RESILIENTPOWER

A project of CleanEnergyGroup

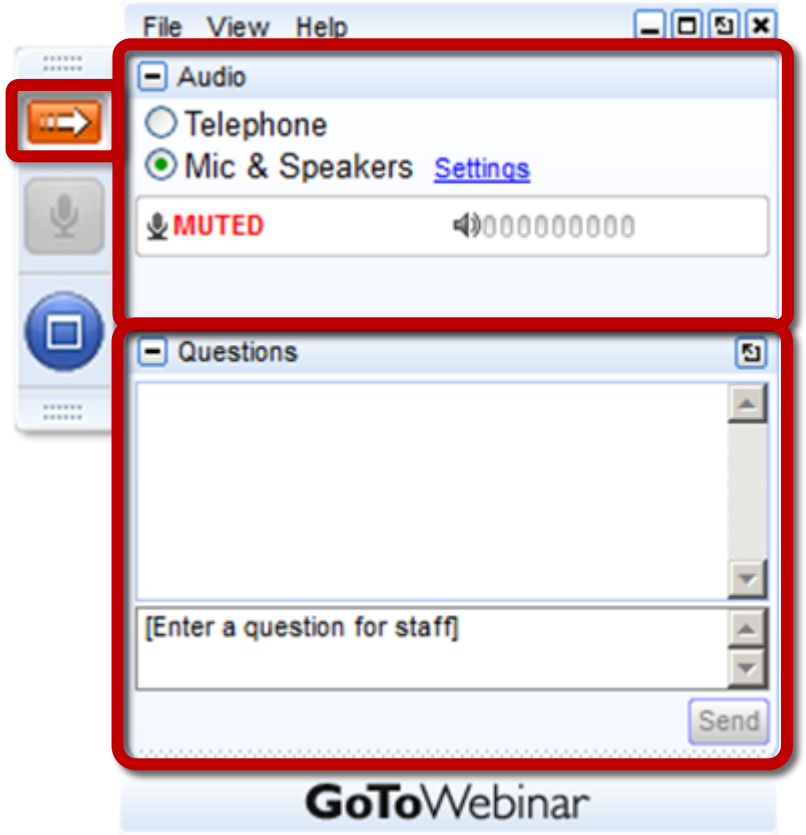
Designing Hybrid Combined Heat and Power Systems: An Introduction to New Features in NREL's REopt Lite Tool

CleanEnergyGroup

Innovation in Finance, Technology & Policy

March 2, 2021

WEBINAR LOGISTICS



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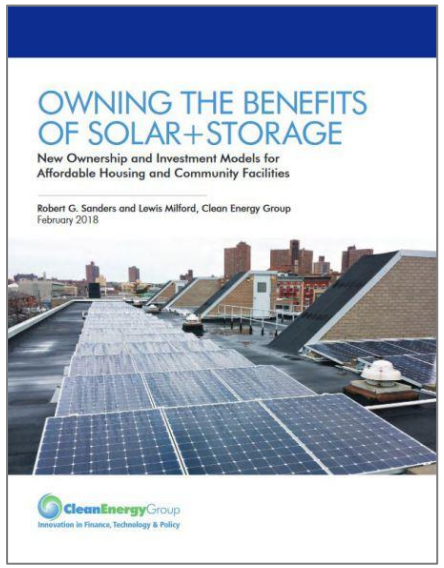
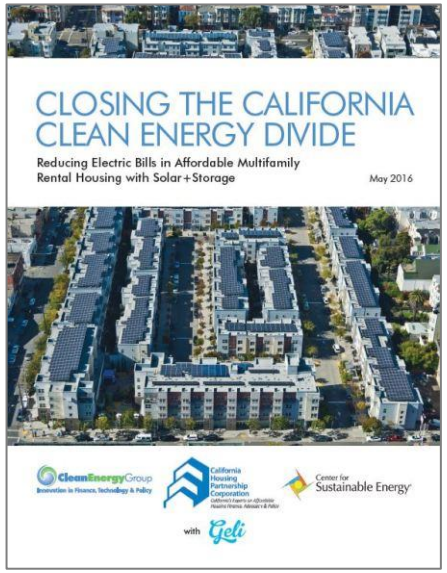
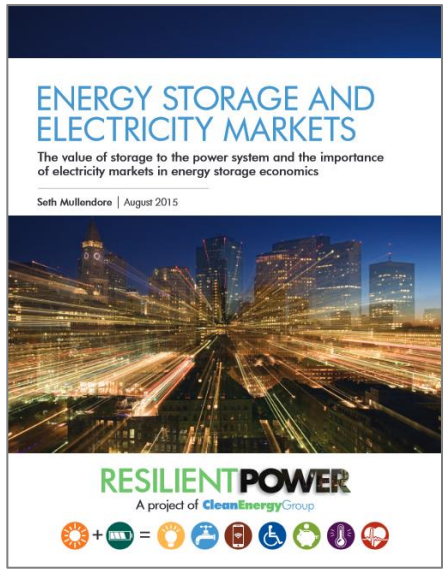
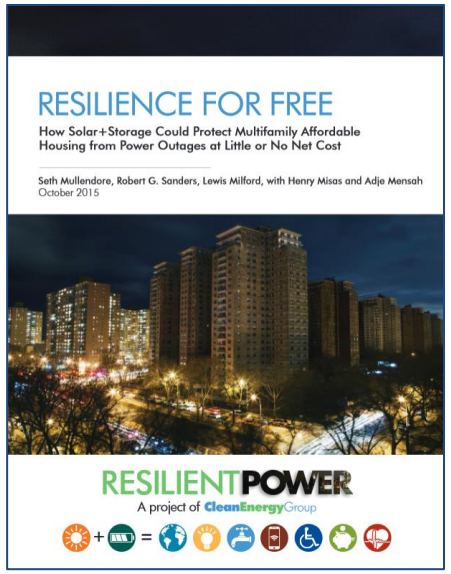
THE RESILIENT POWER PROJECT

- Increase public/private investment in clean, resilient power systems (solar+storage)
- Protect low-income and vulnerable communities, with a focus on affordable housing and critical public facilities
- Engage city, state and federal policy makers to develop supportive policies and programs
- Visit www.resilient-power.org for more information and resources









SUPPORTING 150+ PROJECTS ACROSS THE COUNTRY

WEBINAR SPEAKERS

Kate Anderson
Group Manager – Modeling and Analysis, NREL

Dan Olis
Researcher – Mechanical Engineering, NREL

William Becker
Researcher – Model Engineering, NREL

Seth Mullendore
Vice President and Project Director, Clean Energy Group (moderator)

NREL

CleanEnergyGroup
Innovation in Finance, Technology & Policy

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

REopt Lite Combined Heat and Power Model

Kate Anderson, Dan Olis, Bill Becker
NREL REopt Team
March 2, 2021
reopt.nrel.gov

REopt Integration and Optimization

REopt Lite Web Tool Transforms Complex Decisions Into Actionable Results

- The free, publicly available web tool guides investment in economic, resilient energy technologies
- Transforms complex decisions into actionable results for building owners, utilities, and industry
- Integrating CHP enables analysis of hybrid CHP (CHP + PV, wind, and/or storage)
- Open Source API access to the tool enables analysis at scale

Will Hybrid CHP Work for Your Site?

RE Resource

Technology Costs & Incentives

Resilience Goals

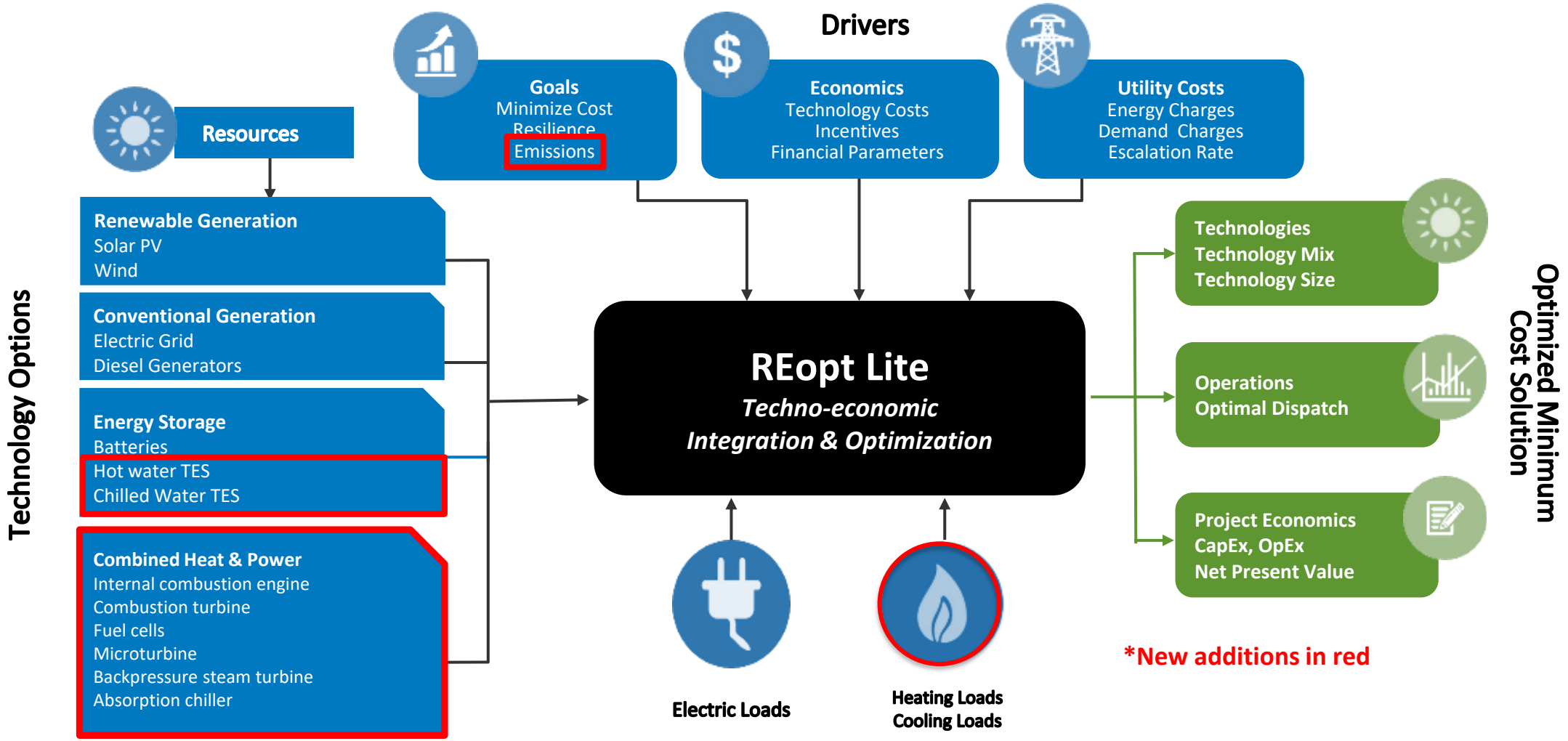
Utility Cost & Consumption

Financial Parameters

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

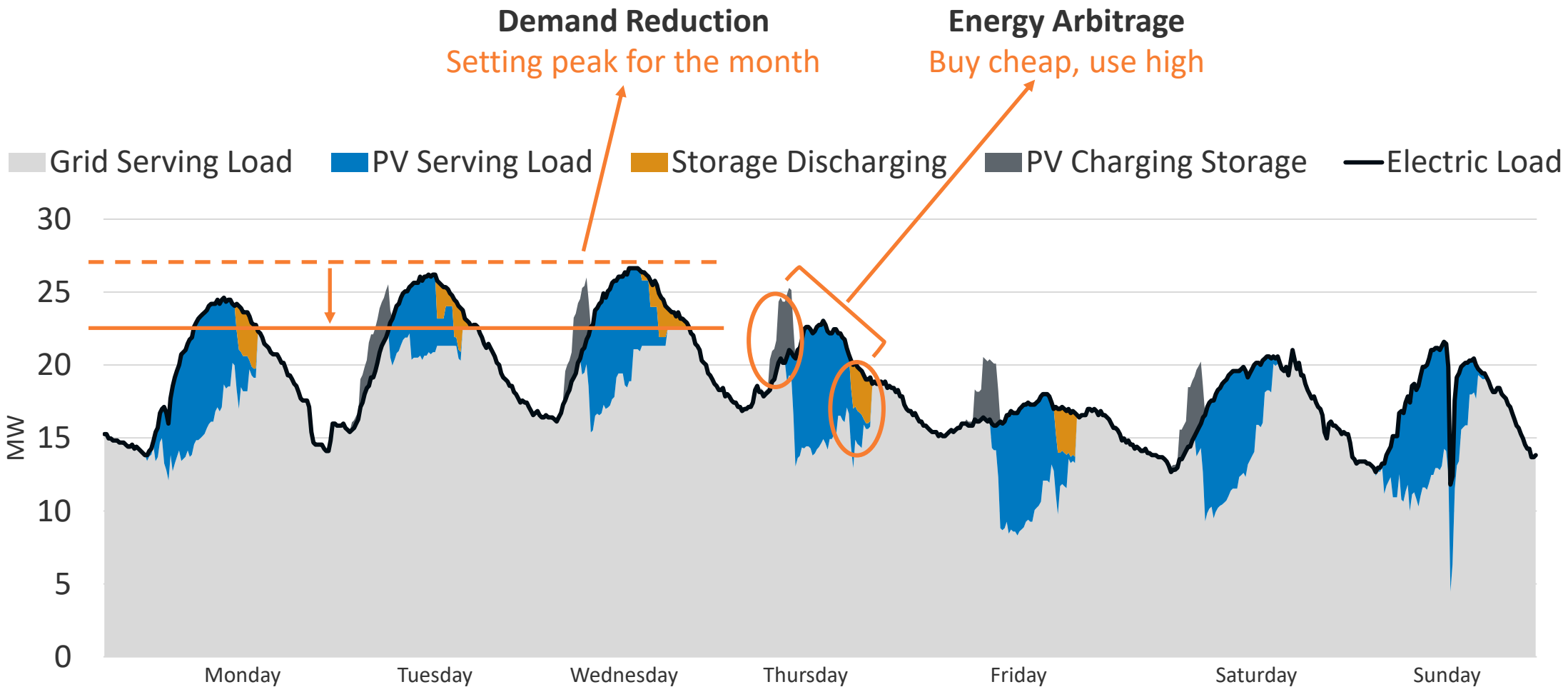
REopt Lite: Free Web Tool to Optimize Economic and Resilience Benefits of DERs

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



How Does REopt Lite Work?

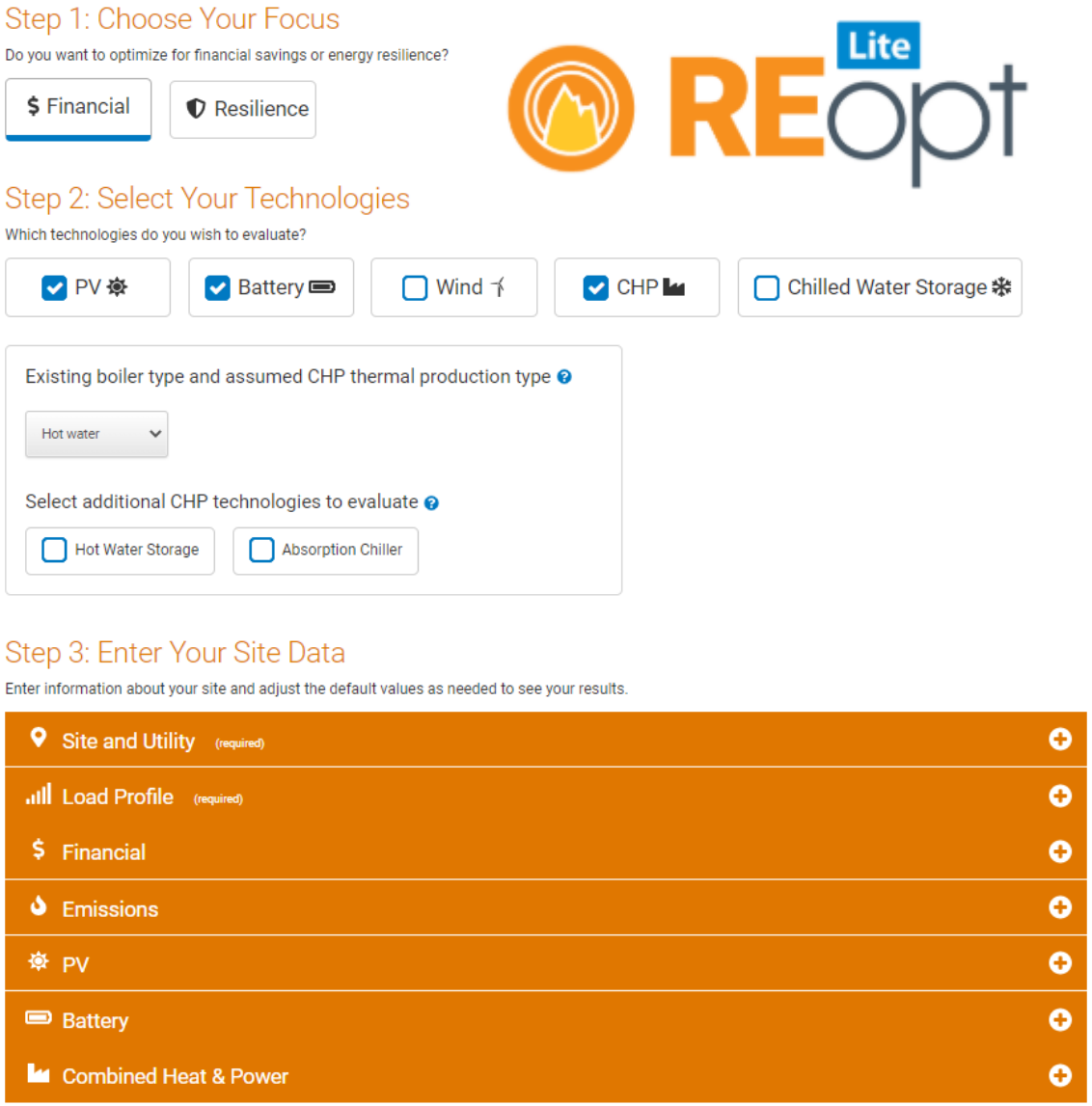
REopt Lite considers the trade-off between ownership costs and savings across multiple value streams to recommend optimal size and dispatch



Example of optimal dispatch of PV and BESS

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 technology sizes and dispatch strategy to minimize life cycle cost of energy
- **Resilience mode** optimizes technology mix to sustain critical load during grid outages and to minimize life cycle cost of energy
- To access REopt Lite: https://reopt.nrel.gov/tool



REopt Lite Key Outputs

System Size and Net Present Value

Results for Your Site

New Evaluation

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

Copy | Download PDF

REopt Lite

Your recommended solar installation size

1,751 kW
PV size

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

328 kW battery power

1,557 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 recommended CHP electric capacity

392 kW
CHP reciprocating engine size

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

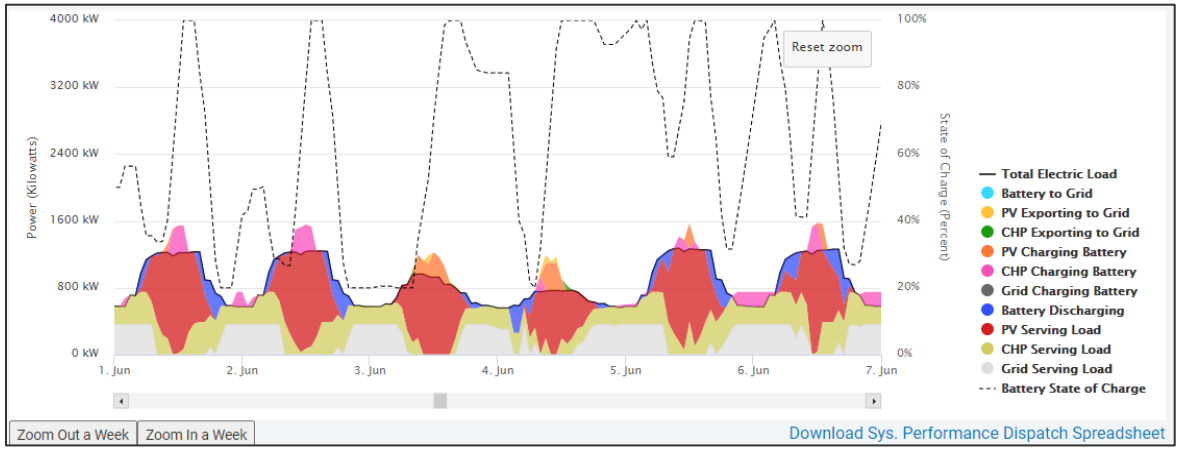
This optimized size may not be commercially available. The user is responsible for finding a commercial product that is closest in size to this optimized size.

Your 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.

$2,813,245

Hourly Dispatch



Detailed Financial and Energy Outputs

Summary Financial Metrics			
Total Upfront Capital Cost Before Incentives	N/A	$4,828,681	N/A
Total Upfront Capital Cost After Incentives	N/A	$3,070,132	$3,070,132
Lifecycle O&M and replacement costs, after tax	N/A	$1,399,584	$1,399,584
Total Life Cycle Costs	$15,056,424	$12,243,179	$2,813,245
Net Present Value	$0	$2,813,245	$2,813,245
Payback Period	N/A	5.56 yrs	5.56 yrs
PV Levelized Cost of Energy	N/A	$0.074	$0.074
Internal Rate of Return	N/A	16.23%	16.23%

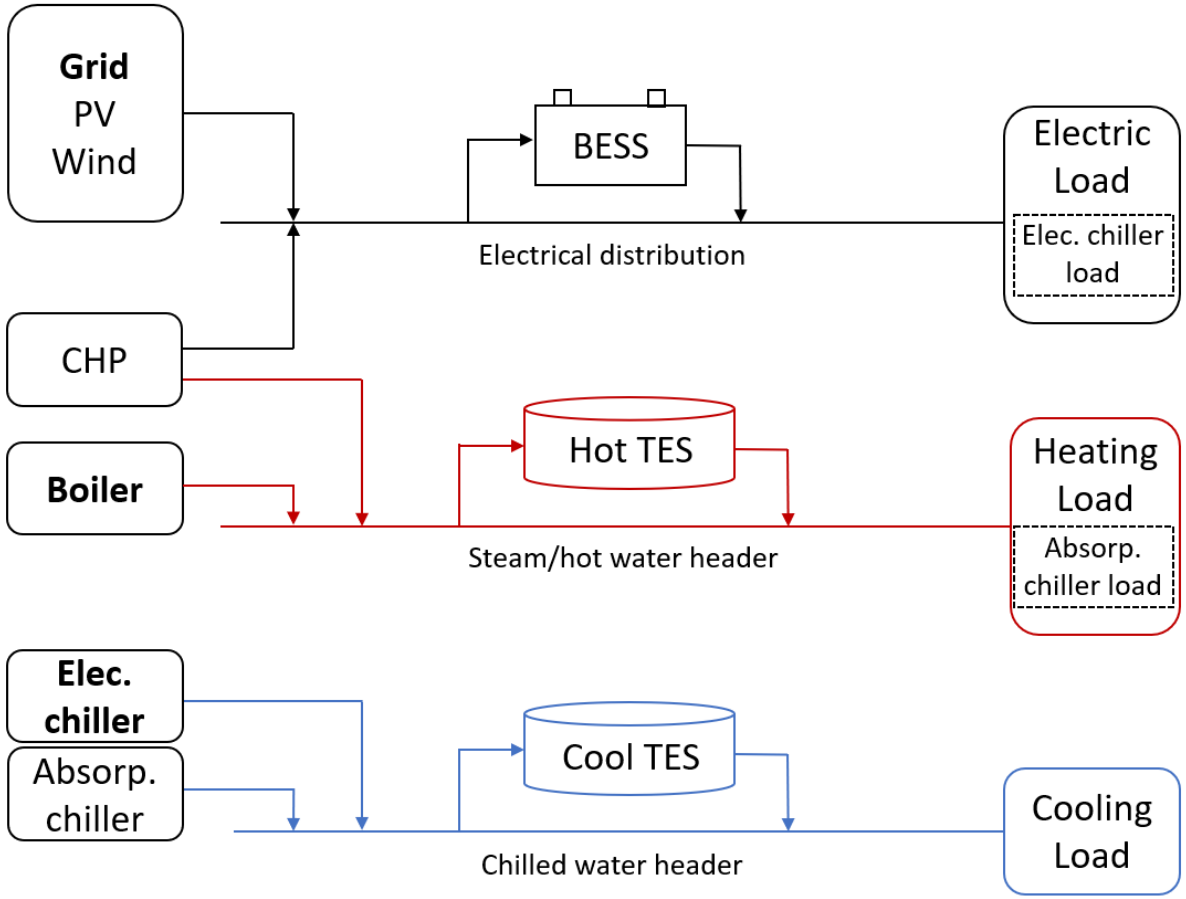
CHP and Related Technologies in REopt Lite

Scope

1. CHP and Hybrid CHP
2. Screening for technical and economic potential; not a design tool, i.e., does not replace consultation with technical experts and application engineers
3. Retrofit application
4. Defaults based on commercial to small industrial scale
5. Technology sizes are typically an output although the user can fix sizes

Assumptions

- Existing conditions:
  - Electrical service from a utility
  - Service from natural gas pipeline or fuel storage and delivery infrastructure
  - Central heating plant
  - Central cooling plant if absorption chillers and chilled water TES are analyzed
- CHP system can operate in parallel with electric utility and centralized heating and cooling plants
- CHP can serve some, all, or none of the electric and heating loads
- No equipment redundancy requirements and factors of safety
- User-entered loads and available renewable resources do not change significantly over the analysis period
- There is space at the facility to install equipment



Existing infrastructure in the figure shown in **bold**

Prime Mover Defaults

- Defaults provided for:
  - Reciprocating engine
  - Microturbine
  - Combustion turbine
  - Fuel cell
- Primarily from DOE Fact Sheets except part load conditions
- ISO-like conditions, natural gas
- Prime mover model includes part-load impacts on fuel efficiency and heat recovery
- Specific heat recovery configurations and process fluid conditions (linked to the heat recovery)
  - 160 F inlet / 180 F exit water, or
  - 150 PSIG saturated steam

Prime Mover	Reciprocating Engine					
Class size low (kW)	30	30	100	630	1,140	3,300
Class size high (kW)	9,300	100	630	1,140	3,300	10,000
Minimum electric power capacity (kW)	0	0	0	0	0	0
Minimum non-zero power capacity (kW)	15	15	50	315	570	1,650
Maximum electric power capacity (kW)	10,000	10,000	10,000	10,000	10,000	10,000
Installed cost function, installed cost ($/kW), and size pair at lower size	$3,300, 30 kW	$3,300, 30 kW	$2,900, 100 kW	$2,700, 630 kW	$2,370, 1,140 kW	$1,800, 3,300 kW
Installed cost function, installed cost ($/kW), and size pair at larger size	$1,430 9,300 kW	$2,900, 100 kW	$2,700, 630 kW	$2,370, 1,140 kW	$1,800 3,300 kW	$1,430 9,300 kW
Fixed O&M ($/kW/yr)	0	0	0	0	0	0
Variable O&M cost ($/kWh)	0.019	0.0245	0.0225	0.020	0.0175	0.0125
Electric efficiency at 100% load (HHV basis)	35.6%	29.6%	32.1%	35.8%	39.0%	41.5%
Hot water thermal efficiency at 100% load (HHV basis)	43.6%	50.3%	47.9%	43.6%	40.5%	36.8%
Steam thermal efficiency at 100% load (HHV basis)	14.8%	0.0%	18.2%	16.9%	14.4%	12.8%
Cooling thermal factor (single effect)	0.83	0.80	0.83	0.85	0.85	0.85
Min. electric loading of prime mover (% of rated electric capacity)	50%	50%	50%	50%	50%	50%

Live Demo of REopt Lite

REopt Lite CHP Development Team

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Thank you!

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

www.nrel.gov

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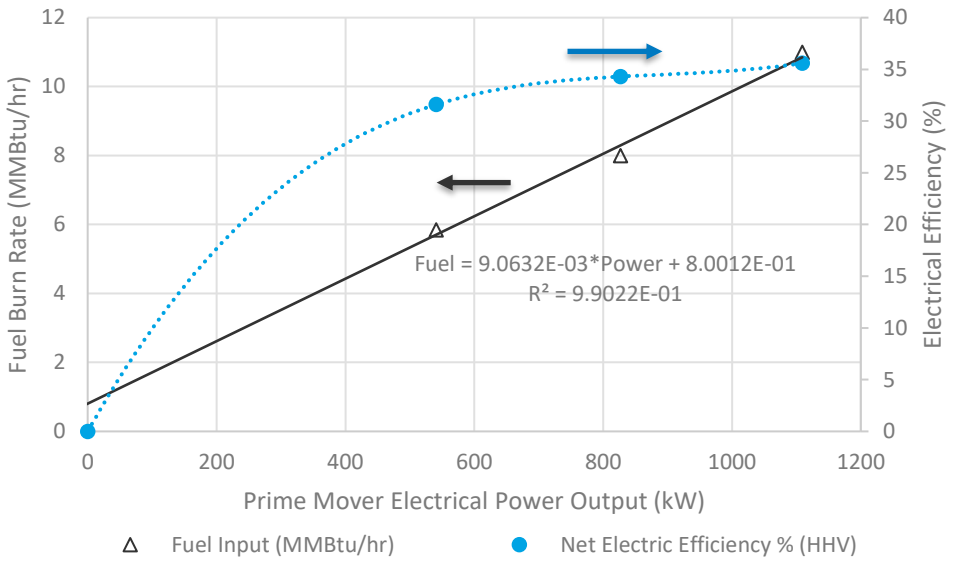
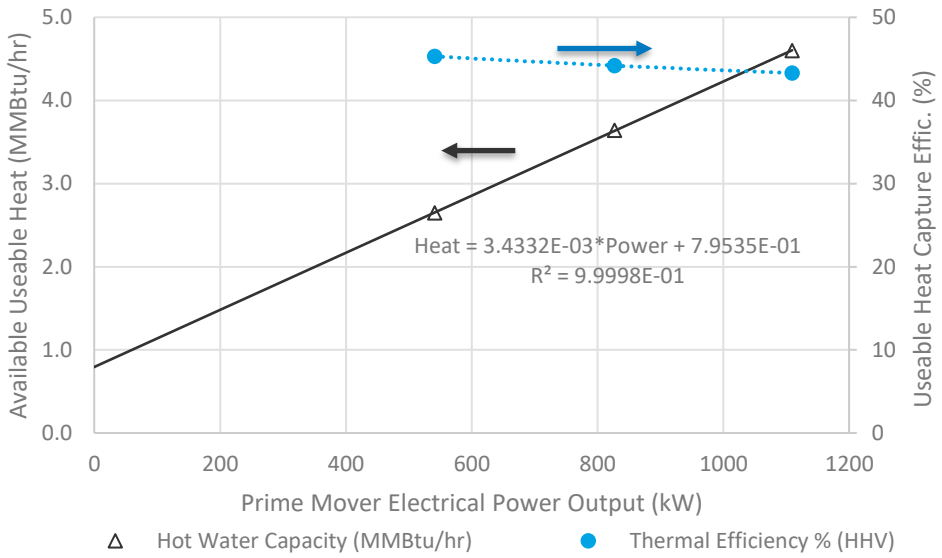
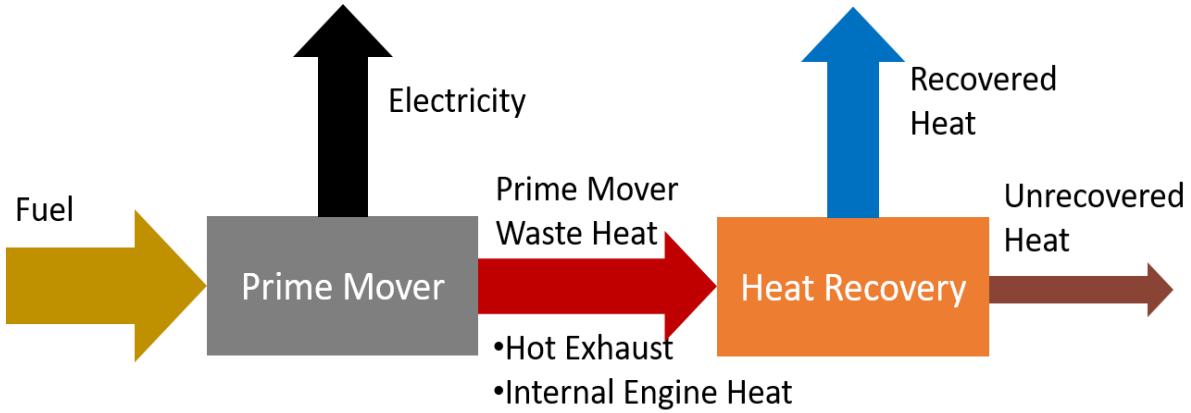
Backup slides

Modeling CHP Prime Mover

- Currently, topping cycle only
- Fuel and heat are linearized with power

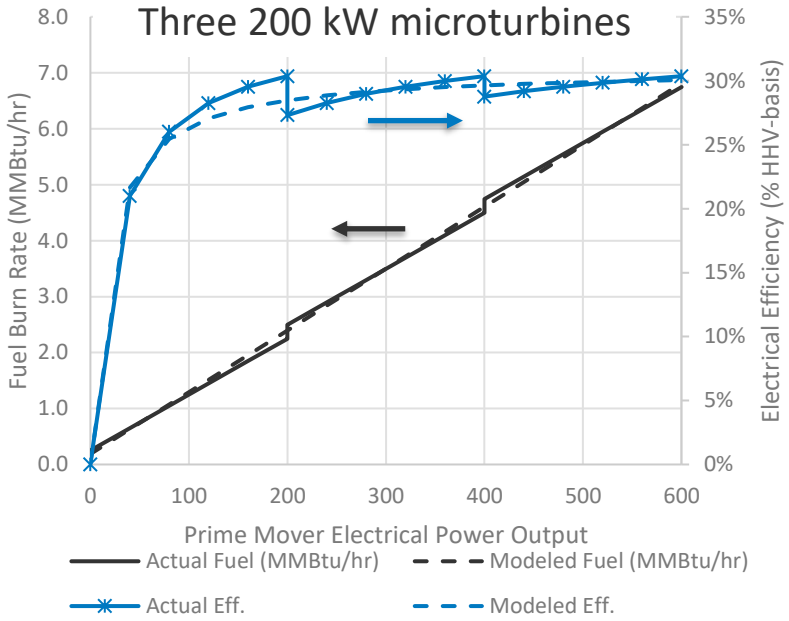




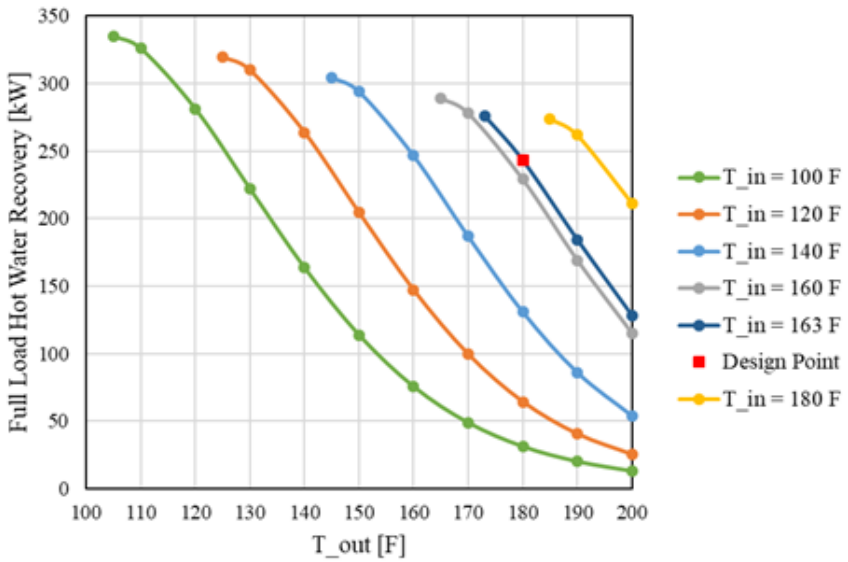


Prime Mover Additional Details

- Modeling multiple generators operating as a CHP system requires simplifying fuel and heat recovery to linear functions
- Derate for altitude and inlet air
- Heat recovery adjustments for process fluid conditions that differ from default conditions
- Exploring more complex adjustments in fuel and heat parameters for non-ISO conditions



Heat recovery performance mapping for 200 kW microturbine



Heating Plant

- Heating plant is assumed to be comprised of boiler(s)
  - Hot water or steam
- User inputs for existing plant efficiency and hourly fuel consumption
- User can select heating loads from building models or enter their own data if better estimates are available
  - Commercial reference building types can be blended to user
  - Annual or monthly fuel totals can be used to scale model load profiles
- Efficiency of existing heating plant is constant
- No turndown limits / minimum unloading ratio

Cooling Plant

- Cooling plant is assumed to include one or more electrically-driven chillers
- To consider chilled water TES or absorption chiller, COP of existing CW plant and hourly electricity usage are needed
- User can select cooling loads from building models or enter their own data if better estimates are available
- COP of existing and absorption chiller are constant
- No turndown limits / minimum unloading ratio

Thermal Energy Storage

- Allows decoupling of the resource from the load
- Hot water and chilled water storage available
- Stratified tank with a thermocline
- Simple ‘thermal bucket’ model linearizes complex heat transfer to approximate daily typical figure of merit
- Time-dependent thermal decay
- Thermal capacity per unit tank volume is dependent on process heating and chilled water loop temperatures

Thank you for attending our webinar

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Upcoming Webinars

- Solar+Storage for Puerto Rico Fire Station Resilience (3/3)
- Building Community Resilience Hubs: A Conversation with the Asian Pacific Environmental Network and RYSE Center (3/10)
- ConnectedSolutions: How a New Program Improves the Economics and Social Benefits of Solar+Storage in Massachusetts and Beyond (3/12)
- Collaborating with Community-Based Organizations: An Energy Justice Primer for States (3/23)

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