

Better Buildings Webinar Series

We'll be starting in just a few minutes....

Tell us...

What topics are you interested in for future webinars?

Please send your response to the webinar organizers via the question box.



Save Money and Build Resilience With Distributed Energy Technologies

February 4, 2020

3:00 – 4:00 pm EDT



John Agan

U.S. Department of Energy

Today's Presenters



Emma Elgqvist
National Renewable Energy Laboratory



Nicholas DeForest
Lawrence Berkeley National Laboratory

Polls

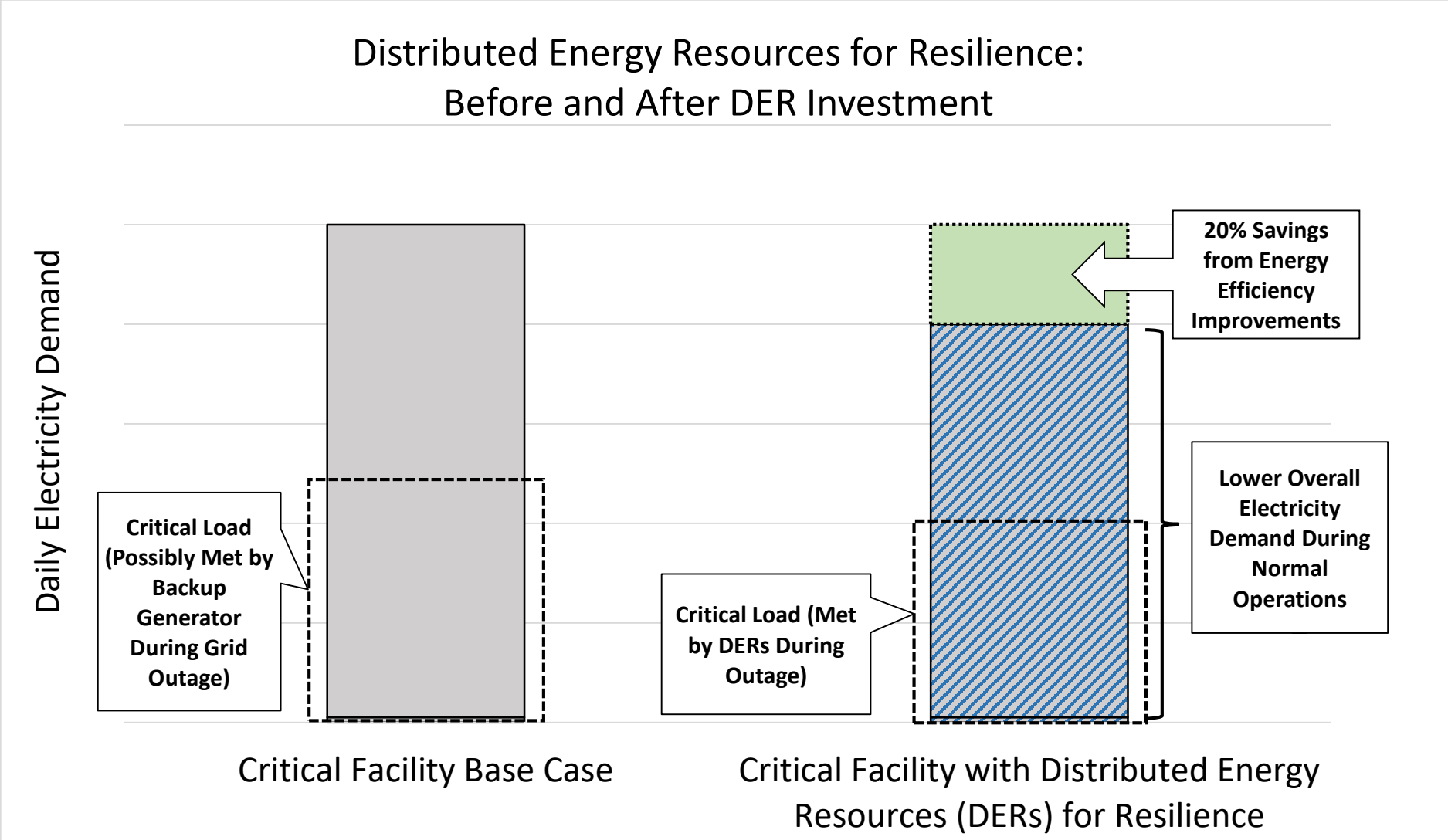
Resilience



In 2017, the U.S. experienced natural disasters* that cost more than \$300 billion in damages and led to **longer and more frequent disruptions in power**

*Droughts, floods, freezes, hurricanes, and wildfires
Source: National Oceanic and Atmospheric Administration

With EE, critical load is lower and DG investment needed is cheaper





How Distributed Energy Resources Can Improve Resilience in Public Buildings: Three Case Studies and a Step-by-Step Guide

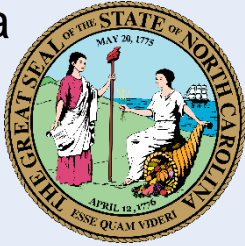

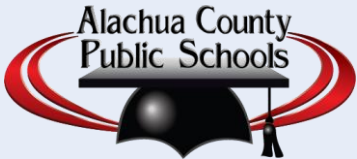
- Introduces readers to the benefits of integrating energy efficiency with other DERs to achieve resilience objectives
- Describes two tools to analyze DER options at critical facilities, presenting case studies with completed analysis for three partners in DOE's Better Buildings Challenge
- Provides step-by-step guidance for conducting new analysis

Analysis: BBC Partners

Better Buildings Challenge (BBC) partners commit to:

- Reduce energy intensity of building portfolio by at least 20% over ten years
- Share successful strategies and results.



Partner	Improvement Since Baseline	New Analysis: Identified Buildings	Simulated Outage Details
North Carolina 	16%	8 critical facilities, including some used as shelters	Hurricane Season – 48-96 hours 50% of building load
Hillsboro, OR 	26%* *Goal Achiever - Set a new goal in 2018	8 community facilities, including potential shelters	Four seasonal outages, 24 hours each
Alachua County Public Schools (FL) 	7%	11 schools used as emergency shelters	Hurricane Season – 120 hours 30% of normal load

North Carolina

Background: Executive Order 80: Reduce energy intensity in state-owned buildings by 40% by 2025

Analysis: Six sites assessed for solar PV and battery storage, two for CHP

Outcomes:

- Ample savings opportunities exist when energy efficiency is integrated
- Modeled solar PV arrays provide 20-28% of each of the six sites' annual electric consumption

Modeled Results for Meeting 50% of Building Load During a 2-day (48-hour) Grid Outage					
NC Facility and Electricity Usage Scenario	Battery Storage Size (kWh)	PV System Size (kW)	Annual PV Production (kWh)	Solar PV Production As % of Electricity Consumption	Installed Cost
NC Facility #6 - Business as Usual (BAU)	361	191	233,475	22%	\$491,550
NC Facility #6 - 10% More Efficient	325	172	210,128	22%	\$442,395 (~\$49,000 less than BAU)
NC Facility #6 - 20% More Efficient	289	152	186,780	22%	\$393,240 (~\$98,000 less than BAU)
NC Facility #6 - 40% More Efficient	217	114	140,085	22%	\$294,959 (~\$197,000 less than BAU)

Additional DOE Resources

- Resilience Resources
 - [How Distributed Energy Resources Can Improve Resilience in Public Buildings: Three Case Studies and a Step-by-Step Guide](#)
 - [Energy Efficiency and Distributed Generation for Resilience: Withstanding Grid Outages for Less](#)
 - [Distributed Generation for Resilience Planning Guide](#)
 - [Efficiency-Resilience Nexus Fact Sheet](#)
- EE Financing Resources
 - [Better Buildings Financing Navigator](#)
 - [Commercial Property Assessed Clean Energy \(C-PACE\) for Resiliency Toolkit](#)
 - [Energy Savings Performance Contracting \(ESPC\) Toolkit](#)



Stay Connected

- **State and Local Solution Center:**

<http://energy.gov/eere/slsc>

- More than **500** tools, resources, and best practices

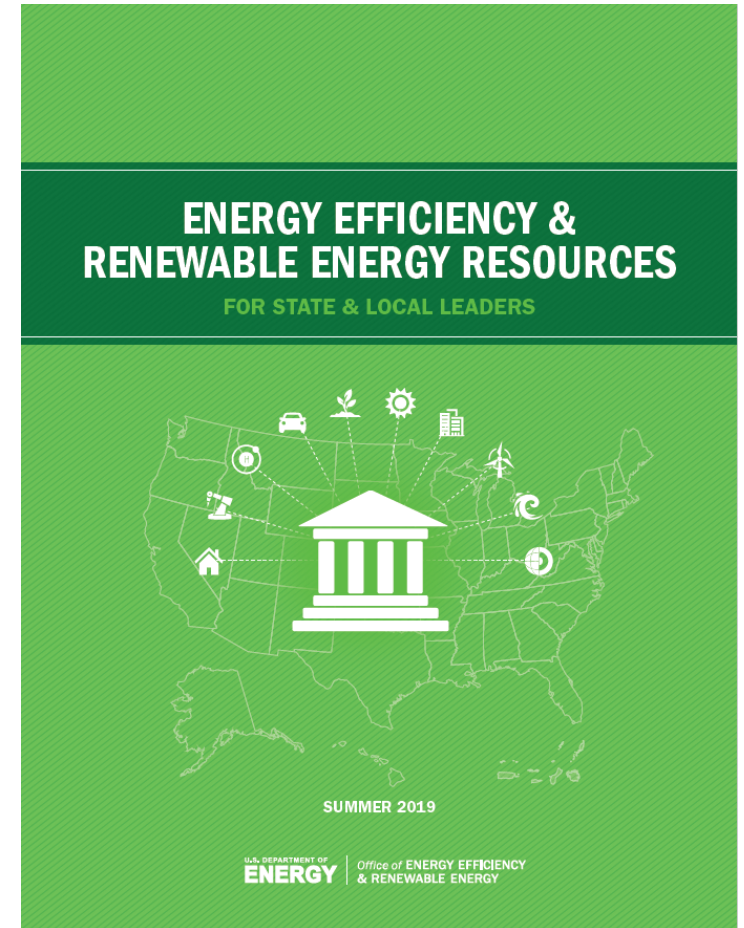
- **State and Local Spotlight:**

<http://energy.gov/slsc/subscribe>

- Monthly newsletter with ~**33,000** subscribers

John Agan
John.Agan@ee.doe.gov

State and Local Inbox
stateandlocal@ee.doe.gov



[Energy Efficiency and Renewable Energy Resources for State and Local Leaders](#)



Emma Elgqvist

National Renewable Energy Laboratory



Assessing PV + Storage Project Feasibility using NREL's REopt Lite Tool

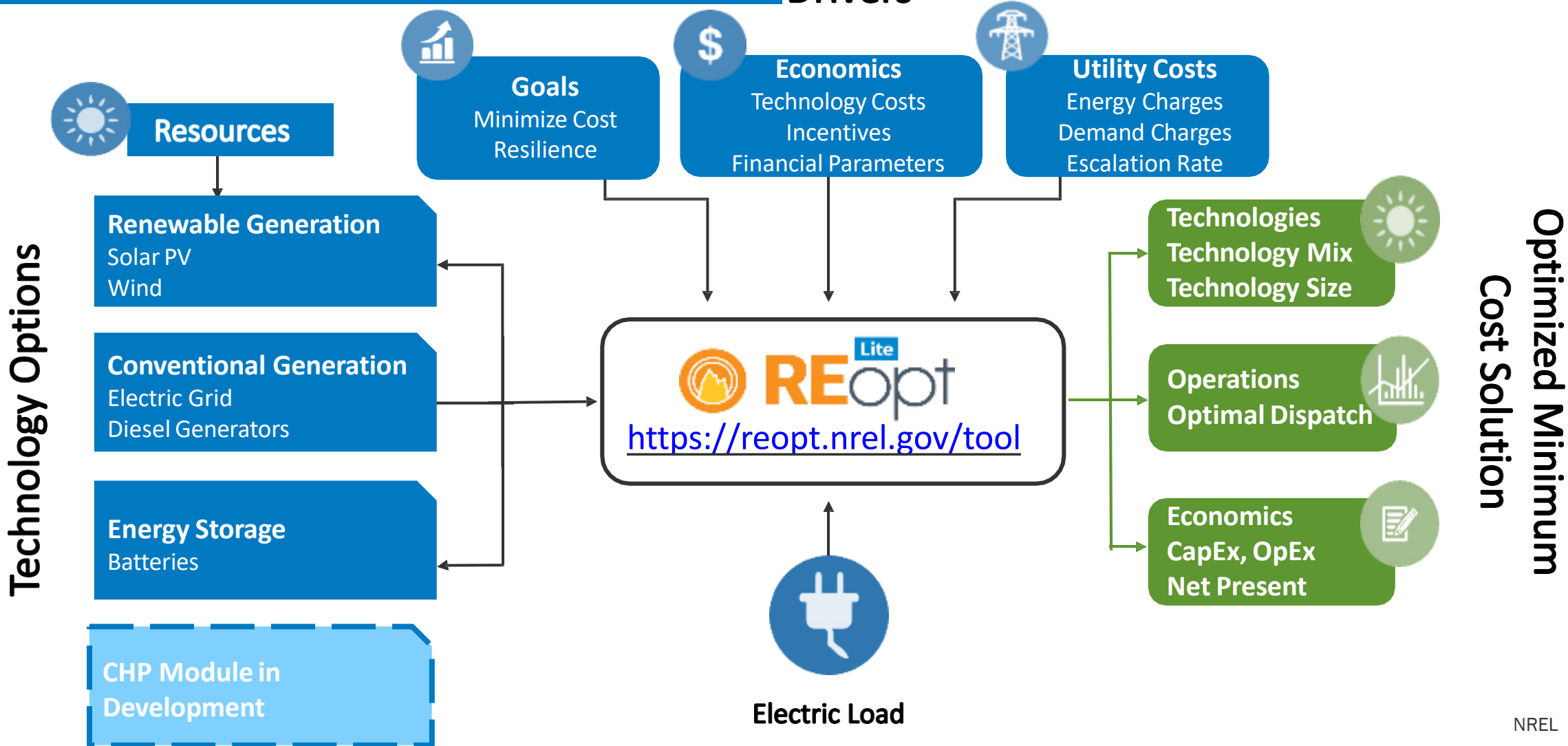
Emma Elgqvist, Engineer, National Renewable Energy Laboratory

Better Buildings Webinar Series: Save Money and Build Resilience with Distributed Energy Technologies

February 4, 2020

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

Drivers



REopt Lite Web Tool

- **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 battery systems, along with back-up generators to sustain critical load during grid outages
- To access REopt Lite: <https://reopt.nrel.gov/tool>

Step 1: Choose Your Focus

Do you want to optimize for financial savings or energy resilience?

\$ Financial

🛡️ Resilience



Step 2: Enter Your Data

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

Site and Utility (required) ⊖

* Required field

* Site location 🔗 🔗 Use sample site

* Electricity rate 🔗

Custom electricity rate 🔗

Net metering system size limit (kW) 🔗

Enter 0 if net metering is not available

Wholesale rate (\$/kWh) 🔗

Load Profile (required) ⊕

\$ Financial ⊕

Step 3: Select Your Technologies

Which technologies do you wish to evaluate?

PV ⚙️

Battery 🔋

Wind 🌬️

⚙️ PV ⊕

🔋 Battery ⊕

🌬️ Wind (Beta Version) ⊕

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.

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.

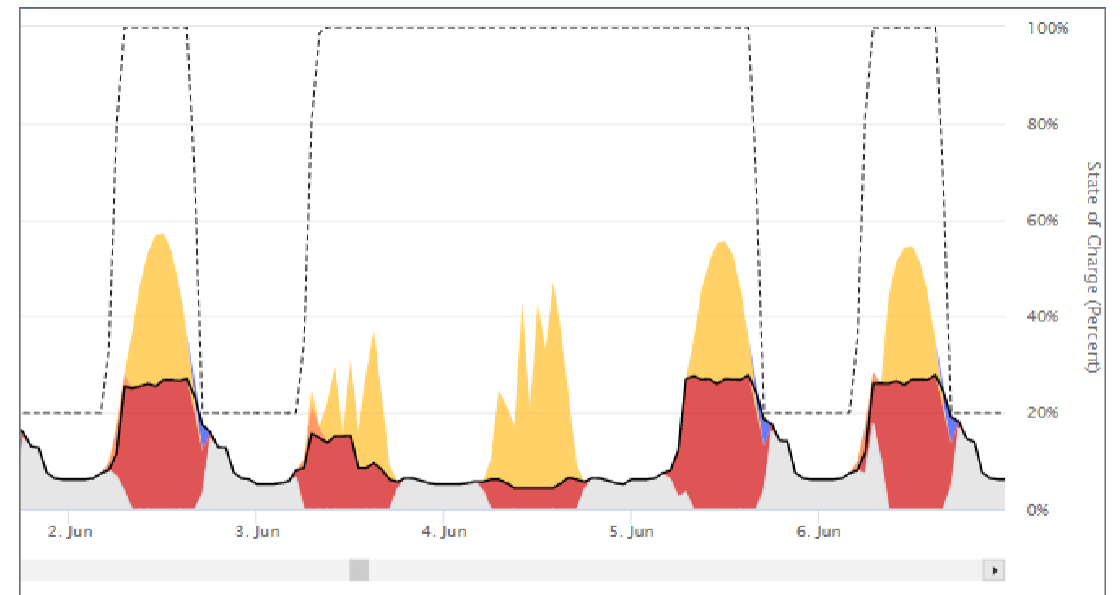


Your potential life cycle savings (20 years)

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 NPV




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

Recent Resilience Update

- 
- **October 2019:** Resilience Modeling, Diesel Generator Sizing, Load Profile Dashboard, Utility Rate Help, International Guidelines, and Updated Cost Assumptions
 - **April 2019:** PVWatts and Solar Resource Data Set Upgrade
 - **March 2019:** Custom Hourly Rate Tariffs and Integrated Critical Load Builder
 - **November 2018:** Wind Module, Custom Monthly Rate Tariffs, Critical Load Builder, and User Dashboard
 - **June 2018:** Enhanced Resilience Features
 - **March 2018:** Application Programming Interface
 - **September 2017:** REopt Lite's Initial Release

Resilience Inputs

Resilience (required) ⊖

*** Critical load** ?
How would you like to enter the critical energy load profile?

Percent Upload Build

Critical load factor (%) ?

[Download critical load profile](#) [Chart critical load data](#)

*** Outage information**

*** Outage duration (hours)** ?

*** Outage start date** ? Autoselect using critical load profile ?

*** Outage start time** ?

Type of outage event ?

What load needs to be met during the outage?

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

Generator Modeling

Step 3: Select Your Technologies

Which technologies do you wish to evaluate?

PV  Battery  Wind  Generator 

Generator option for resilience evaluation

Generator

Install cost (\$/kW)

Diesel cost (\$/gal)

Fuel availability (gallons)

Existing diesel generator?

* Existing diesel generator size (kW)

[Advanced inputs](#) [Reset to default values](#)

Specify existing generator, and/or let REopt Lite size it

Defaults are for diesel generator but can be modified

Resilience Outputs



Your Potential Resilience

This system sustains the 75% critical load during the specified outage period, from January 4 at 12am to January 11 at 12am.

This system sustains the critical load for 72% of all potential 168 hour outages throughout the year.



[System survives specified 168-hour outage](#)

72%

[System survives 72% of 168-hour outages](#)

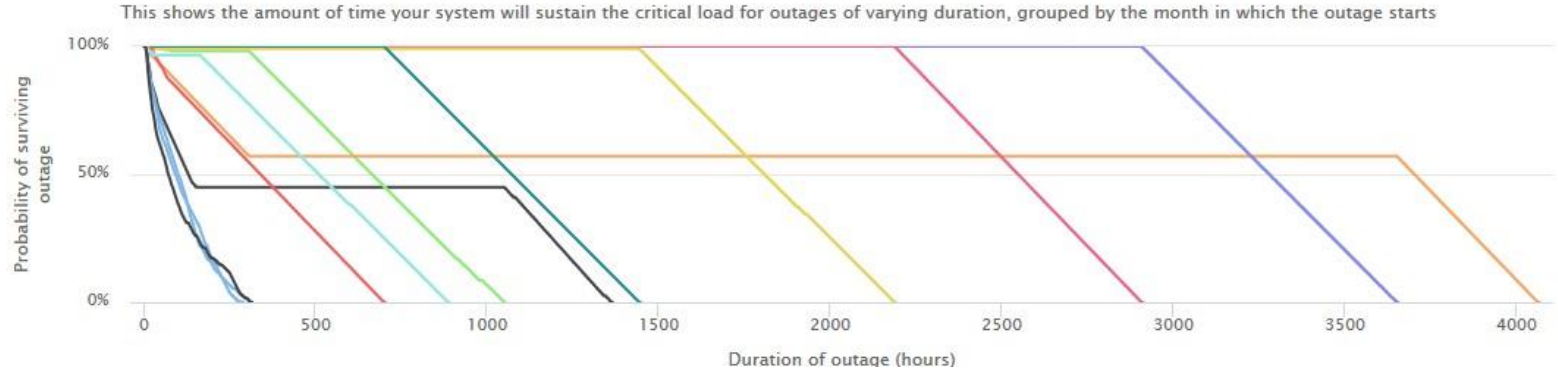


REopt Lite optimizes system size and dispatch to survive specified outage

Outage Simulation

Evaluate the amount of time that your system can survive grid outages.

- Yearly
- Monthly
- Hourly

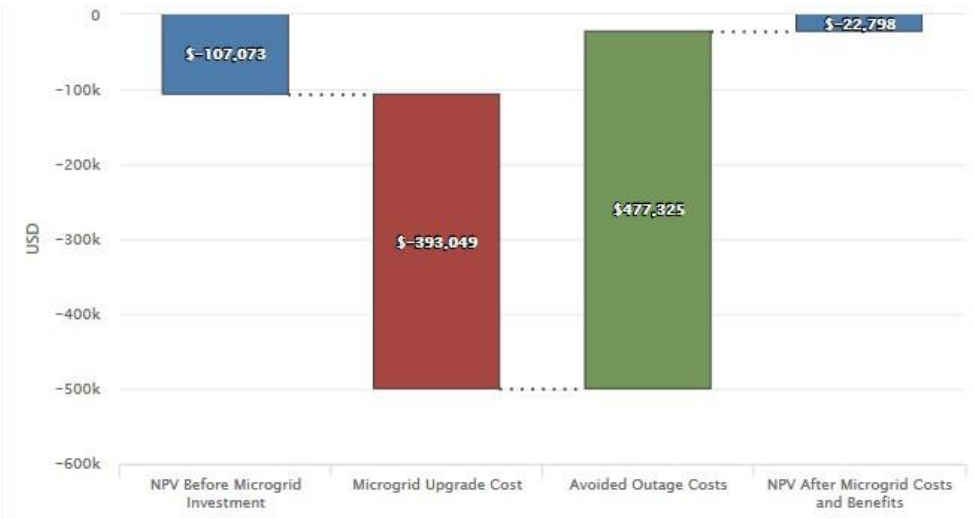


REopt Lite simulates outages of varying length throughout the year

Resilience Outputs

	Business As Usual ?	Resilience ?	Financial ?
System ?	None	729 kW PV 220 kW Battery 1,288 kWh Battery	361 kW PV 78 kW Battery 253 kWh Battery
NPV ?	\$0	-\$107,073	\$209,419
Survives Specified Outage ?	No	Yes	No
Average ?	0 hrs	1,115 hrs	10 hrs
Minimum ?	0 hrs	4 hrs	0 hrs
Maximum ?	0 hrs	4,061 hrs	63 hrs

Compare results of resilience analysis to financial optimum



Microgrid Upgrade Cost ?

Avoided Outage Costs ?

Explore impact of microgrid upgrade costs and value of avoiding an outage

REopt Lite API

- What is an API?
 - Application Programming Interface.
 - Programmatic way of accessing REopt Lite (sending and receiving data from a server)
 - File format used for sending and receiving the data: JSON
- Advantages:
 - Multiple simulations for different sites can be run programmatically
 - Scenario analysis can be automated
 - Integration with other programs

Developer Network

HOME

DOCUMENTATION

COMMUNITY

[Documentation](#) » [Energy Optimization](#) » [REopt Lite™ API \(Version 1\)](#)

REopt Lite™ API (Version 1)

The REopt Lite™ API recommends an optimal mix of renewable energy savings and energy performance goals, including the hourly optimum. It provides an interface for interactively setting up input parameters.

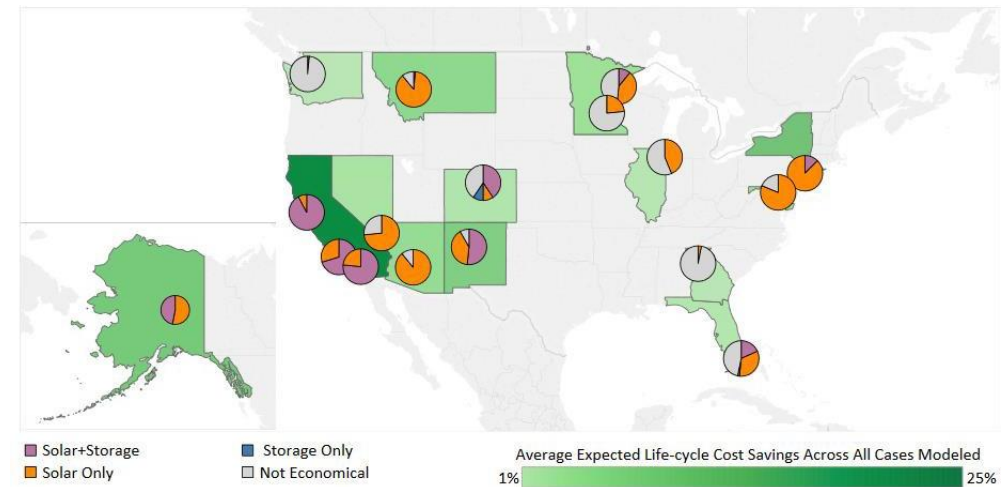
The API uses utility rates from the [Utility Rate Database](#) and solar and custom load profiles, but is also equipped with simulated profiles for

- [Endpoints](#)
- [User Workflow](#)
- [Formatting and Posting a Job](#)
- [Getting Results](#)
- [Downloading a Proforma](#)
- [Getting Resilience Statistics](#)
- [Example Workflow](#)
- [Common Errors](#)

<https://developer.nrel.gov/docs/energy-optimization/reopt-v1/>

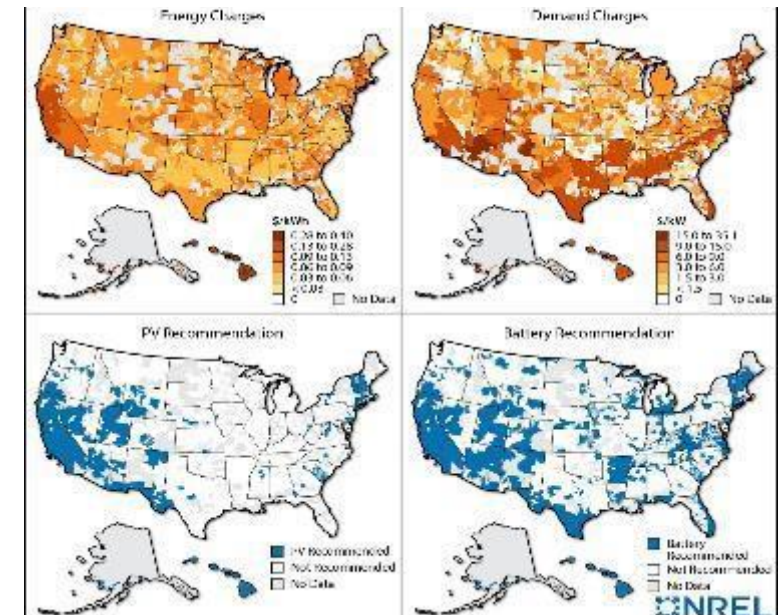
Analysis Enabled by API

- 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 costs is storage adopted across the US?
 - How does varying utility rate, escalation rates, and incentive structures impact storage profitability?
 - How (and where) can stationary storage support DC-fast-charging electric vehicle economics and deployment?



Identifying Critical Factors in the Cost-effectiveness of Solar and Battery Storage in Commercial Buildings

<https://www.nrel.gov/docs/fy18osti/70813.pdf>



Technology Solutions To Mitigate Electricity Cost for Electric Vehicle DC Fast Charging

<https://www.sciencedirect.com/science/article/pii/S0306261919304581>

FY20 Development Plans

- **Third-party financing:** Develop a financial model for third-party ownership of photovoltaic, wind, or battery systems.
- **Federal scenarios:** Create analysis assumptions and results for federal users.
- **Run comparison:** Compare results from different REopt Lite scenarios.
- **Utility rates:** Add features such as ratchets and peak load contribution.
- **Constraints:** Add ability to constrain solution based on budget, emissions, and renewable energy goals.
- **Combined heat and power:** Integrate a combined heat and power technology option.
- **Online user forum:** Allow users to ask and respond to questions, and share insights and successes.
- **Electric vehicles:** Add option to include electric vehicle loads in optimizations.
- **Open source:** Release REopt Lite open source software.
- **Additional resources:** Add new REopt Lite case studies and tutorials.

Thank You

Emma Elgqvist

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www.nrel.gov



- REopt Lite (tool and help manual): <https://reopt.nrel.gov/tool>
- REopt Website (analysis services and case studies): <https://reopt.nrel.gov/tool>
- Send tool feedback & ask a question: reopt@nrel.gov





Nicholas DeForest

Lawrence Berkeley National Laboratory



DER-CAM

DECISION SUPPORT TOOL FOR
DECENTRALIZED ENERGY SYSTEMS

ANALYTICS | PLANNING | OPERATIONS

Introduction to DER-CAM

Better Buildings Webinar Series: Save Money and
Build Resilience with Distributed Energy Technologies

Feb 4, 2020

Nicholas DeForest
Grid Integration Group, Berkeley Lab



Why DER & Microgrids?



**Reduce Total
Energy Costs**

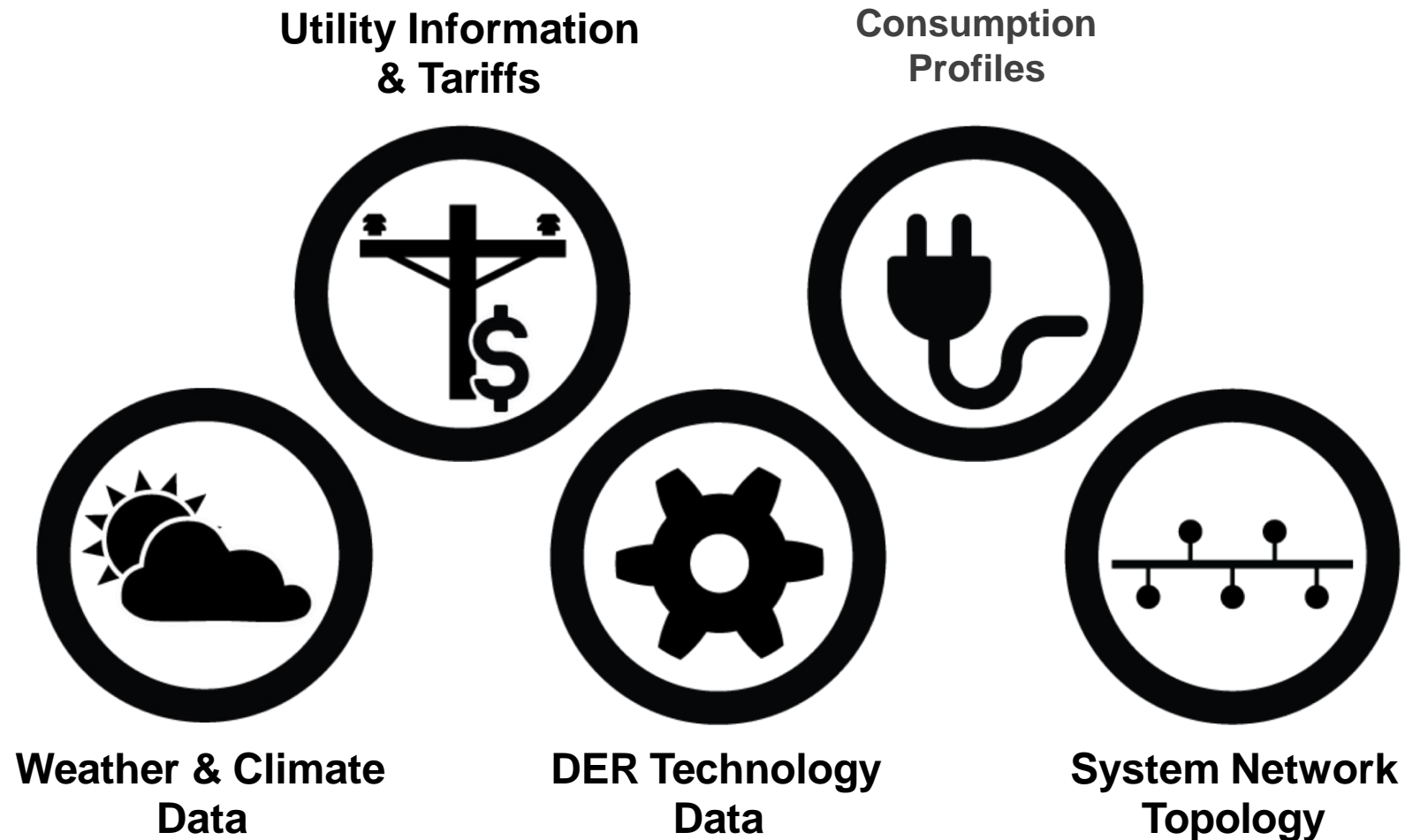


**Reduce Total
CO₂ Emissions**



**Reduce Outages &
Ensure Energy
Security**

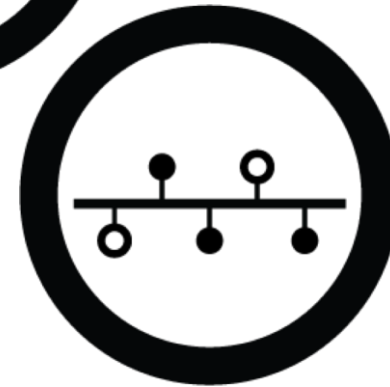
What Impacts a System's Potential?



What Guidance is Needed?

Cost & Performance Metrics

New Technology Investments



New Technology Capacity Sizing

Operational Schedules

Placement Within Network



Objectives



Inputs



DER-CAM

Outputs





DER Technologies & Investments

Generation

- Solar PV
- Combined Heat & Power
 - Combustion Engines
 - Fuel Cells
 - Micro-turbines,
- Solar Thermal Panels
- Wind And Hydro Power

Energy Storage

- Battery Storage
- Heat Storage
- Chilled Water And Ice Storage
- Electric Vehicles

Load Management

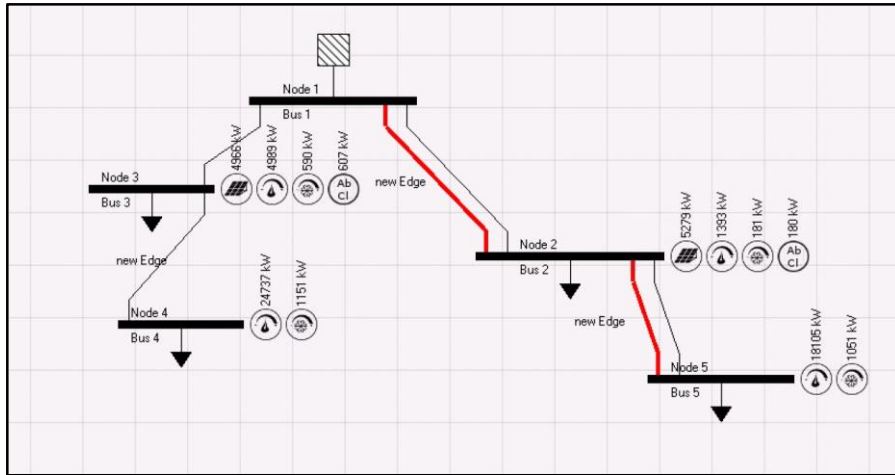
- Demand Response
- Load Shifting
- Load Curtailment

Energy Efficiency Measures



DER Value Streams

- Volumetric electricity purchases
- Monthly demand charges
- Electricity exports
- Demand response
- Ancillary services
- Reduced energy consumption
- Improved service efficiencies



- Multi-building networked microgrids
- Heat and power flow modeling
- Multi-energy microgrids
- AC & DC microgrids
- N-1 security constrained designs

Advanced Features

DER-CAM Desktop UI

The image displays the DER-CAM Desktop User Interface (UI) with three overlapping windows. Each window features a menu bar, a toolbar, a left-hand navigation pane, and a main data table. The windows are titled 'Solar Radiation', 'Wind Power Potential', and 'Ambient Hourly Temperature'. Each window also includes a 'Help' pane on the right side.

Solar Radiation - Help
 The solar radiation is given as average fraction of maximum solar insolation.

F1	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 January	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0407	0.2931	0.4336	0.5875	0.6559	0.6423	0.6237
2 February	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0896	0.2938	0.4643	0.5129	0.599	0.5812	0.5945
3 March	0.00	0.00	0.00	0.00	0.00	0.00	0.0012	0.2018	0.4227	0.6011	0.7108	0.8197	0.8177	0.7625

Wind Power Potential - Help

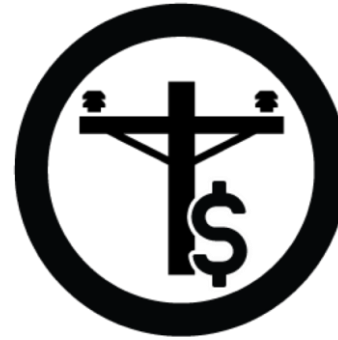
F1	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 January	28.9261	25.4619	23.5633	26.9506	27.5886	25.425	29.6506	32.2706	27.6983	25.1842	19.4589	19.075	22.1	22.1

Ambient Hourly Temperature - Help
 The ambient hourly temperature data must be inserted in degrees Celsius. This information is relevant to estimate changes in internal load inside the building when passive retrofit options are considered (such as improved windows), and it is also used to estimate the efficiency of panels.

F1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 January	8.10	7.90	7.80	7.70	7.80	7.90	8.00	8.90	9.70	10.60	11.50	12.40	13.30	13.40	13.30
2 February	9.70	9.50	9.30	9.10	8.80	8.60	8.20	9.50	10.70	12.00	13.20	14.40	15.50	15.60	15.50
3 March	11.10	10.60	10.10	9.60	9.30	9.00	8.70	9.90	11.10	12.30	13.40	14.50	15.60	15.90	16.00
4 April	10.30	9.80	9.40	9.00	9.40	9.70	10.10	11.50	13.00	14.50	15.60	16.80	18.00	18.10	18.00
5 May	11.20	11.10	10.80	10.40	10.90	11.30	11.70	13.20	14.60	16.10	17.50	18.90	20.40	20.20	20.00
6 June	13.00	12.90	12.70	12.30	12.90	13.60	14.20	15.50	16.70	18.00	19.40	20.70	22.00	21.60	21.10
7 July	13.40	13.30	13.10	13.00	13.40	13.70	14.10	15.50	16.90	18.30	19.80	21.30	22.80	22.40	22.20
8 August	14.00	13.80	13.60	13.40	13.50	13.70	13.90	15.20	16.50	17.90	19.60	21.40	23.10	22.60	22.20
9 September	14.80	14.50	14.10	13.70	13.50	13.70	14.70	16.20	17.70	19.00	20.60	22.20	23.40	23.60	23.30
10 October	13.40	12.90	12.40	11.90	12.10	12.30	12.50	14.20	15.80	17.40	18.60	19.90	21.10	21.20	21.10
11 November	10.80	10.20	9.60	9.20	9.30	9.30	9.90	11.50	13.40	14.40	15.30	16.60	17.10	17.40	17.10
12 December	8.20	7.90	7.40	6.90	6.90	7.00	7.00	8.10	9.30	10.40	11.50	12.60	13.60	13.80	13.30

DER-CAM Data Resources

Reference building
load profiles

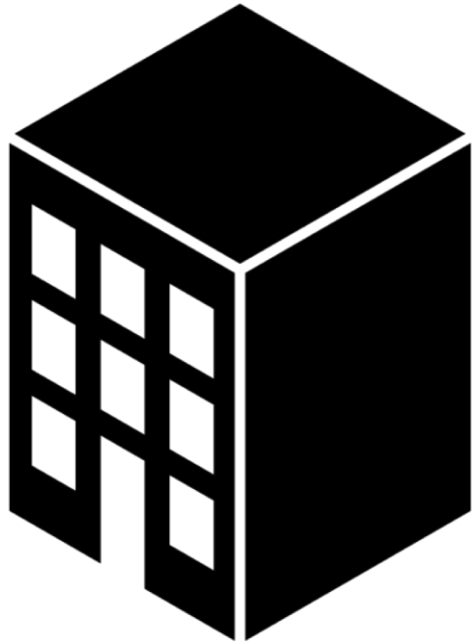


Electricity tariff
database

Typical insolation
profiles



DER technology
libraries



Quick Feasibility Studies



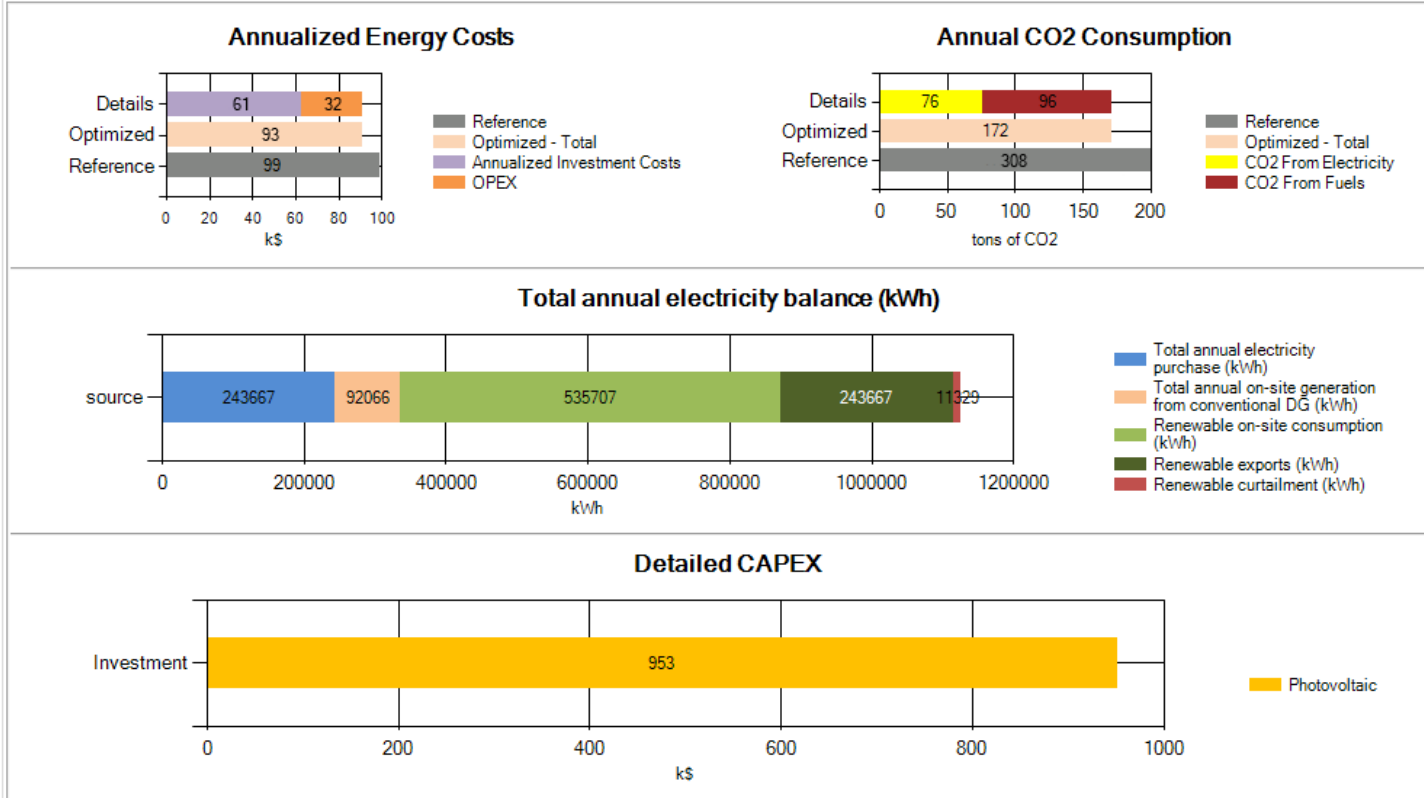
• Results

Summary Electricity Dispatch Heat Dispatch Cooling Dispatch Investment Decisions Economic Results Energy & Fuel Supply Environmental Results Detailed

Summary Table

	DER Solution	Reference	Total Savings (%)
Total Annual Energy Costs (k\$)	93	99	6.1
Total Annual CO2 emissions (metric tons)	172	308	44

Charts Summary



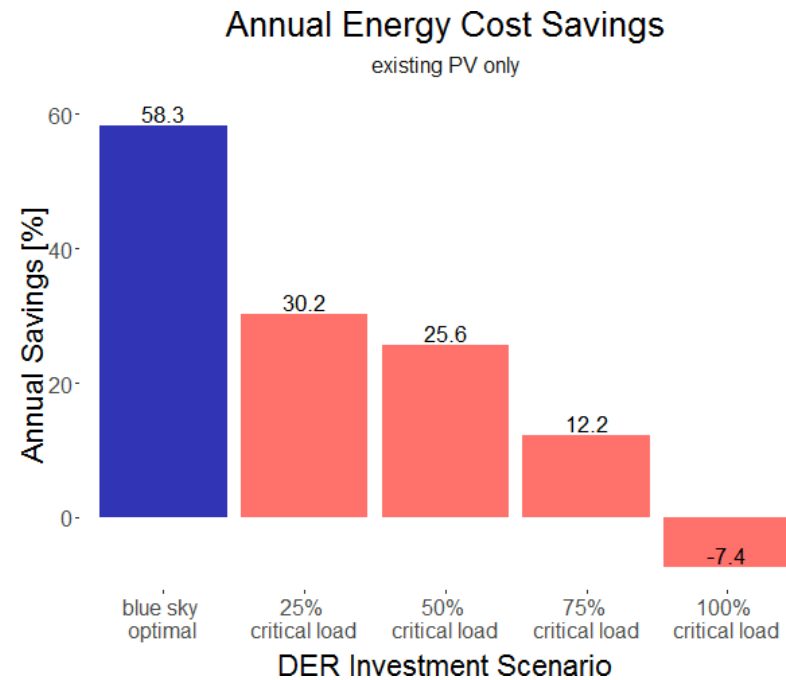
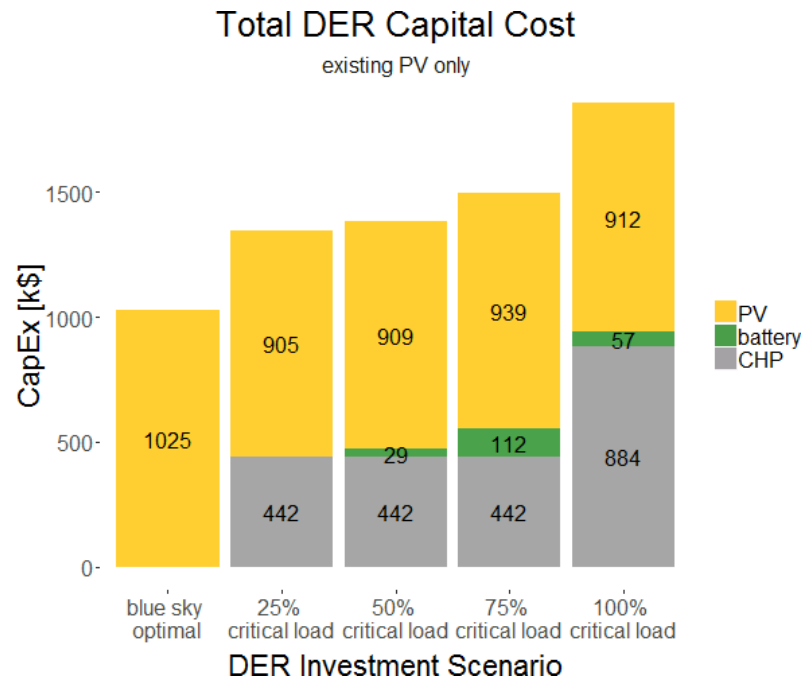


Scenario & Parametric Analysis

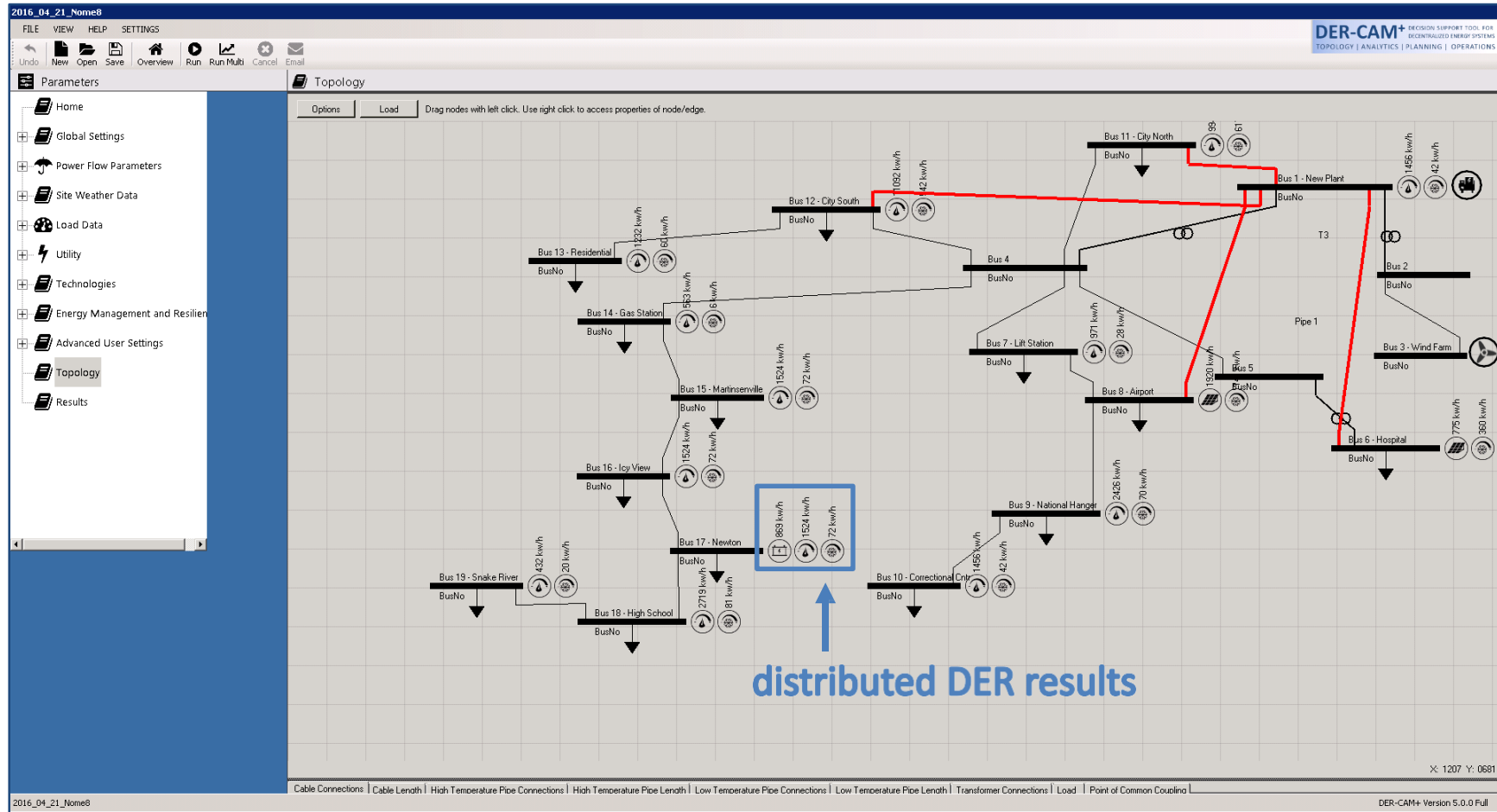
- DER Technologies & Costs
- Tariffs & Energy Rates
- Load Profiles
- Etc.



Resilience Modeling Scenario Analysis



Networked Microgrids & Remote Systems





- Simple DER-CAM API
- Data support for Energy Efficiency
- Automate scenario-based resiliency analysis
- Expanded ancillary service options

Upcoming Developments



DER-CAM

**BERKELEY
LAB**

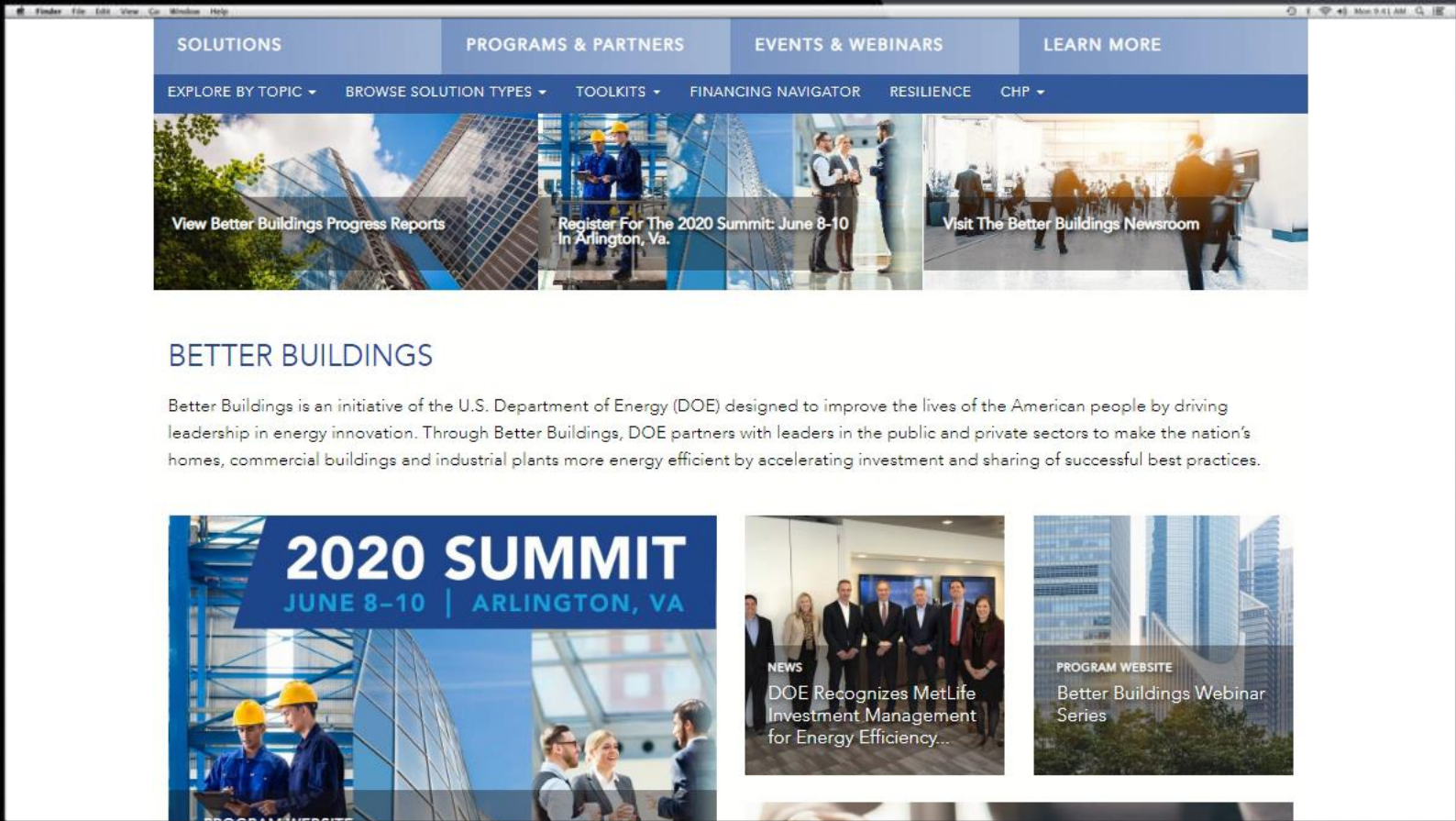


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dercam.lbl.gov

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CHP ▾

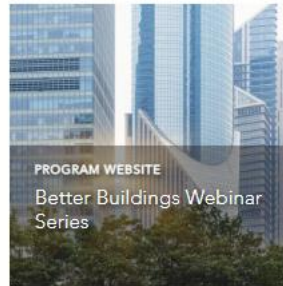
View Better Buildings Progress Reports

Register For The 2020 Summit: June 8-10
in Arlington, Va.

Visit The Better Buildings Newsroom

BETTER BUILDINGS

Better Buildings is an initiative of the U.S. Department of Energy (DOE) designed to improve the lives of the American people by driving leadership in energy innovation. Through Better Buildings, DOE partners with leaders in the public and private sectors to make the nation's homes, commercial buildings and industrial plants more energy efficient by accelerating investment and sharing of successful best practices.



Q & A

2019-2020 Better Buildings Webinar Series



BACK BY POPULAR DEMAND: THE BEST OF THE 2019 BETTER BUILDINGS SUMMIT

Tue, Sep 17, 2019 | 3:00 - 4:00 PM ET



HOW BUILDINGS OF ALL SHAPES AND SIZES ARE BECOMING ZERO ENERGY USERS

Tue, Dec 3, 2019 | 3:00 - 4:00 PM ET

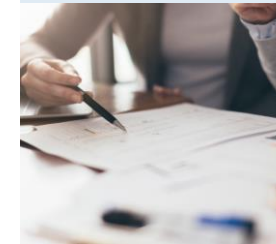
FINANCE + RESILIENCE: a two-part miniseries



PART 1: BUILDING THE FINANCIAL BUSINESS CASE FOR RESILIENCE

Tue, Apr 21, 2020 | 3:00 - 4:00 PM ET

[REGISTER TODAY >](#)



PART 2: TAKING ACTION TO IMPROVE RESILIENCE & DISCLOSE PERFORMANCE

Tue, Apr 28, 2020 | 3:00 - 4:00 PM ET

[REGISTER TODAY >](#)



GETTING TO 100%: OVERCOMING BARRIERS TO TENANT DATA COLLECTION

Tue, Oct 1, 2019 | 3:00 - 4:00 PM ET



BEST OF THE BETTERS: THE 2019 BETTER PROJECT AND BETTER PRACTICE PRESENTATIONS

Tue, Jan 7, 2020 | 3:00 - 4:00 PM ET



ENERGY EFFICIENCY AND RENEWABLE ENERGY IN SMALL AND RURAL K-12 SCHOOLS

Tue, Oct 22, 2019 | 3:00 - 4:00 PM ET



SAVE MONEY AND BUILD RESILIENCE WITH DISTRIBUTED ENERGY TECHNOLOGIES

Tue, Feb 4, 2020 | 3:00 - 4:00 PM ET



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- [Efficiency-Resilience Nexus](#)

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