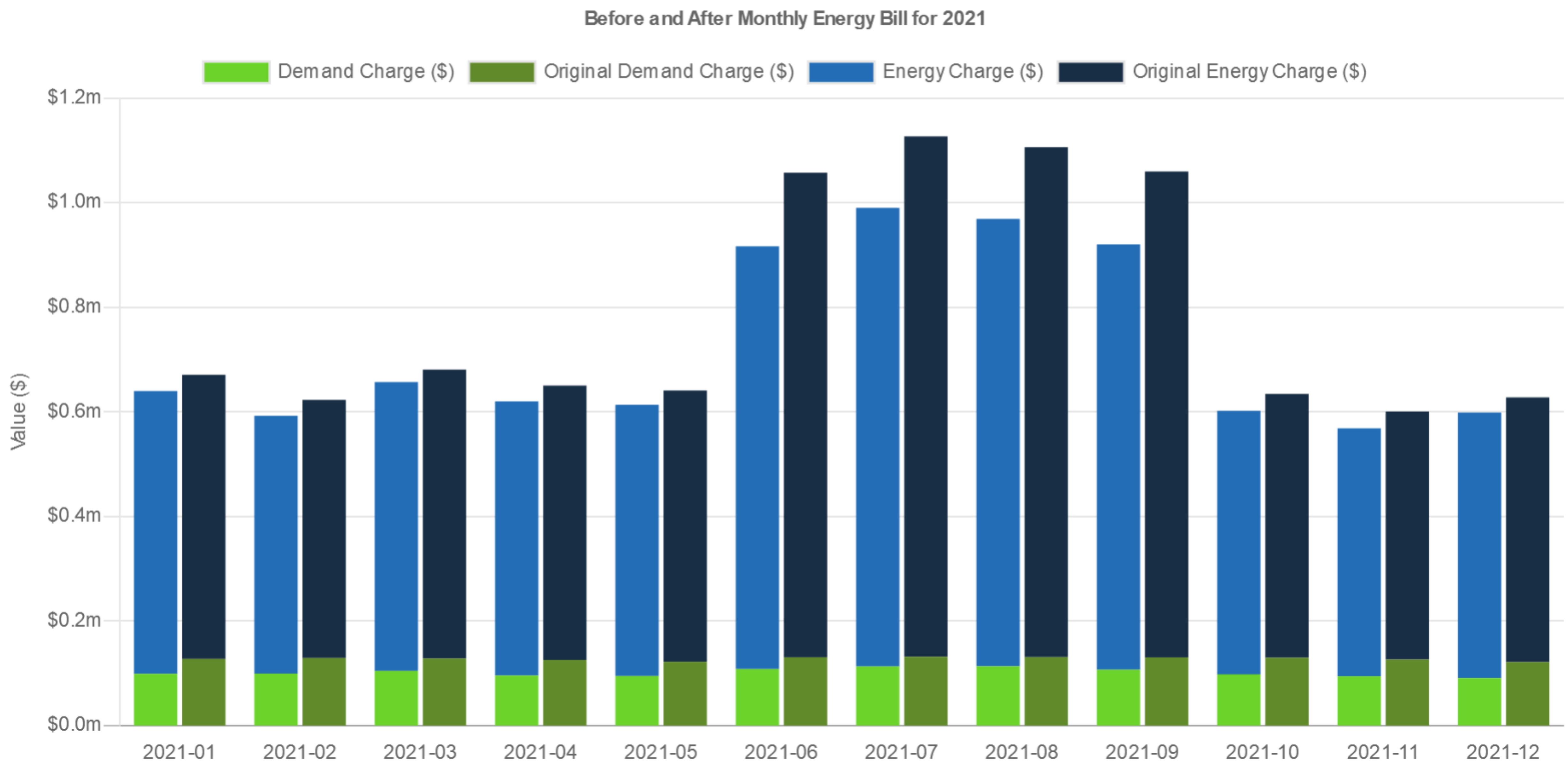
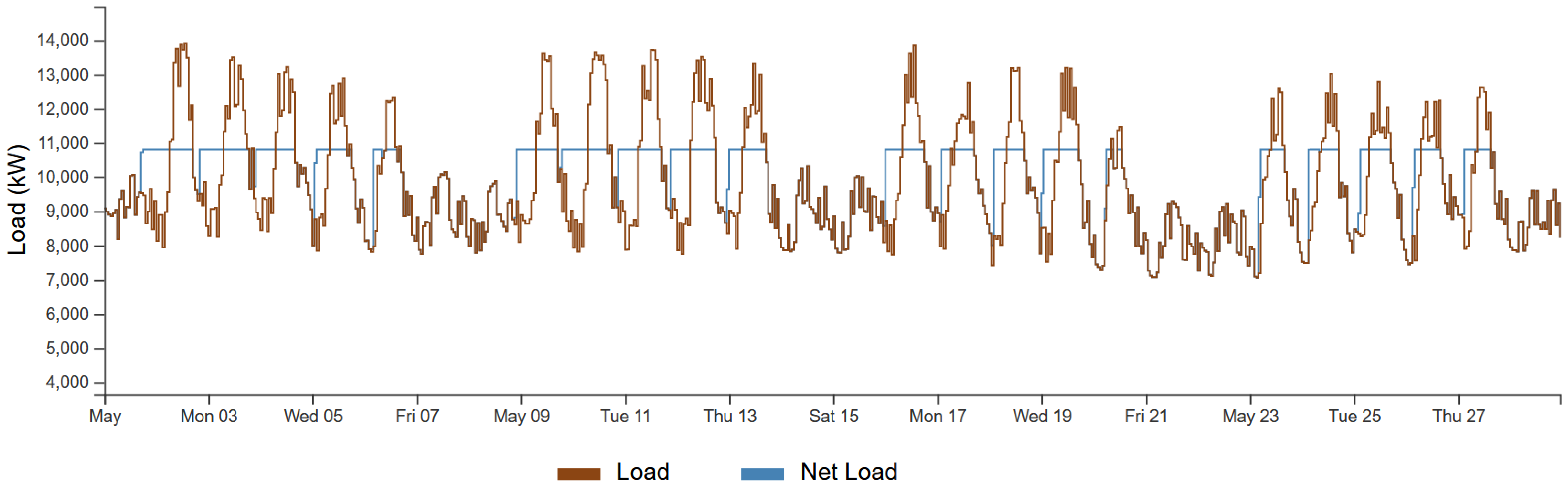

Before and After Monthly Energy Bill for 2021
Demand Charge ($)
Original Demand Charge ($)
Energy Charge ($)
Original Energy Charge ($)
Value ($)
$1.2m
$1.0m
$0.8m
$0.6m
$0.4m
$0.2m
$0.0m
2021-01
2021-02
2021-03
2021-04
2021-05
2021-06
2021-07
2021-08
2021-09
2021-10
2021-11
2021-12

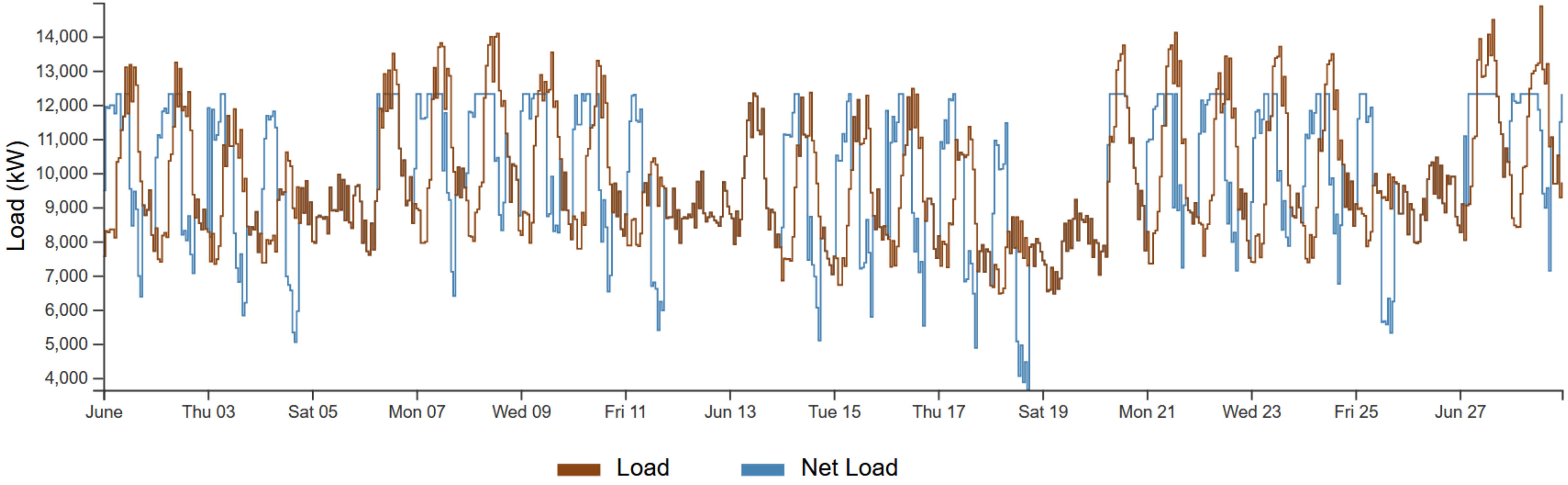
Pro-forma (Nominal Cash Flow)

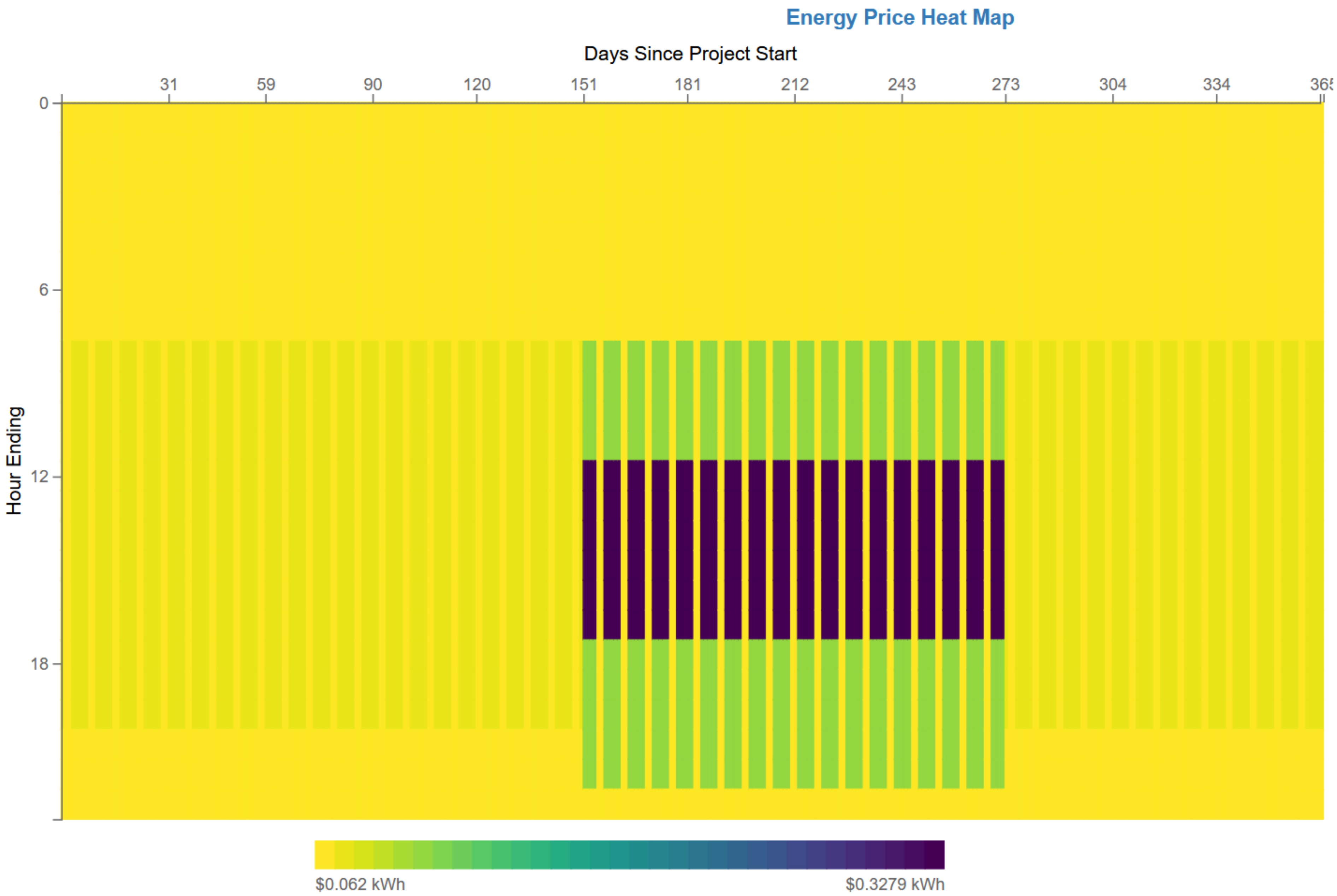
Year	Avoided Demand Charge	Avoided Energy Charge	Battery Capital Cost	Battery Fixed O&M Cost	Battery Variable O&M Costs
CAPEX Year	$0	$0	-$8,365,350	$0	$0
2021	$315,458	$474,998	$0	$0	-$38,479
2022	$322,398	$485,448	$0	$0	-$39,326
2023	$329,491	$496,128	$0	$0	-$40,191
2024	$336,739	$507,043	$0	$0	-$41,075
2025	$344,148	$518,198	$0	$0	-$41,979
2026	$351,719	$529,598	$0	$0	-$42,902
2027	$359,457	$541,249	$0	$0	-$43,846
2028	$367,365	$553,157	$0	$0	-$44,811
2029	$375,447	$565,326	$0	$0	-$45,797
2030	$383,707	$577,763	$0	$0	-$46,804
2031	$392,148	$590,474	$0	$0	-$47,834
2032	$400,775	$603,465	$0	$0	-$48,886

Operational Results (Winter - Mostly Flat Energy Prices)



Operational Results (Summer – Strong TOD Energy Prices)




Energy Price Heat Map
Days Since Project Start
31
59
90
120
151
181
212
243
273
304
334
365
Hour Ending
0
6
12
18
$0.062 kWh
$0.3279 kWh

Size Results

System Name	Energy Rating (kWh)	Charge Rating (kW)	Discharge Rating (kW)	Duration (hours)	Power Capacity (kW)	Quantity
Battery	21,823.0000	3,637.0000	3,637.0000	6.0003	0.0000	1

Rated Power and Energy Cost

Costs for Battery		
$8,365,350.00		Total Cost
$0.00		Fixed Cost
$5,455,750.00		Cost per kWh
=	21,823.0 kWh x $250/kWh	
$2,909,600.00		Cost per kW
=	3,637.0 kW x $800/kW	

Conclusions

- The maximum demand charge savings for a 3,637 kW battery would be
  $8.77/kW * 3,637 kW * 12 mo = **$382,757/year**
- Given the load and battery's energy capacity, this system could optimally achieve **$315,548/year**
- A real system would likely actually achieve less than this depending on the quality of its control or real-world performance.

Conclusions

- Optimal energy charge savings: **$474,998** per year
  - 20 years of consistent performance
  - Optimal result for 1 year does not consider degradation
  - Actual operation should be more conservative with the battery and result in lower energy charge savings.

Conclusions - Reliability

- Critical load > economically-optimal battery power capacity