Microgrids, Fuel Cells, & Battery Energy Storage Systems

CIRCA:

Municipal Energy Resilience Webinar Series

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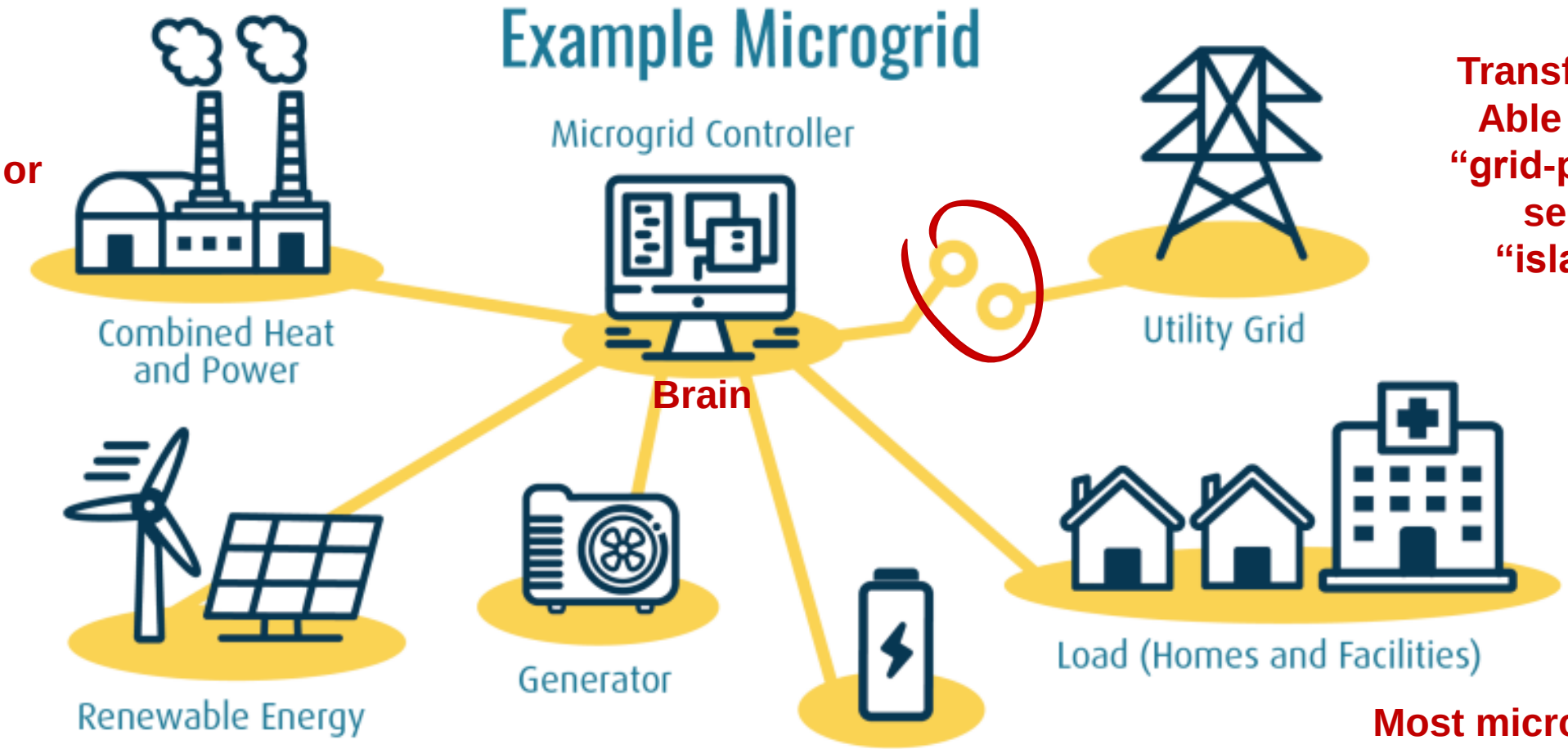
Microgrids

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?



Baseload or reactive

Transfer Switch: Able to operate "grid-parallel" or separately in "island mode"

"Renewable" but intermittent & unreliable

Reactive or "Peak Shaver"

Most microgrids have "anchor" load

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

Benefits of a Microgrid

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

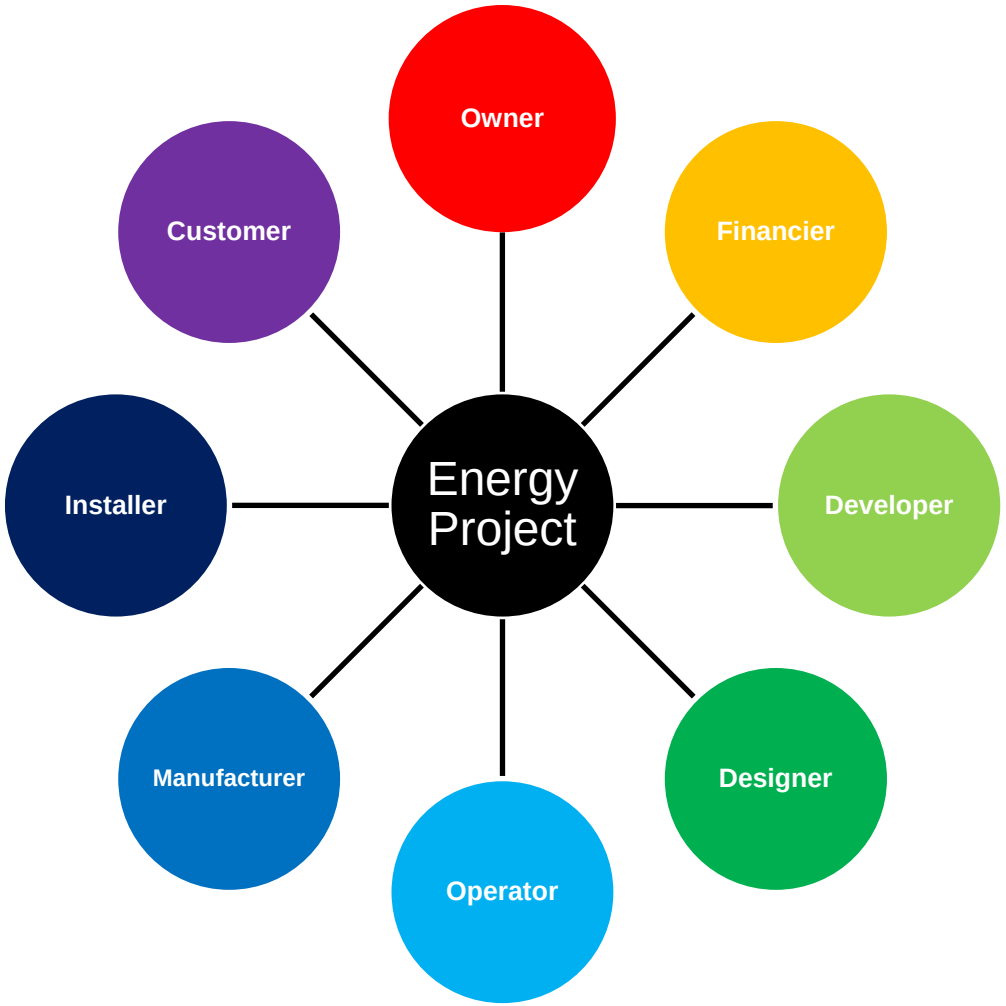
Ownership Structures

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.

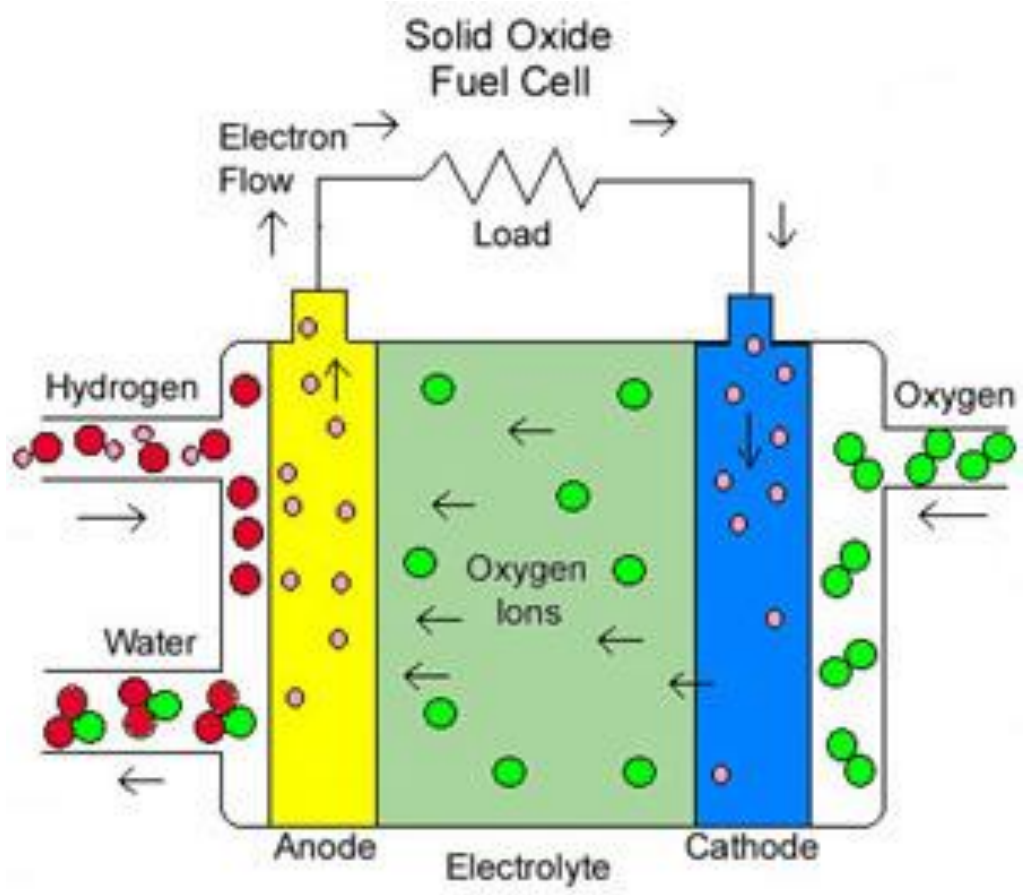
Fuel Cells

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 and 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.



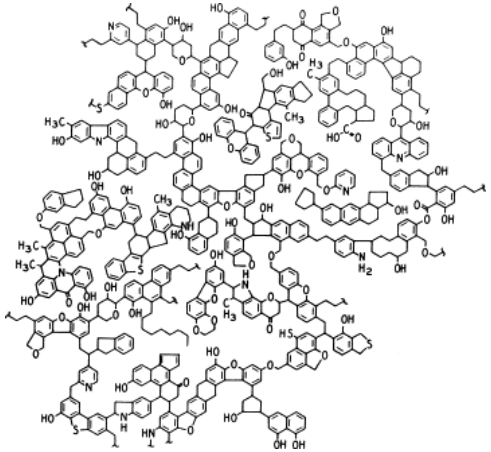
Natural Gas

- 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

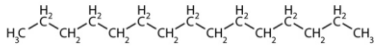
More Efficient

Coal

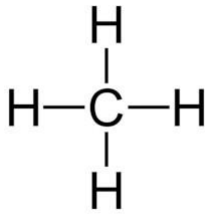


Methane is the cleanest "brown" fuel

Oil



Methane

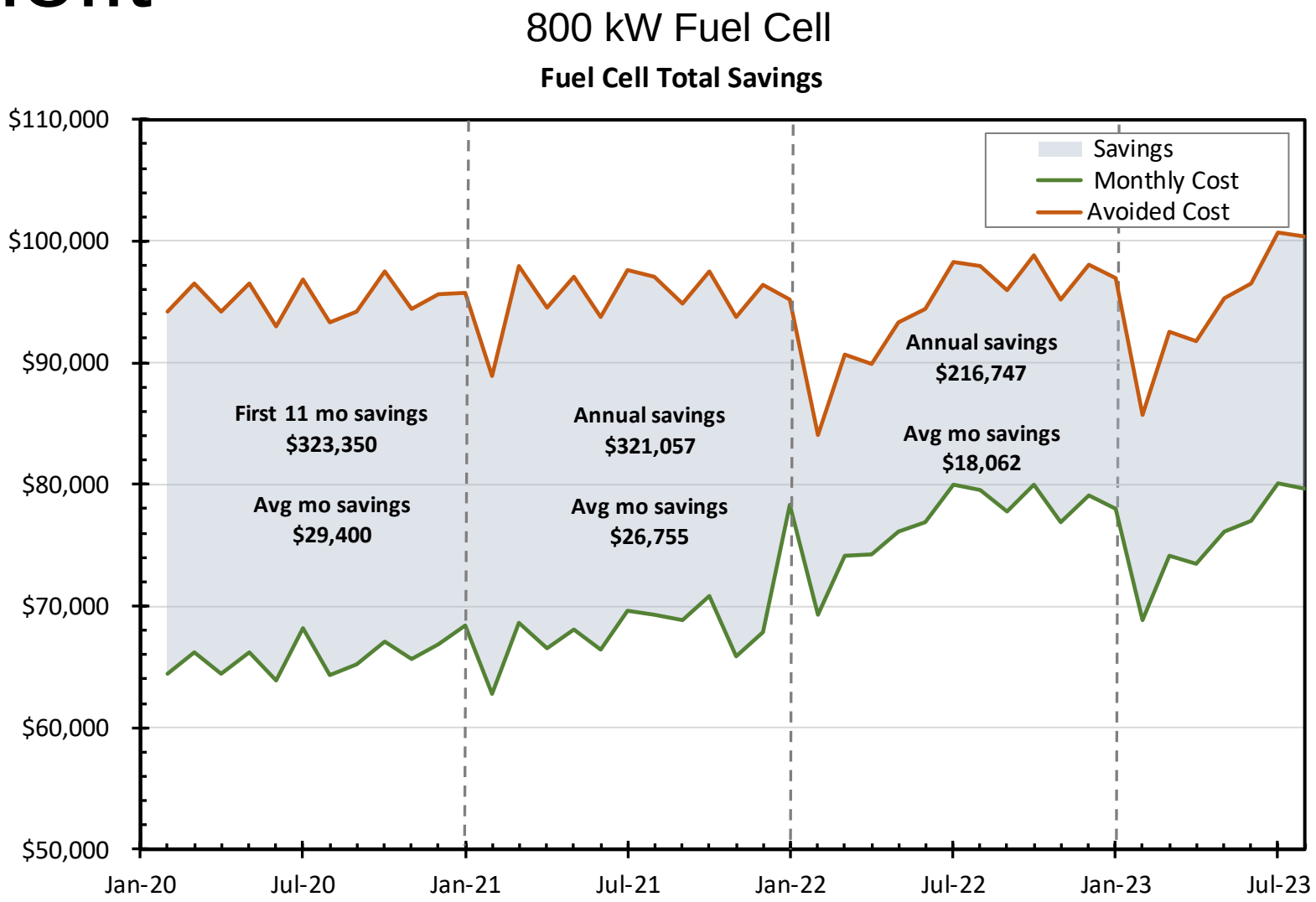


Benefits

- 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



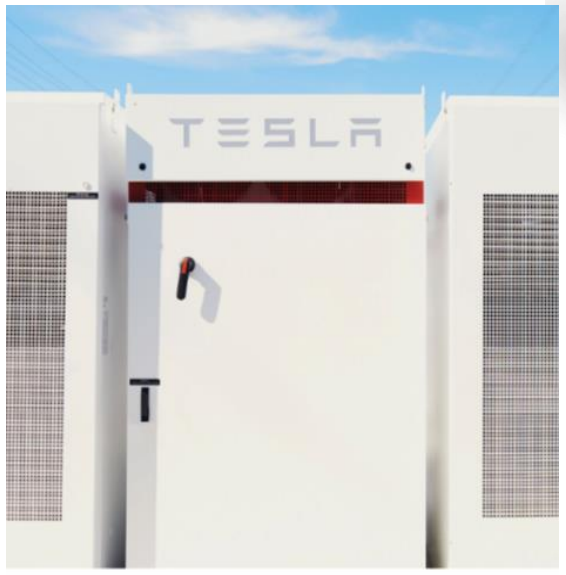
Municipality Cheat Sheet
Fuel Cells

- 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

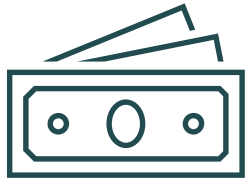
Battery Energy Storage System

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

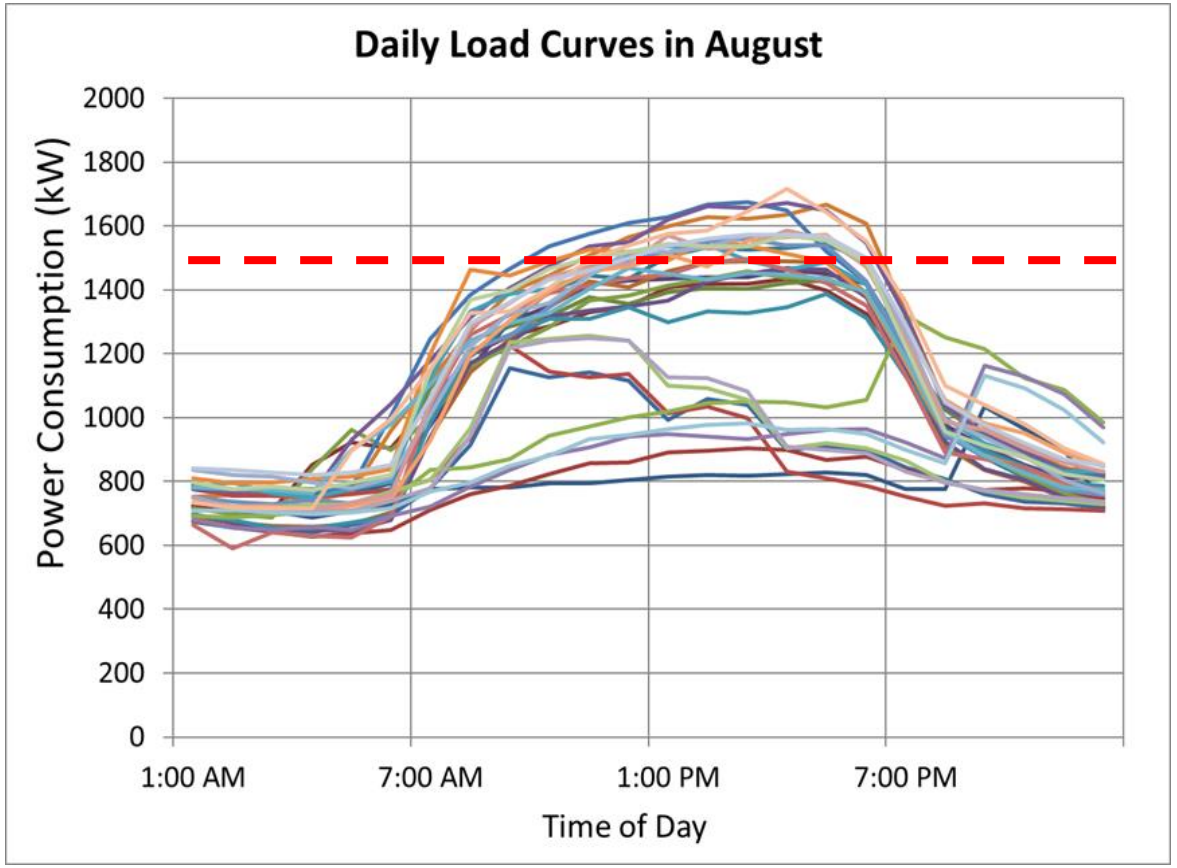
- Provides short term backup power
- Allows for seamless power transition in the event a grid outage occurs

Supports Renewables and Resiliency

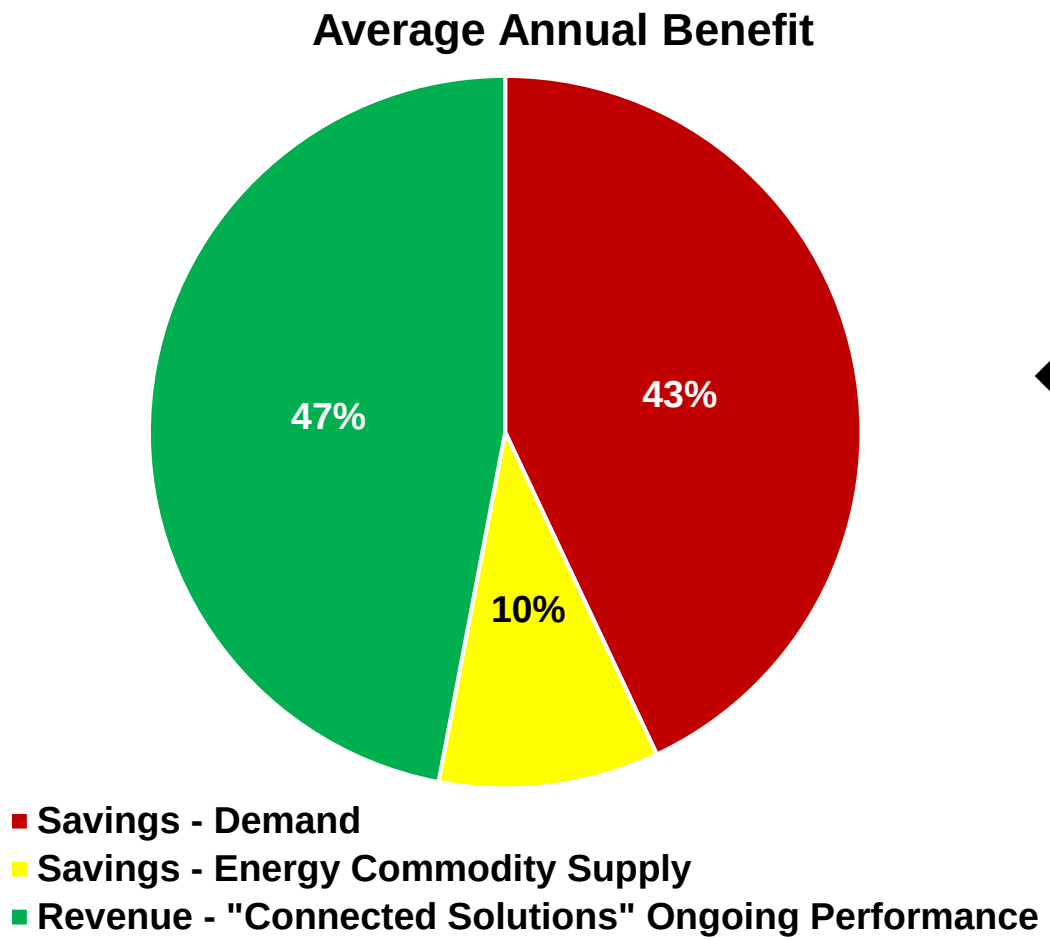
- Implementation of renewable energy systems
- Reliability and resiliency of the grid
- Decrease regional emissions

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



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

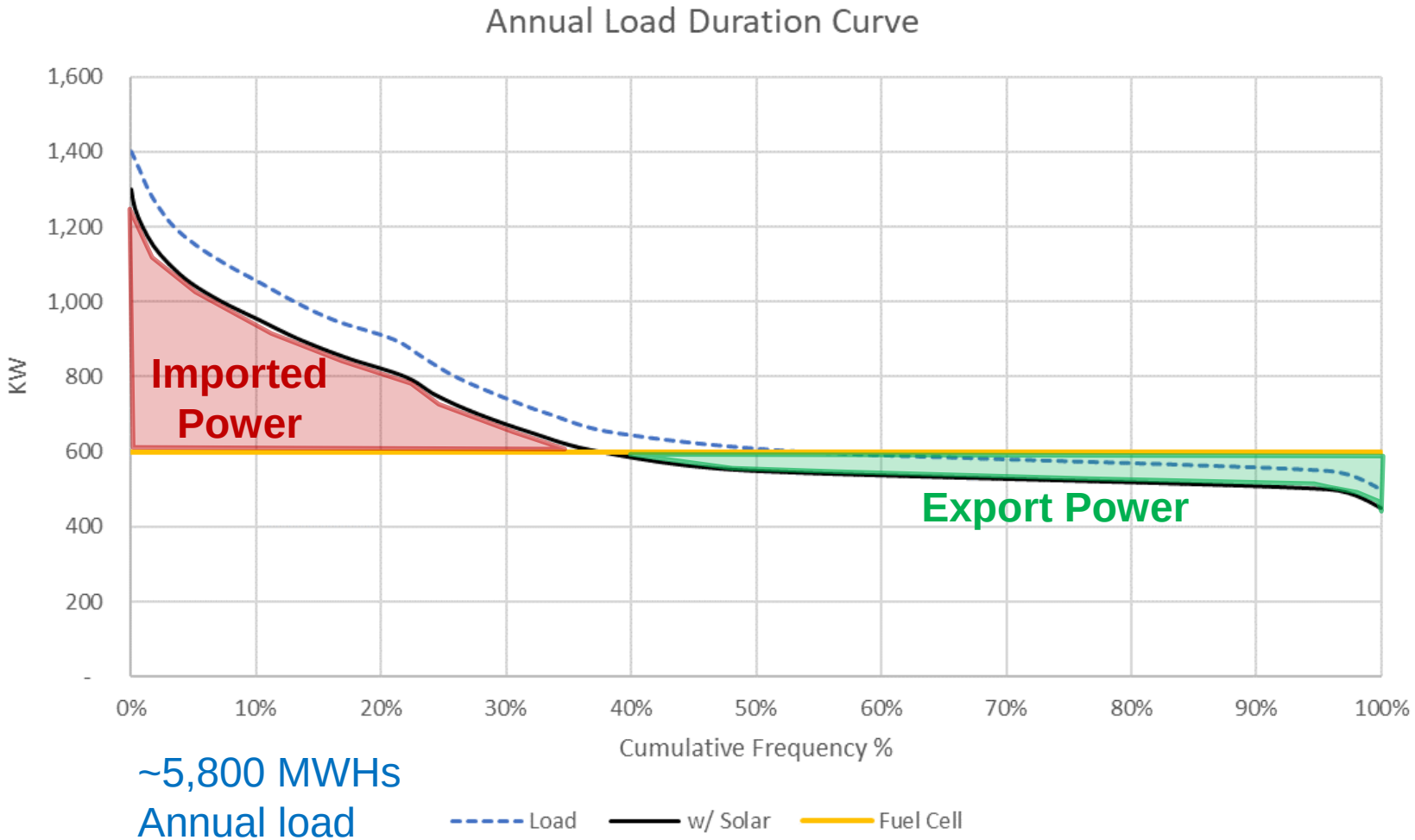
Municipality Considerations

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



~5,800 MWHs Annual load

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.