Energy Exchange Pre-Conference Workshop: Distributed Energy Technologies for Resilience and Cost Savings

August 19, 2019, Colorado Convention Center

Session 4: 3:30–5:30 Room 303

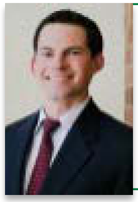
Experts in the Room

Rachel Shepherd
FEMP, Program Lead
Federal distributed energy projects
rachel.shepherd@ee.doe.gov

Emma Elgqvist
NREL, Engineer
Solar PV + Storage economics
emma.elgqvist@nrel.gov

Andy Walker
NREL, Principal Engineer
Solar PV
andy.walker@nrel.gov

Alicen Kandt
NREL, Senior Engineer
Federal distributed energy projects
alicen.kandt@nrel.gov



Doug Gagne
NREL, Engineer
Federal Project Financing
doug.gagne@nrel.gov

Keith McAllister
Kestava Energy LLC, Manager
CHP
keith@kestavaevergy.com

Bill Becker
NREL, Engineer
CHP
william.becker@nrel.gov

Kathleen Krah
NREL, Engineer
Solar PV + storage economics
kathleen.krah@nrel.gov

Chuck Kurnik
NREL, Senior Engineer
Microgrids
chuck.kurnik@nrel.gov

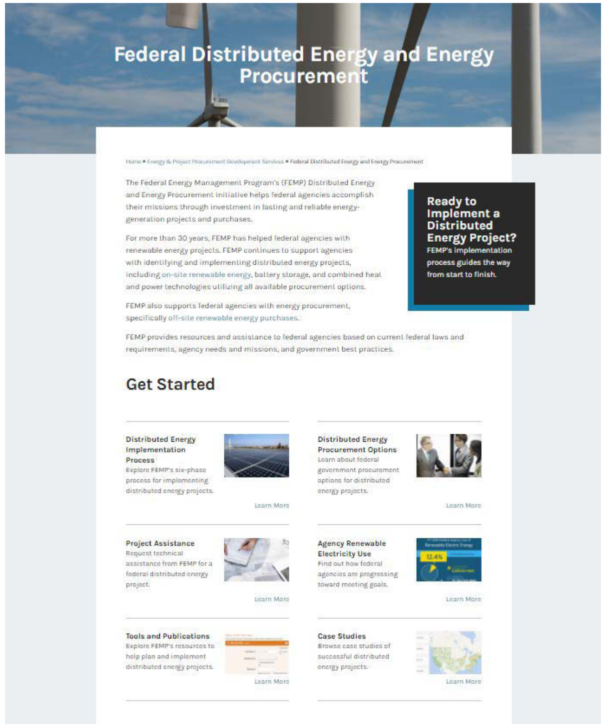
Kevin DeGroat
Antares Group, Project Director
Federal project reporting
kdegroat@antaresgroupinc.com

Workshop Agenda

Intro and icebreaker	15 minutes
Technical presentations	45 minutes
Solar photovoltaics (PV) + storage	
Combined heat and power (CHP)	
Microgrids	
REopt Lite	20 minutes
Q&A with panel of experts	30 minutes

FEMP's Distributed Energy Program

FEMP's Distributed Energy (DE) Program facilitates the implementation of cost-effective, on-site renewable energy, energy storage, and combined heat and power technologies for federal agencies.



[FEMP's Distributed Energy Program Website](https://www.energy.gov/eere/femp/federal-distributed-energy-and-energy-procurement)

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[FEMP's Distributed Energy Program Factsheet](https://www.energy.gov/sites/prod/files/2018/08/f54/femp_dep_0.pdf)

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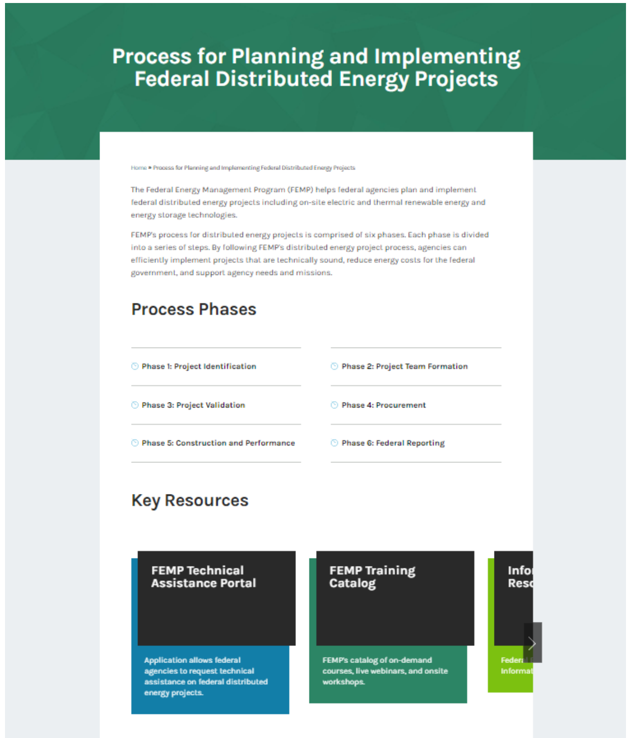

[FEMP's Distributed Energy Implementation Process Website](https://www.energy.gov/eere/femp/process-planning-and-implementing-federal-distributed-energy-projects)

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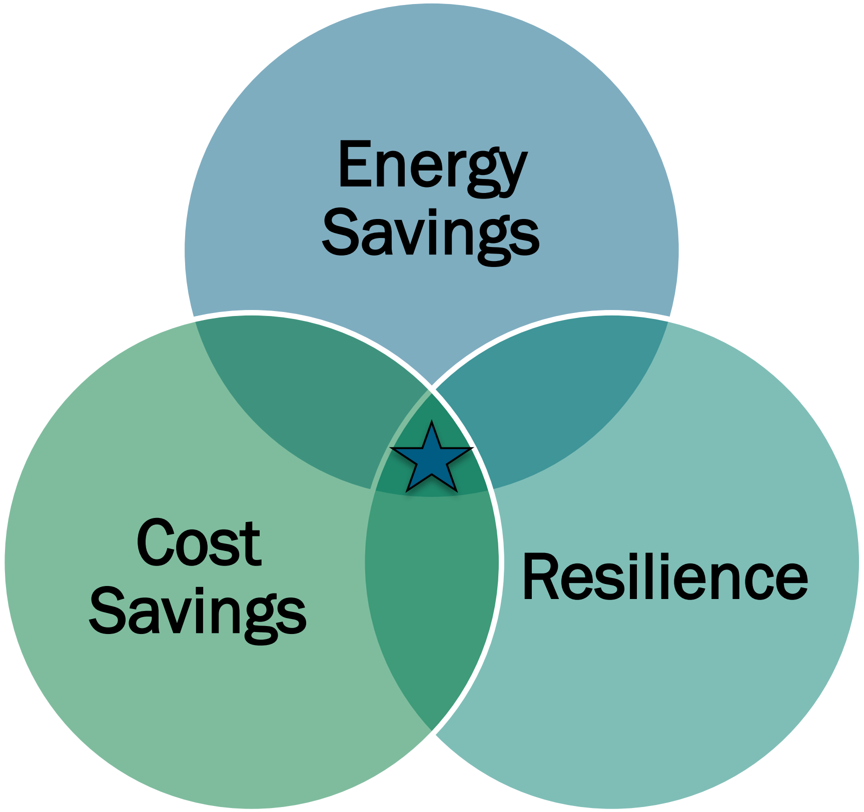
Why Distributed Energy for Resilience

- **Distributed energy resources (DERs) include renewable energy (RE) technologies, storage, and combined heat and power (CHP)**
- **DERs can provide revenue streams and savings while grid connected**
  - Savings may allow for the incorporation of additional microgrid components
- **When integrated into a microgrid, DERs can increase survival time during a grid outage when fuel supplies are limited**



FEMP's PV Performance Initiative

- **Federal PV capacity has increased tenfold in the last eight years**
  - Maximizing return on these 20+ year investments requires assets are performing as expected or better
- **FEMP is seeking federal sites in FY20 interested in evaluating the performance of its on-site PV systems**
- **Key output of initiative include performance ratio of system**
  - Individualized report for site
  - Anonymized summary of federal projects
- **Email rachel.shepherd@ee.doe.gov**

Site Data for Evaluation	
Energy delivered	Hourly (or over specific time period)
System description	Date & location installed
	System size
	Tilt & azimuth
	Tracking option
	Panel make & model

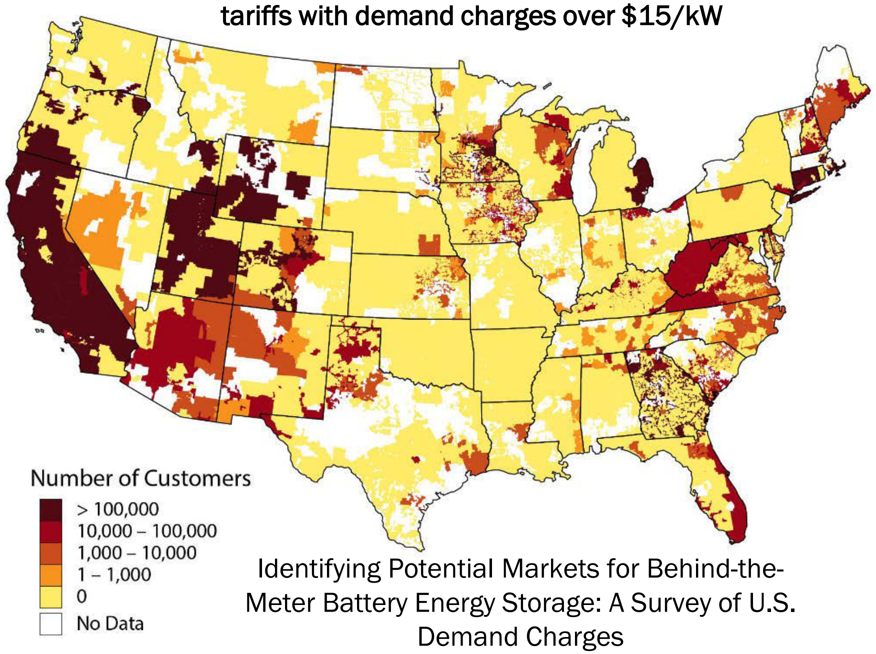
PV panels damaged by hailstorm. Photo by Andy Walker

Future Offering: Utility Rate Analysis Assistance

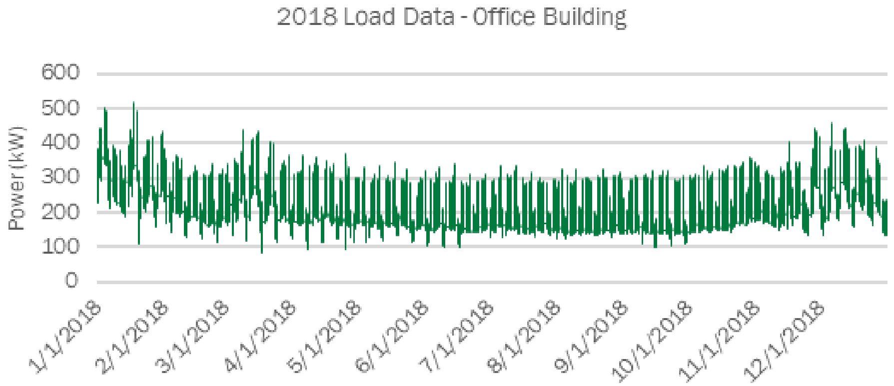
Express interest now in future utility rate analysis support by contacting Tracy Niro; tracy.niro@ee.doe.gov.

- Utility rate options are becoming increasingly more complex
- Understanding your rate options can help lower utility costs
- Federal agencies may want to review their electricity rate for several reasons:
  - Your site may qualify for multiple rates—which is optimal?
  - Your forecasting increased or decreased load at your site—which rate is optimal?
  - You're considering an energy project at your site—how will it impact your utility costs?

Number of commercial customers who can subscribe to tariffs with demand charges over $15/kW



Identifying Potential Markets for Behind-the-Meter Battery Energy Storage: A Survey of U.S. Demand Charges
https://www.nrel.gov/docs/fy17osti/68963.pdf



To Receive IACET-Certified CEUs for a Webinar

To receive IACET-certified CEUs, attendees must:

- Attend the training in full (no exceptions).
  - If you are sharing a web connection during the training, you must send an email to Elena Meehan and indicate who was on the connection, who showed as connected (will reflect in the WebEx roster), and for how long.
- Complete an assessment demonstrating knowledge of course learning objectives **within six weeks of the training**. A minimum of 80% correct answers are required.
- Complete an evaluation of the training event within **six weeks of the training.**

To access the webinar assessment and evaluation, visit https://www.wbdg.org/continuing-education/femp-courses/fempws08192019l

- If you do not have a Whole Building Design Guide account created, you will be required to create one.

Note: As per webinar instructions provided before the event, please include your full name and email address to verify event attendance for CEU certification and award.

For logistical questions related to the webinar or evaluation, email Elena Meehan at elena.meehan@ee.doe.gov.

Related Energy Exchange Technical Sessions

Track / Session	Title	Date	Time	Room
T13-S01	Making the Business Case for Resilience Projects	Tuesday, August 20	10:30 a.m.–12:00 p.m.	502
T06-S02	Grid Load and Plant Management for Resilience and Efficiency	Tuesday, August 20	2:00 p.m.–3:30 p.m.	407
T04-S03	Using Combined Heat and Power for Efficient Resilience	Tuesday, August 20	4:00 p.m.–5:30 p.m.	403
T04-S04	Integrating Renewables and Non-Renewables for Resilience	Wednesday, August 21	8:30 a.m.–10:00 a.m.	403
T02-S05	Measuring Success in Resilience	Wednesday, August 21	10:30 a.m.–12:00 p.m.	401
T03-S06	Designing Resilient Microgrids	Wednesday, August 21	2:00 p.m.–3:30 p.m.	303
T03-S07	Incorporating Onsite Generation Design using Comprehensive Energy Strategy	Wednesday, August 21	4:00 p.m.–5:30 p.m.	303
T07-S08	O&M for Renewable and Distributed Power	Thursday, August 22	8:30 a.m.–9:30 a.m.	507
T13-S09	Perspectives on Valuing Resilience	Thursday, August 22	10:00 a.m.–11:00 a.m.	502

Icebreaker: Three Questions to Ask Your Neighbor

- **Who are you?**
  - Name
  - Agency/Organization
  - Role

- **How many times have you been to Energy Exchange?**

- **What is the most fun thing you did (or will be doing) this summer?**

- **What is the strangest energy-related issue you have encountered?**

Save Your Questions for the End (and Write Them Down)!

- We will have a 30-minute Q&A session with a panel of experts
- As you are listening to these presentations, please write down any questions and comments you have
- There is pen and paper on each table, write down your questions, and place them in the bucket
- Your question can be general or very specific
- You can put your name on your question, but you don't have to

Solar PV + Battery Storage

Solar PV and Battery Storage Overview

- **Federal agencies have long history of implementing grid-connected solar PV projects for cost savings**
  - Value stream is well understood: Electricity is generated when the sun is shining, and lowers utility electricity purchases
- **Opportunities for grid-connected battery storage are emerging, and more complicated**
  - Value stream is more complicated: there are multiple ways to provide savings, but they depend on how the battery is operated
- **When configured to do so, PV + storage can provide back-up power in the event on an outage**
  - This requires additional equipment at added cost

Installation of one of the 3,632 solar modules on NREL's parking garage. The garage can produce up to 1.15 megawatts Photo by Dennis Schroeder / NREL 21487

NREL and Raytheon, perform system level testing on the Miramar ZnBr Flow Battery Photo by Dennis Schroeder / NREL 32582

Quiz tip: a typical solar PV system requires modification to provide backup generation during an extend outage

Range of PV + Storage Use Cases

	Off Grid PV + Storage	Grid Connected PV + Storage	Grid Connected PV + Storage with Microgrid	PV + storage for Large-scale Power Generation
Purpose	Providing continuous power in lieu of utility	Lowering cost of utility purchases	Lowering cost of utility purchases Providing power during grid outage	Large-scale generation for off-site sale
Why/Where it works	• Remote sites with high fuel costs • Low grid reliability	• High demand charges • TOU rates • Ancillary service markets	• High demand charges • TOU rates • Ancillary service markets • Resilience requirements	• Deregulated market • Interested offtaker • large land-availability
Primary Power Supply	DERs (typically including generators)	Grid + DERs	Grid + DERs	Grid only
Back-up	None	None	DERs	Typically none but could be possible

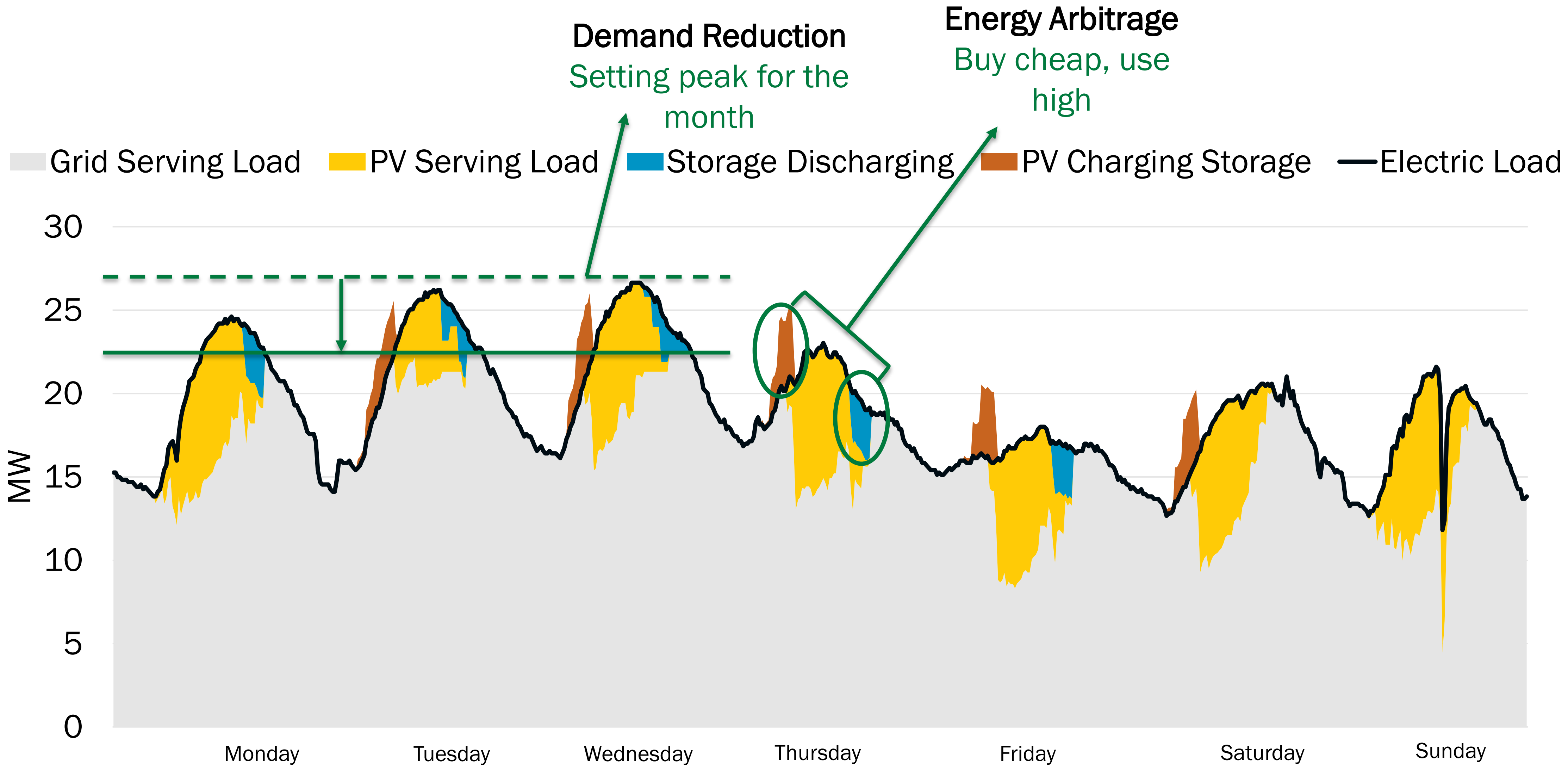
Quiz tip: solar PV plus batteries can be cost-competitive when compared to back-up diesel generators, but it depends on the location and application

Value Streams by Use Case

Value Stream	Description	Off Grid	Grid Connected	Large Scale
Fuel Offset	Offset fuel cost in off-grid remote locations	X		
Demand charge reduction	Use stored energy to reduce demand charges on utility bills		X	
Energy Arbitrage	Energy time-of-use shift (from on-peak to off-peak hours or selling during high cost and charging during low cost)		X	X
Demand response	Utility programs that pay customers to lower demand during system peaks		X	
Frequency regulation and capacity markets	Stabilize frequency on moment-to-moment basis or supply spinning, non-spinning reserves (ISO/RTO)		X	X
Voltage support	Insert or absorb reactive power to maintain voltage ranges on distribution or transmission system			X
T&D Upgrade Deferral	Deferring the need for transmission or distribution system upgrades, e.g. via system peak shaving			X
Resiliency / Back-up power	Using battery to sustain a critical load during grid outages		X	

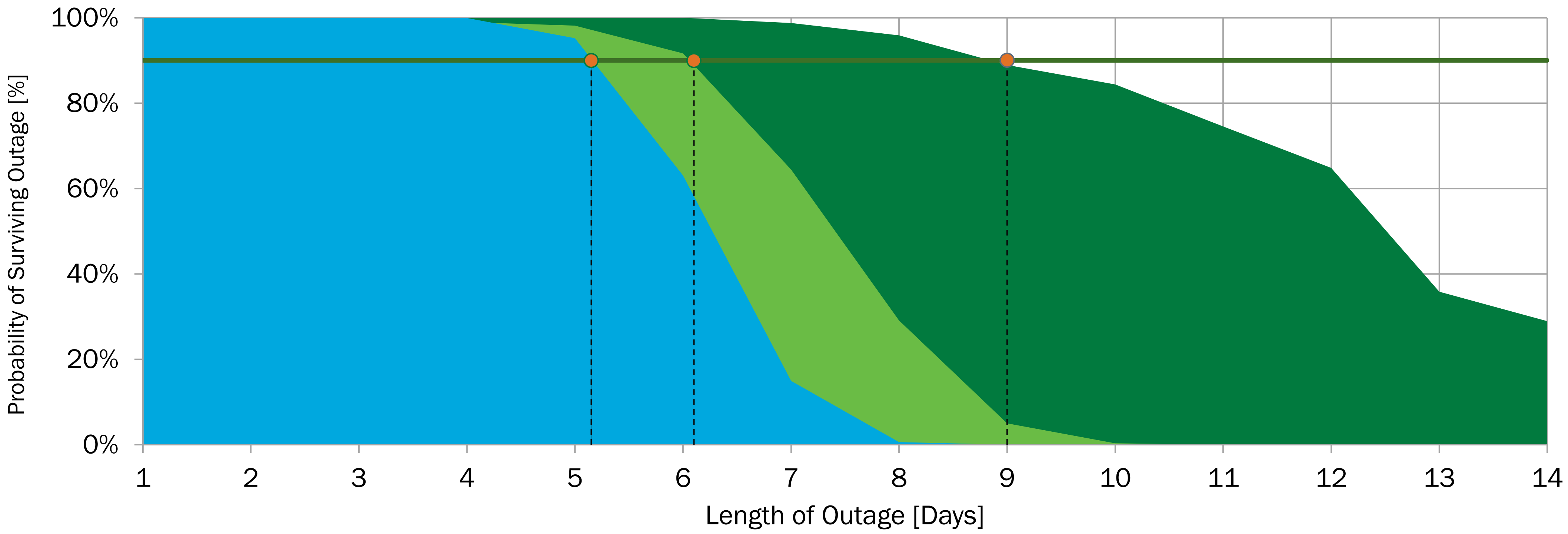
Quiz tip: During normal grid connected operations, battery storage has the potential to provide demand charge reduction and time-of-use energy arbitrage, and enable participation in demand response programs

Example of Demand Reduction and Energy Arbitrage



Surviving Outage vs. Cost Savings

	Generator	Solar PV	Storage	Lifecycle 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



In a case study at a military base, NREL evaluated thousands of random grid outages and durations throughout the year and compared number of hours the site could survive with a diesel generator and fixed fuel supply vs. generator augmented with PV and battery.

Microgrid Ready PV

- If there are future microgrid plans at a site, consider microgrid ready PV

- Microgrid ready PV: the practice of including low or no-cost measures when installing a PV system that will facilitate the integration of that PV system into a microgrid at a later point

- Microgrid ready PV includes:
  - Inverters capable of operating in both grid-interactive and microgrid modes
  - Inverters capable of responding to commands from a microgrid controller
  - Reserved space near the PV system for microgrid and equipment expansions

- Check out FEMP's factsheet on Microgrid-Ready Solar PV – Planning for Resiliency (https://www.nrel.gov/docs/fy18osti/70122.pdf)

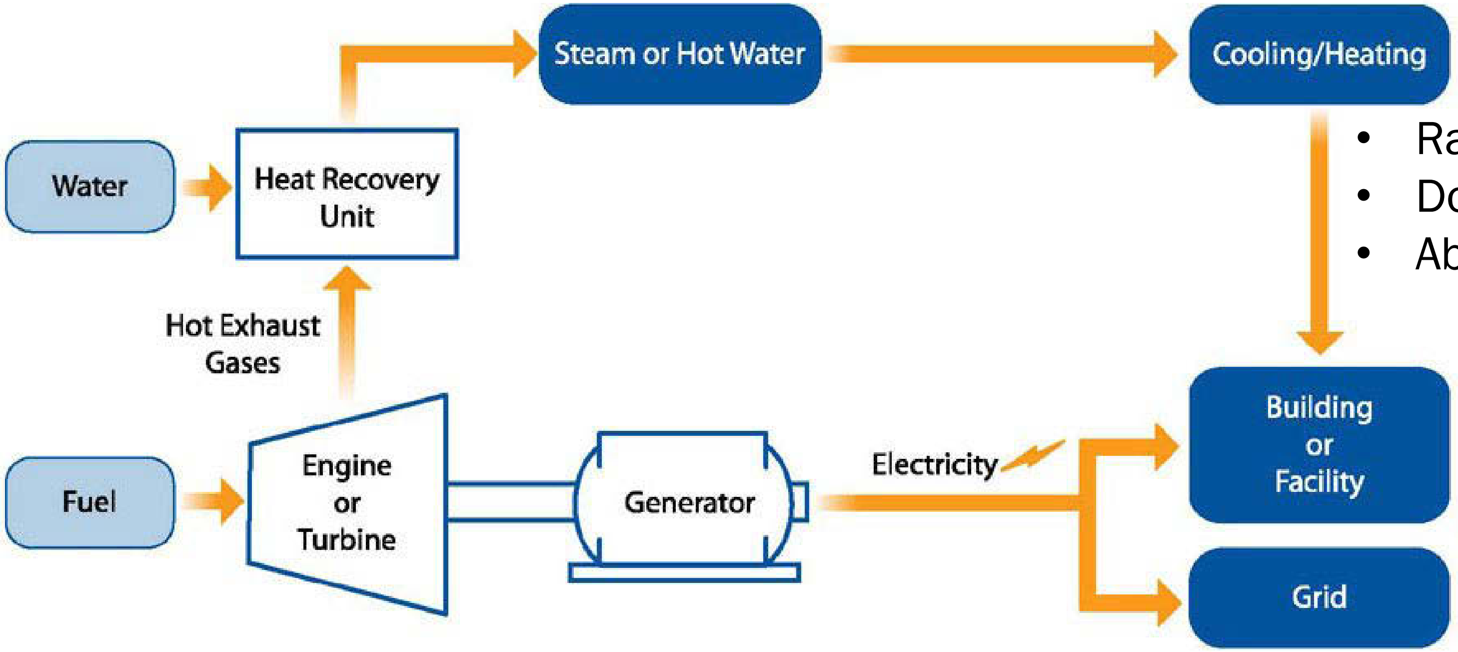
Quiz tip: Microgrid ready PV includes inverters capable of operating in both grid-interactive and microgrid modes, inverters capable of responding to commands from a microgrid controller, and reserving space near the PV system for microgrid and equipment expansions

Combined Heat and Power (CHP)

What Is CHP?

CHP* is the coincident generation of electricity and usable thermal energy

-Typically located near the load/building, so that thermal energy can be directly used



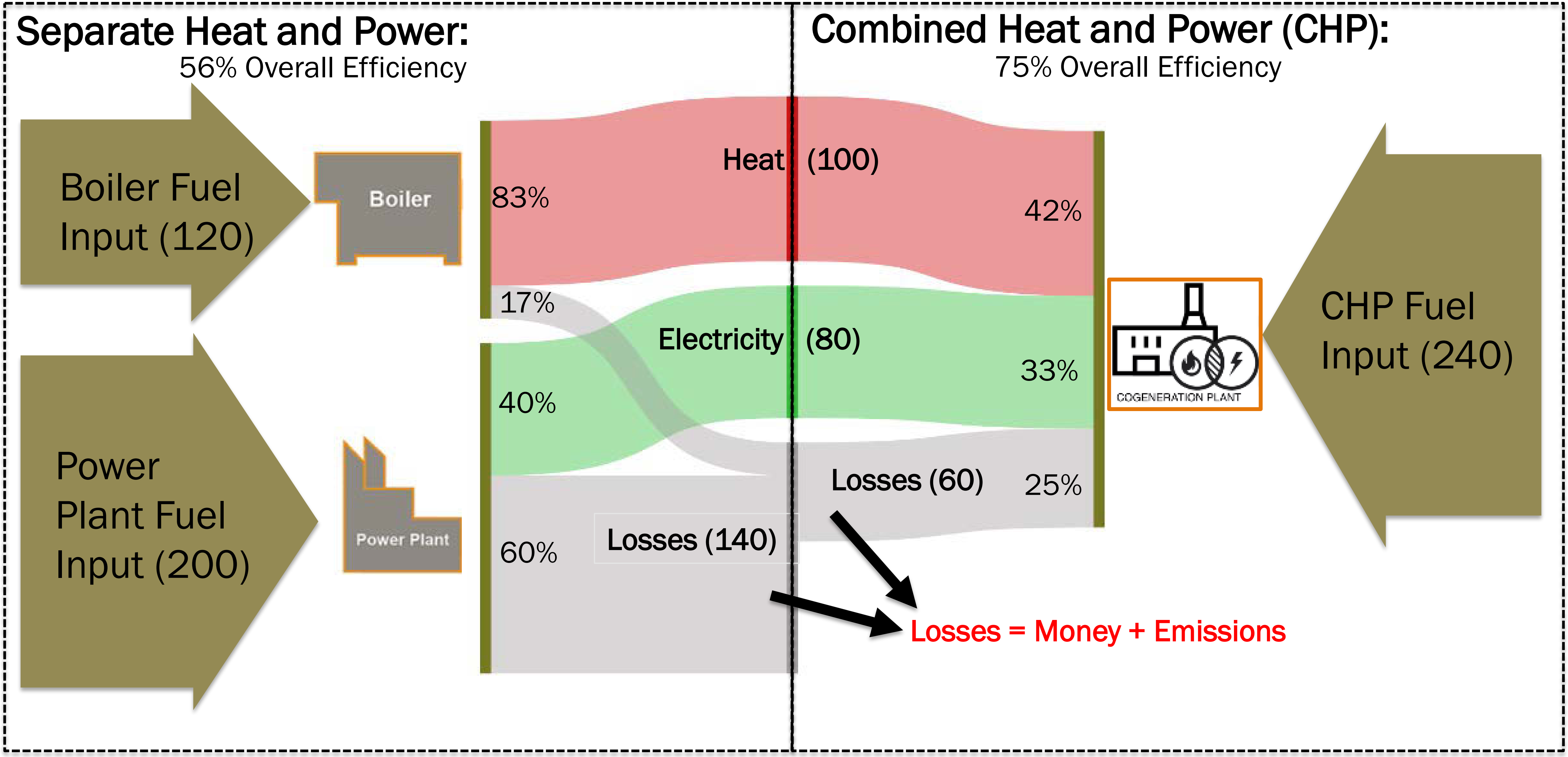
- Radiators for space heating
- Domestic hot water
- Absorption chilling

Image from: https://www.energy.gov/sites/prod/files/2017/12/f46/CHP%20Overview-120817_compliant_0.pdf

*CHP is also called "cogeneration" – these are synonymous terms

Quiz tip: CHP stands for Combined Heat and Power

Why COMBINED heat and power instead of SEPARATE?



If you answer "yes," improves CHP viability

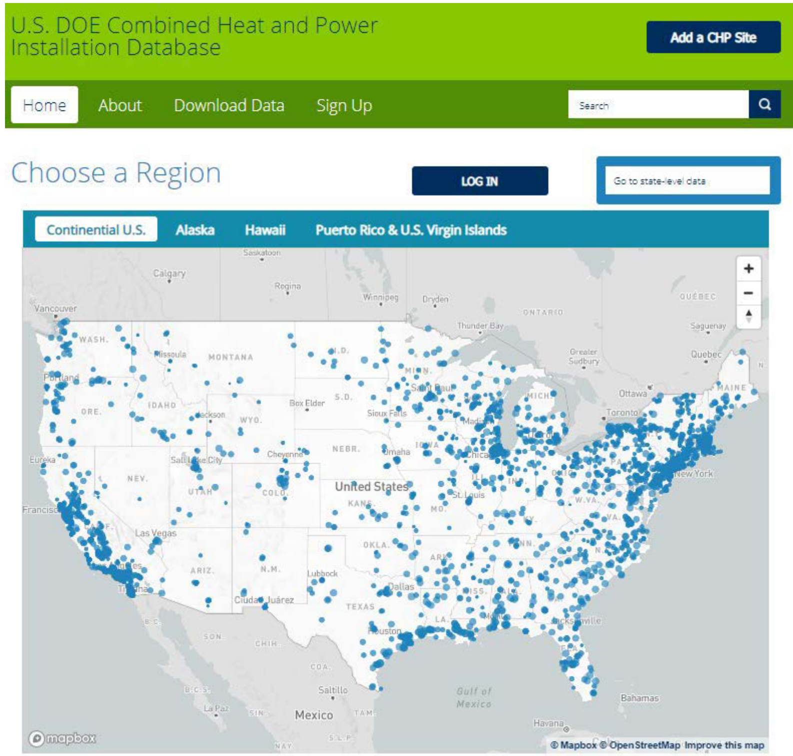
- Do you have a year-round, baseload need for electricity *and* heat?
- Do you have high electricity prices?
- Do you have space-heating radiators compatible with hot water?
- Is there a significant loss of revenue due to grid outages?
- Are there critical loads which must be served during a grid outage?

Quiz tip: The economics of CHP improve if there is a year-round need for both electricity and heat (e.g., laundry, food service, absorption cooling, etc.) at a federal site with a central heating system.

Common Applications for CHP

- Colder climates, remote communities
- Buildings which have hot water distribution systems currently supplied by a boiler
- Use of absorption chilling in the summer (heat-driven cooling)
- Common fuels (% by count, not by capacity):
  - Natural gas (~70%)
  - Biomass digester gas (~10%)
- Common building types (% by count, not by capacity):
  - Multi-family residential (~10%)
  - Schools (~8%)
  - Hospitals (~5%)
  - Food processing (~5%)

Existing CHP installations:



CHP Costs and Benefits

- CHP has *high-initial capital cost*, and modest operating and maintenance (O&M) costs
- CHP should be sized to operate most of the year at a **high-capacity factor** (>75%) to produce energy savings to justify initial investment
- CHP typically increases on-site natural gas consumption (fuel for CHP), but lower grid-electricity purchases result in a ***net savings***
- CHP typically *lowers overall emissions* created by the site (with site-to-source ratios for electricity), even though on-site emissions likely increases

CHP for Resilience

- CHP provides on-site electricity generation which can provide back-up power during a grid-outage, and thermal loads can still be met

- The natural gas supply (fuel for CHP) is much more reliable (less "outages") than the electric grid

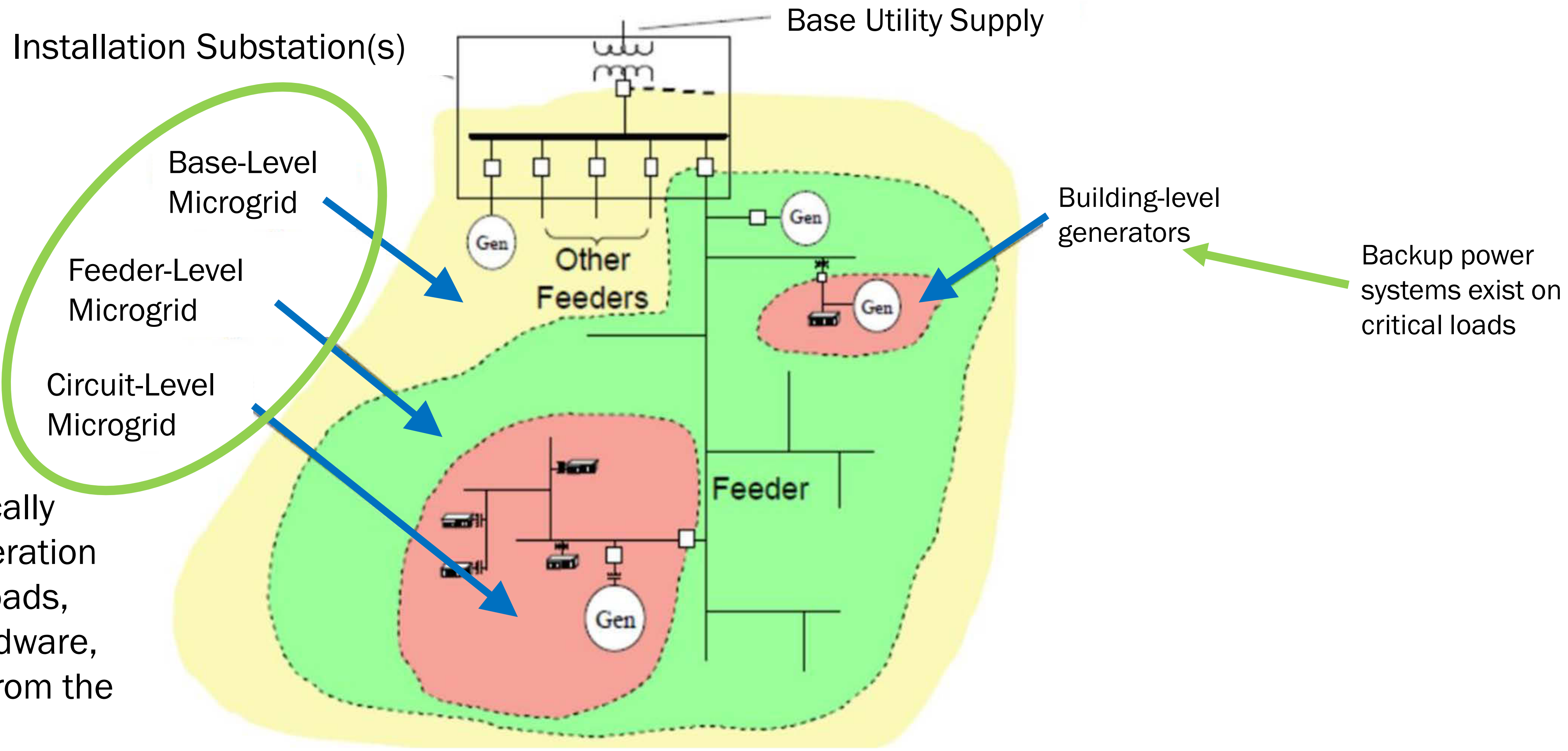
- For highly critical back-up needs that anticipate the natural gas supply could be interrupted, dual-fuel prime-movers are available
  – A backup diesel or propane storage tank on-site would enable the prime-mover to continue operation

Microgrids

What Is a Microgrid?

Microgrid – DOE Definition

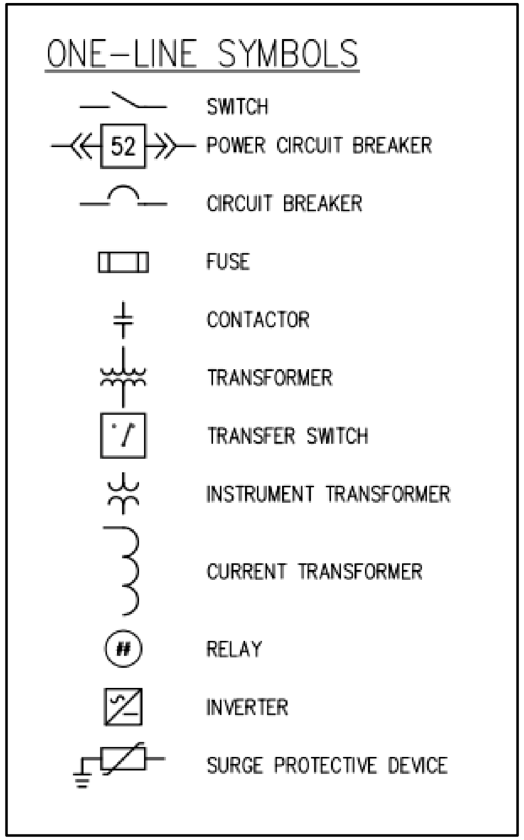
- A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid, and can operate in both grid-connected or island-mode (DOE 2011).



Quiz tip: a microgrid typically includes distributed generation assets, interconnected loads, control software and hardware, and capability to island from the utility grid

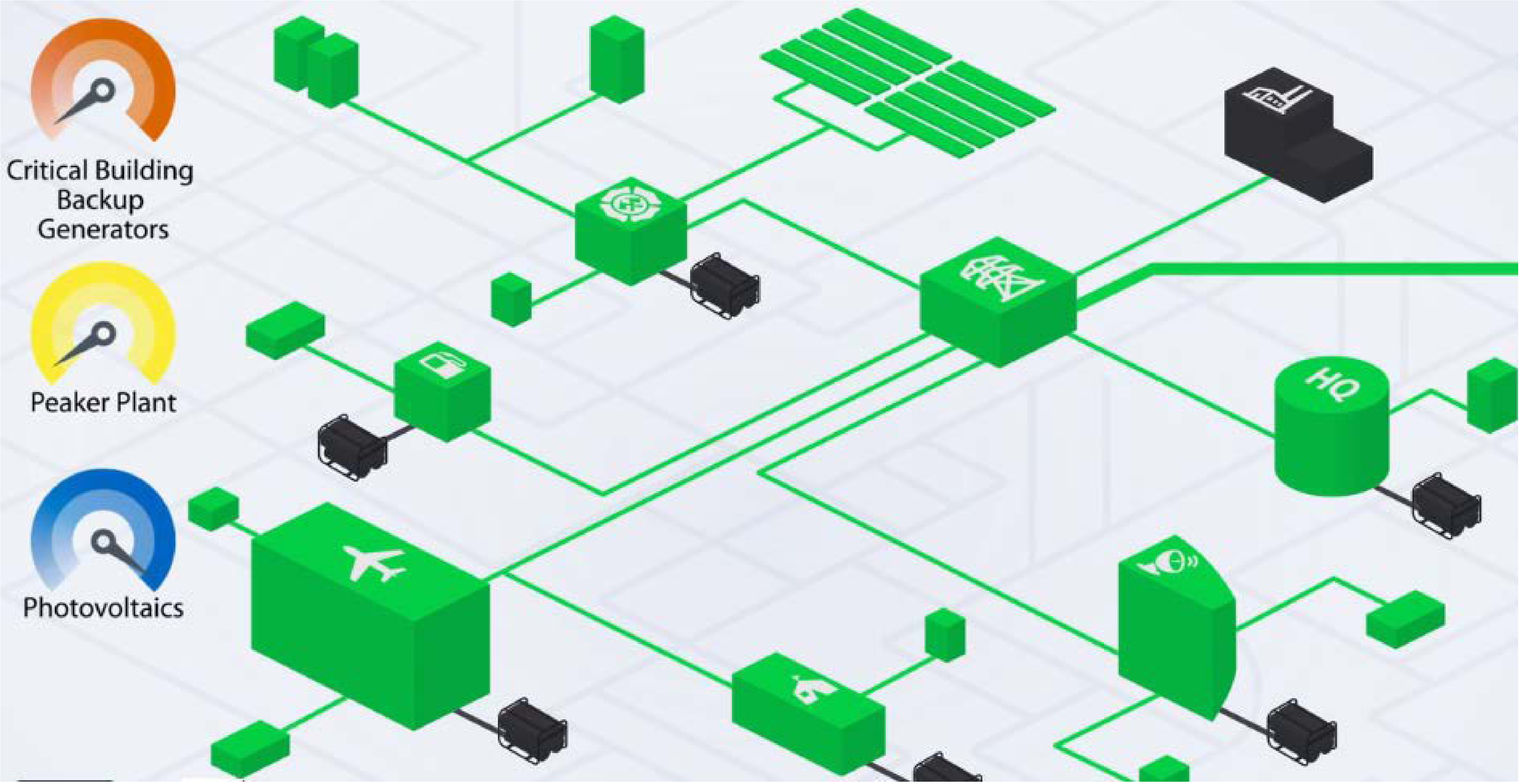
Components of a Microgrid

- **Distributed generation assets**
- **Energy storage**
- **Interconnected loads**
- **Conductors**
- **Switching devices to island from the utility grid**
  - Disconnect Switch
  - Transfer Switches (automatic or manual)
- **Protection Devices**
  - Protective Relays/Circuit Breakers
  - Recloser
  - Fuses
- **Power Factor Correction**
  - Voltage Regulator
  - Capacitor
- **Microgrid Control Software and Hardware**
  - This is an often-overlooked cost component of a microgrid
  - This can be a significant portion of the overall microgrid's cost, especially for smaller microgrid systems



Quiz tip: microgrid costs that are often overlooked include the microgrid control software and hardware

Unplanned Utility Outage: Transition to Microgrid Operations



A Phased Approach to Microgrids

Basic

- **Grid-level generators that can island groups of loads from grid**
  - Connected generators can parallel
  - Manual operation of all switching and generation

Intermediate

- **Grid-level generators that can remotely island loads from grid**
  - System is half-automated, but still requires manual load shedding
  - Generators can be remotely controlled once loads are shed

Advanced

- **Full Smart Microgrid capability**
  - Entire installation can be islanded
  - Central control of load shedding
  - Central control of generator output

Quiz tip: a microgrid is *<u>not</u>* a recommended solution at all federal sites

Do You Need a Microgrid?

Whether an agency pursues a microgrid is typically based on two factors:

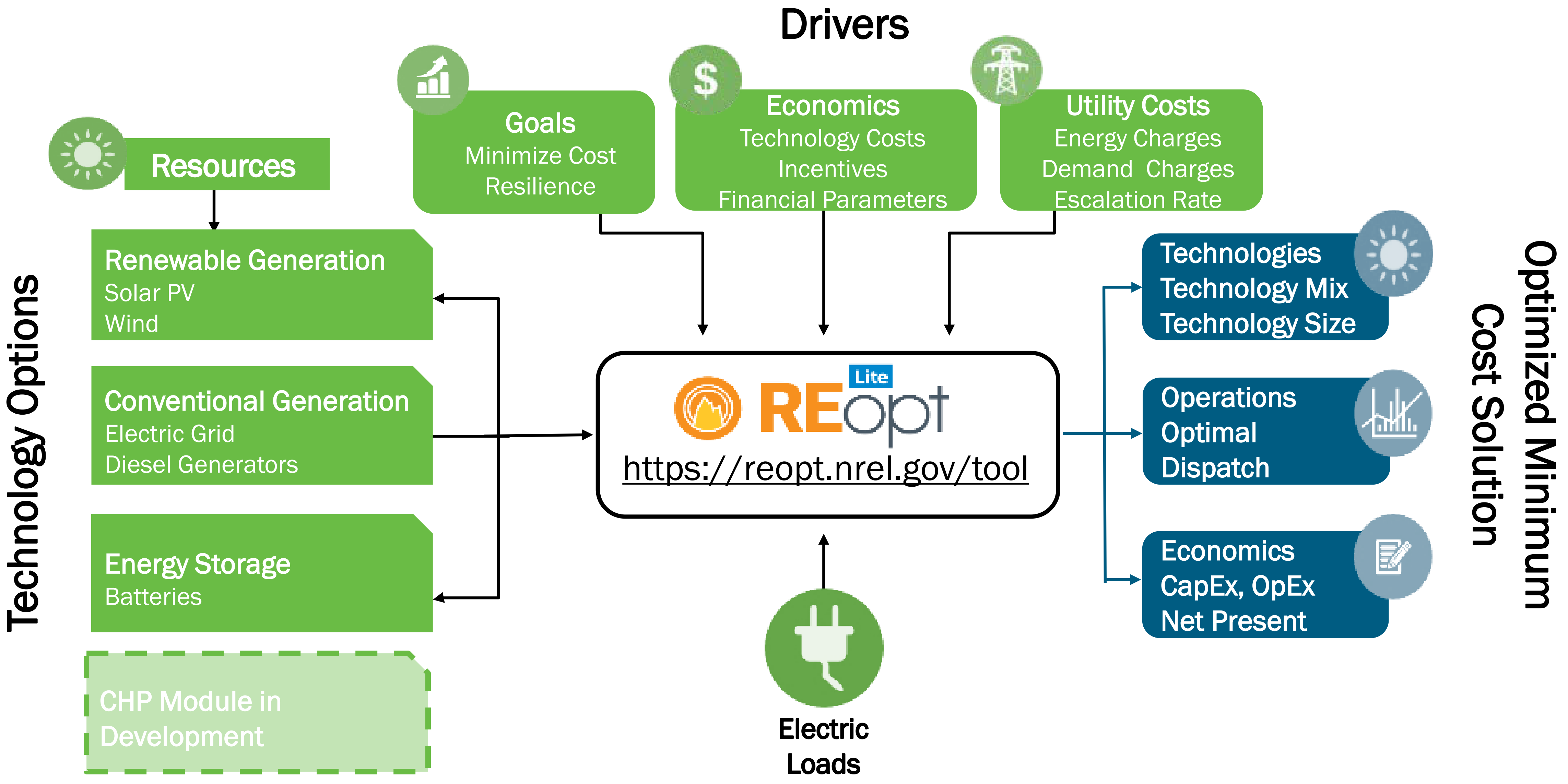
1. **The agency has a need for increased resilience:**
   - Are there critical site functions that could result in significant risk to loss of life or equipment if disrupted?
     - Examples: hospitals, flight operations, laboratory tests, emergency shelters
   - Is your utility power unreliable?

2. **The cost and economic benefits of the microgrid:**
   - Is the improvement in resilience worth the added cost?
     - Microgrids are generally very expensive, because each site is different and requires tailored analysis, engineering, and equipment.
   - Can the microgrid provide savings during normal operations?
     - Microgrids can provide a variety of financial benefits, including: Peak shaving, energy price arbitrage, demand response, RECs, capacity market payments, among others.

Quiz tip: microgrids are *not* always cost effective and recommended for every site

REopt Lite Overview and Exercise

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



REopt Lite Exercise

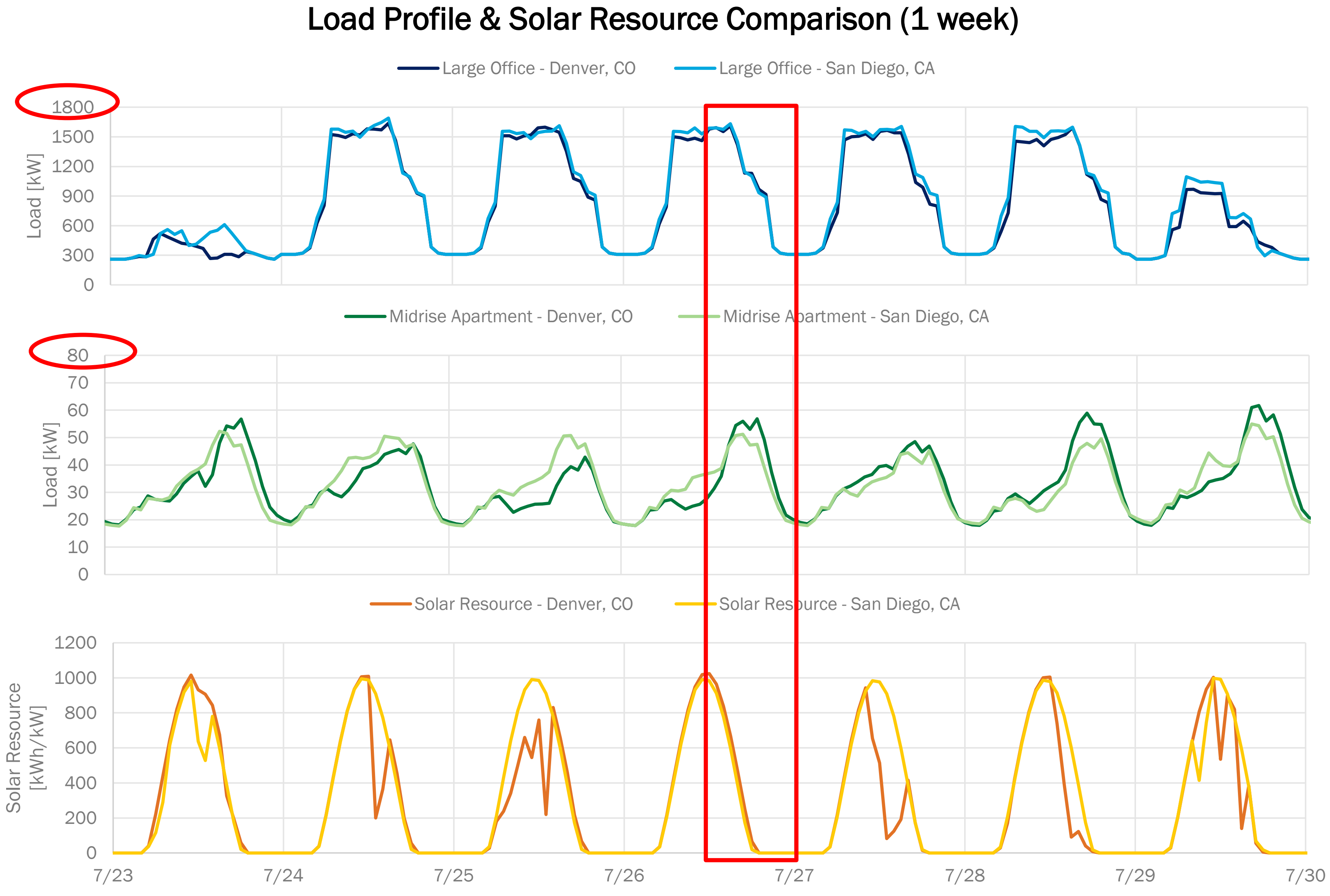
- **Using your laptop (preferred), tablet, or cell, go to the REopt Lite webtool: https://reopt.nrel.gov/tool/**
  - Choose your focus: select "financial"
  - Enter your site data (see information sheet on your table)
  - Write down your results
- **WiFi information provided**

- **Each table has a different set of inputs and should expect different outputs**
- **You can work together with someone at you table, or alone**
- **If you get stuck, raise your hand**
- **We will go through the results at the end**

Results

	Location	Electric rate structure	Net metering	Building/ load type	PV size	Battery size	NPV [$]	1-hr outage Surviva-bility	12-hr outage Surviva-bility
1	Denver	Flat	2,000 kW	Large office	0 kW	0 kW / 0 kWh	$0	0%	0%
2	Denver	Demand	2,000 kW	Large office	2,000 kW	18 kW / 24 kWh	$ 189k	30%	~0%
3	Denver	Flat	2,000 kW	Midrise apartment	0 kW	0 kW / 0 kWh	$0	0%	0%
4	Denver	Demand	2,000 kW	Midrise apartment	41 kW	0 kW / 0 kWh	$ 1k	24%	0%
5	San Diego	Flat	10,000 kW	Large office	4,654 kW	0 kW / 0 kWh	$ 3,339k	39%	1%
6	San Diego	Demand	10,000 kW	Large office	4,654 kW	137 kW / 181 kWh	$3,864k	49%	2%
7	San Diego	Flat	10,000 kW	Midrise apartment	174 kW	0 kW / 0 kWh	$ 124k	39%	~0%
8	San Diego	Demand	10,000 kW	Midrise apartment	174 kW	1 kW / 2 kWh	$ 130k	40%	~0%

Load Profile, Solar Resource, & Utility Rate Comparison



Utility Rate

Location	Rate structure	Energy charges [$/kWh]	Demand charges [$/kW]
Denver	Flat rate	$0.0958	$0
Denver	Demand rate	$0.0958	$15
San Diego	Flat rate	$0.1525	$0
San Diego	Demand rate	$0.1525	$18

Net Metering Limit

Location	Net metering limit
Denver	2,000 kW
San Diego	10,000 kW

Resources

- **REopt Lite: https://reopt.nrel.gov/tool**
  - Tool
  - Help manual
  - Send tool feedback & ask a question: reopt@nrel.gov

- **REopt Website (full model)**
  - Analysis services
  - Case studies

Q&A Session

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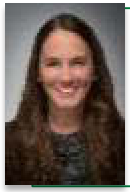
Rachel Shepherd
FEMP, Program Lead
Federal distributed energy projects
rachel.shepherd@ee.doe.gov

Emma Elgqvist
NREL, Engineer
Solar PV + Storage economics
emma.elgqvist@nrel.gov

Andy Walker
NREL, Principal Engineer
Solar PV
andy.walker@nrel.gov



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NREL, Senior Engineer
Federal distributed energy projects
alicen.kandt@nrel.gov

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Chuck Kurnik
NREL, Senior Engineer
Microgrids
chuck.kurnik@nrel.gov

Kevin DeGroat
Antares Group, Project Director
Federal project reporting
kdegroat@antaresgroupinc.com

Submit a Request: https://www7.eere.energy.gov/femp/assistance/

End Of Presentation

Emma.Elgqvist@nrel.gov

NREL/PR-5D00-74625

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