



Microgrids, Fuel Cells, & Battery Energy Storage Systems

CIRCA:
Municipal Energy Resilience Webinar Series

June 7th, 2023



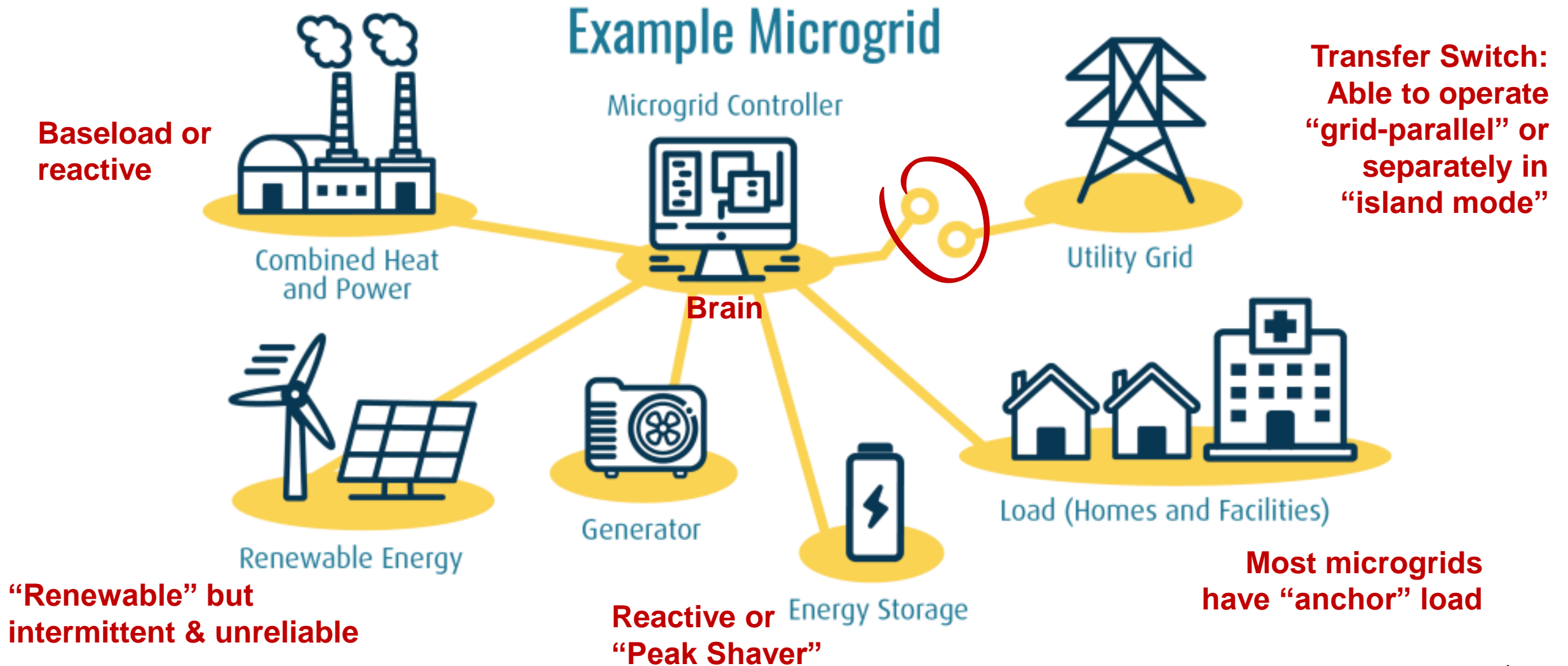
Microgrids

What is a Microgrid?





The U.S. DOE Microgrid Exchange Group defines a microgrid as “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. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.”

<https://www.naseo.org/issues/electricity/microgrids>

What is a Microgrid?



Benefits of a Microgrid

-  **Resiliency** – Outage prevention
-  **Save money** – Energy/operations/risk
-  **Reliability** – Everyday availability
-  **Sustainability** – More efficient, grid carbon intensity, complement renewables

Ownership Structures



Customer purchase and installation

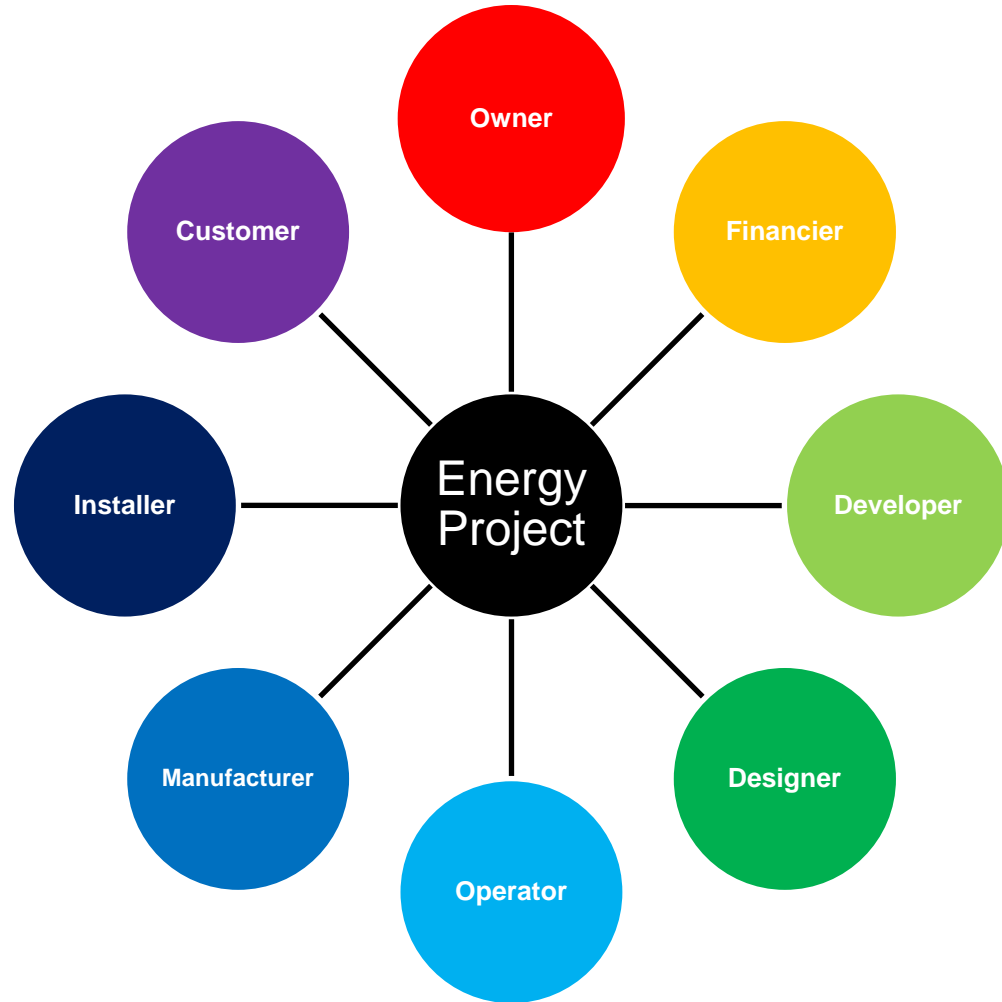


Lease arrangement



Third party owned and operated with shared savings to customer

Energy Project Participants



**Municipality Takeaway:
Do your homework before putting it out to bid.**

Fuel Cells

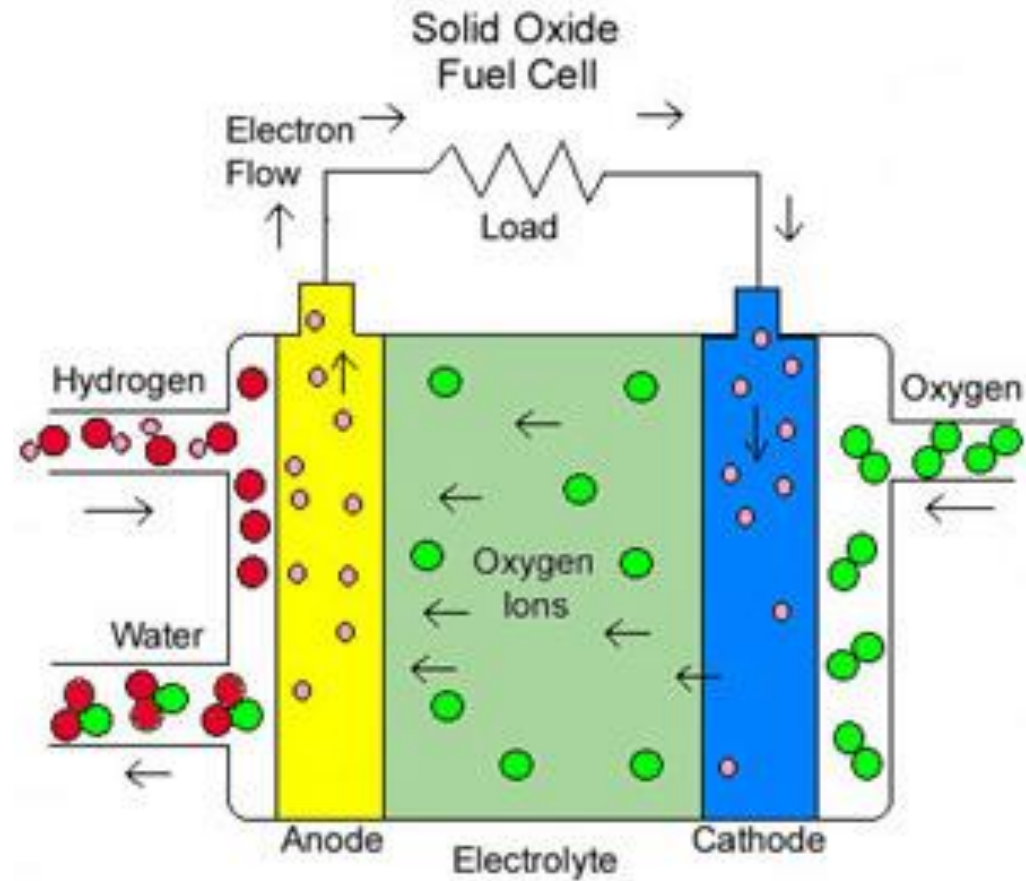


What is a fuel cell?

- A type of CHP system.
- Technology invented in 1842 by a Welsh physicist. Used by NASA in 1965.
- Instead of the combustion process of an engine or turbine, a fuel cell is a non-combustion electro-chemical process that produces electricity and heat.
- Runs on hydrogen rich fuels to produce combustion-free electricity with high-reliability.
- Fuel flexibility makes fuel cells a “bridge” technology. [hydrogen or natural gas]

How Fuel Cells Work

1. Hydrogen is fed to the anode, and air is fed to the cathode.
2. A catalyst at the anode separates hydrogen molecules into protons and electrons, which take different paths to the cathode.
3. The electrons go through an external circuit, creating a flow of electricity.

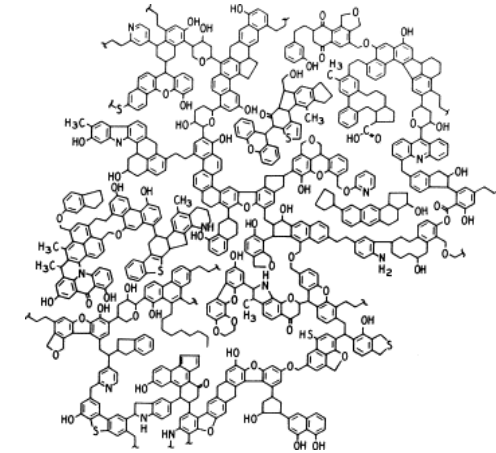


Natural Gas

- Most fuel cells currently house the reforming process of natural gas to hydrogen within the unit
- Power plants
 - Traditional gas combustion power plant
 - » 33-57% efficiency
 - Combined heat and power plant
 - » 65-80% efficiency
 - Fuel cell
 - » 60-90% efficiency

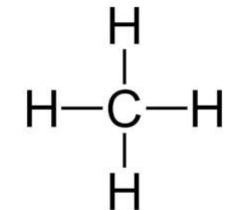
More Efficient

Coal

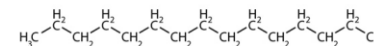


Methane is the cleanest "brown" fuel

Methane



Oil



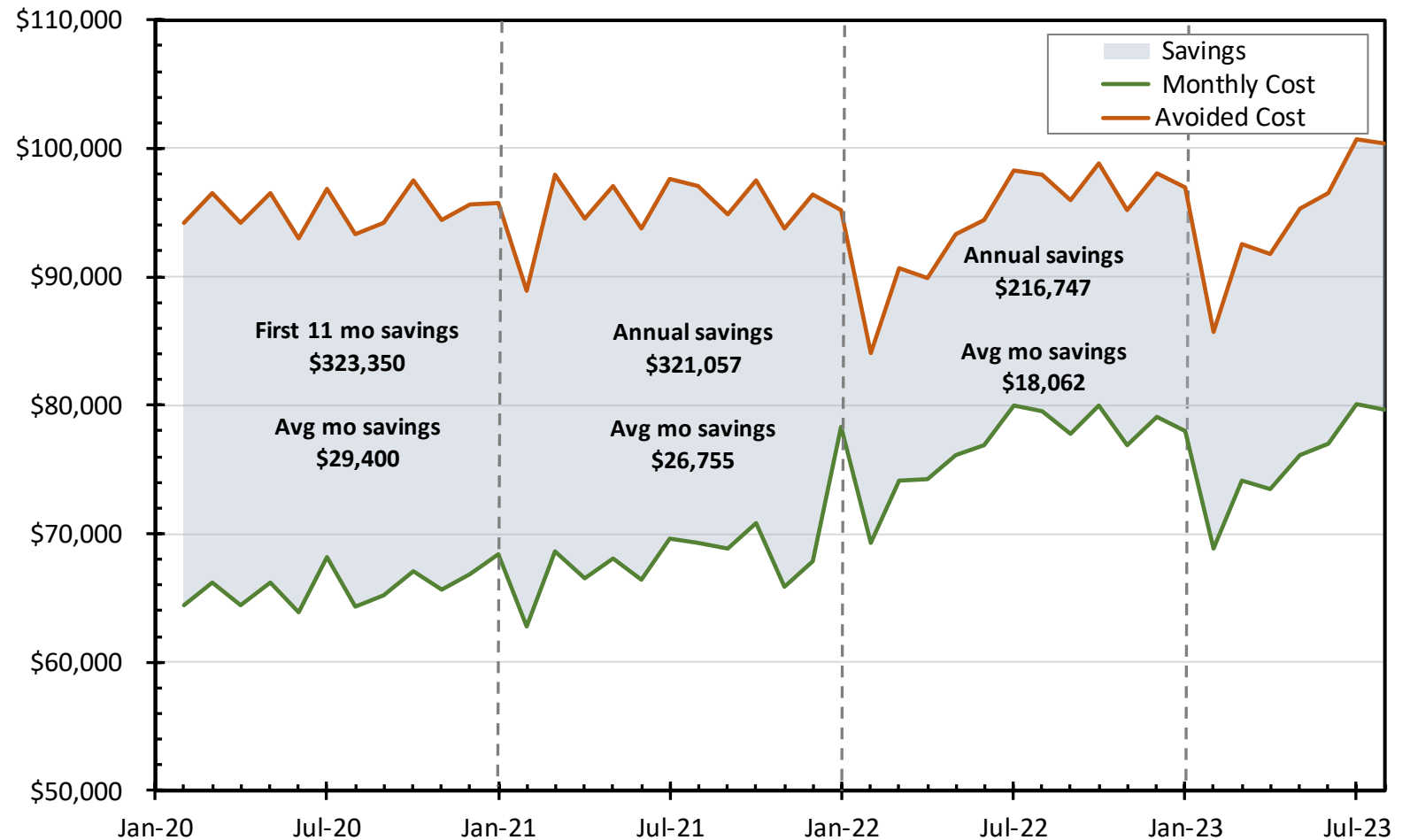
Benefits

- All-in savings vs. grid power
- Low maintenance
- Hedge against market prices
- Flexible sizing & applications
- Flexible grid arrangements: Grid parallel vs. Islanding
- Compatible with add on technologies (heat recovery, carbon capture, etc)
- Resiliency
- Reliability
- Sustainability

Economic Benefit

- CT based resource providing economic resilience to the state
- Opportunity to fix energy costs for 20+ years
 - Budget certainty and operations expense reduction

800 kW Fuel Cell
Fuel Cell Total Savings



Municipality Cheat Sheet

Fuel Cells

- Class I renewable generating asset in CT
- Qualifies for State Programs (ex: NRES & SCEF) and Federal programs (ex: Tax Credits)
- Key potential asset for a microgrid
- Better uptime and less operational burden vs. a traditional CHP
- Fuel cell minimum size: >250 KW, serving a load >2,000,000 kwh annually, and 3 parking spots of physical space
 - Solar equivalent ~1,600 KW or 2.5 acres
- CT has monthly consumption vs. generation accounting
 - Bank excess monthly generation with an annual reset
- CT has demand cost protections for temporary outages





Battery Energy Storage System

Battery Types

- Lithium-Ion
- Iron Flow
- Vanadium Flow



Why Battery Storage?



Savings Opportunity

- On-Bill Savings
 - Capacity tag reduction
 - Demand charge management
- Cashflow positive



Backup power

- Provides short term backup power
- Allows for seamless power transition in the event a grid outage occurs

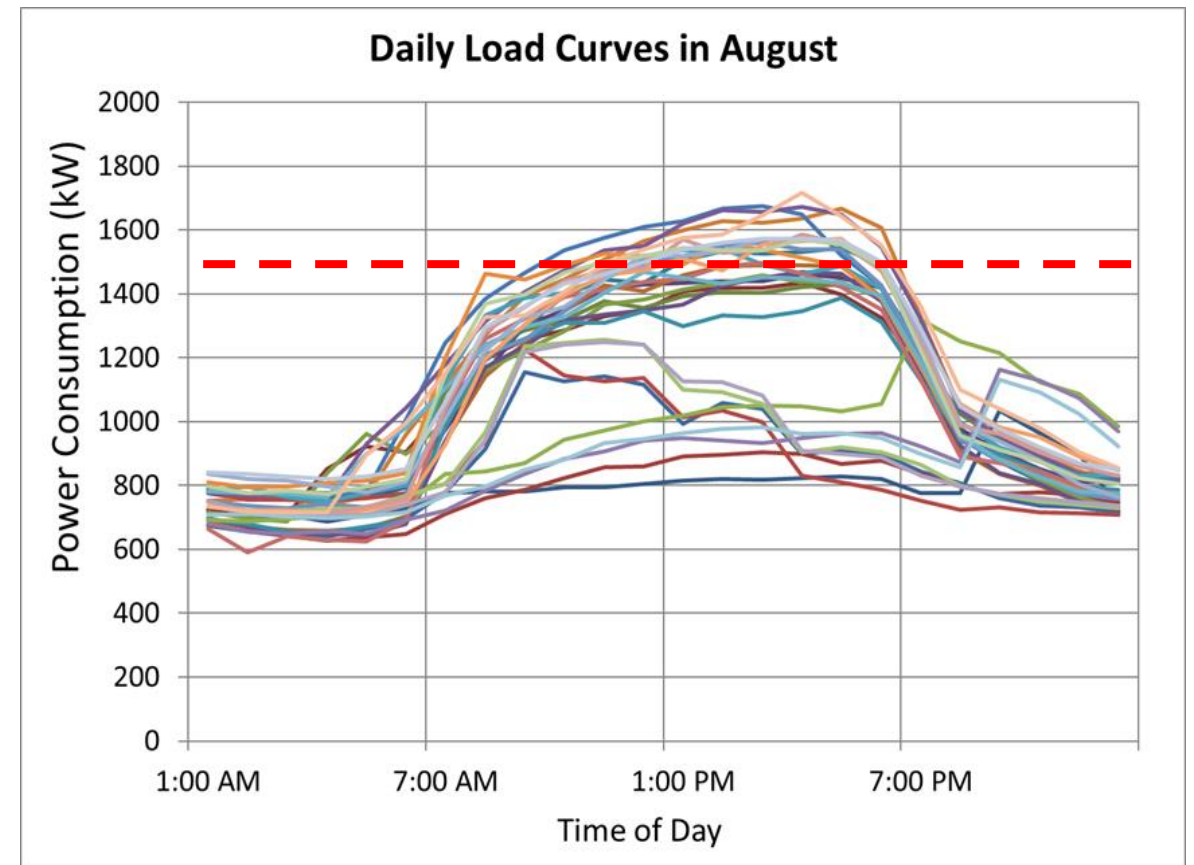


Supports Renewables and Resiliency

- Implementation of renewable energy systems
- Reliability and resiliency of the grid
- Decrease regional emissions

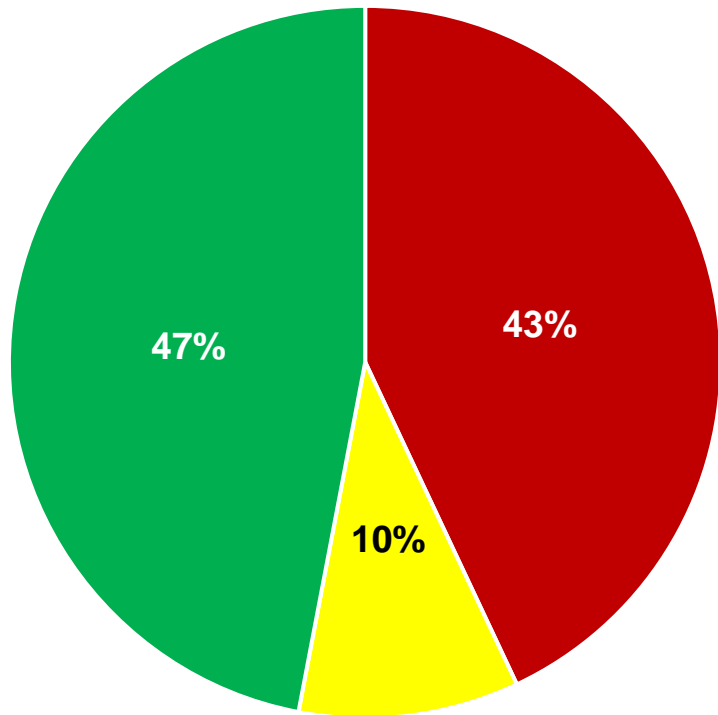
How Batteries Work

- Battery will charge at night and discharge in the day to clip the peak power use.
- Peak demand will typically be reduced by 20%
- All power above the dotted red line will be supplied by the battery



Example Value Streams

Average Annual Benefit



- Savings - Demand
- Savings - Energy Commodity Supply
- Revenue - "Connected Solutions" Ongoing Performance

Battery Example

340kw/680kwh 2-hour battery

- Net cost after rebate = \$350,000
- Annual Savings = \$80,000
- Simple Payback = 4.3 years
 - Facility Peak Demand = 1,700kw
 - Assumes 20% of peak demand of 1,700kw



CT Energy Storage Solutions

Table 4: Commercial and Industrial Upfront Incentives (2022-2024)⁸

Installed Capacity (MW)	Small Commercial (\$/kWh)	Large Commercial (\$/kWh)	Industrial (\$/kWh)
50	\$200	\$175	\$100

- Limited space
- Capped at 50% project cost

Upfront Rebate

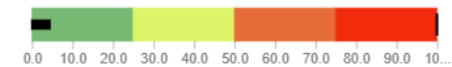
C&I Current Tranche is:
2

C&I MW Approved and Capacity Remaining

4.4✓

MW Capacity Limit: 100.0 (+95.61%)

C&I MW Approved Progress to Capacity Limit



<https://energystoragect.com/ess-performance-report/>

Table 5: Performance-Based Incentives (All Customer Classes 2022-2024)

Years 1-5		Years 6-10	
Summer (\$/kW)	Winter (\$/kW)	Summer (\$/kW)	Winter (\$/kW)
\$200	\$25	\$115	\$15
\$225 annual		\$130 annual	

Ongoing Performance Revenue

Upfront rebate generally 10-20% of project cost. Stacks on top of federal ITC benefits.

Ongoing Performance Revenue “Connected Solutions” is the primary/largest value stream over the battery’s lifespan.

Municipality Takeaway:
Tranche 2 likely to fill in 3-6 months

Municipality Considerations

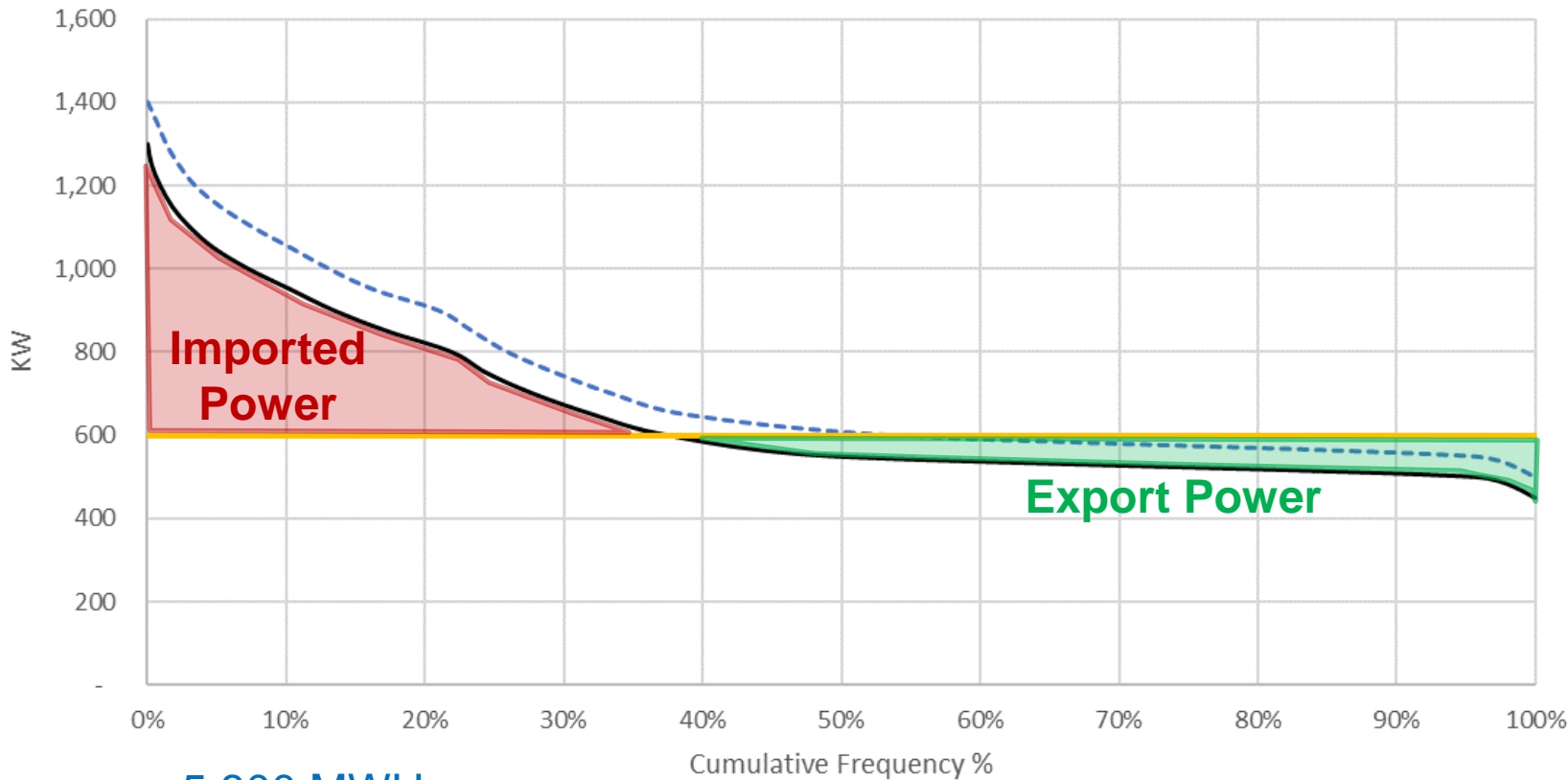
Battery Energy Storage Systems

- Discuss fire code (if applicable)
- Grid capacity important for sizing
- Ownership model (buy, lease, service agreement, purchase agreement)
- Operations (conflicts of interest with owner of system)
- Warranty vs. planned usage & ownership
- Opportunity cost of poor performance or delayed timelines
- Liability
- Current and future value
- Accounting classification
- Renewable/Sustainability Goals

Microgrid Example

Fuel Cell + Solar + Battery + Generator

Annual Load Duration Curve



~5,800 MWHs
Annual load

--- Load — w/ Solar — Fuel Cell

Solar reduces 10% annual volume est. 485 KW system.

600 KW Fuel Cell base load. In CT billed 0 volumetric charges, however billed the red area for demand charges.

Typical battery sizing would be 20% of peak load (~250 KW/ 500 KWH). In CT, program allows sizing up to 1.5X peak demand (this example ~2,000 KWH).

Max battery + FC + Solar will suffice 75% of days.

Still need ~1,000 KW emergency generator for peaks w/out solar.