U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Audits and Energy Efficiency in Support of Resilience

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FEMP
Federal Energy Management Program

Speakers and Agenda

Alicen Kandt, National Renewable Energy Laboratory (NREL)
Senior Engineer
Moderator
Speaker - Overview of Energy Efficiency (EE)+Resilience Nexus

Emma Elgqvist, NREL
Engineer
Speaker - REopt Lite

Tony Karwoski, Redhorse Corporation
REM
Speaker - Case Study

Alex Young, NREL
Energy Resilience Analyst
Speaker - Technical Resilience Navigator

Introduction

Alicen Kandt, NREL

Drivers for Conducting Audits

An audit is an evaluation of a facility to identify and assess energy and water efficiency opportunities and improvements.

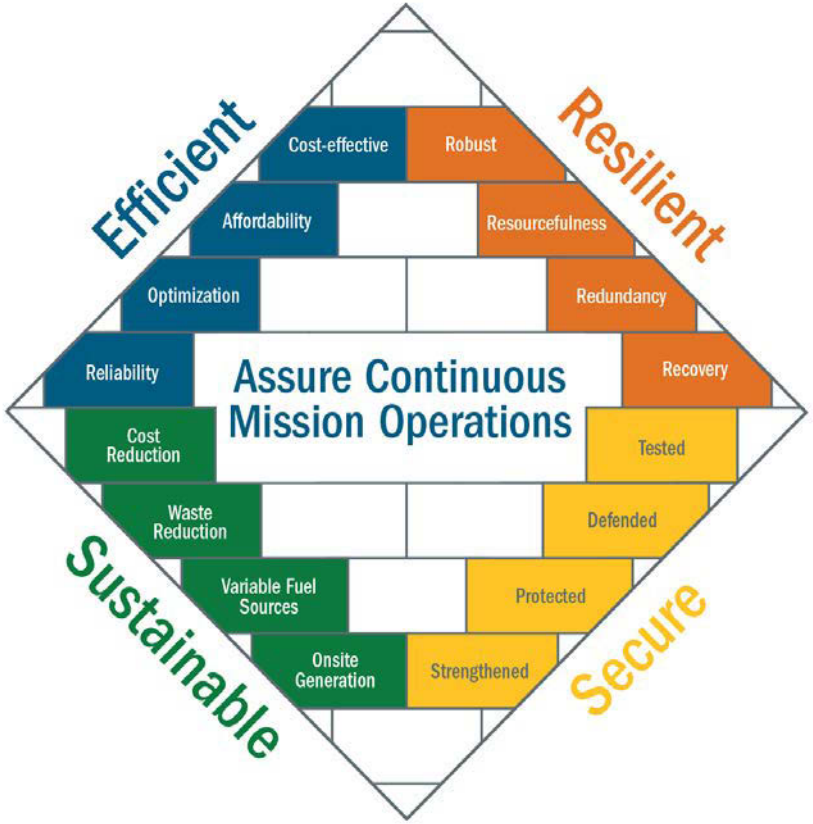
Federal agencies conduct audits for a multitude of reasons, including:

- To satisfy the Energy Independence and Security Act of 2007 (EISA) Section 432 evaluation requirement;
- To develop energy conservation projects such as Energy Savings Performance Contracts (ESPCs) or Utility Energy Services Contracts (UESCs);
- To lower the amount of expenditures for utility bills;
- To improve a facility's energy intensity; and
- To improve the resilience of a facility.

Efficiency Supports Resilience

Audit-related resilience benefits:

- Reducing on-site energy and water use directly results in a reduction in backup generation needs and associated costs for the backup generation assets.
- If the backup generation assets are non-renewable, such as a diesel generator, a reduction in energy load and generation capacity yields reductions in fuel use and vulnerabilities associated with fuel resupply.
- Audits can identify operations and maintenance (O&M) and security issues which can improve system reliability leading into enhanced resilience.



Related Resources

Several existing resources document the synergies between audit and resilience planning activities:

- Better Buildings Solution Center Efficiency-Resilience Nexus Resources https://betterbuildingssolutioncenter.energy.gov/resilience
- Rocky Mountain Institute's article, "A Resilience Strategy Based on Energy Efficiency Delivers Five Core Values" https://rmi.org/a-resilience-strategy-based-on-energy-efficiency-delivers-five-core-values/
- REopt Lite Study Models Resilience Scenarios Before and After Energy Efficiency Measures, Illustrates Potential Cost Savings https://reopt.nrel.gov/projects/case-study-wip.html

Case Study

Tony Karwoski, Redhorse Corporation

Demand Response

Aggregators with DLA contracts:

Viridity Energy

Converge

EnelX formerly EnerNoc

Voltus

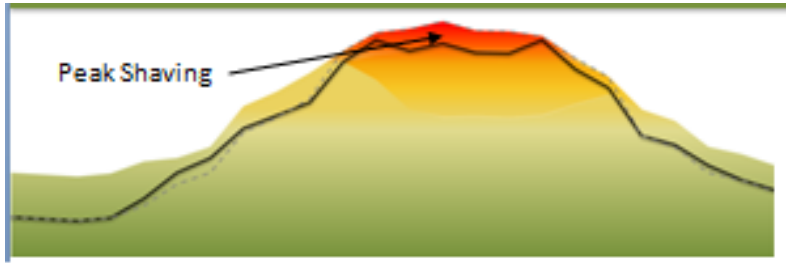
(Many others)

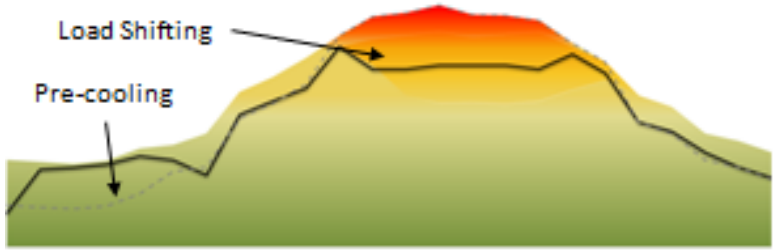
What does an aggregator do?

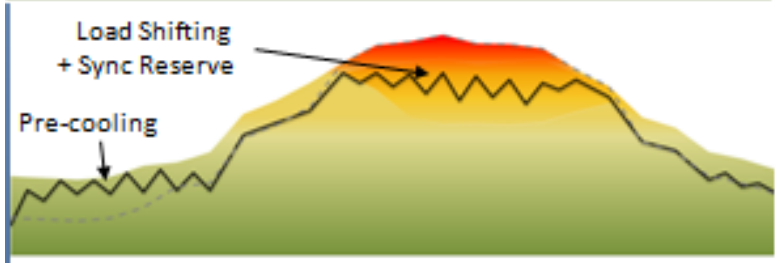
How do they improve your resilience posture?

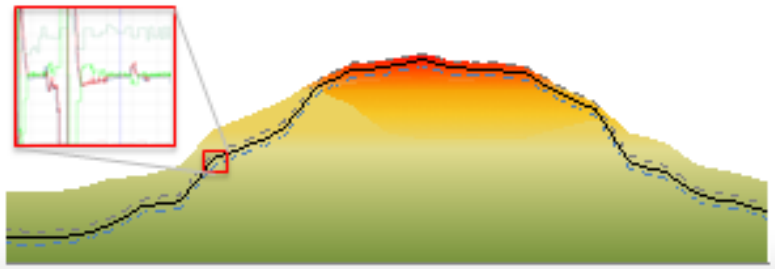
Why does it matter?

Synchronized Reserve Comparison to Other Programs









Capacity Programs

- Low frequency, mandatory response
- A reactive way to earn additional revenue

Economic Programs

- High frequency, voluntary response
- A proactive way to earn additional revenue

Synchronized Reserve

- Higher frequency, voluntary participation, mandatory response
- Requires automated response due to short notice times and duration
- Paid to be "on-call"

Regulation

- Highest frequency & payments, voluntary participation
- Inject into or pull power from the grid in small increments, following a 2-second signal
- Requires automated response, often performed by batteries or VFDs

Resilience Benefits

- Advance notice of extreme weather
- Advance notice of electric grid disruption
- Monthly payment sent directly to electric bill
- Advance funding for system upgrades
- National Operations Center (NOC) reviews your energy profile, provides data and services

Example: 1,500-kWh reduction = $54,000 for ELRP and
$73,500 for Synchronous Reserve

REopt Lite

Emma Elgqvist, NREL

https://reopt.nrel.gov/tool

Will Distributed Energy Resources (DERs) Work for Your Site?

RE Resource

Technology Costs & Incentives

Resilience Goals

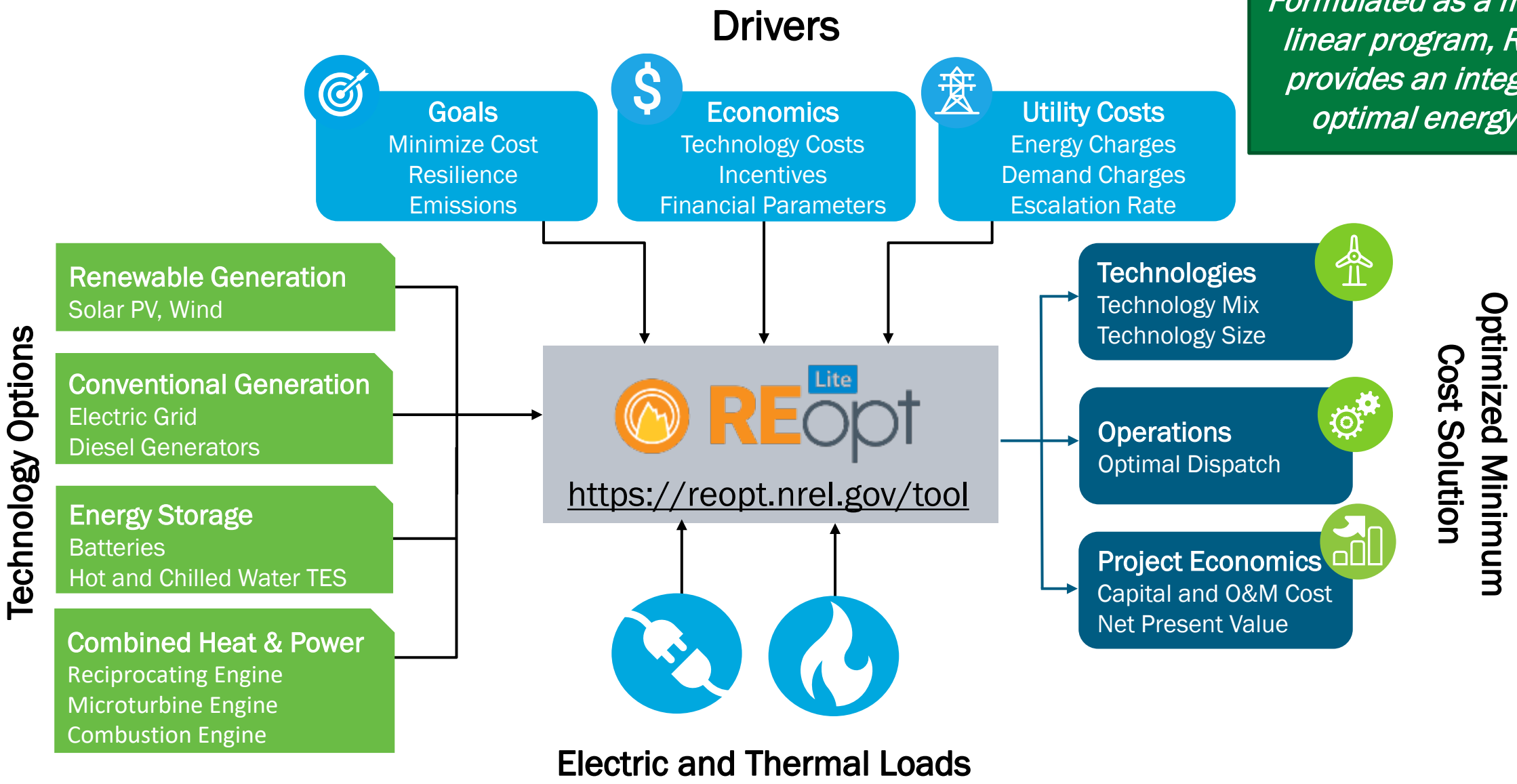
Utility Cost & Consumption

Financial Parameters

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

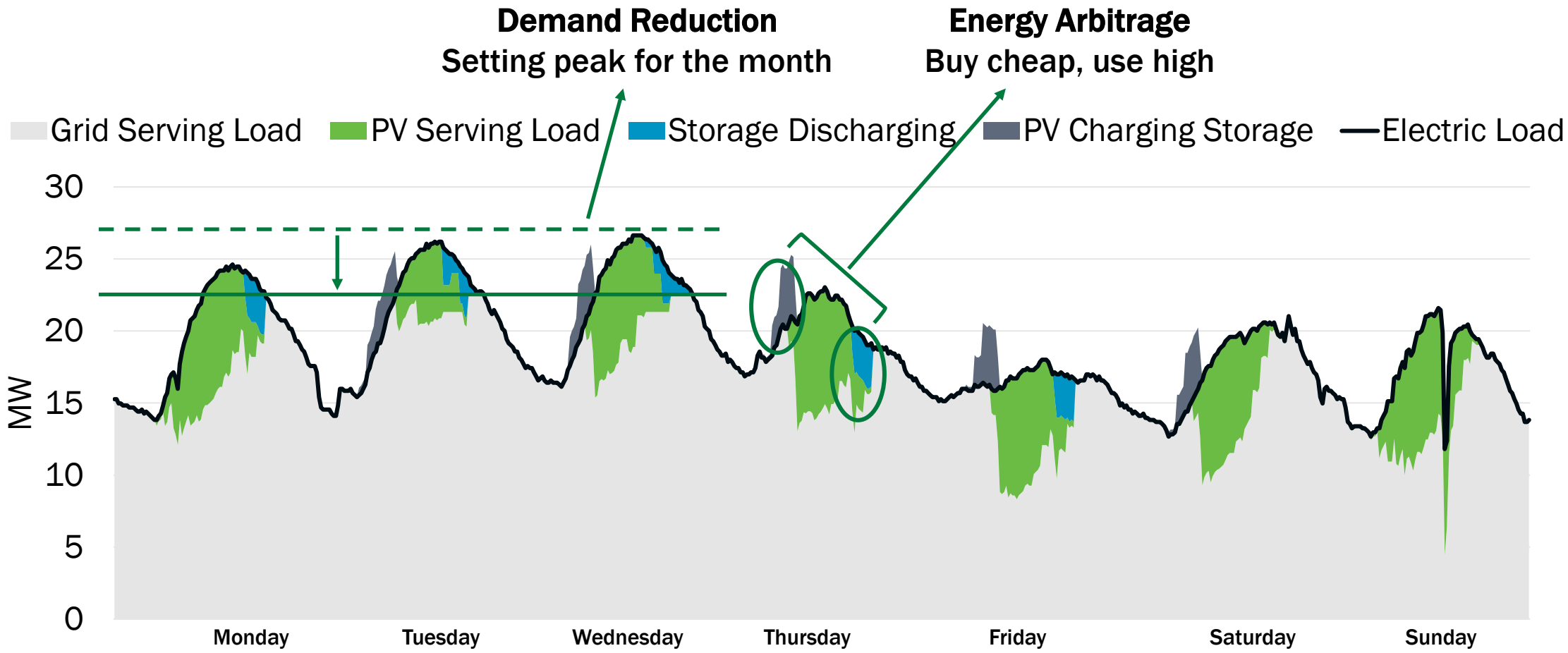
REopt Lite: Free Web Tool to Optimize Economic and Resilience Benefits of DERs

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



How Does REopt Lite Work?

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

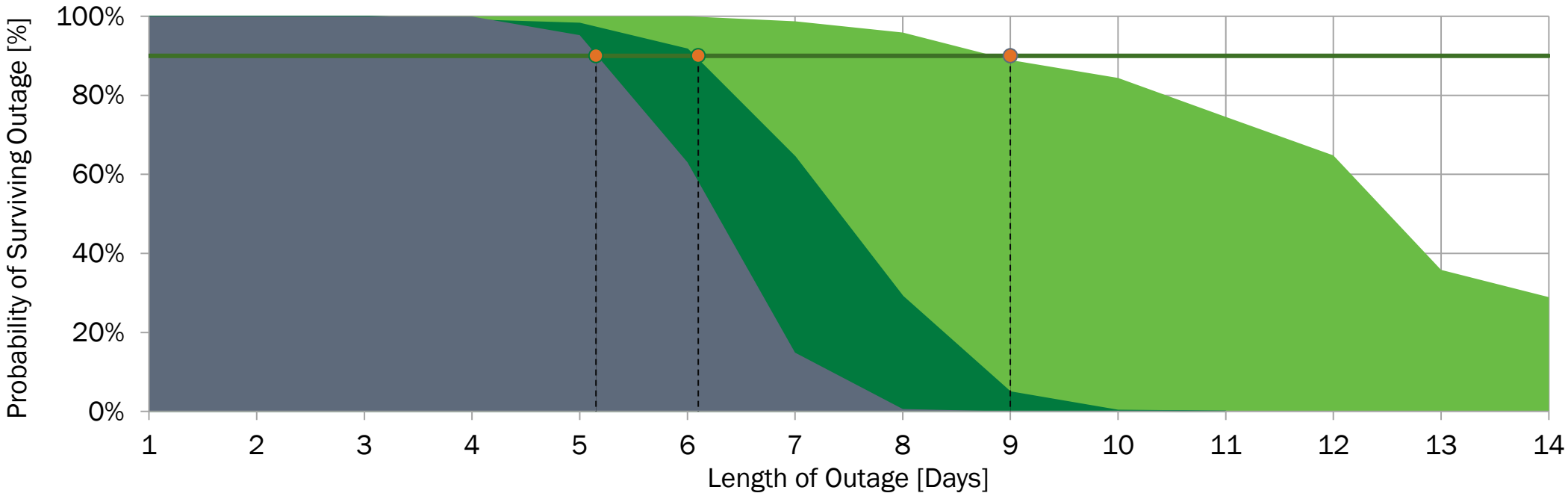


Example of optimal dispatch of solar photovoltaics (PV) and battery energy storage systems (BESS)

How Does REopt Lite Work for Resilience?

REopt Lite evaluates thousands of random grid outages to estimate hours survived and impact on life cycle cost. It quantifies the economic and resilience benefit of DERs by comparing the number of hours the site could survive with different technology combinations.

	Generator	Solar PV	Storage	Life Cycle Cost	Outage
1. Base case	2.5 MW	-	-	$20 million	5 days
2. Lowest cost solution	2.5 MW	625 kW	175 kWh	$18.5 million	6 days
3. Proposed system	2.5 MW	2 MW	500 kWh	$19.9 million	9 days

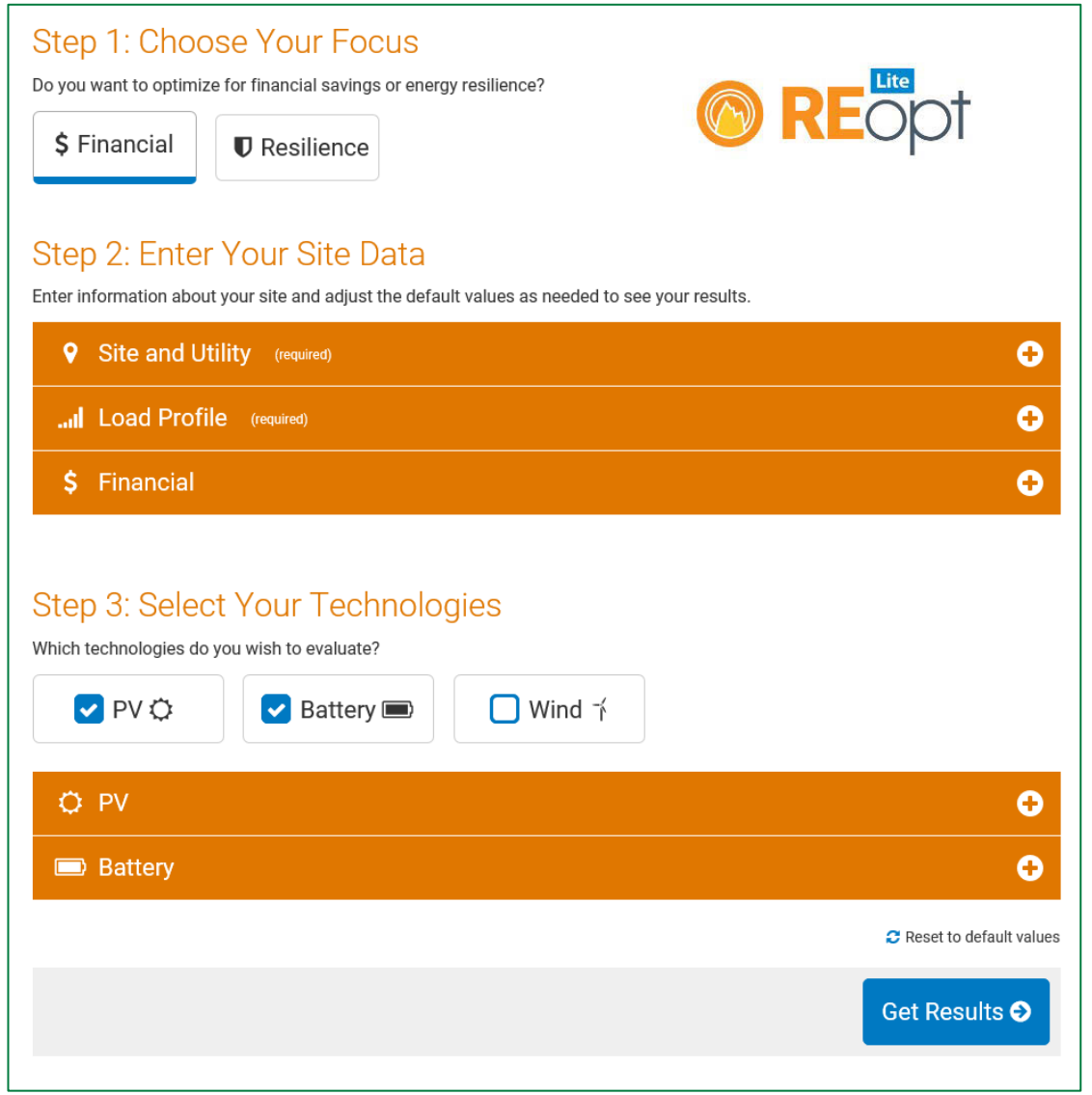


REopt Lite User Interface

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 backup generators, to sustain critical load during grid outages.

Access REopt Lite at reopt.nrel.gov/tool



REopt Lite Key Outputs

Results for Your Site

New Evaluation

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

REopt Lite

Back

Your recommended solar installation size

3,885 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

276 kW
battery power

598 kWh
battery capacity

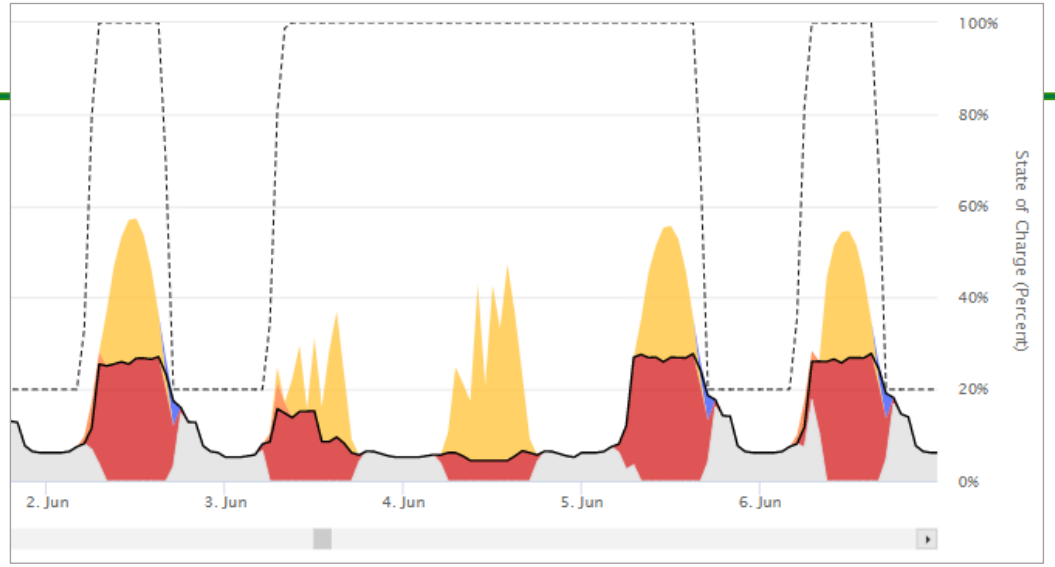
This system size minimizes the life cycle cost of energy at your site. The battery power and capacity are optimized for economic performance.

Your potential life cycle savings (20 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.

$1,972,493

System Size and Net Present Value



Hourly Dispatch

	Business As Usual	Financial	Difference
System Size, Energy Production, and System Cost			
PV Size	0 kW	113 kW	113 kW
Annualized PV Energy Production	0 kWh	132,000 kWh	132,000 kWh
Battery Power	0 kW	0 kW	0 kW
Battery Capacity	0 kWh	0 kWh	0 kWh
Net CAPEX + Replacement + O&M	$0	$133,318	$133,318
Energy Supplied From Grid in Year 1	132,000 kWh	65,384 kWh	66,616 kWh
Year 1 Utility Cost — Before Tax			
Utility Energy Cost	$18,112	-$404	$18,515
Utility Demand Cost	$0	$0	$0
Utility Fixed Cost	$0	$0	$0
Utility Minimum Cost Adder	$0	$0	$0

Detailed Financial Outputs

Analysis Enabled by API

- **The REopt Lite API enables national-scale analysis of storage economics and impacts on adoption/deployment.**
- **Analysis questions include:**
  - Where in the country is storage (and PV) currently cost-effective?
  - At what capital cost is storage adopted across the United States?
  - How do varying utility rates, escalation rates, and incentive structures impact storage profitability?
  - How (and where) can stationary storage support DC-fast-charging electric vehicle economics and deployment?

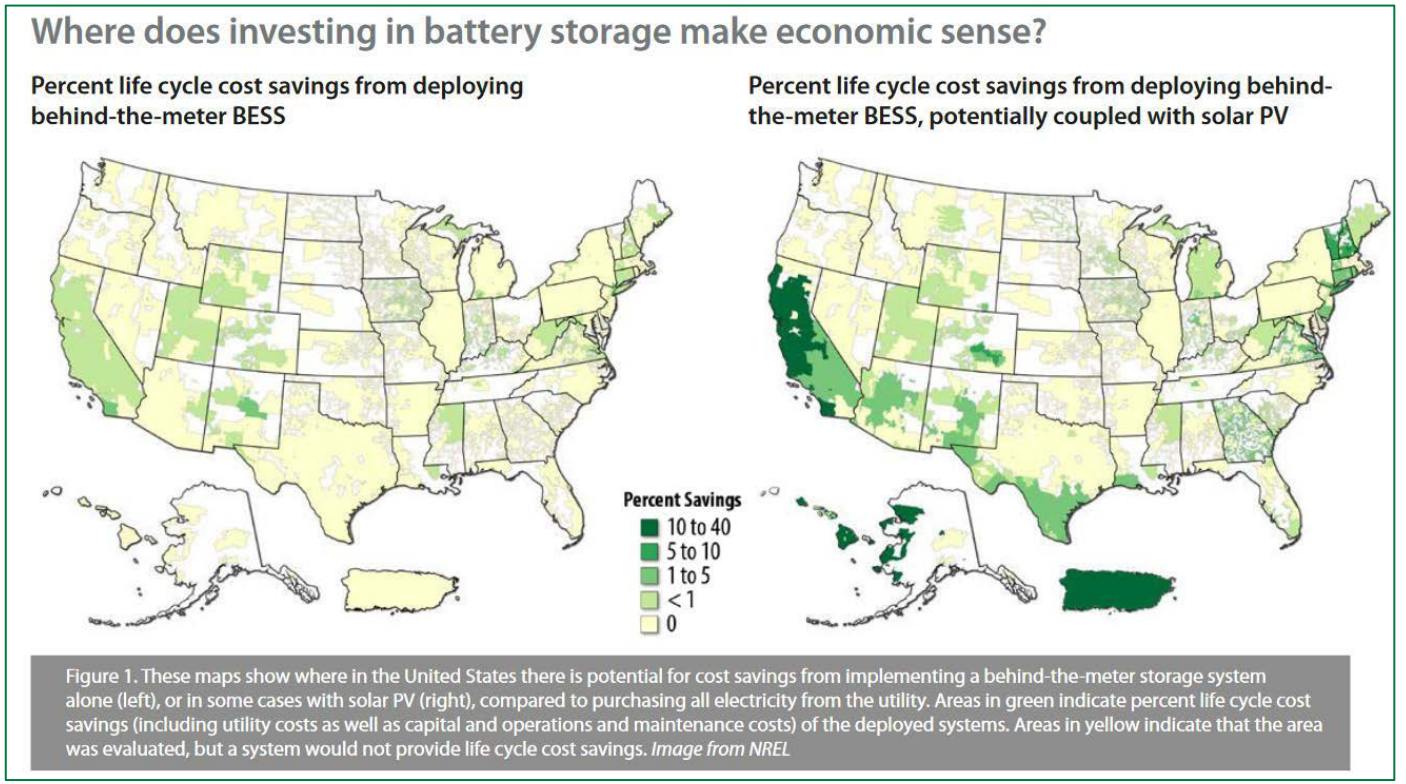
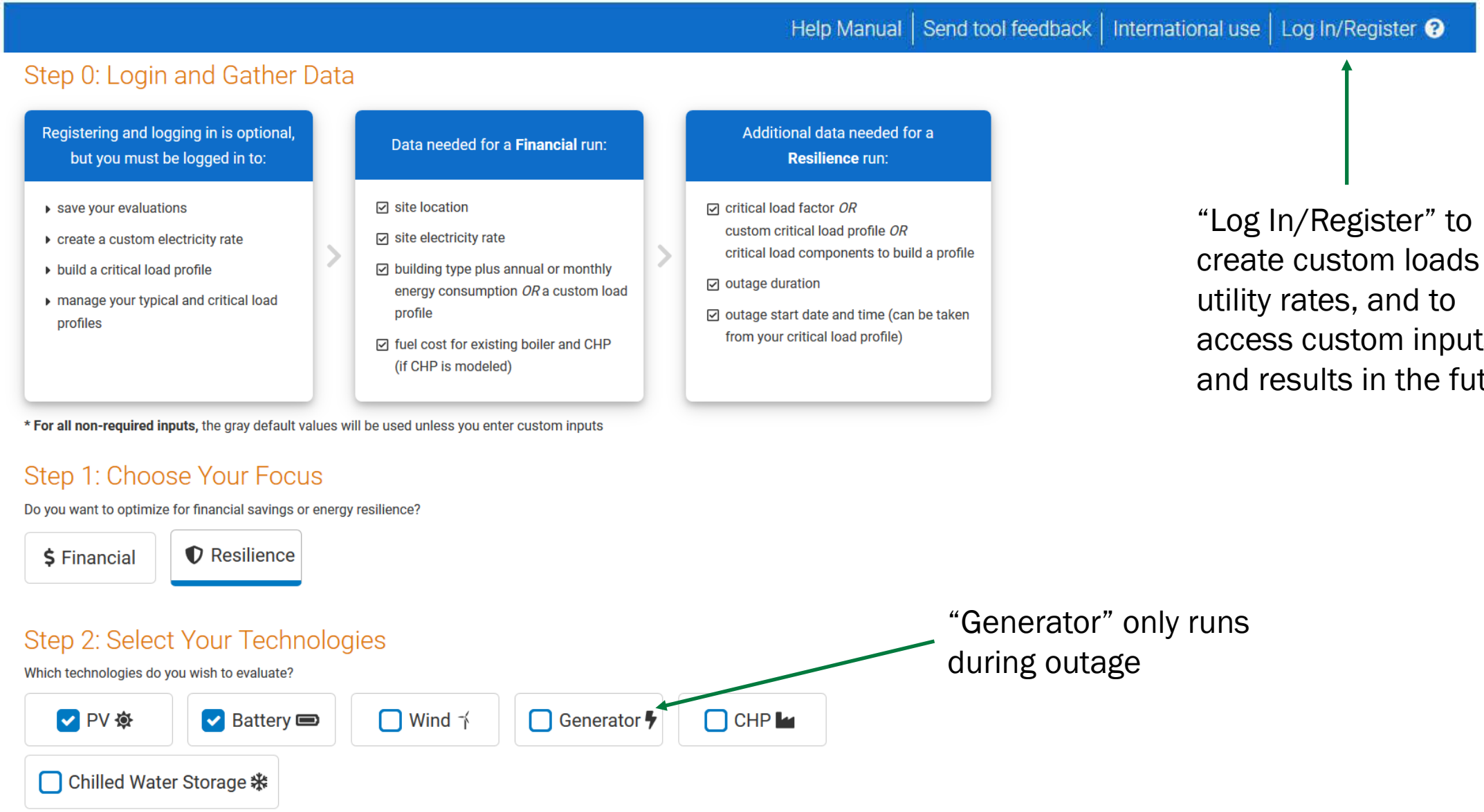


Figure 1. These maps show where in the United States there is potential for cost savings from implementing a behind-the-meter storage system alone (left), or in some cases with solar PV (right), compared to purchasing all electricity from the utility. Areas in green indicate percent life cycle cost savings (including utility costs as well as capital and operations and maintenance costs) of the deployed systems. Areas in yellow indicate that the area was evaluated, but a system would not provide life cycle cost savings. *Image from NREL*

WHERE AND WHEN DOES SOLAR PLUS STORAGE MAKE SENSE FOR COMMERCIAL BUILDINGS? NREL Researchers Make Their "BESSt" Guess Using REopt Lite Modeling Tool
https://www.nrel.gov/docs/fy21osti/77112.pdf

REopt Lite Web Tool

Select Focus and Technologies

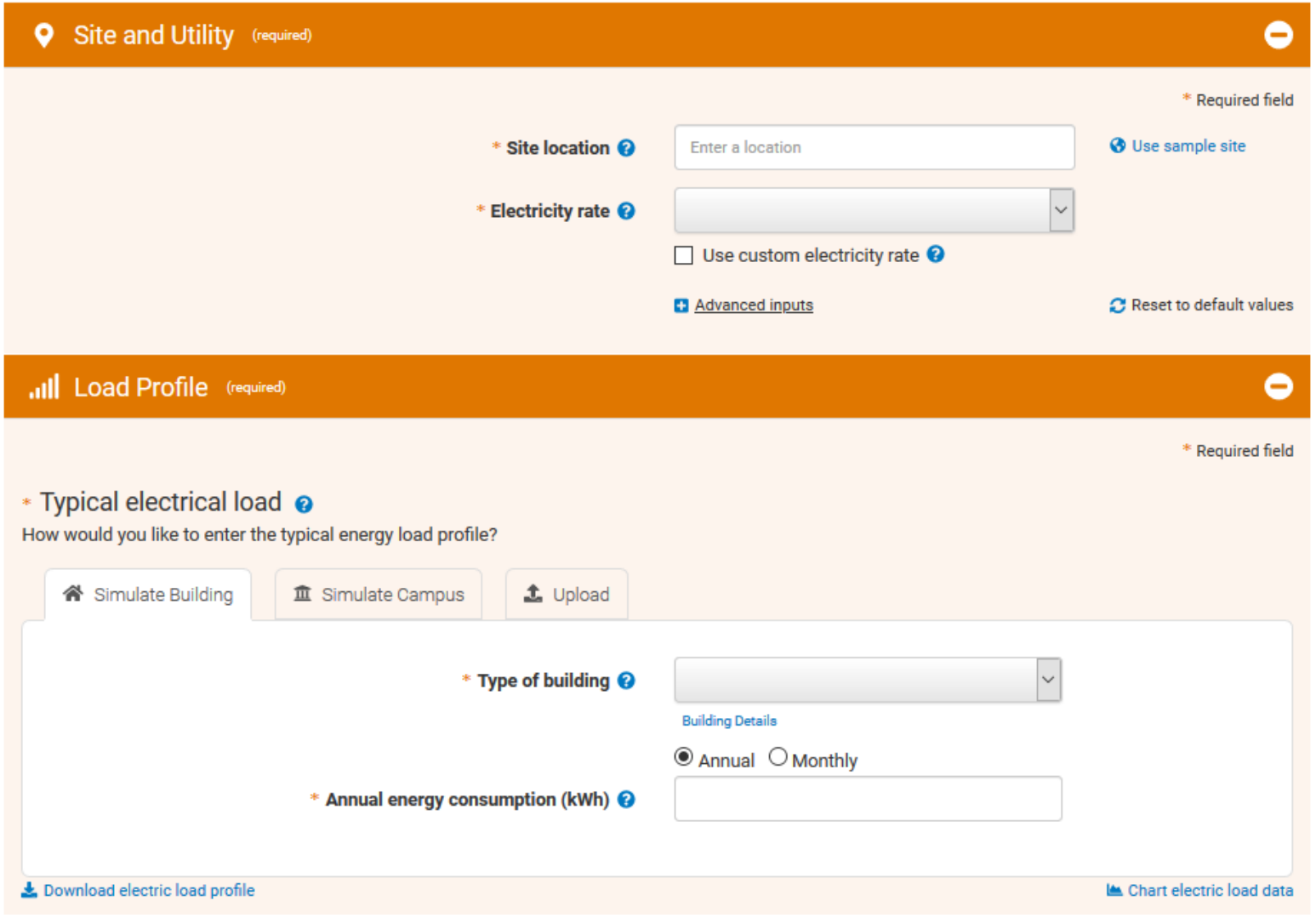


"Log In/Register" to create custom loads and utility rates, and to access custom inputs and results in the future.

"Generator" only runs during outage

Site Information

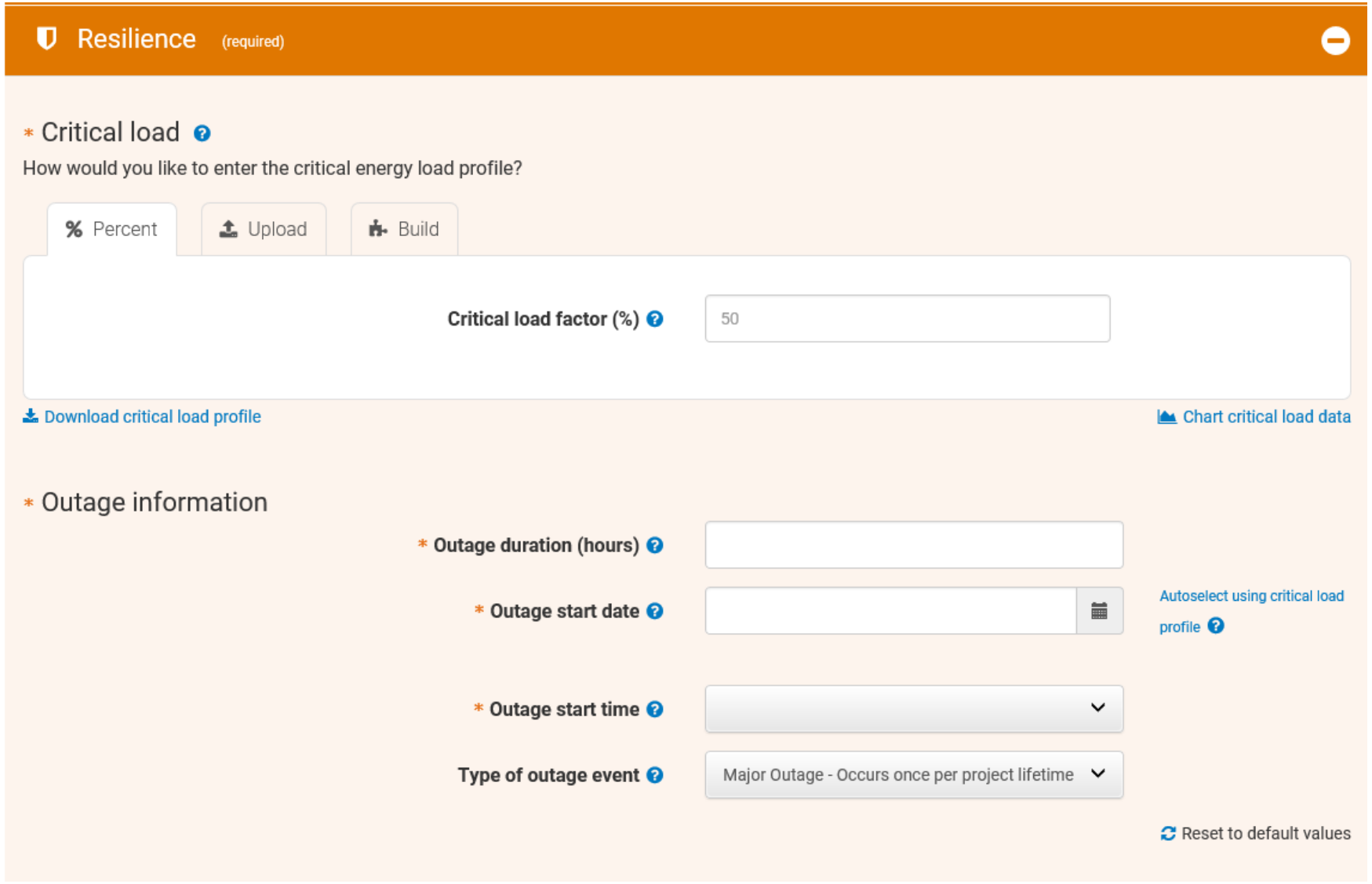
Step 3: Enter Your Site Data



Location and utility rate

Typical load profile – simulated, campus, or actual

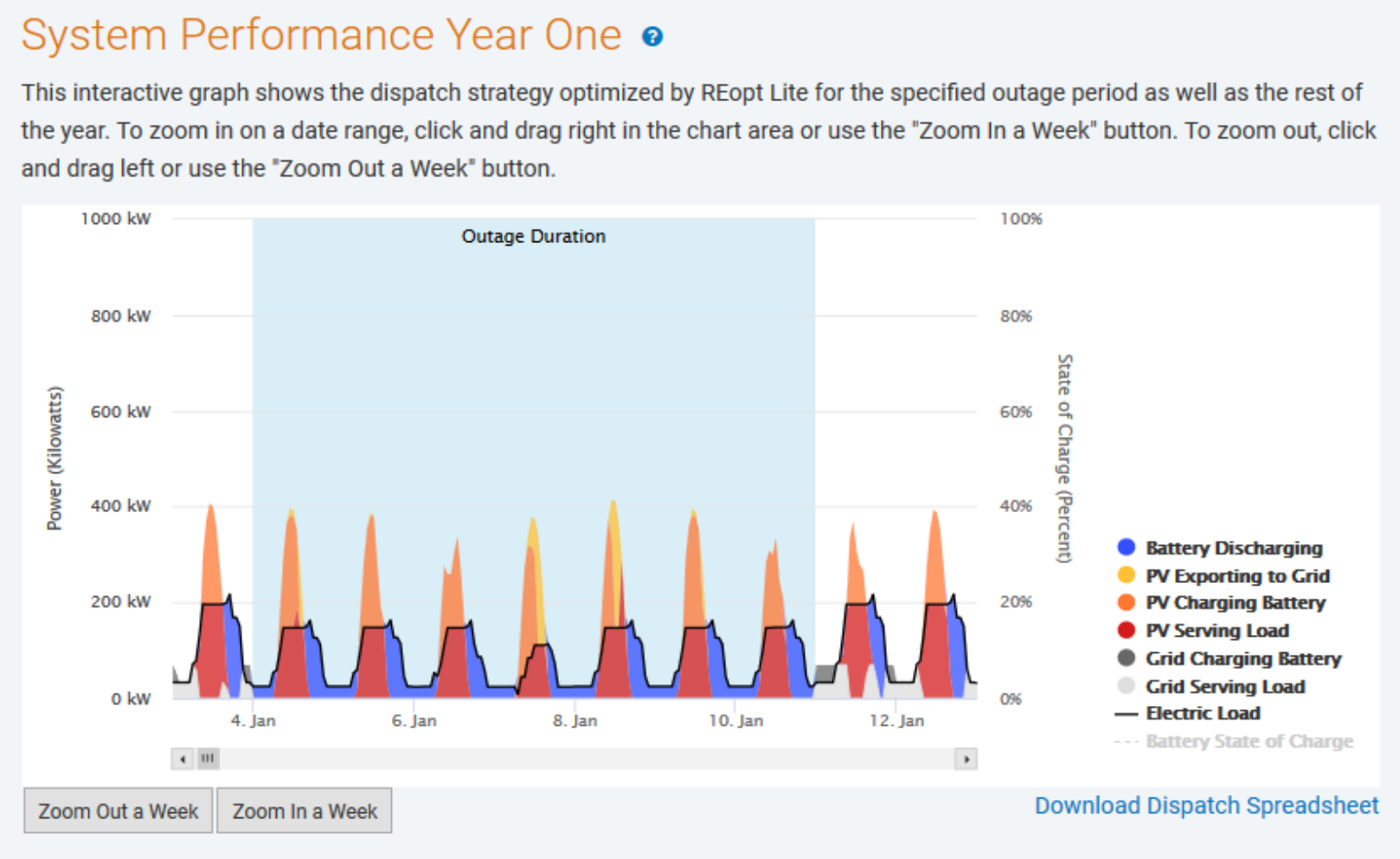
Critical Load and Outage Start Date and Duration



What load needs to be met during the outage?

When is the outage expected to occur, and how long will it last?

Resilience Output: Dispatch During Outage

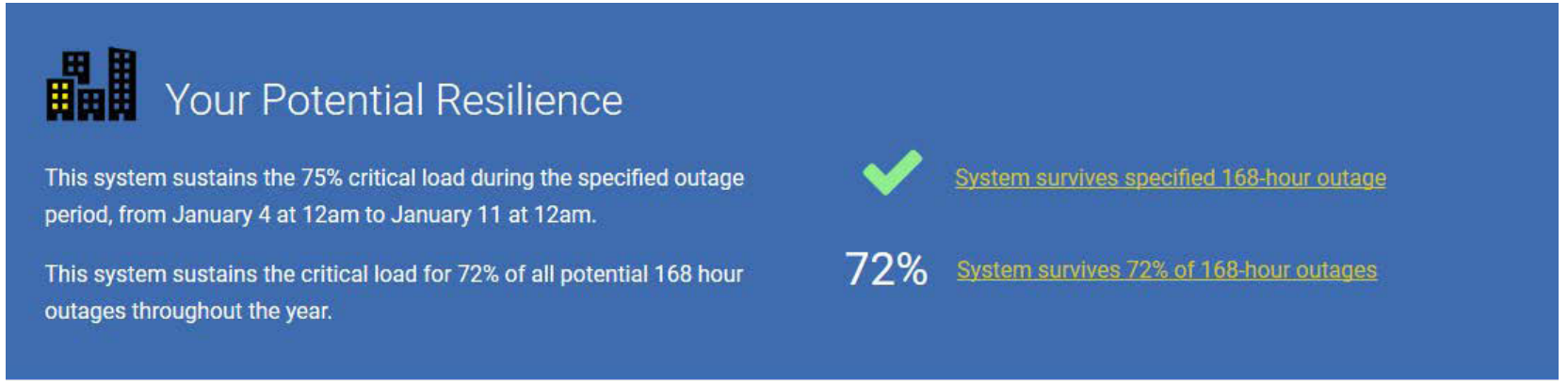


The specified outage event is highlighted in blue (lower load).

The load is met exclusively by the PV and storage that REopt Lite selected.

As soon as the outage ends, the site goes back to purchasing grid electricity.

Resilience Output: System Sized to Meet Outage



REopt Lite optimizes system size and dispatch to survive a specified outage.

REopt Lite simulates outages of varying lengths throughout the year.

Resources

REopt Lite (tool and help manual): reopt.nrel.gov/tool

REopt Website (analysis services and case studies): reopt.nrel.gov/

Send tool feedback and ask a question: reopt@nrel.gov

Technical Resilience Navigator (TRN)

Alex Young, NREL

https://trn.pnnl.gov/

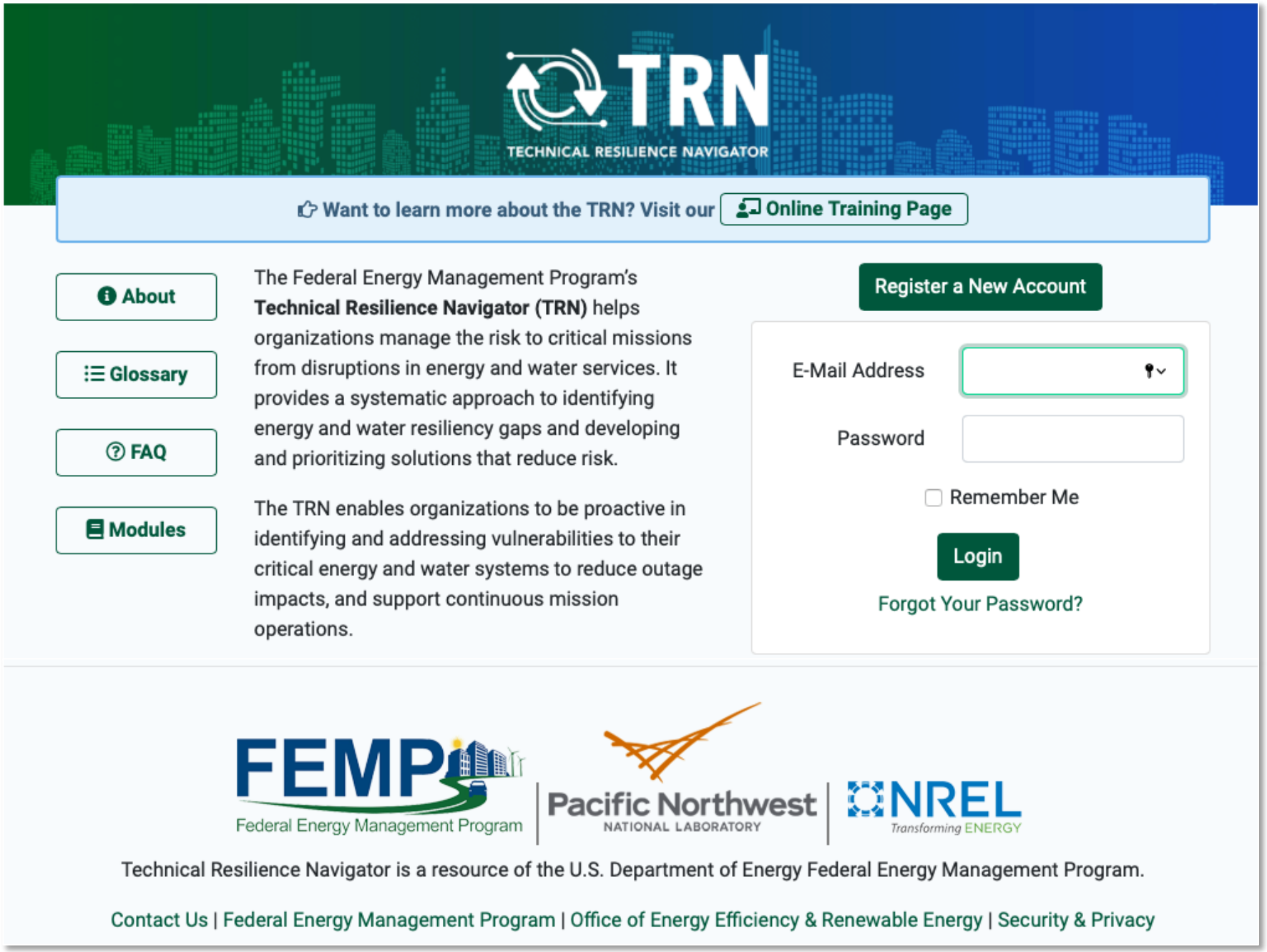
Technical Resilience Navigator

The Federal Energy Management Program's Technical Resilience Navigator (TRN) helps users assess risk to a site's critical functions from energy and water utility disruptions and prioritize solutions that reduce risk.

- **Manage the risk to critical missions** from disruptions in energy and water services.
- **Identify energy and water resiliency gaps** and **develop and prioritize solutions** that reduce risk and address other site priorities.
- Proactively **discover and address vulnerabilities** to critical energy and water systems to reduce outage impacts and support continuous mission operations.

Technical Resilience Navigator

- ✓ Federally focused but not federally exclusive
- ✓ Speaks to all levels of resilience planning expertise
- ✓ Modular approach to resilience planning
- ✓ Specific energy and water lens
- ✓ Flexible method for relevant assessments
- ✓ Web-based application with multiple utilization levels



Web-Based Application Features

- Create (or join) a resilience framework.
- Build and manage a resilience team.
- Track progress as actions are completed.
- Choose the level of data sensitivity that's right for your site.

https://trn.pnnl.gov/

TRN Site-Level Planning and Baseline Development

Site-Level Planning Actions

Establish Resilience Team and Engage Stakeholders

Collect and Review Relevant Information

Define Site-Level Resilience Priorities and Scope and Boundaries

Identify Critical Functions

Recognize Resilience Gaps

Baseline Development Actions

Collect and Review Baseline Documentation

Establish Energy and Water Requirements

Establish Baseline Conditions of Energy and Water Systems

Site-Level Planning Outcomes

Resilience Planning Team

Site Resilience Priorities

List of Critical Functions

Criticality of Functions

Resilience Gap Identification

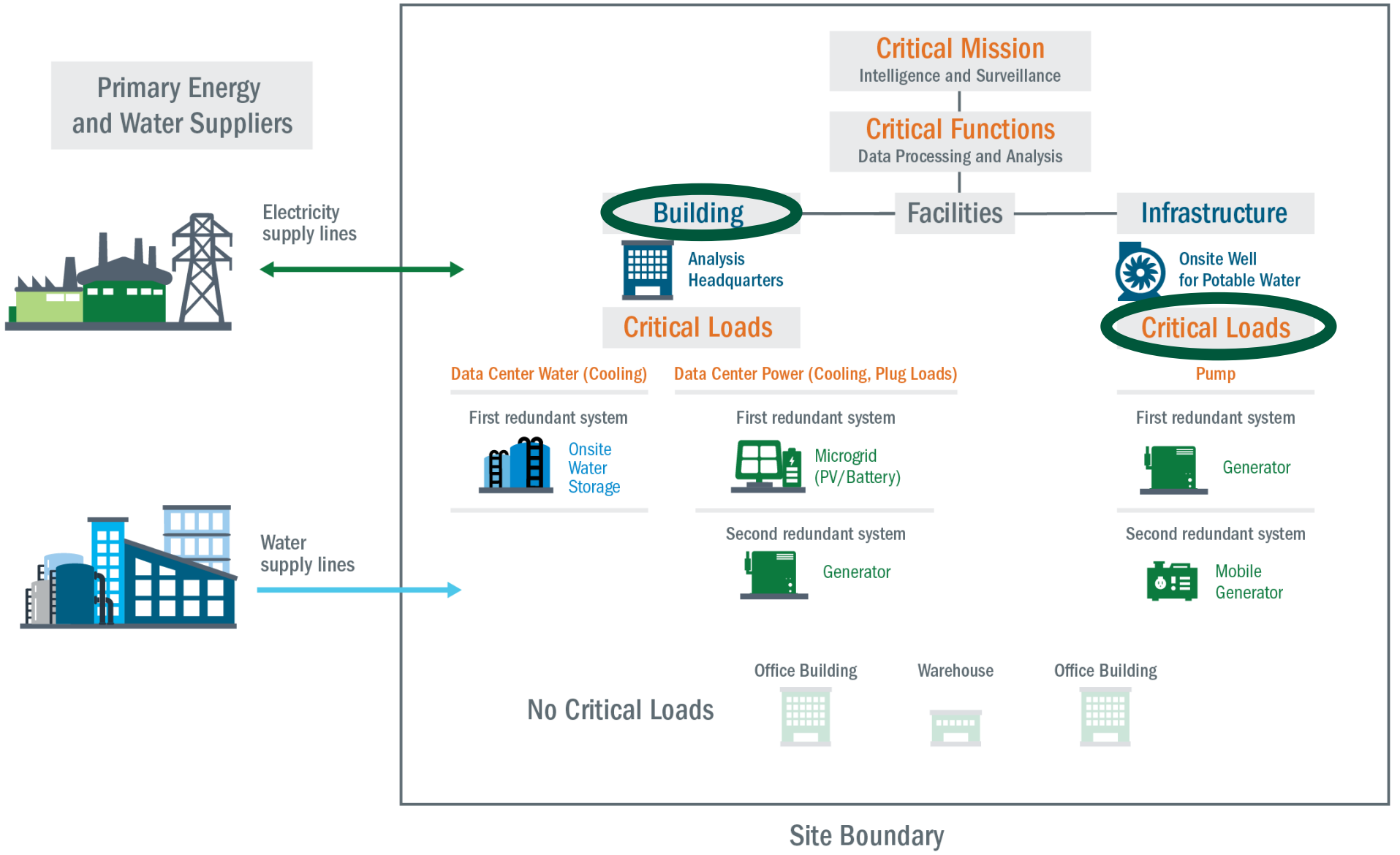
Baseline Development Outcomes

Critical Energy and Water Loads

Baseline Condition of Energy and Water Systems

Outage Time Tolerance for Critical Loads

Establishing Energy and Water Requirements



TRN Risk Assessment

Risk Assessment Actions

Characterize Critical Loads for Risk Assessment

Identify Hazards and Threats

Assess Vulnerabilities

Summarize Risk

Risk Assessment Outcomes

Identified Hazards

Risk Scenarios

Expanded List of Resilience Gaps

Risk Screening Summary

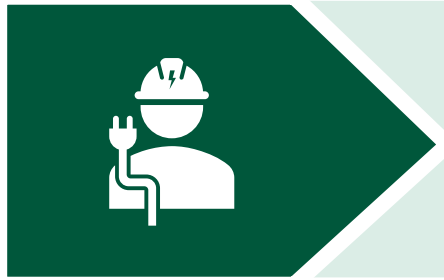
Risk = Hazards and Threats x Vulnerability x Consequences

Frequency of a hazard impacting system

Probability that protections fail

Severity of impact if protections fail

Risk Assessment Actions

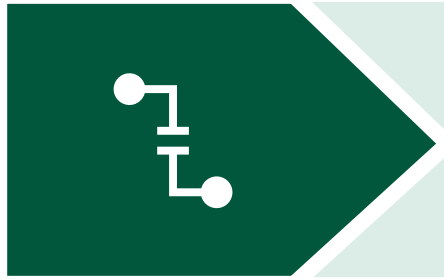


Characterize Critical Loads for Risk Assessment

This action collects the previously established relative importance of critical functions served by critical loads, the critical function or load restoration capabilities, and the tolerable outage duration of critical loads.

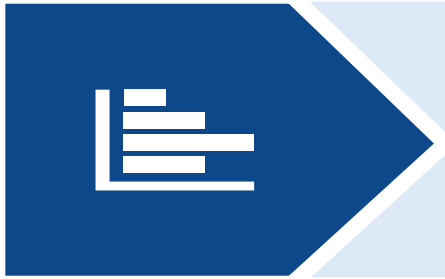
Identify Hazards and Threats

To identify hazards and threats, users record site-specific energy/water resource loss frequencies and durations and hazards that could affect both primary service and site-specific systems.



Assess Vulnerabilities

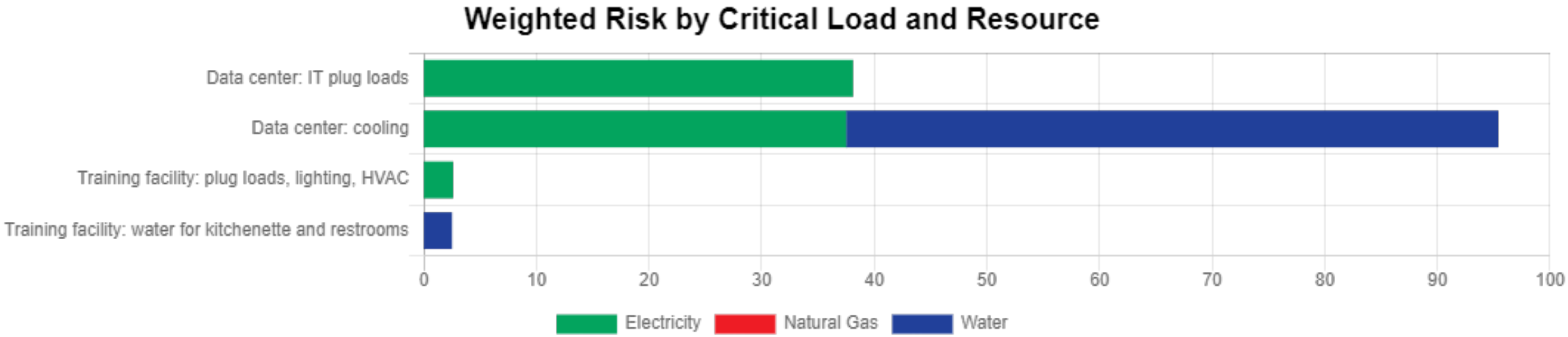
Vulnerabilities are assessed by establishing the capabilities of the redundant systems and identifying the design, operational, and maintenance factors that could affect system reliabilities.



Summarize Risk

The previous actions generate a risk summary that displays the distribution of unweighted and weighted risk across critical loads, hazards, and scenarios. The risk summary gives users insight into their risk distribution and greatest risk drivers.

Example TRN Risk Assessment Output



TRN Solution Development

Solution Development Actions

Analyze Resilience Gaps

Identify Resilience Solutions

Solution Development Outcomes

Resilience Gap Analysis

List of Solutions to Identified Gaps

- What gaps contribute to the greatest risk drivers?
- Are gaps technological, operational, or institutional?
- What solutions can enhance the resourcefulness, robustness, redundancy, and recovery of energy and water systems?

TRN Solution Prioritization

Solution Prioritization Actions

Screen Solutions

Model Solution Risk Reduction Potential

Review Priorities and Costs

Prioritize Solutions

Solution Prioritization Outcomes

Post-Solution Risk Reduction

Key Non-Risk Criteria for Solution Evaluation

Priority Solution List

- Which solutions decrease risk the most?
- What priorities should guide decision making?

Solution Prioritization Actions

Screen Solutions

This action includes the initial narrowing down of solutions, via Go/No-Go criteria such as extreme cost, technical difficulty, and those not of interest to the site currently. Remaining solutions and solution sets are for further analysis.

Determine Solution Risk Reduction Potential

In this action, users identify which hazard scenarios and resources are affected by the solution. The weighted risk calculated in the Risk Assessment module serves as a baseline. Users adjust the vulnerability or consequence to reflect how these solutions could impact risk.

Review Priorities and Costs

Users can specify additional prioritization criteria, which can include decision-making factors important to the site and weight them to reflect importance. The high-level cost of the solution, both for implementation and accounting for any ongoing costs, is also calculated.

Prioritize Solutions

In this action, users qualitatively rate solutions against the additional criteria and then use the TRN to calculate the Resilience Solution Benefit Potential as a weighted average score. This includes the categorized risk reduction efficacy and categorized ratings against criteria and criteria weights.

Example TRN Solution Prioritization Output

User selects sorting mechanism:

1. Potential benefit (descending), cost (ascending)
2. Cost (ascending), potential benefit (descending)

Priority Order	Solution	Potential Benefit	Cost Category	Priority	10-Year Total Cost
1	Solution set: MOU/mutual aid agreement to obtain fuel resupply + seismic upgrades for elec redundant system + improvement of process to move data center operations offsite.	High	High	8	$920,000
2	Solution set: MOU/mutual aid agreement to obtain fuel resupply + seismic upgrades for elec and water redundant systems + water efficiency + improvement of process to move data center operations offsite.	High	High	8	$1,430,000
3	Reduce required time to move operations to offsite data center, and train on that process.	Moderate	Low	10	$200,000
4	Implement COOP plan.	Moderate	Moderate	11	$650,000
5	Solution set: seismic upgrades for elec and water redundant systems + water efficiency + improvement of process to move data center operations offsite.	Moderate	High	12	$1,310,000
6	Implement ability to move training offsite.	Low	Minimal	13	$70,000
7	Improve water efficiency to extend water redundant system capability.	Low	Low	14	$110,000
8	Arrange MOU/mutual aid agreement to obtain fuel resupply, extending electrical redundant system capability.	Low	Low	14	$120,000
9	Upgrade electrical redundant system with seismic design.	Low	Moderate	15	$600,000
10	Upgrade electrical and water redundant systems with seismic design.	Low	High	16	$1,000,000

Example sorted by option 1

Technical Resilience Navigator

Roadmap To Action

Under Construction

Create a TRN account

https://trn.pnnl.gov/

Wrap Up and Questions

Thank you

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