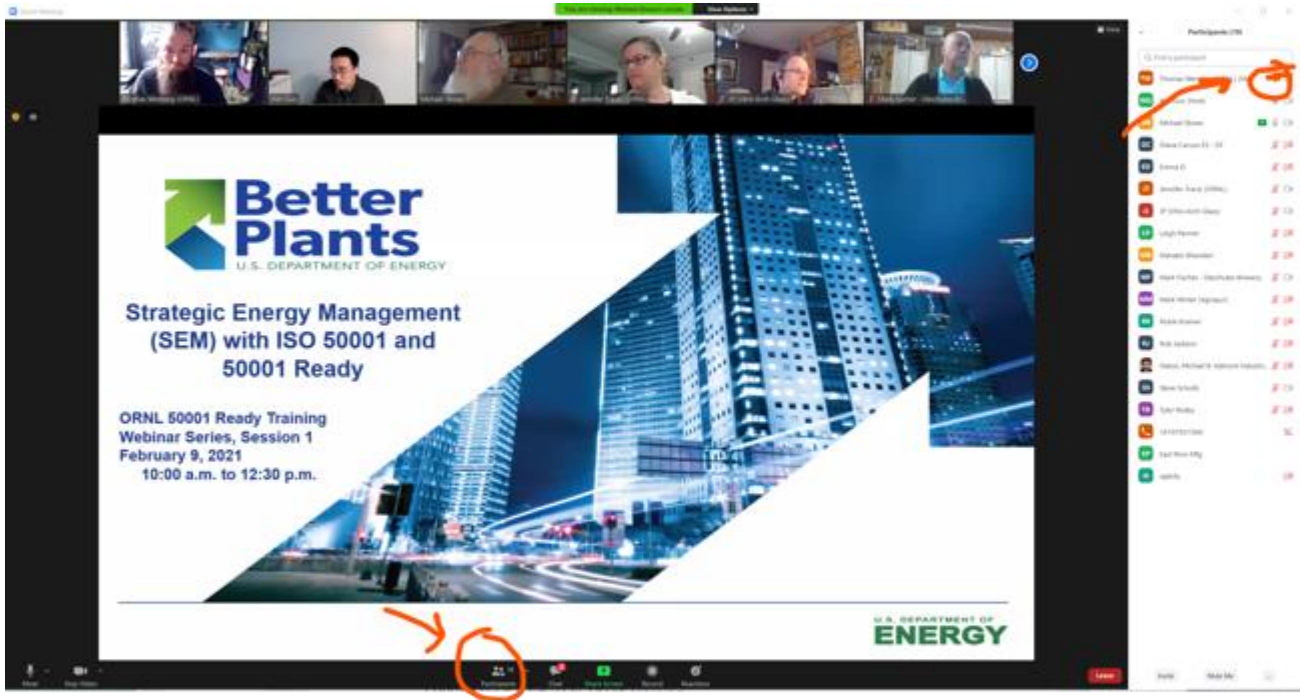
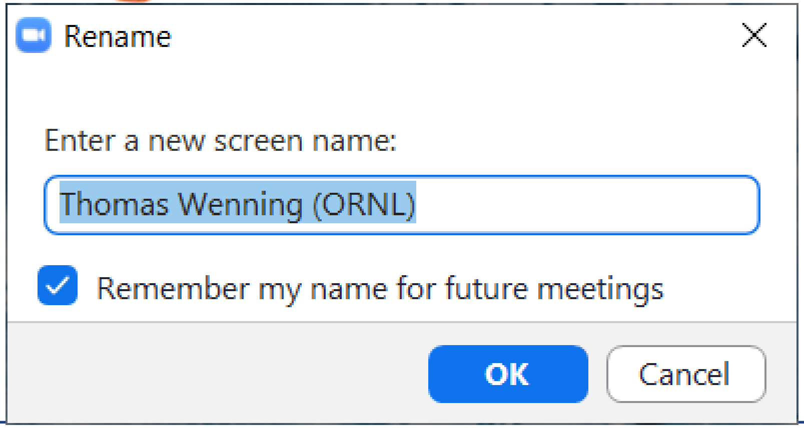
Rename Yourself to be your Real Name (Company Name)

1. Click on Participant list
2. Go to the right and hover over your name
3. Select “More” & “Rename”
4. Enter your company name in brackets
5. Turn on your camera ☺





Virtual Training: Combined Heat & Power Systems

Integrating CHP with Microgrids and Other Renewable Onsite Energy Technologies

Session #4
December 17, 2024
10:00am – 12:30pm EST

Agenda

1. Review Session #3 Homework
2. Introduction to the Onsite Energy Program and the Onsite Energy Technical Assistance Partnerships
   - Meegan Kelly, *U.S. DOE, EERE, IEDO*
3. Benefits of CHP in Combination with Other Onsite Energy Technologies and Case Studies
   - Bruce Hedman, *Entropy Research, LLC*
4. REopt: Energy Decision Analysis
   - Bill Becker, *NREL*
5. Onsite Energy Program Available Resources
   - Isaac Panzarella, *DOE Southeast Onsite Energy TAP*
6. Q&A

Today's Speakers

Meegan Kelly

Technology Manager,
U.S. DOE, EERE, IEDO

Bruce Hedman

Managing Director,
Entropy Research, LLC

Bill Becker

Senior Engineer,
NREL

Isaac Panzarella

Director,
DOE Southeast Onsite Energy TAP

U.S. DEPARTMENT OF ENERGY

Review of Session #3 Homework

1. What is the difference between Scope 1, 2, and 3 emissions?
2. Fuel used for onsite CHP operations would fall under which Scope of emissions?
   a. Scope 1
   b. Scope 2
   c. Scope 3
   d. All of the above
3. How are the GHG assessment boundaries different between Inventory and Project Accounting?
4. Which of the following are not sources of marginal emissions data? Select all that apply. [multiselect]
   a. eGRID
   b. CAISO
   c. AVERT
   d. Cambium
   e. GWP
5. Why is Inventory Accounting unable to fully capture the emissions savings associated with CHP plants?
6. What are some strategies that CHP can use to continue to decarbonize as the grid gets cleaner?

Review of Session #3 Homework

1. What is the difference between Scope 1, 2, and 3 emissions?
   - Scope 1 emissions are directly generated by a company's operations. Scope 2 emissions stem from the electricity, heat, or cooling a company purchases and uses. Scope 3 emissions are all other indirect emissions throughout a company's value chain.
2. Fuel used for onsite CHP operations would fall under which Scope of emissions?
   a. **Scope 1**
   b. Scope 2
   c. Scope 3
   d. All of the above
3. How are the GHG assessment boundaries different between Inventory and Project Accounting?
   - The assessment boundary for project accounting encompasses GHG effects regardless of where they occur. For inventory accounting, the boundary is based on a facility's physical boundary.

Review of Session #3 Homework

4. Which of the following are not sources of marginal emissions data? Select all that apply.
   a. eGRID
   b. CAISO
   c. AVERT
   d. Cambium
   e. GWP

5. Why is Inventory Accounting unable to fully capture the emissions savings associated with CHP plants?
   - Scope 2 Inventory accounting uses average emissions factors instead of marginal emissions factors
   - Inventory accounting doesn't capture emissions impacts outside of the plant boundary

6. What are some strategies that CHP can use to continue to decarbonize as the grid gets cleaner?
   - Alternative Fuels and/or dispatching based on grid carbon intensity

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Introduction to the Onsite Energy Program and the Onsite Energy Technical Assistance Partnerships

Meegan Kelly
U.S DOE, EERE, IEDO

U.S. DEPARTMENT OF ENERGY

IEDO Technical Assistance and Workforce Development

Direct engagement with industry to drive the widespread adoption of proven technologies and practices to improve energy performance and reduce GHG emissions

Support the deployment of energy efficiency and decarbonization technologies and practices

Foster feedback from stakeholders on critical technology challenges that may be addressed through RD&D

IEDO offers no-cost tools and programs to improve energy efficiency, competitiveness, & sustainability:

Better Plants® U.S. DEPARTMENT OF ENERGY
- Expert technical assistance and training on energy efficiency
- Access to Innovation & instruments
- National recognition for achievements

Better Climate CHALLENGE U.S. DEPARTMENT OF ENERGY
- Energy efficiency + decarbonization technical assistance & training
- Facilitated peer-to-peer knowledge sharing
- National recognition for achievements

50001 Ready U.S. DEPARTMENT OF ENERGY
- Tools, guidance and recognition for facilities that implement an ISO 50001-based energy management system
- No-cost, self-paced, audit-free

Onsite Energy U.S. DEPARTMENT OF ENERGY
- Regional network of Onsite Energy Technical Assistance Partnerships (TAPs)
- Site screenings for multi-technology solutions and more advanced analysis
- Market analysis, outreach, and stakeholder engagement

NO-COST TOOLS & SOFT-WARE

- MEASUR Software Suite
- 50001 Ready Navigator Tool
- REopt Web Tool
- Financing Navigator
- Low Carbon Action Plan Tool
- Carbon Inventory Calculator
- Electrification Impact Calculator

Onsite Energy Program

The U.S. Department of Energy's (DOE) Onsite Energy Program provides technical assistance, market analysis, and best practices to help industrial facilities and other large energy users increase the adoption of onsite clean energy technologies.

battery storage | combined heat and power | district energy | fuel cells | geothermal | industrial heat pumps

renewable fuels | solar PV | solar thermal | thermal storage | waste heat to power | wind

Why is Onsite Energy Important?

Cost Savings:
Significant cost savings can be achieved through **utility bill reductions** and the **sale of excess electricity production** back to the grid.

Resilience:
Organizations can **ensure uninterrupted operations during grid outages or emergencies** with onsite energy solutions, enhancing operational resilience and reducing the risk of financial losses.

Sustainability:
Onsite energy deployment contributes to environmental sustainability by **reducing carbon emissions,** demonstrating corporate responsibility, and **aligning with sustainability goals and regulations.**

Independence:
By **reducing dependence on external energy sources**, onsite energy systems enhance energy independence and security, **mitigating risks** associated with energy price volatility and supply chain disruptions.

Grid Support:
Onsite energy resources can **provide ancillary services to the grid** (e.g., voltage support and frequency regulation) and **peak shaving**, enhancing grid stability and reliability.

Community Engagement:
Onsite energy projects can **foster community involvement** through cooperative ownership models, shared savings programs, and educational initiatives, **strengthening social cohesion and resilience**.

Innovation:
Investing in onsite energy technologies drives **innovation and technological advancement in renewable energy and energy storage**, positioning organizations at the forefront of the clean energy transition.

Onsite Energy Technical Assistance Partnerships (TAPs)

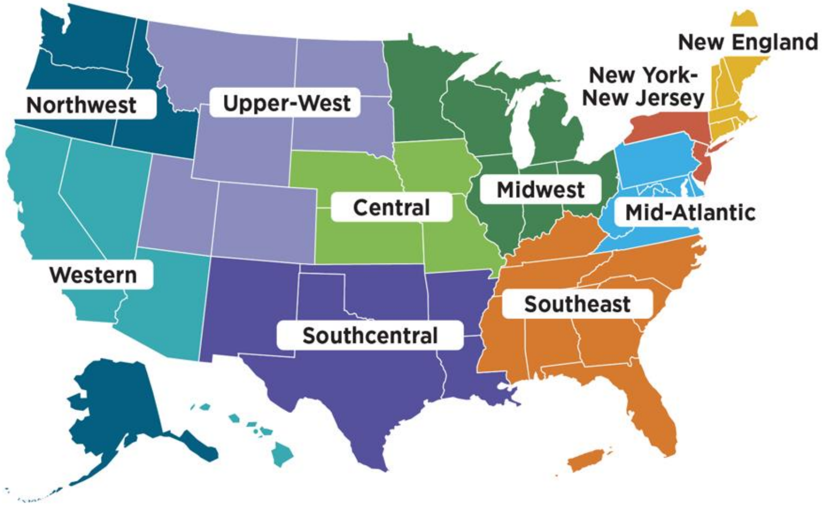
DOE's 10 regional Onsite Energy TAPs provide technical assistance to end users and other stakeholders about technology options for achieving clean energy objectives. Key services include:

Technical Assistance: Screen sites for opportunities to implement onsite energy technologies and provide advanced services to maximize economic impact and reduce risk from initial screening to installation to operation and maintenance.

End-User Engagement: Partner with organizations representing industrial and other large energy users to advance onsite energy as a cost-effective way to transition to a clean energy economy.

Stakeholder Engagement: Engage with strategic stakeholders, including utilities and policymakers, to identify and reduce barriers to onsite energy through fact-based, unbiased education.

Onsite Energy Technical Assistance Partnerships
U.S. DEPARTMENT OF ENERGY



https://betterbuildingssolutioncenter.energy.gov/onsite-energy/taps

Onsite TAP Services Across Project Development Phases

Identification

- Operational goals
- Portfolio analysis
- Technology screening
- Economic analysis
- Regulatory review

Design & Development

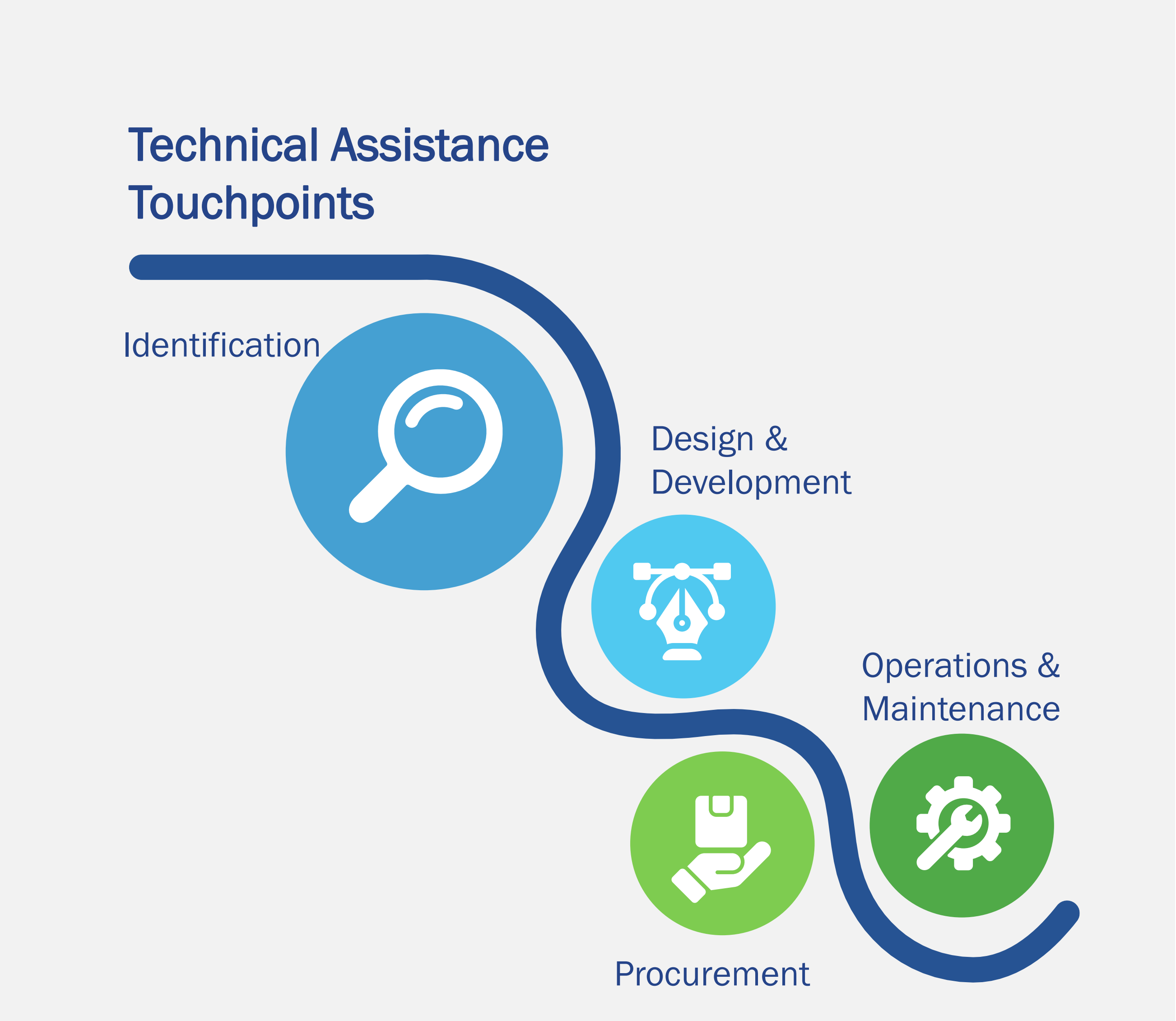
- Planning
- Equipment options
- Equipment siting
- Third-party reviews
- Utility rate analysis

Procurement

- Specifications review
- Finance identification
- Permitting support

Operations & Maintenance

- Measurement & verification
- Optimizing performance
- Reporting



Onsite Energy TAP Program Partners and Stakeholders

Industrial Facilities:
Manufacturing plants, refineries, lumber and sawmills, and other industrial facilities can use onsite energy solutions to enhance energy efficiency, reduce operational costs, and improve environmental performance.

High Energy Use Facilities:
Commercial and institutional facilities with significant energy demands, such as data centers, hospitals, universities, and others can leverage technical expertise and resources to reduce energy costs and enhance resilience.

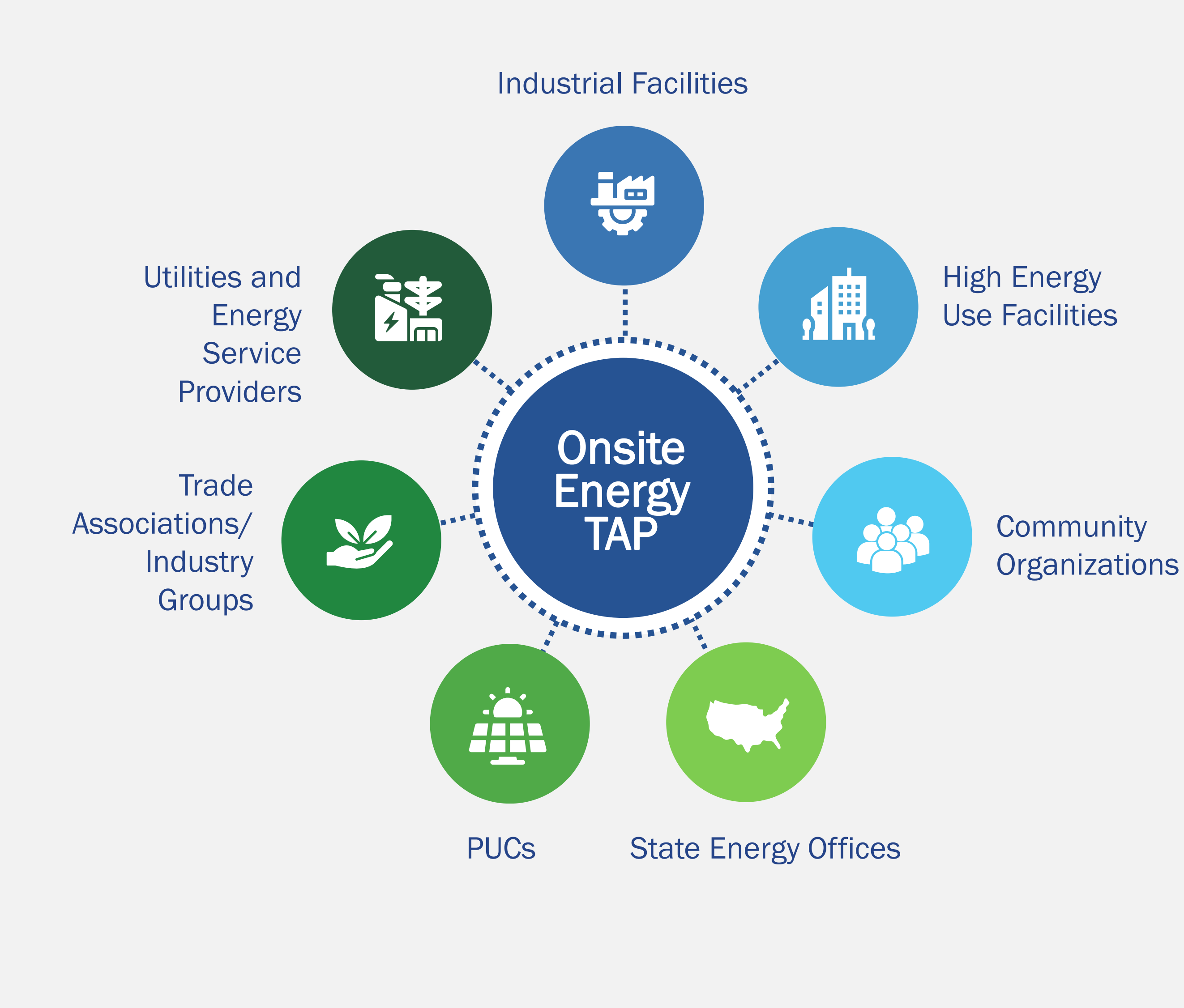
Community Organizations:
Local community groups and environmental organizations can engage with the Onsite Energy TAPs to promote community-scale energy projects and raise awareness about the benefits of onsite energy solutions.

State Energy Offices:
Onsite Energy TAPs can support state agencies in energy planning efforts, provide market data and trends related to onsite energy deployment at the state level, and support state-led events, convenings, and other engagements.

Public Utility Commissions:
Regulators can benefit from subject matter expertise, policy analysis, and technical support that help inform decision-making related to onsite energy deployment topics.

Trade Associations and Industry Groups:
Organizations representing trades, technology suppliers, or end-users can partner with the Onsite Energy TAPs to build awareness of solutions and reduce barriers to onsite energy deployment.

Utilities and Energy Service Providers:
Utilities and energy service companies can collaborate with the Onsite Energy TAPs to explore innovative business models, offer tailored solutions to customers, and integrate distributed energy resources into grid operations.



U.S. Department of Energy's (DOE) Onsite Energy Technical Assistance Partnerships (TAPs)

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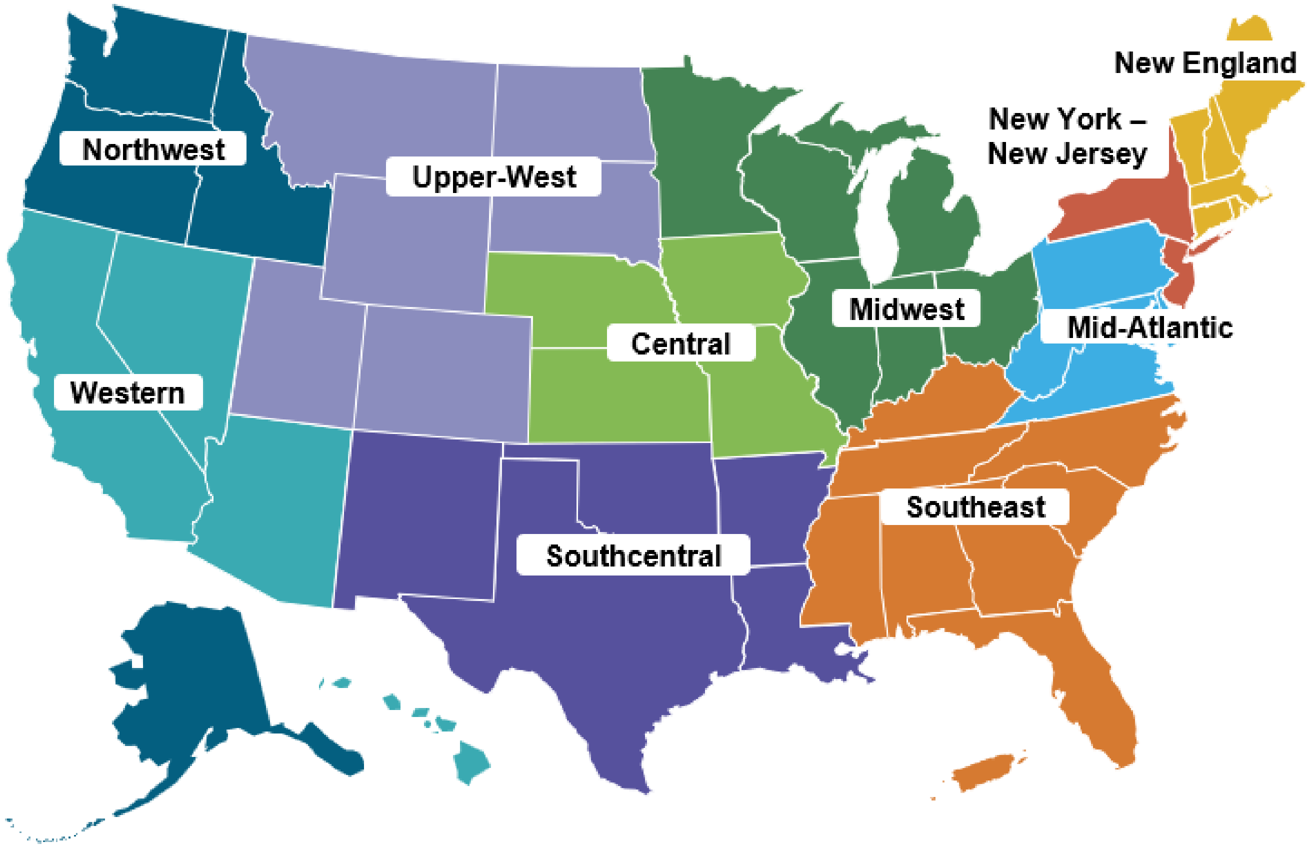

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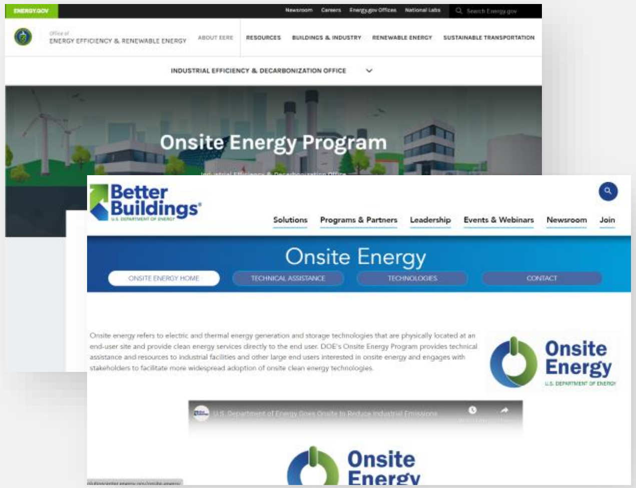
For More Information

Visit the Webpages

http://bit.ly/3xGoCrz



Read the Fact Sheet

https://bit.ly/3zuZhkW

Watch the Video

https://bit.ly/3ztJjrn

DOE Onsite Energy Program Contacts

https://bit.ly/3xMM7zc

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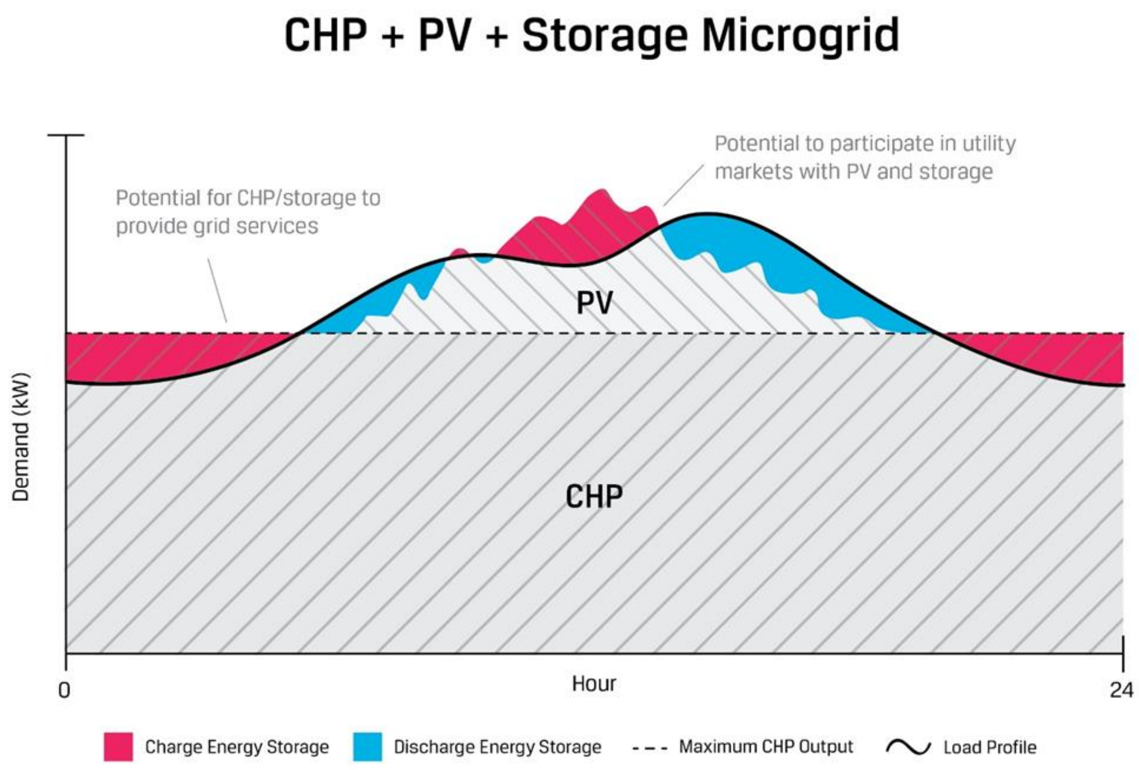
Benefits of CHP in Combination with Other Onsite Energy Technologies

Bruce Hedman
Entropy Research, LLC

U.S. DEPARTMENT OF ENERGY

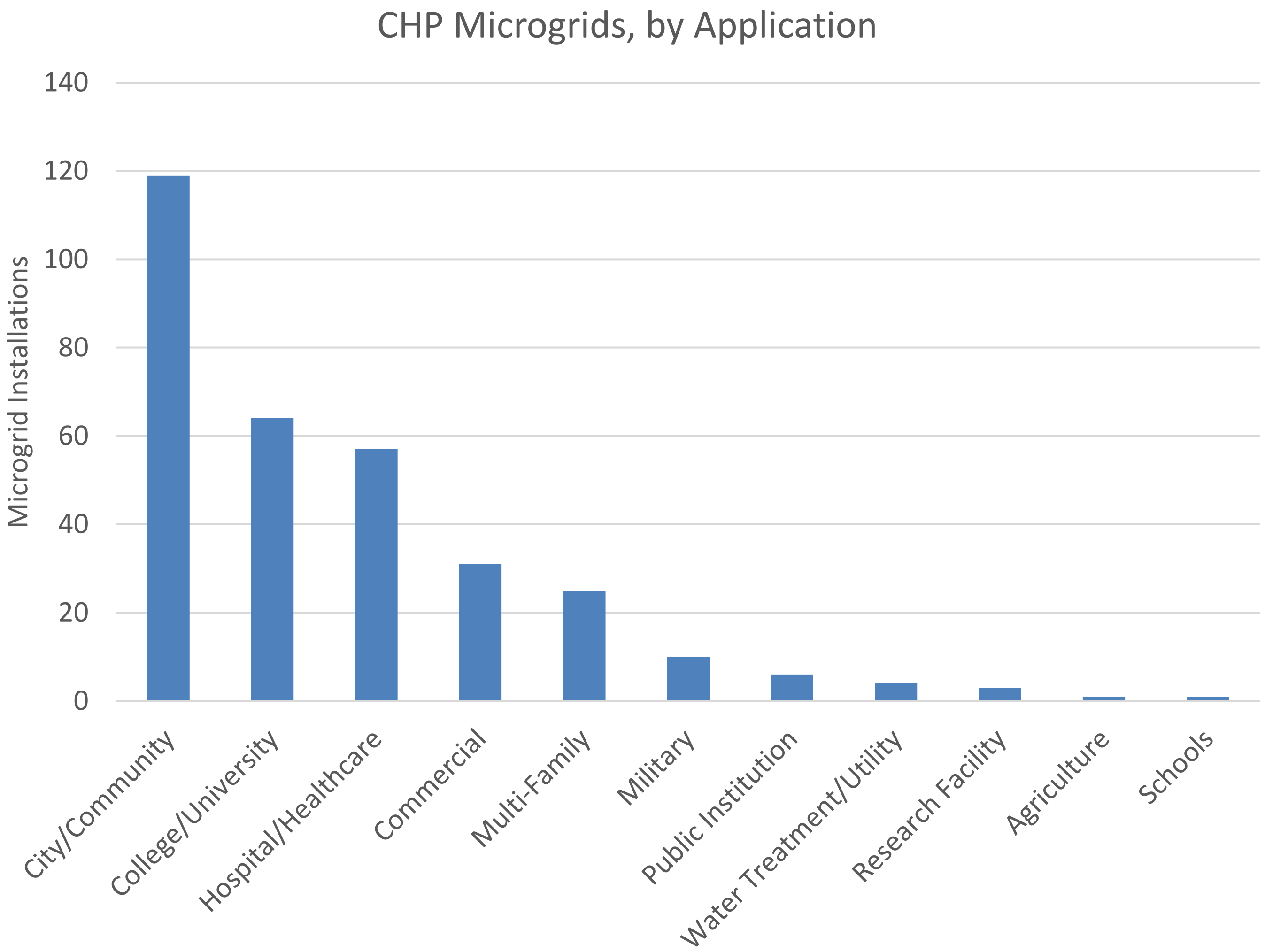
CHP Can Play a Key Role in Clean, Resilient Microgrids

- CHP provides efficient, resilient, baseload power and localized thermal energy
- CHP can support increased integration of renewable energy sources
- Storage adds additional flexibility and can help optimize CHP sizing and operation
- CHP enables the move toward a resilient, distributed, more renewable grid
- Flexible CHP systems can ramp up and down as needed to balance loads, enhance reliability and provide grid services if needed



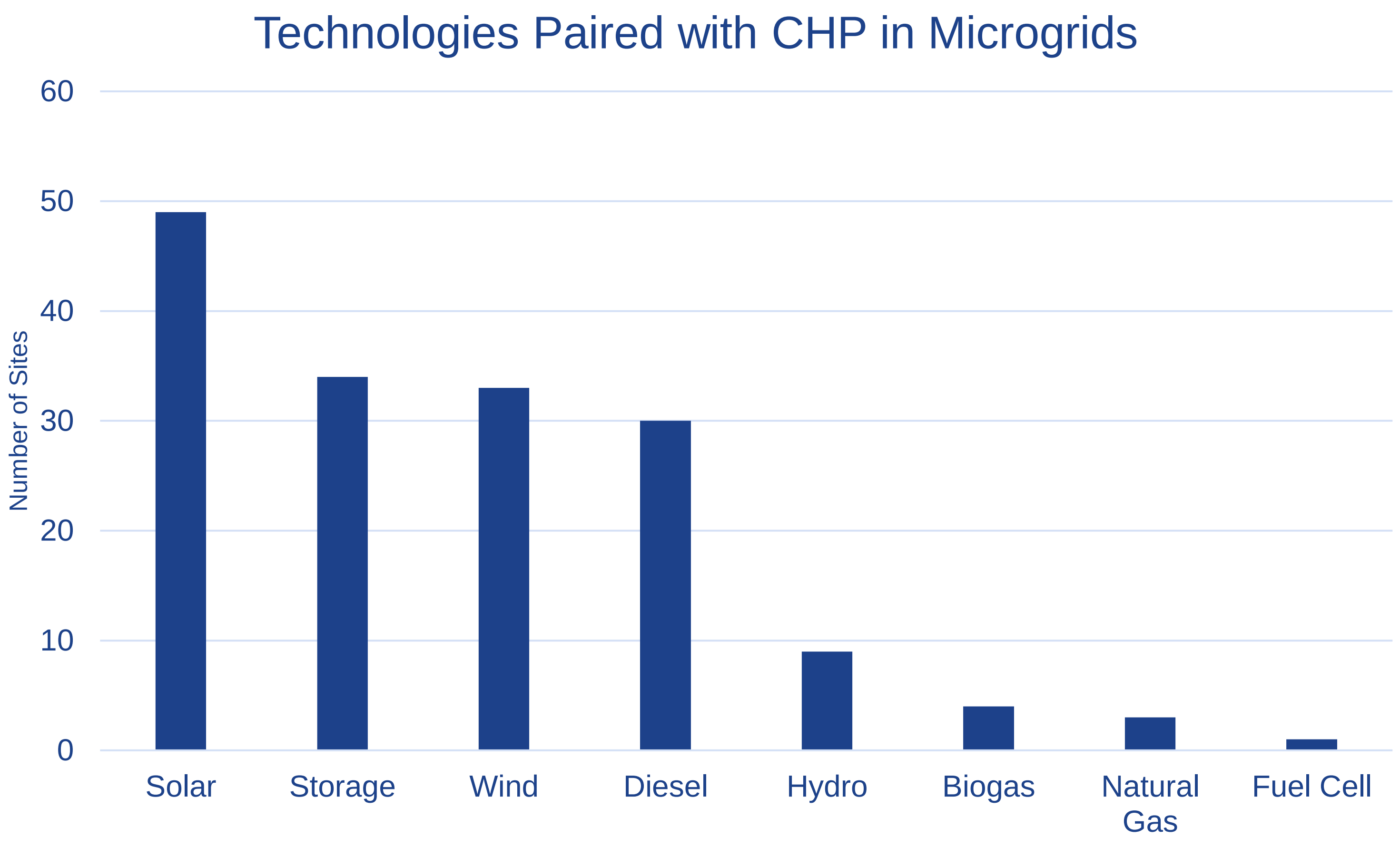
CHP Serves as an Anchor for Resilient Microgrids

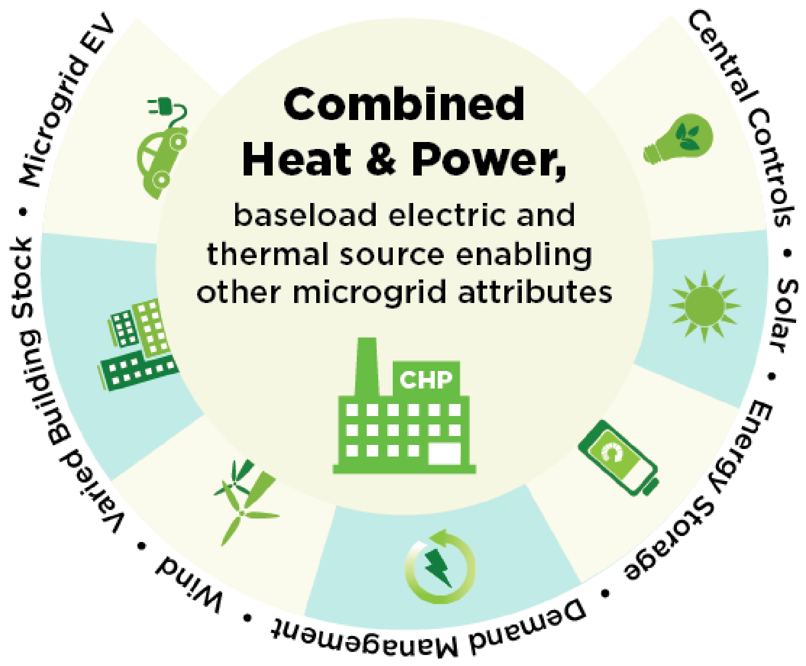
- CHP provides reliable baseload heat and power, and can act as a resilient anchor for microgrids connecting multiple technologies and loads
- 321 microgrids with CHP
  - Total capacity: 2,944 MW
  - 2,573 MW (87%) from CHP
- CHP is most often used for microgrids at cities/communities and colleges /universities (over 180 total sites)



Source: DOE Microgrid Installation Database, as of June 2024

Hybrid Onsite Generation Solutions for Microgrids with CHP

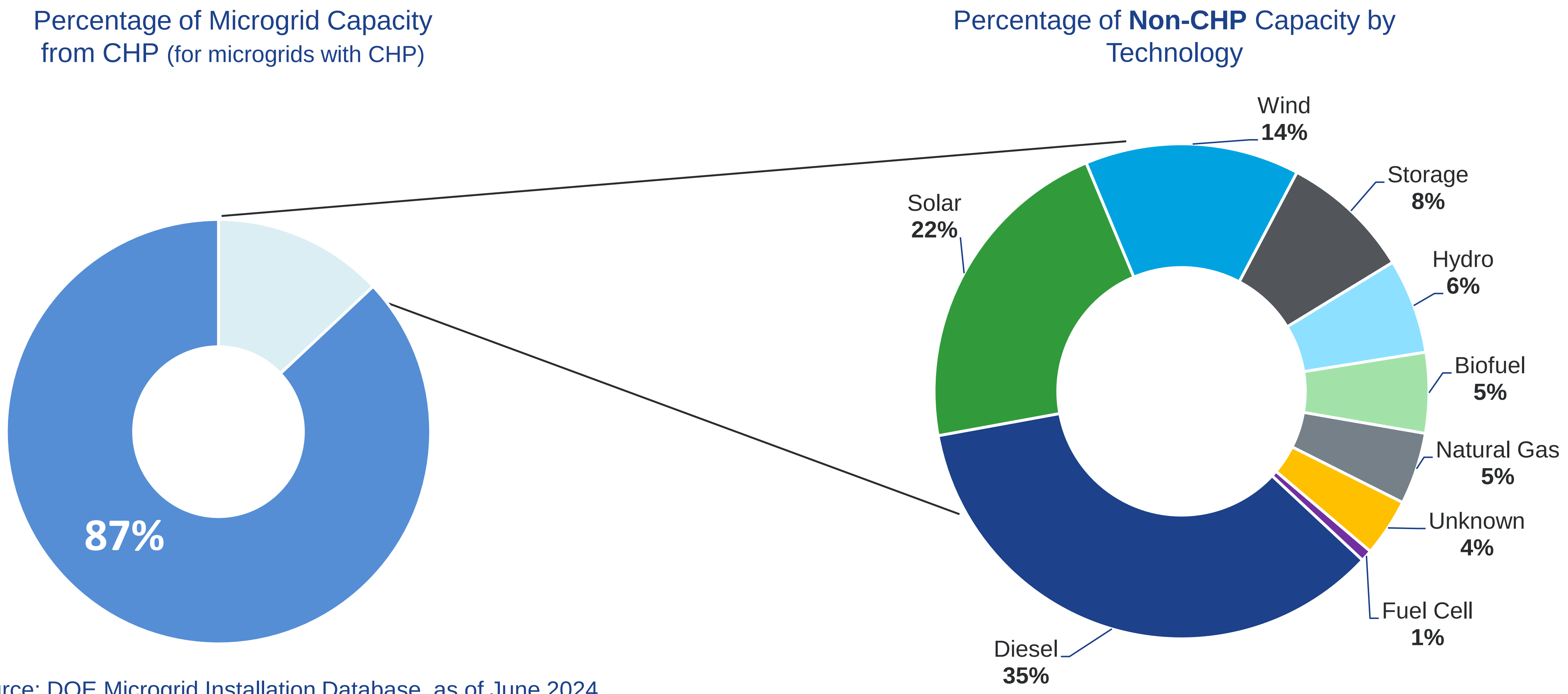




Source: DOE Microgrid Installation Database, as of June 2024

CHP Microgrid Capacity by Technology

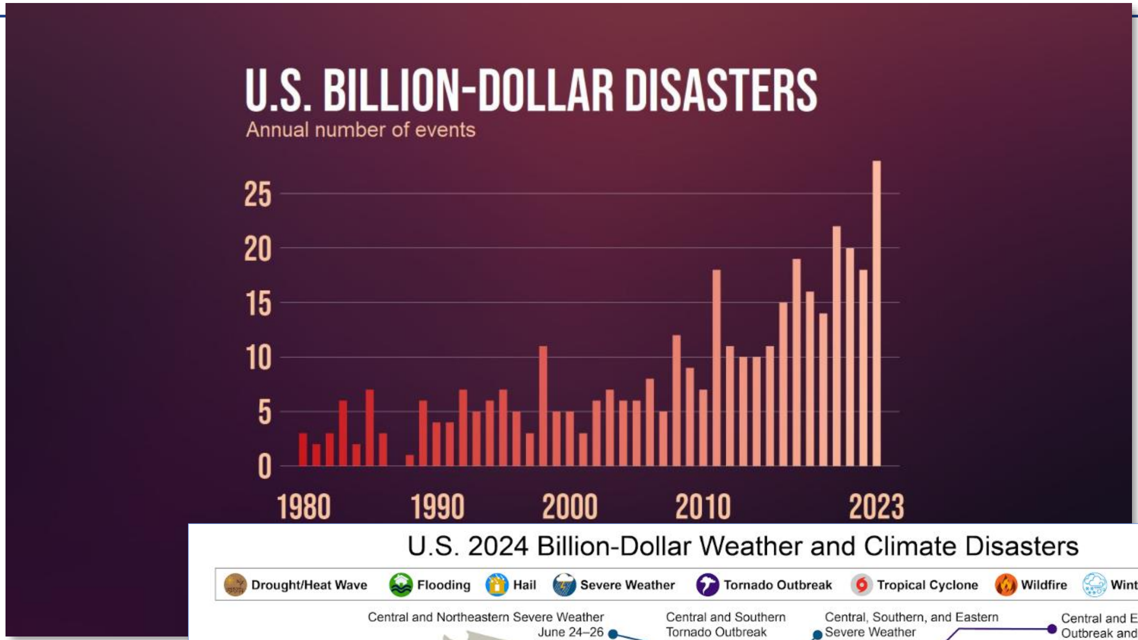
CHP represents 87% of capacity in microgrids **that incorporate CHP**

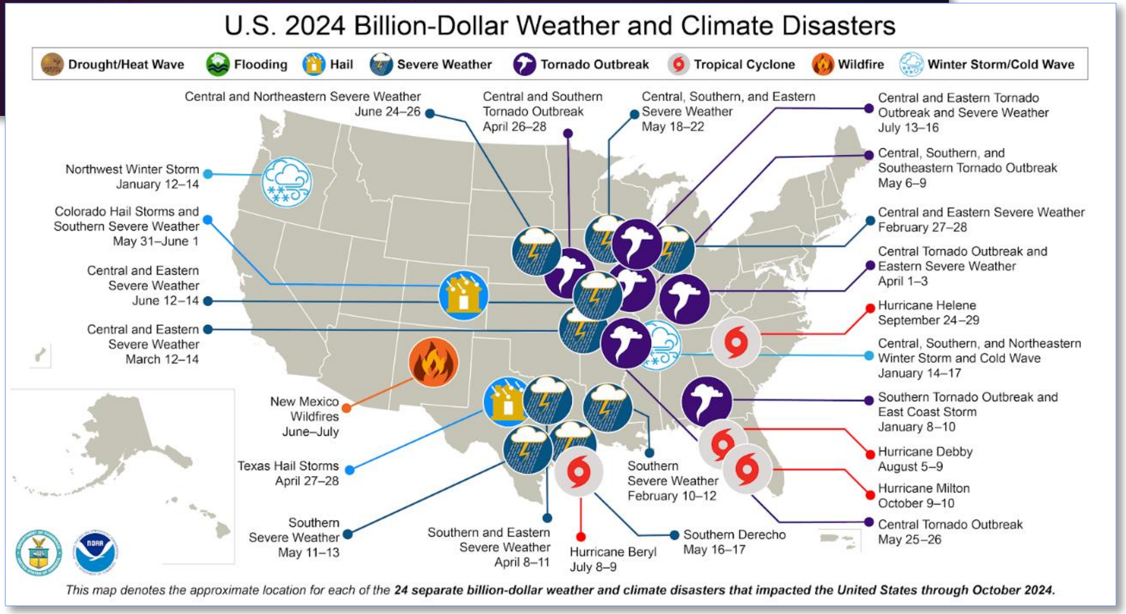


Source: DOE Microgrid Installation Database, as of June 2024

Reliable and Resilient Power Is an Increasing Concern

- Higher reliability and levels of power quality are needed to meet customer requirements
- Increased incidences of grid outages
- More intense and more frequent weather events
- Susceptibility to terrorism and other man-made disturbances
- Consequences for health and safety, and for business continuity





https://www.ncei.noaa.gov/access/billions/

CHP Provides Resilience for Long Duration Outages

CHP vs. Backup Generation

Metric	CHP	Backup Generation
System Performance	▪ Designed and maintained to run continuously ▪ Improved performance and reliability	▪ Only used during emergencies
Fuel Supply	▪ Natural gas infrastructure typically not impacted by severe weather	▪ Limited by on-site storage – finite fuel supply
Cost Effectiveness	▪ Provides financial benefits through energy savings every day	▪ Only used during emergencies
Energy Supply	▪ Electricity ▪ Thermal (heating, cooling, hot/chilled water)	▪ Electricity
Emissions	▪ Typically natural gas fueled ▪ Greater system efficiencies (80%) ▪ Lower emissions	▪ Commonly burn diesel fuel

Public Safety Headquarters, Gaithersburg, Maryland

Project Snapshot: CHP Microgrid

Application	Government Buildings
Technologies	CHP, Solar PV
Technology Details	865 kW Natural Gas CHP
	2 MW Solar PV

The CHP system is accompanied with 2 MW of solar capacity.
Photo courtesy of Montgomery County.

Project Highlights:
The PSHQ microgrid system can generate 9.6 million kWh annually, providing an estimated 90 percent of the facility's annual electricity consumption and nearly infinite backup capacity with minor adjustments to operations.

Project Testimonial
"On a typical operating day at the PSHQ advanced microgrid, the combined heat and power system can provide up to 70% of the site's energy from CHP with the remainder from on-site solar with very little utility power."
- Eric Coffman, Chief – Office of Energy and Sustainability, Montgomery County

Source: https://chptap.ornl.gov/profile/135/MoCoPublicSafetyHQ-Project_Profile.pdf

Montgomery County Correctional Facility, Boyds, Maryland

Project Snapshot: CHP Microgrid

Application	Correctional Facility
Technologies	CHP, Solar PV
Technology Details	220 kW Natural Gas Engine CHP
	2.8 MW Solar PV

220 kW CHP system with 2.8 MW of solar PV capacity.
Photo courtesy of Montgomery County.

Project Highlights:
The 220 kW CHP system combined with 2.8 MW of solar PV enables the facility to generate almost 100% of its electricity needs. The CHP system and solar PV operate under an "energy-as-a-service" contract.

Project Testimonial
"The Combined Heat and Power system at the Correctional Facility provides power and heat for the facility while bolstering resilience and reducing the environmental impact of the facility." - Eric Coffman, Chief – Office of Energy and Sustainability, Montgomery County

Source: https://chptap.ornl.gov/profile/134/MoCoCorrectionalFacility-Project_Profile.pdf

Paul L. Bruner Water Pollution Control Plant
Fort Wayne, Indiana

CITY UTILITIES
WATER THAT WORKS

Project Snapshot: CHP Microgrid

Application	Wastewater Treatment Plant
Technologies	CHP, Solar PV, BESS
Technology Details	800 kW Biogas (Food Waste) CHP
	9 MW Floating Solar PV
	1 MW Battery Energy Storage System

Two 400kW Engine Driven CHP Systems w/ Heat Recovery (Photo Courtesy of WPCP)

WPCP Anaerobic Digester Tanks (Photo Courtesy of WPCP)

Floating Solar Array (Photo Courtesy of WPCP)

Project Highlights:

The Microgrid Energy Project's primary goal is to provide emergency power to the Water Pollution Control Plant, Three Rivers Filtration Plant and Wet-Weather Pump Station when electric power outages occur. The Microgrid will reduce greenhouse gas emissions by 4,600 tons annually.

Project Testimonial

"Our Microgrid brings clear environmental and economic benefits. We're confident it will increase reliability in emergencies and diminish storm-related vulnerabilities. It also has the potential to save us significantly with projected electricity cost avoidance of $8-$10 million in the first 20 years and $60-$70 million over 40 years."
- Matthew Wirtz, City Utilities Deputy Director of Engineering

Sources:
https://utilities.cityoffortwayne.org/go-time-for-the-microgrid-city-utilities-ingenuity-builds-resilience-and-sustainability/
https://www.journalgazette.net/opinion/editorials/microgrid-will-mitigate-future-energy-costs-reduce-utilitys-carbon-footprint-by-20/article_514cbe2a-9aca-11ef-bc79-d3f7d968d624.html

TWA Hotel, New York City, New York

Project Snapshot: Offgrid CHP Microgrid

Application	Hotel
Technologies	CHP, BESS
Technology Details	1 MW CHP
	1 MWh Battery Energy Storage System

JFK Airport's TWA Hotel
(Photo Courtesy of Thermo Systems TWA account executive, Serge Zinger)

Project Highlights:
The CHP microgrid with an energy management system was chosen for the TWA site because its flexible, resilient technology would maximize the system's uptime, ensuring the building's power goes uninterrupted. In addition, it's a highly efficient, economical, and sustainable source of power.

Project Testimonial
"It is running on its own power, and it has severed its connection from the grid. It is able to supply all of the heating, cooling and electrical needs. It is truly a small grid. It has on-site energy generation, storage and feeds the need of the convention center and hotel."
- Jesse Douglas, Vice President of Business Development for Veolia, which operates the 1 MW plant

Sources:
https://thermosystems.com/twa-hotel-officially-open-another-win-for-thermo/
https://www.microgridknowledge.com/editors-choice/article/11429645/newly-opened-jfks-twa-hotel-is-always-grid-independent

Penn Medicine Princeton Medical Center, Plainsboro, New Jersey

Penn Medicine Princeton Health

Project Snapshot: CHP Microgrid

Application	Hospital
Technologies	CHP, Solar PV, Backup Generators, TES
Technology Details	4.5 MW Natural Gas CHP
	203 kW Solar PV
	7.5 MW Diesel Backup Generators
	30,000 tons/hr Thermal Ice Storage

Princeton Medical Center's CHP system provides $2.5 million dollars annually in energy savings. The project was developed via a public-private partnership with Clearway Energy, Inc, who Princeton Medical Center purchases energy from under an energy services agreement.
Photo courtesy of Clearway Energy, Inc.

Project Highlights:
Penn Medicine Princeton Medical Center uses a CHP-anchored microgrid to ensure reliable operation of the facility. Incorporating CHP, solar panels, backup generators, and thermal energy storage, the facility rode through 50 power dips in 2018 without any adverse impacts on hospital function.

Project Testimonial

"CHP enables us to use environmentally sustainable energy as we fulfill our mission of providing high-quality healthcare. It meets our hospital's energy needs while reducing our operating costs and protecting the environment."

- Barry Rabner, President and CEO
  Penn Medicine Princeton Health

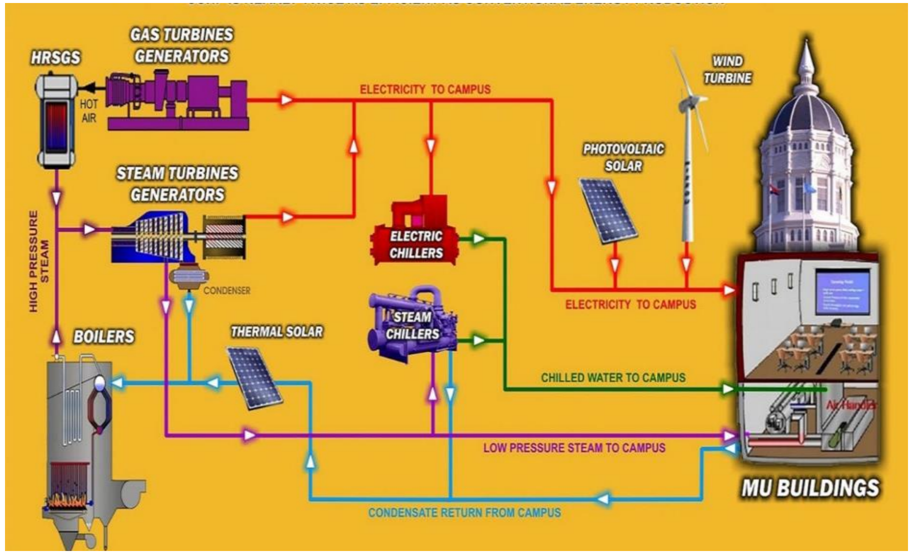
Sources:
https://chptap.ornl.gov/profile/181/PennMedicine-Project_Profile.pdf
https://cordiaenergy.com/resources/penn-medicine-princeton-health-case-study/

University of Missouri, Columbia, Missouri

Mizzou
University of Missouri

Project Snapshot: District Energy Microgrid

Application	University
Technologies	CHP, Wind, Solar PV, Solar Thermal, Boilers, Chillers
Electrical Generation	68.3 MW CHP
	34 kW Solar PV
	20 kW Wind
Thermal Generation	Solar Thermal
	6 Boilers
	2 Heat Recovery Steam Generators
	36 Chillers (33,000 tons chilled water)



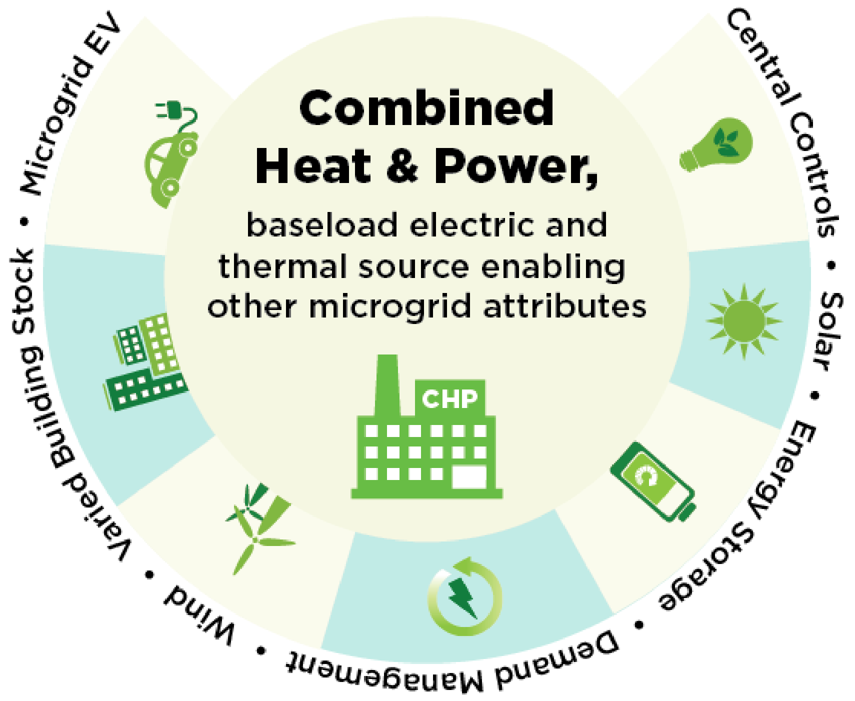
University of Missouri Microgrid
(Source: University of Missouri)

Project Highlights:
The CHP driven microgrid normally operates in parallel with the electric grid but is able to operate isolated from the grid if needed (islanded mode), has black start capability, is fuel flexible (natural gas and biomass), employs weather resistant underground distribution lines, has built in resiliency with multiple generation assets, and utilizes the electric grid as back up if needed.

Project Testimonial
"A hundred years ago the primary fuel source was coal. The department started a transition away from coal in 2008. The current plant serves the campus needs with 34% renewable energy; the remainder primary fuel source is natural gas."
- Michael O'Connor, Director of MU Energy Management

Source: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/University%20of%20Missouri%20District%20Energy%20Microgrid%20Case%20Study.pdf

CHP Is a Resilient Anchor for Other Microgrid Technologies



- CHP systems can provide resilient electric and thermal energy in integration with:
  - Solar and wind resources
  - Energy storage
  - Demand management
  - Central controls
  - Electric vehicle charging
- Flexible CHP systems can ramp up and down as needed to balance renewable loads, enhance reliability and provide grid services if needed

5 Minute Break

U.S. DEPARTMENT OF ENERGY

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REopt: Energy Decision Analysis

Bill Becker
National Renewable Energy Laboratory

U.S. DEPARTMENT OF ENERGY

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

Renewable Energy Resource

Technology Costs and Incentives

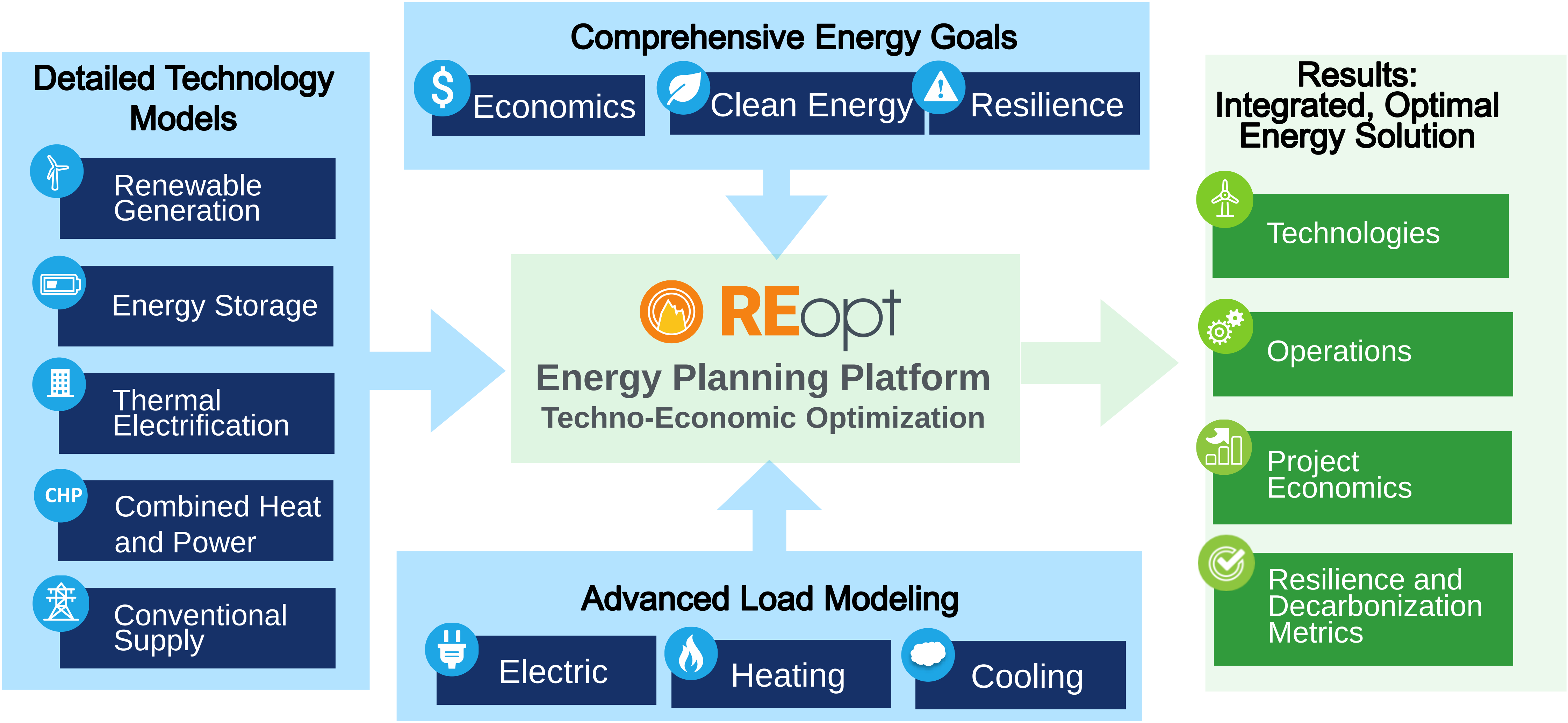
Site Goals (Economics, Resilience, Clean Energy)

Utility Cost and Consumption

Financial Parameters

Many factors affect how DERs may provide cost savings, resilience, and clean energy to your site. REopt allows these factors to be evaluated concurrently.

REopt Energy Planning Platform



Web tool: Google “REopt”, or https://reopt.nrel.gov/tool

REopt Metrics

REopt web tool and open-source code are driving smart investments in clean energy across sectors…

Driving clean, resilient, affordable energy investment decisions for

77,000 users*

3.8 million

analyses completed to date

Users in

174 countries

across the globe

Incorporated into

15 industry tools

from major corporations

Used for research, education, and partnerships by

10 universities

from **homeowners** to **commercial** and **industrial** entities to **governments** and **communities** to **ports/airports** and **utilities**.

Core tool used for the
Onsite Energy Program

*Total 7-year lifetime users, mostly web tool; 29K active users in FY24, 18K were new in FY24

Accessing REopt

Interface	Description	Link
REopt Web Tool	▪ Easy-to-use web access ▪ Key standardized capabilities ▪ Results visualization ▪ User accounts	reopt.nrel.gov/tool
REopt Application Programming Interface (API)	▪ Open-source code ▪ Additional features and capabilities ▪ Programmatic access facilitates large-scale analysis ▪ API: Leverage NREL computational resources	github.com/NREL/REopt_API/wiki
REopt Julia Package	▪ Julia package: Faster solve times, users can run locally	github.com/NREL/REopt.jl/wiki
REopt Analysis Scripts	▪ Scripts (e.g., Jupyter notebooks) to use the API and Julia package	github.com/NREL/REopt-Analysis-Scripts/wiki

Additional Resources

- **Web tool user guides**—Web tool user manual, quick-start videos and fact sheets, YouTube tutorials and webinars, curriculum materials: reopt.nrel.gov/user-guides.html
- **User forum**—Landing page for questions asked and answered regarding the web tool, API, Julia package, and analysis scripts**:** github.com/NREL/REopt-Analysis-Scripts/discussions

REopt Minimizes the Life Cycle Cost of Energy

REopt identifies the **life cycle cost-optimal** DER system that achieves the site's energy goals (**cost savings**, **decarbonization**, and/or **resilience**).

- **Life cycle cost (LCC)** of energy: The present value of all costs of energy at the site throughout the analysis period.

$$\text{LCC} = \text{Capital Costs} - \text{Available Incentives} + \text{O\&M Costs} + \text{Electric Grid Purchases} + \text{Fuel Purchases}$$

- **Net present value (NPV)** of DER system: The life cycle cost savings (difference in LCC) between the business-as-usual (BAU) case and the optimized (OPT) case.

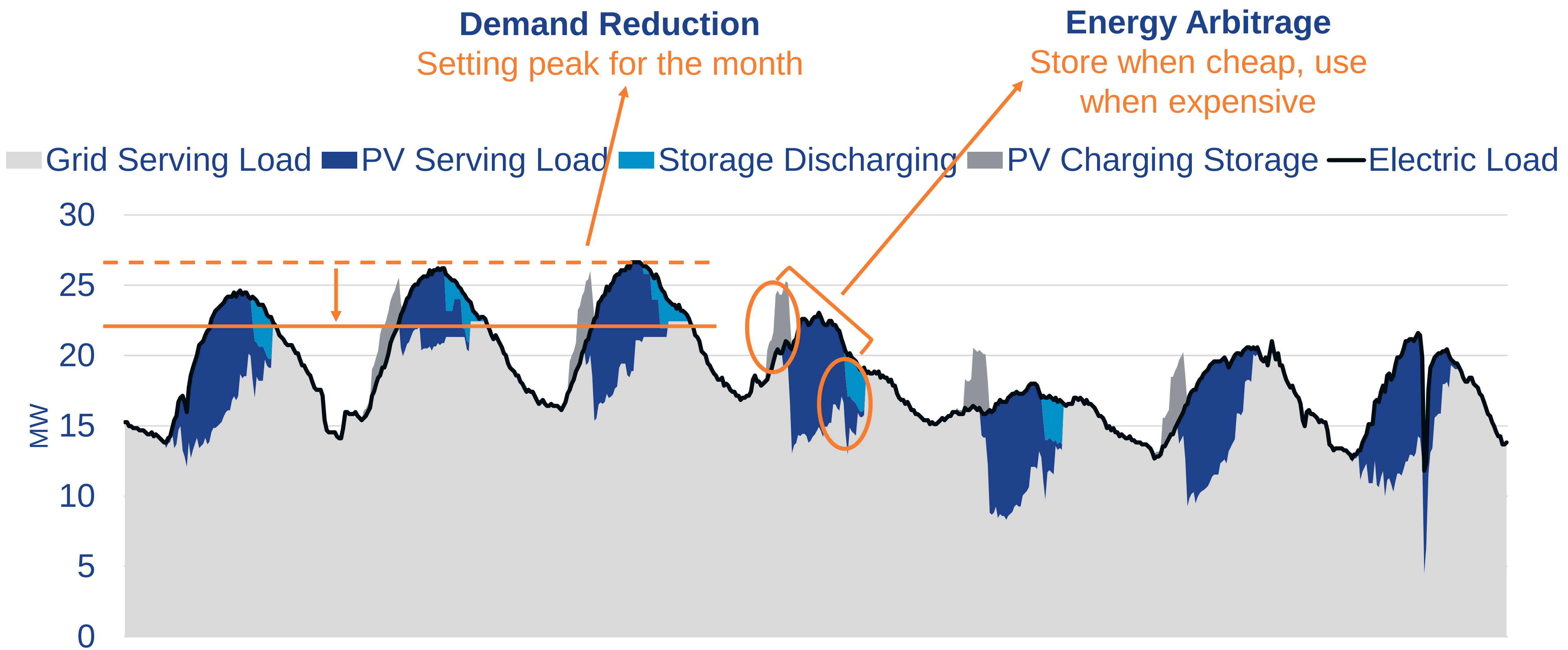
$$\text{NPV} = \text{LCC}_{\text{BAU}} - \text{LCC}_{\text{OPT}}$$

If NPV > 0, the project provides cost savings relative to the BAU case.

If NPV < 0, the project is more expensive than the BAU case.

How Does REopt Work?

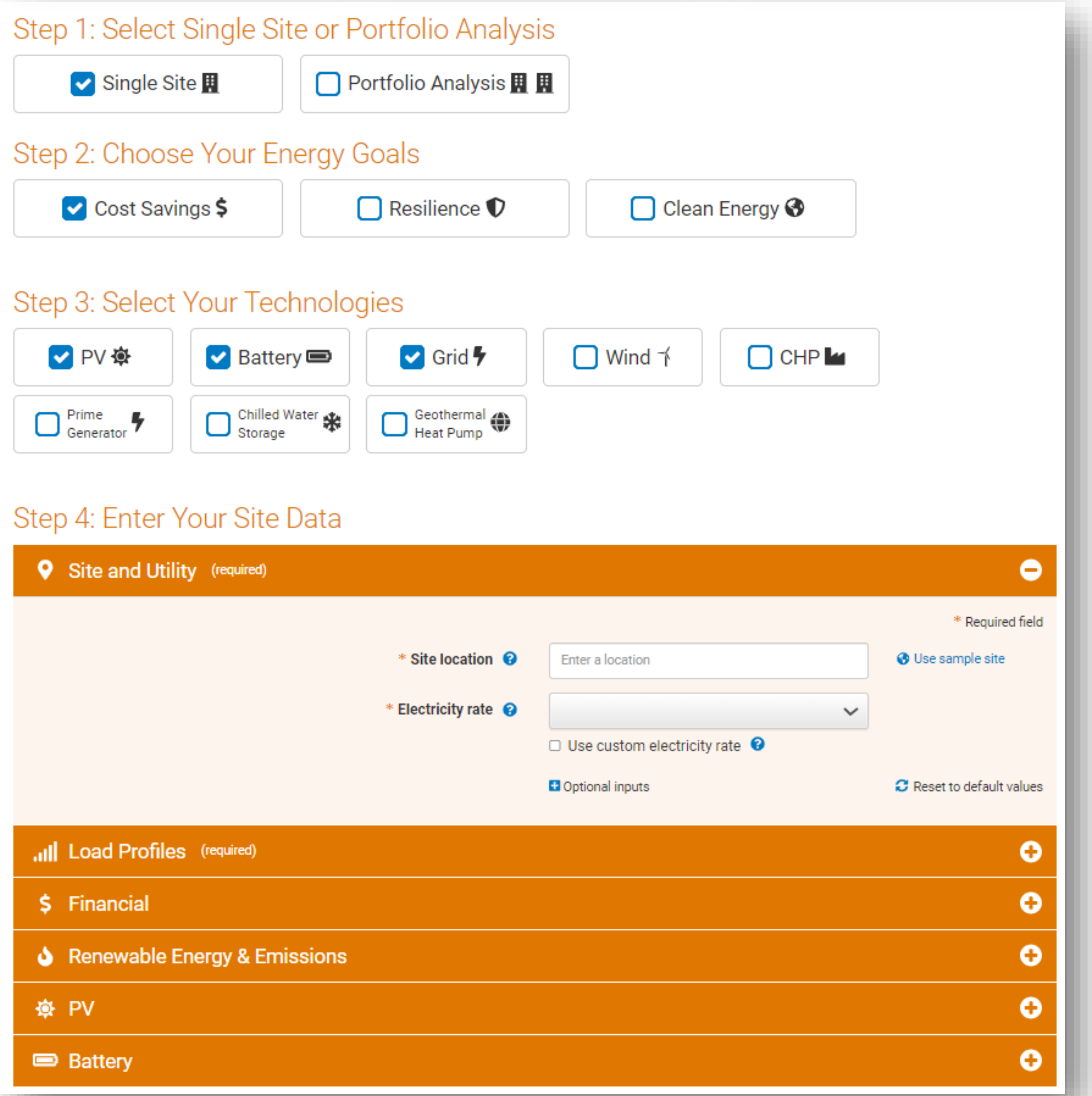
REopt considers the trade-off between ownership costs and savings across multiple value streams to recommend optimal size and dispatch.



Example of optimal dispatch of photovoltaics (PV) and a battery energy storage system (BESS)

REopt Web Tool User Interface

- **REopt web tool** provides free, publicly available, user-friendly capabilities from NREL's comprehensive **open-source REopt model**
- Optimizes **PV, wind, CHP, heat pumps, battery energy storage, and thermal energy storage** system sizes and dispatch strategies to **minimize life cycle cost of energy**
- **Resilience mode** optimizes DER systems, along with backup generators, to sustain critical load during grid outages
- **Clean energy goals** allow users to consider renewable energy targets, emissions reductions targets, and emissions costs in optimization
- Access the REopt web tool at **reopt.nrel.gov/tool**.

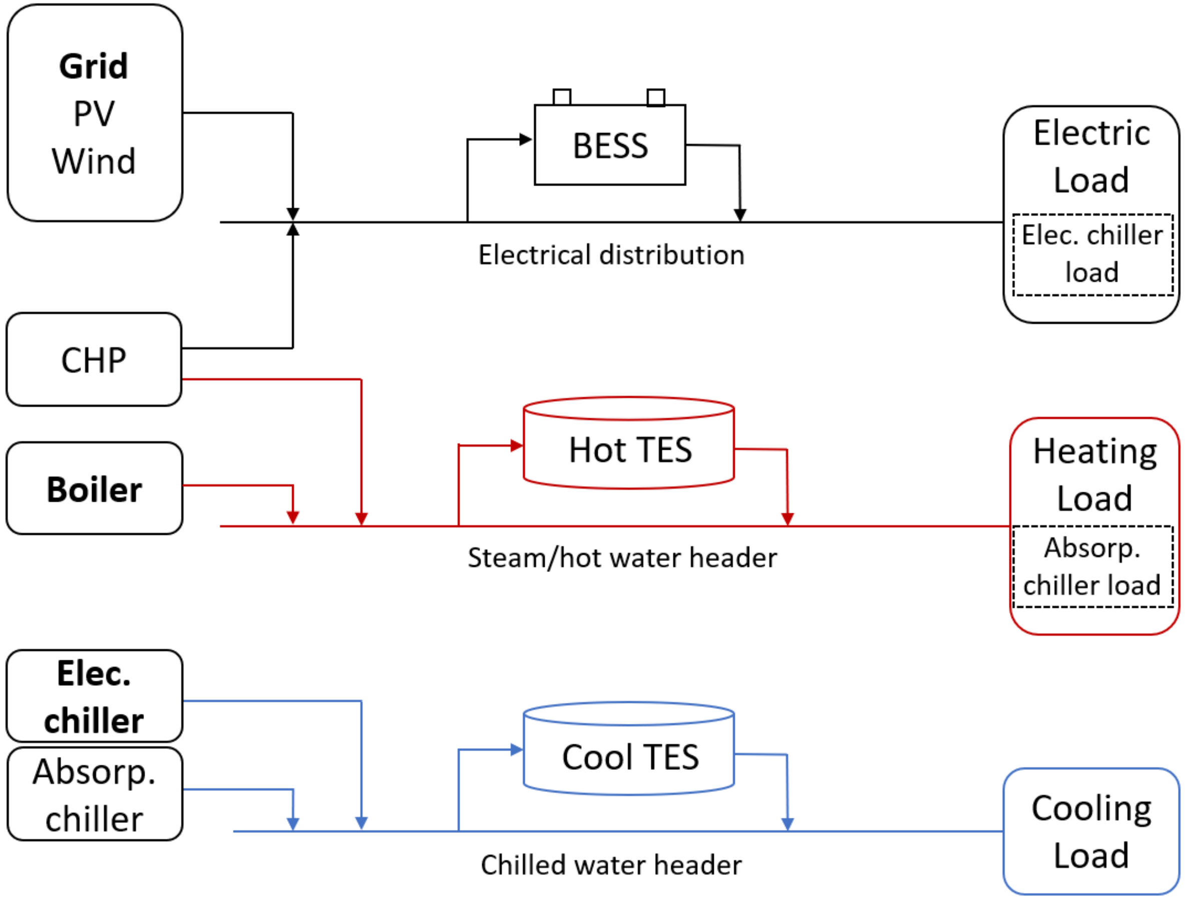


CHP Scope

1. CHP and Hybrid CHP (+ other DERs)
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/industrial scale
5. Technology sizes are typically an output although the user can fix sizes

CHP 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**

CHP Prime Mover Options

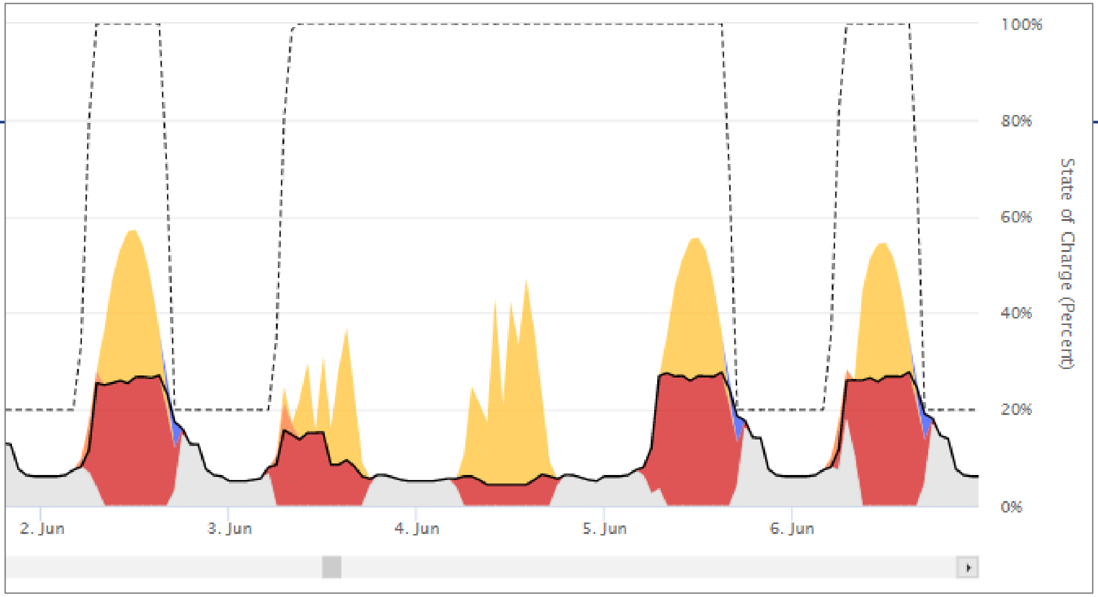
- Defaults provided for these prime mover types:
  - Reciprocating engine
  - Microturbine
  - Combustion turbine
  - Fuel cell
- Cost and performance from the DOE Fact Sheets
- Specific heat recovery configurations and process fluid conditions (linked to the heat recovery)
  - Hot water: 160 F inlet / 180 F exit water, or
  - Steam 150 PSIG saturated

Reciprocating Engine	System							
	1	2	3	4	5	6	7	8
Net Electric Power (kW)	35	99	248	495	990	1,980	2,970	4,455
Fuel Input (MMBtu/hr, HHV)	0.43	1.14	2.58	4.65	9.18	16.80	25.10	37.40
Useful Thermal, Hot Water (MMBtu/hr)	0.23	0.57	1.21	1.95	3.85	6.45	9.65	14.40
Cooling Thermal Factor (Single Effect)	80%	80%	85%	85%	85%	85%	85%	85%
Electric Efficiency (%, HHV, net power basis)	27.7%	29.7%	32.7%	36.3%	36.8%	40.2%	40.4%	40.6%
Hot Water Thermal Efficiency (%, HHV)	54.0%	50.0%	47.0%	41.9%	41.9%	38.4%	38.4%	38.5%
Steam Thermal Efficiency (%, HHV)	N/A	N/A	N/A	18.3%	15.5%	12.9%	13.0%	11.2%
O&M Cost ($/kWh)	$0.030	$0.025	$0.022	$0.020	$0.017	$0.015	$0.014	$0.013
Total Installed Cost ($/kW)	$4,250	$3,700	$3,450	$3,150	$2,800	$2,550	$2,350	$2,000
REopt Class 0								
REopt Class 1								
REopt Class 2								
REopt Class 3								
REopt Class 4								
REopt Class 5								
REopt Class 6								
REopt Class 7								

Heating Plant Assumptions

- 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 or operating schedule-based loads
  - 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

REopt Web Tool Key Outputs



Hourly Dispatch

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

	Business As Usual	Financial	Difference
Renewable Energy			
Annual Renewable Electricity (% of electricity consumption)	0%	58%	58%
Climate & Health Emissions Costs			
Cost of Climate Emissions throughout Analysis Period	$651,584	$273,948	-$377,636
Cost of Health Emissions throughout Analysis Period	$92,811	$39,485	-$53,326
Climate Emissions, CO_2			
Total Year 1 Emissions (t CO_2)	757	318	-439

Climate and Health Emissions Impacts

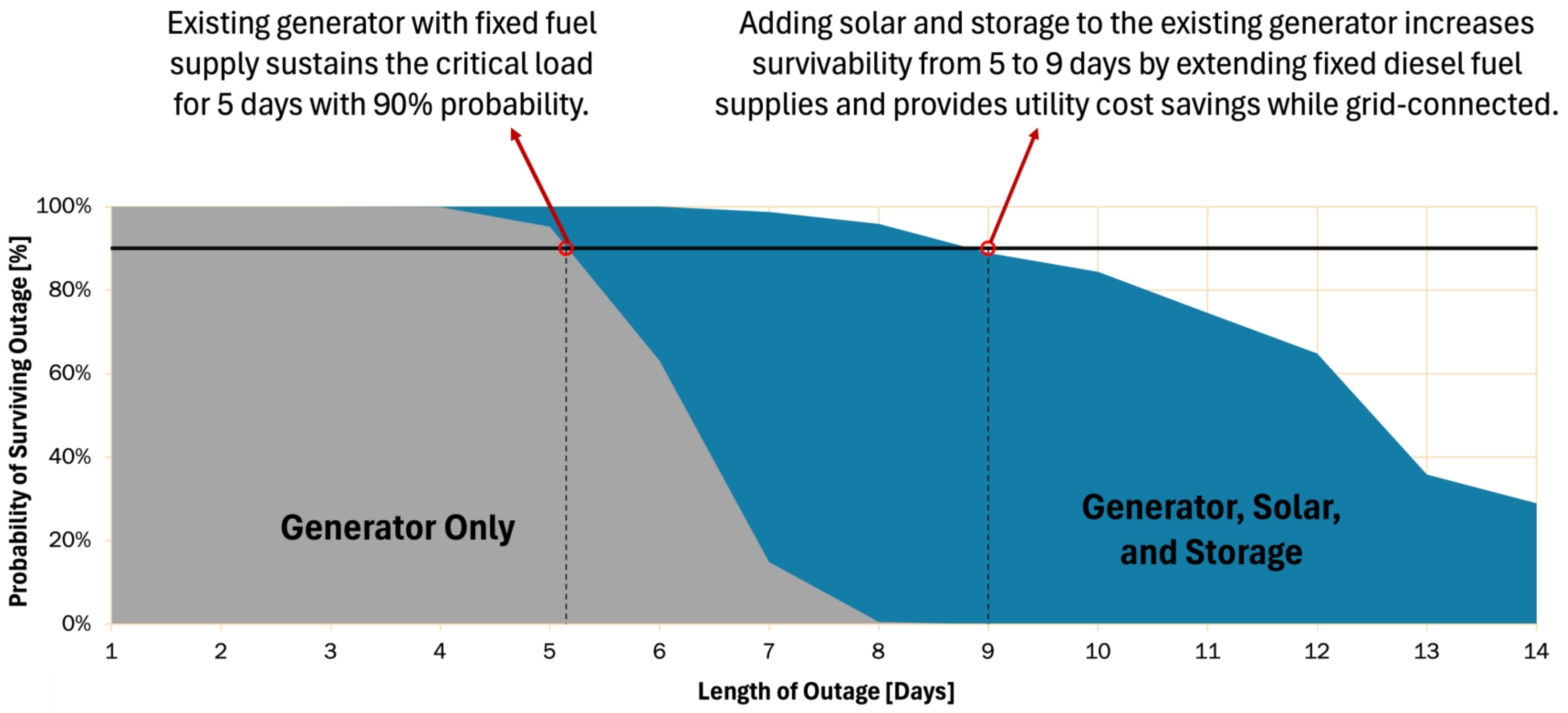
	Business As Usual	Financial	Difference
System Size, Energy Production, and System Cost			
PV Size	0 kW	113 kW	113 kW
Annualized PV Energy Production	0 kWh	132,000 kWh	132,000 kWh
Battery Power	0 kW	0 kW	0 kW
Battery Capacity	0 kWh	0 kWh	0 kWh
Net CAPEX + Replacement + O&M	$0	$133,318	$133,318
Energy 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

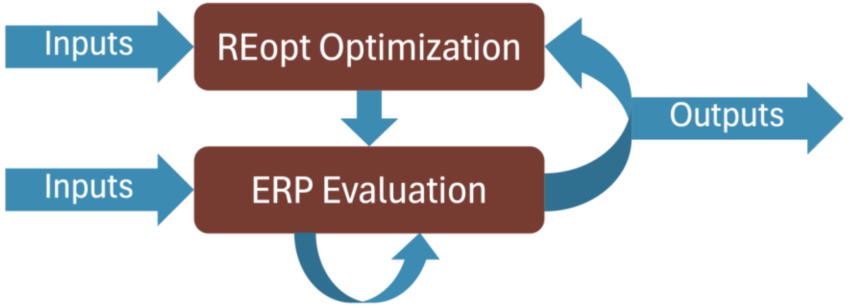
Resilience Evaluations

How does REopt evaluate resilience?

REopt optimization first identifies DER sizing and dispatch that minimize life cycle energy costs for grid-connected operations and can **support critical loads during user-specified grid outage(s).**



Energy Resilience Performance (ERP) Evaluation

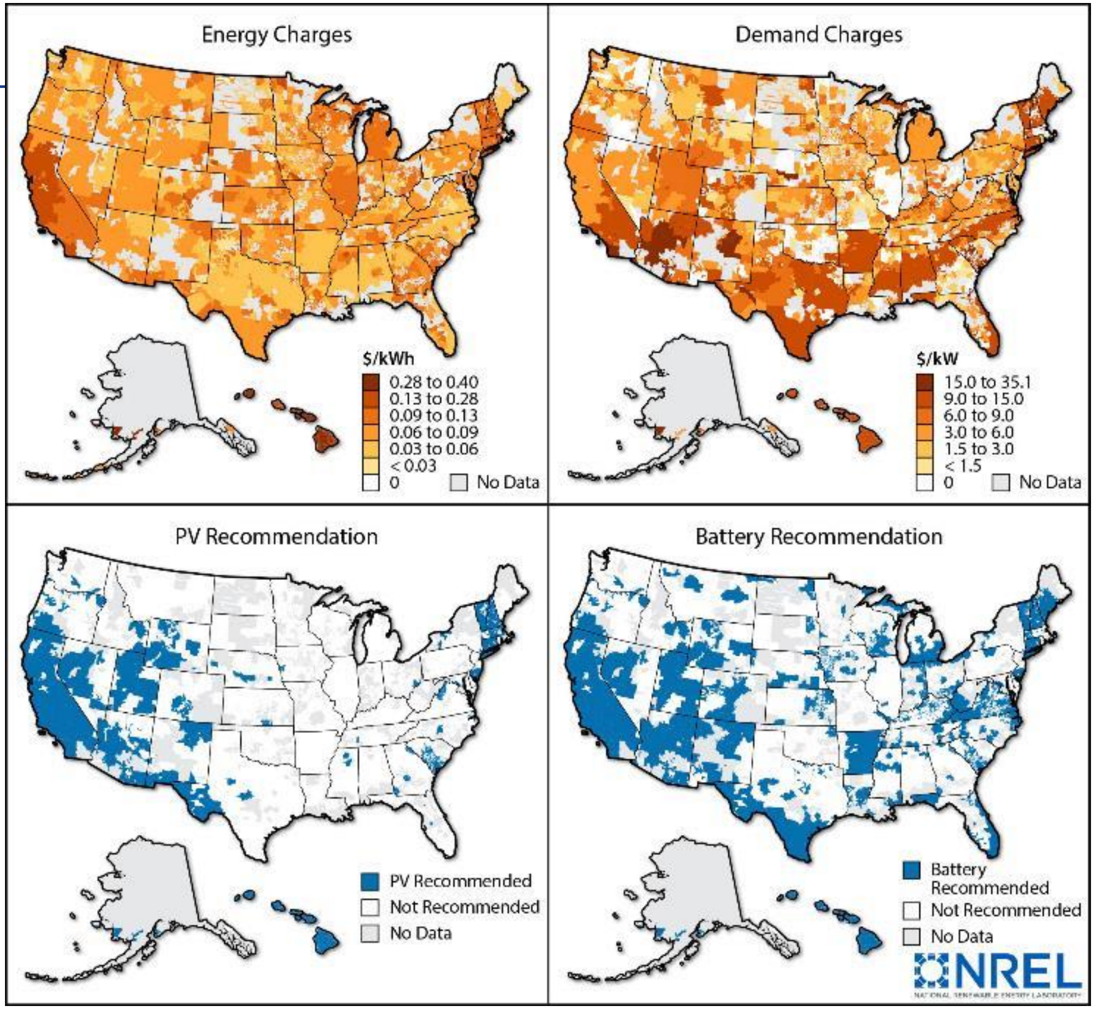


REopt's **Energy Resilience Performance (ERP)** capability then evaluates all possible grid outages of the user-specified outage duration to identify the overall **probability of outage survival**, considering DER availability and reliability.

Users can iterate on the DER sizing and configuration using the ERP capability to arrive at a final system that meets the site's target outage survivability.

National-Scale, or Portfolio Analysis

- The REopt API & Julia package enable national-scale or portfolio analysis of DER economics and impacts on deployment.
  - 10’s to 100’s of thousands of runs
- For example:
  - Where in the country is storage (and PV) currently cost-effective?
  - How does varying utility rate, escalation rates, and incentive structures impact storage profitability?



NREL explored solutions for increasing affordability of DC fast charging (DCFC) nationwide through pairing with solar, storage, and building loads.

REopt Renewable Energy Integration and Optimization

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

Tool feedback and questions: reopt@nrel.gov

www.nrel.gov

NREL/PR-7A40-82426

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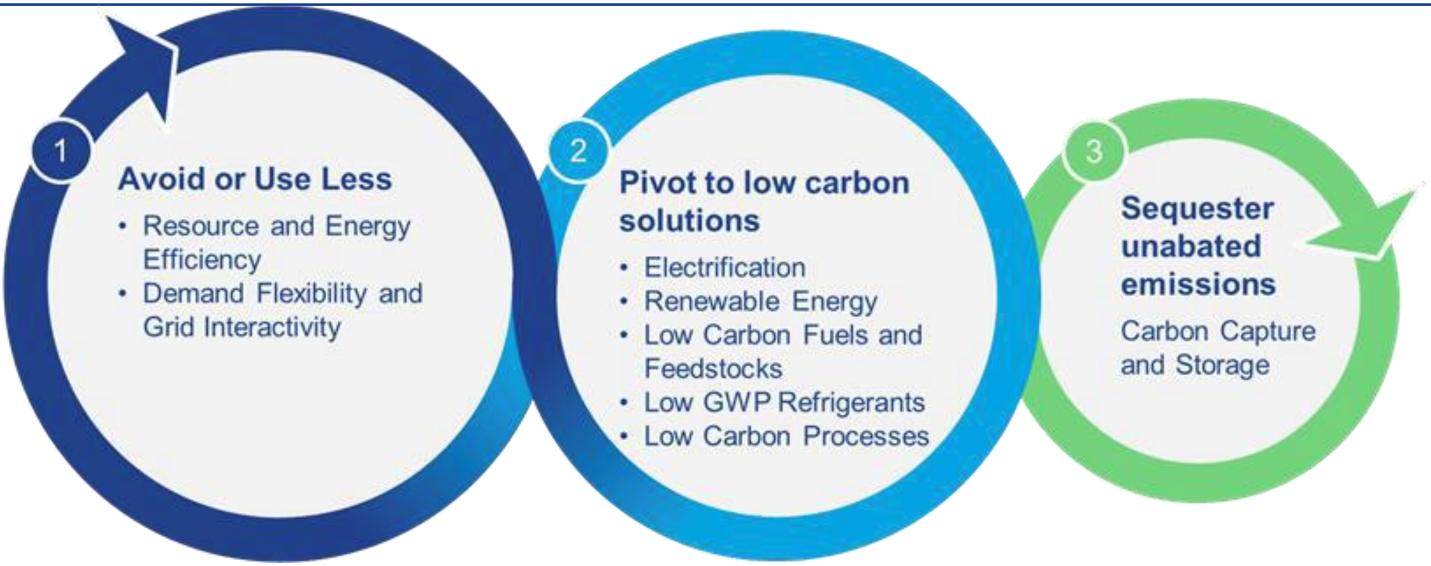
Onsite Energy Program Available Resources

Isaac Panzarella

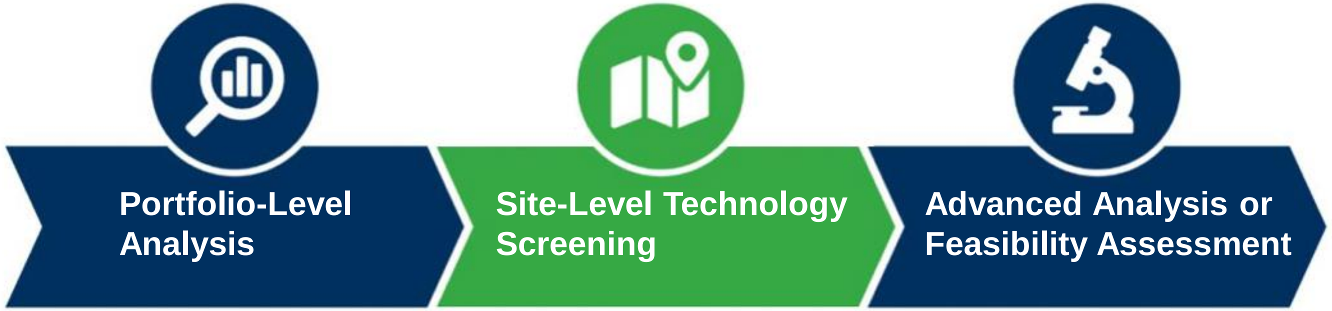
DOE Southeast Onsite Energy TAP

Prioritizing Onsite Energy on the Pathway to Decarbonization



Sierra Nevada Brewing in Mills River, NC has 600 kW of solar PV and 400 kW of biogas microturbines (photo: DOE Onsite Energy TAP)

2.7 MW wind turbine at Western Plains Energy in Oakley, KS (photo: Western Plains Energy)



Onsite Energy TAPS are a Regional Resource

Clockwise starting from upper left: 1) Steve Lysenko, Lead Engineer with the Southeast Onsite Energy TAP leads a tour of NC State University's Centennial Campus Energy Plant for the E4 Carolinas Emerging Leaders program in June 2024. 2) A 182 kW solar PV array on the roof of Fitts Woolard Hall was also part of the tour. 3) The North Carolina Industrial Decarbonization Dialogue brought together manufacturers and stakeholders in November 2023. 4) The Southeast and Midwest Onsite Energy TAPs teamed up to host a booth at IDEA District Energy June 2024 in Orlando. 5) Southeast Onsite Energy TAP team members Brian Lips (far right) and Isaac Panzarella (second from left) along with Jeff Benavides (far left) and Ryan Snow, both of the USGBC, at a USGBC Industrial Buildings Decarbonization Forum at NC State in June 2024.

Getting Started: How to Work with Your Onsite Energy TAP

Contact Your Regional TAP

Contact the Onsite Energy TAP in your region to start exploring onsite energy opportunities.

Discuss Site Characteristics, Goals, Objectives

Meet with the Onsite Energy TAP to discuss preliminary interest in onsite energy and learn about the facility's needs and energy-related goals.

Collect Site Data

Work with the Onsite Energy TAP to collect data needed to perform technical assistance (e.g., facility size, operations, electric and gas usage, etc.).

Conduct Analysis

Onsite Energy TAP works with technical analysis team to perform initial screenings for multi-technology options or advanced analysis to support project installations.

Review Results

When the results are ready, meet with your Onsite Energy TAP to review and discuss next steps (e.g., options worth further analysis or additional support available)

Onsite TAP Analysis and Results

Analysis Results

- Which technologies were analyzed and why
- Identification of promising technologies
- Potential system sizes (MW, MWh)
- Electricity and fuel cost impacts ($/year)
- CapEx ($)
- O&M cost impacts ($/year)
- Incentives ($)
- Simple payback (years)
- Peak demand reduction (kW)
- Annual thermal output (MMBtu)
- Emissions reductions (CO_2)
- Alternate fuel options

Example Analysis Results Summary

	BAU	PV	Wind	CHP	PV + CHP
System Size(s)	-	1,000 kW	1,000 kW	300 kW	PV: 700 kW; CHP: 300 kW
Electricity Cost ($/year)	600,000	400,000	300,000	350,000	200,000
Boiler Fuel Cost ($/year)	150,000	150,000	150,000	160,000	160,000
Incremental O&M Cost ($/year)	-	20,000	40,000	10,000	30,000
Net Operating Cost Savings ($/year)	-	200,000	300,000	250,000	400,000
Net Capital Cost ($)	-	1,500,000	1,400,000	300,000	1,600,000
Simple Payback (years)	-	8	5	1	4
Year 1 Site CO_2e Emissions Reduction (tonnes/year)	-	800	1,200	250	800
Site CO_2e Emissions Reduction (%)	-	7%	11%	2%	7%
BAU: Business as usual; PV: Solar photovoltaic; Wind: Wind turbines; CHP: Combined heat and power					

DOE Southeast Onsite Energy TAP Webinar Series

What: A three-part webinar series to promote Onsite Energy and the TAPs

1. Decarbonization Begins Onsite

Topics:

Knowledge of onsite energy technologies, benefits and applications in manufacturing and on campuses.

Speakers:

Art Samberg, Assistant Director, Southeast Onsite Energy TAP

Isaac Panzarella, Director, Southeast Onsite Energy TAP

2. Policies, Programs & Funding

Topics:

Insight on important policies, programs and funding mechanisms and how to navigate the DSIRE website

Speakers:

Brian Lips, Sr. Policy Advisor Southeast Onsite Energy TAP,

Justin Lindemann, Policy Analyst, Southeast Onsite Energy TAP

3. Deployment Best Practices

Topics:

Understanding of what makes a successful onsite energy project and technical assistance available from the Onsite Energy TAPs

Speakers:

Adiel Burgos, Puerto Rico Branch Manager, 2G Energy

Will Rice, Project Manager, Charlotte Water

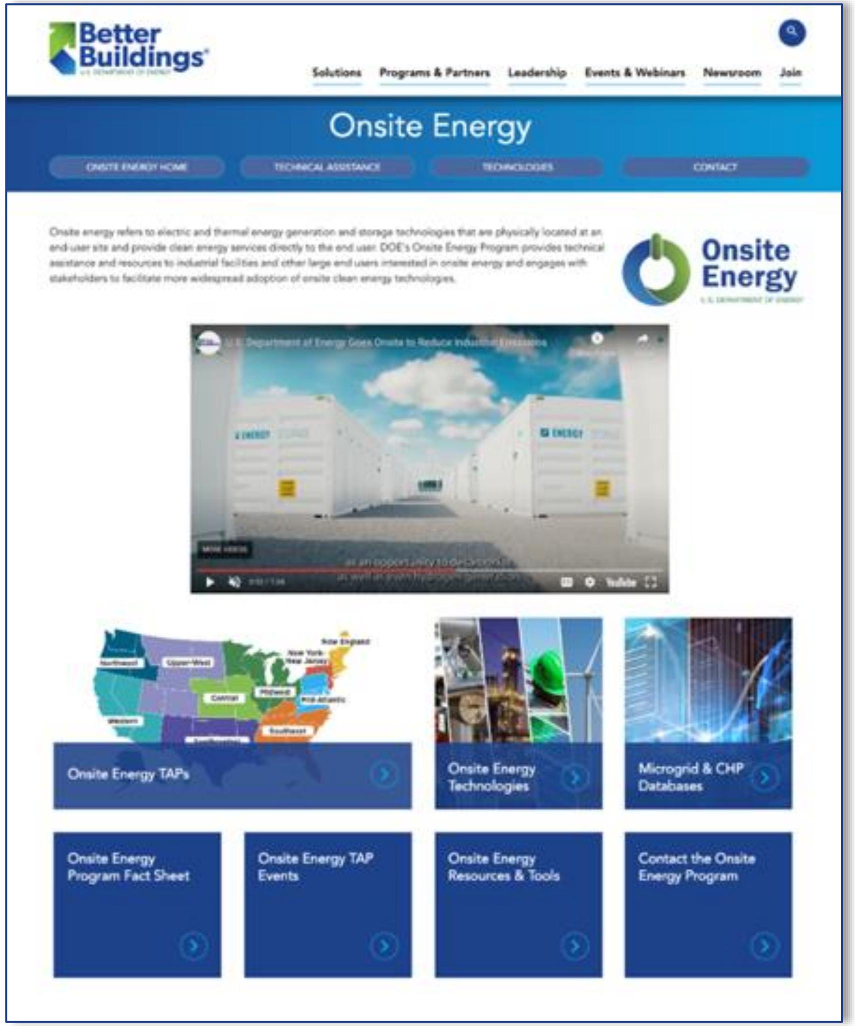
Lessons Learned: Holding series was effective and efficient. Partnerships with organizations like the Puerto Rico Mfg. Assn yield high participation. Need to increase interaction with attendees through polls or other interactions.

Next steps: Following up with key attendees. Holding several webinars co-hosted with state associations. Planning a series for next year on more detailed topics technical analysis, GHG reductions, project economics.

More Resources Available Online

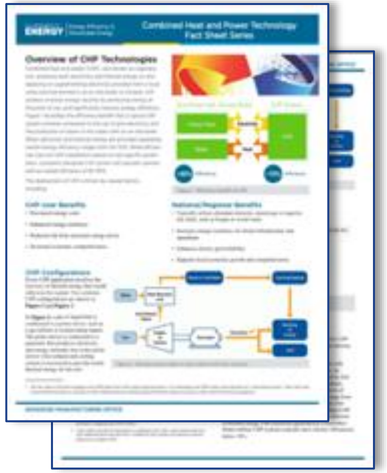
Visit the Onsite Energy page at:

https://betterbuildingssolutioncenter.energy.gov/onsite-energy



Onsite Energy Case Studies

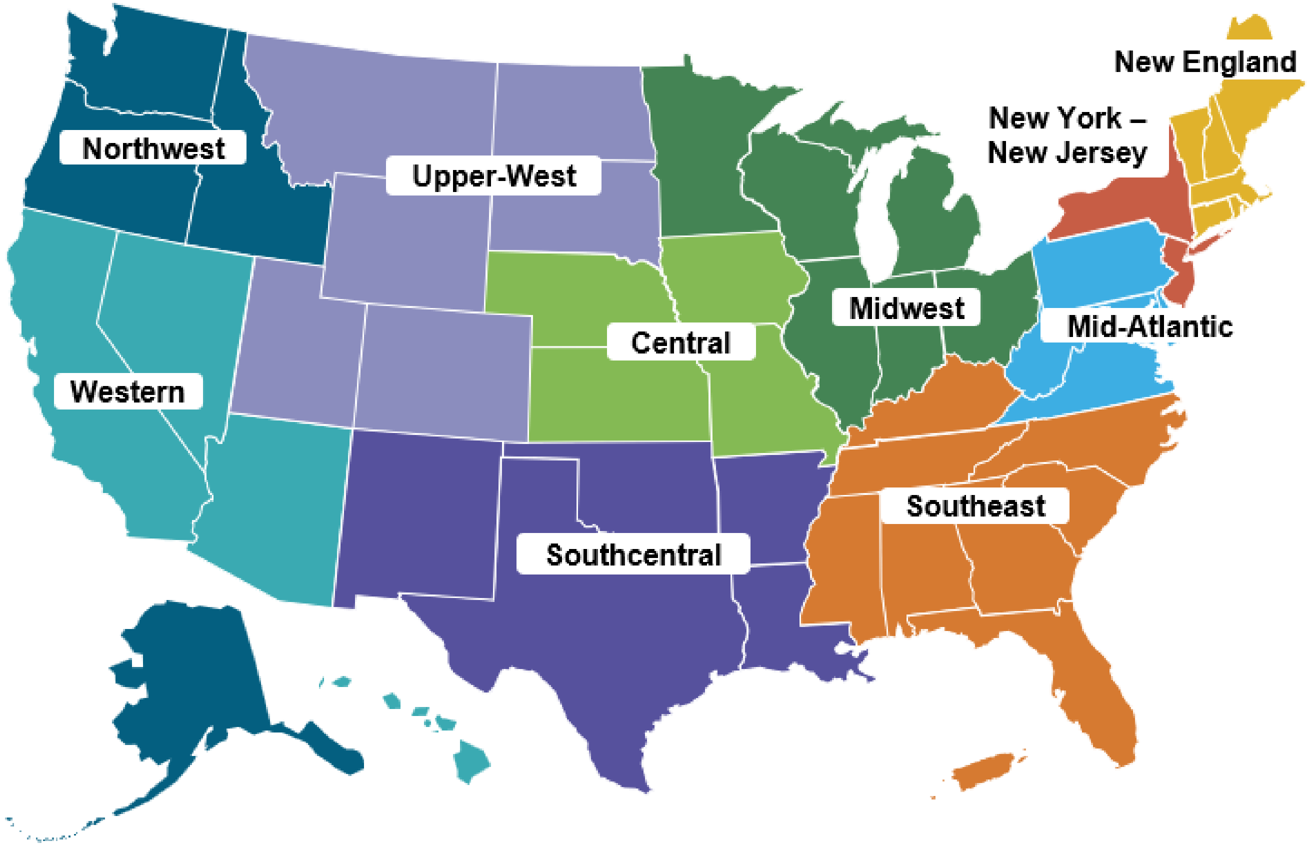
Onsite Energy Technology Fact Sheet Series



DG for Resilience Planning Guide

CHP and Microgrid Installation Databases

U.S. Department of Energy's (DOE) Onsite Energy Technical Assistance Partnerships (TAPs)



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Onsite Energy Technical Assistance Partnerships U.S. DEPARTMENT OF ENERGY
U.S. DEPARTMENT OF ENERGY

Questions?

Kahoot and Q&A

Please use your phones to join our fun Kahoot game, testing your CHP Virtual Training Session #4 knowledge.

Thank you!