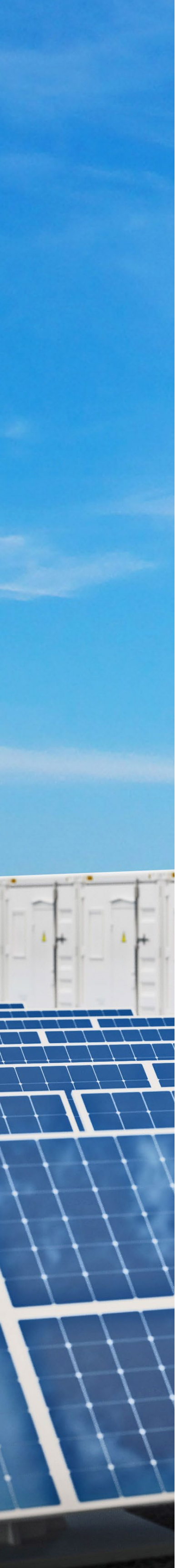

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Energy Storage for Savings and Resilience

February 9, 2023

Jeremy Twitchell

Rural Energy Conference & Workshop

U.S. DEPARTMENT OF ENERGY BATTELLE

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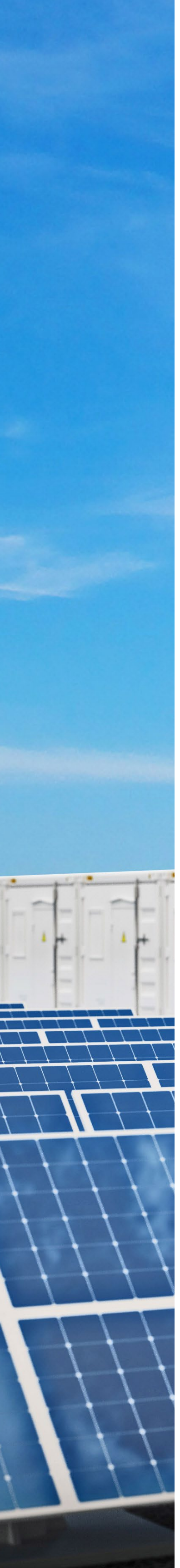
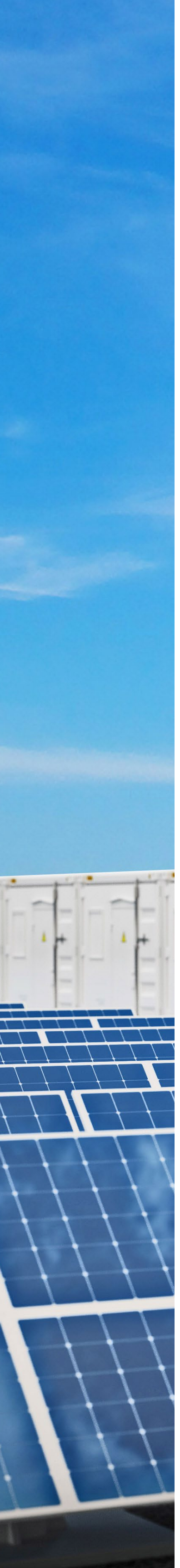


Acknowledgment

The work described in this presentation is made possible through the funding provided by the U.S. Department of Energy's Office of Electricity, through the Energy Storage Program under the direction of Dr. Imre Gyuk.



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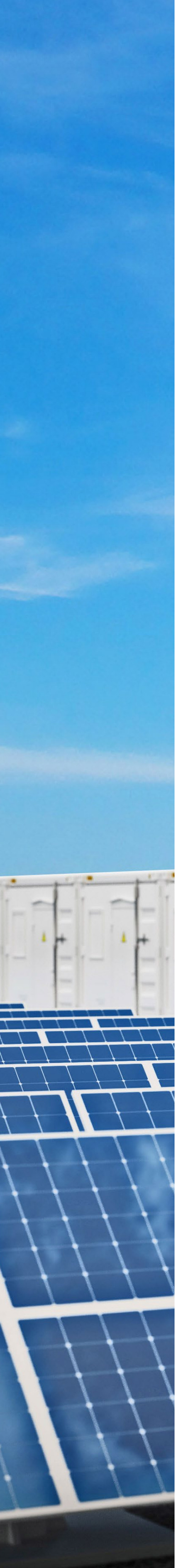
Agenda

- The Benefits of Energy Storage
- Energy Storage for Resilience
- Behind-the-meter Storage Programs



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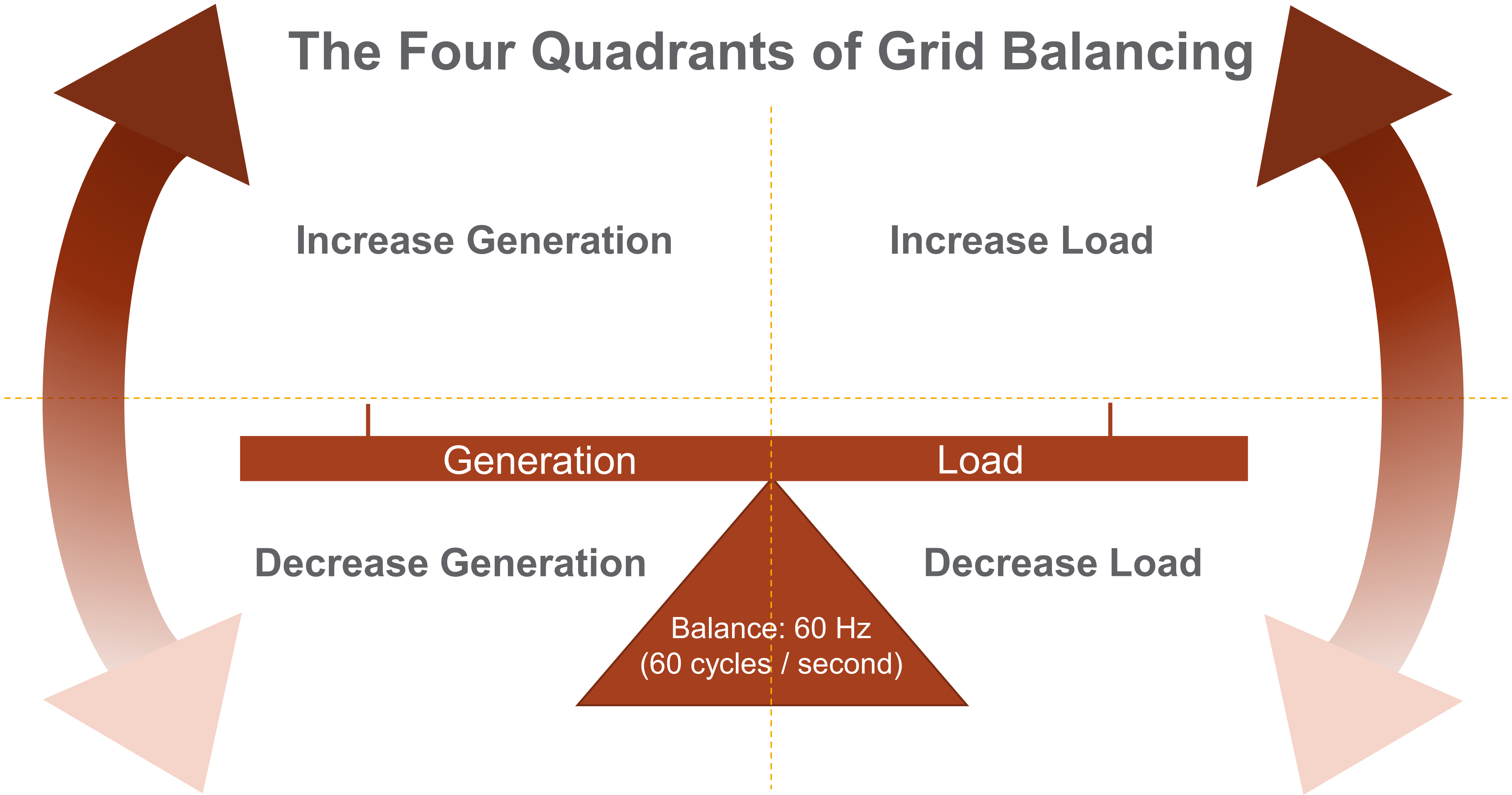
Benefits of Energy Storage

Two defining characteristics make storage unique

First, it is **flexible:**



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Two defining characteristics make storage unique

Second, it is **scalable:**

LG Energy Solutions

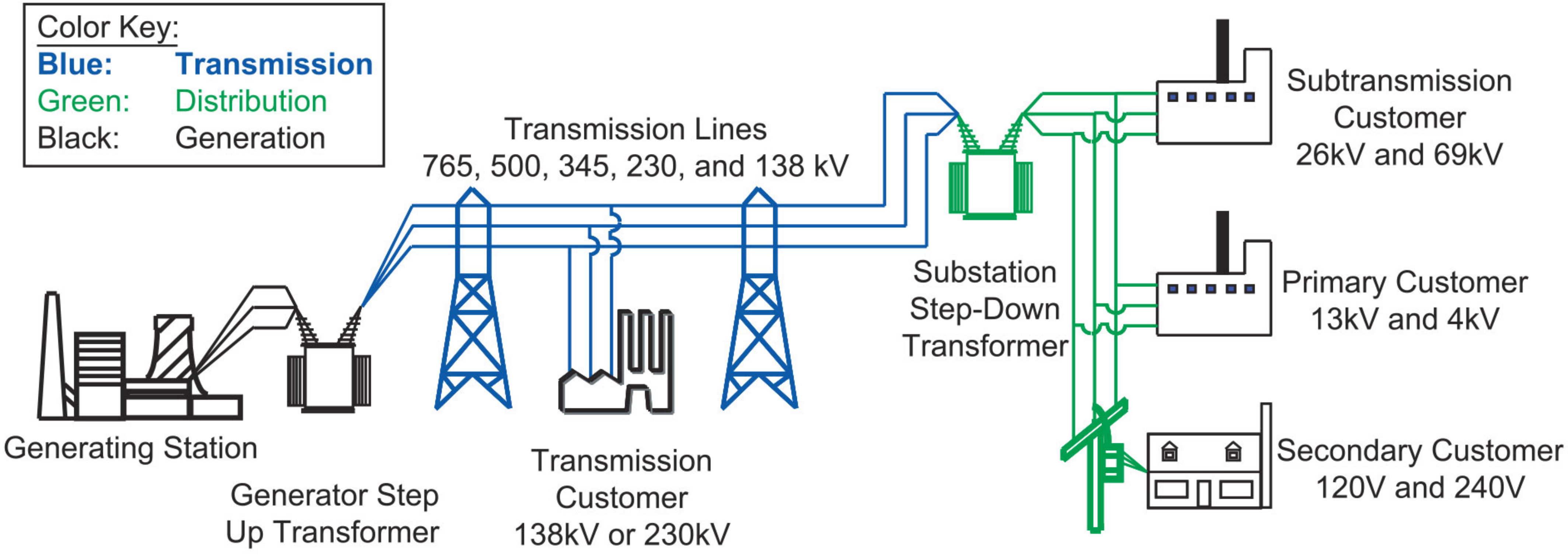
The Moss Landing (CA) Energy Storage Project is the largest in the world, at 400 MW/400 MWh.

And anything in between

Tesla

At 5 kW/13.5 kWh, a Tesla Powerwall can power an average home for a few hours and is small enough to be mounted on a wall.

This Lets Storage Do a Lot of Things

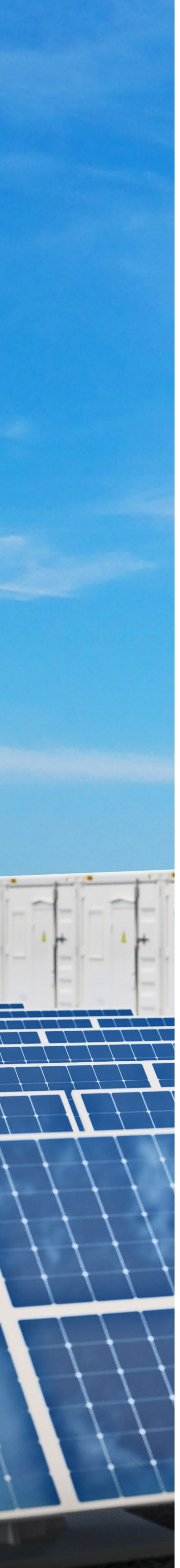


Behind the Meter
- Time-of-use rate management
- Backup power
- Distributed generation management

As Generation
- Resource adequacy (Peak Demand)
- Ancillary services (Grid flexibility)

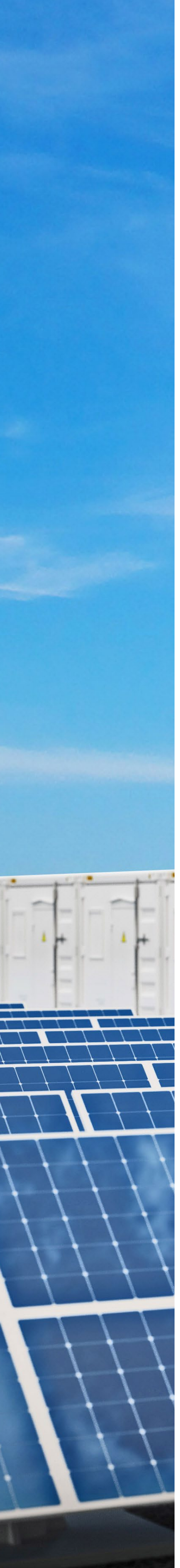
As Transmission
- Thermal management (Keeping a transmission line within its operational limits)
- Congestion relief (Improving transmission efficiency)
- Contingency plan (Maintain service to customers when a line fails)

As Distribution
- Voltage support (Line management)
- Conservation voltage reduction (System efficiency)
- Increased hosting capacity (More distributed generation)



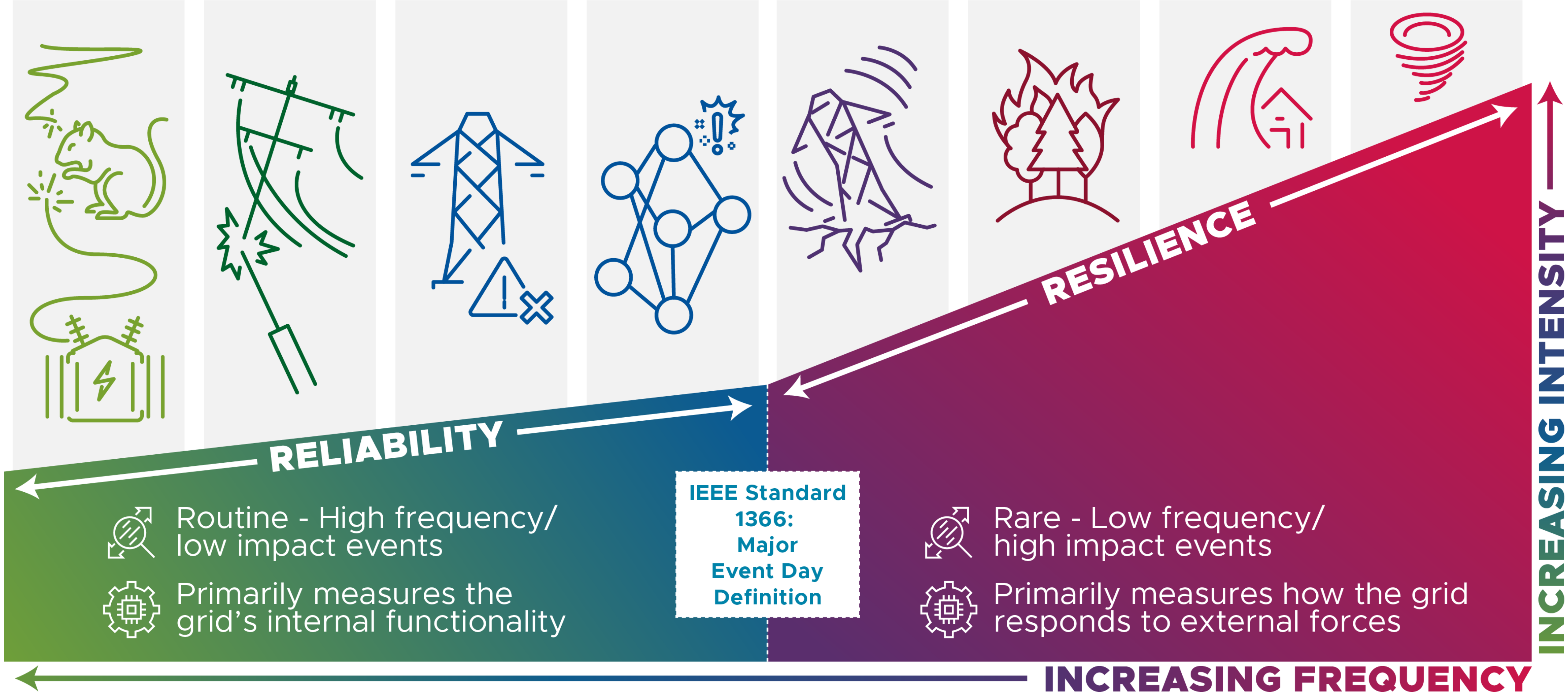
The Limiting Factor of Energy Storage Assets

- Energy storage devices are energy limited
- An electric generator can continue to produce as long as it is attached to its fuel source, but
  - An energy storage asset holds its own fuel, and must recharge once that fuel is depleted
- Energy generators are measured in terms of their maximum potential power output, in megawatts (MW) or kilowatts (kW)
- Storage is also measured in terms of its maximum power output (MW or kW), but because it is energy limited, its is also measured in terms of its energy content in megawatt-hours (MWh) or kilowatt-hours (kWh)

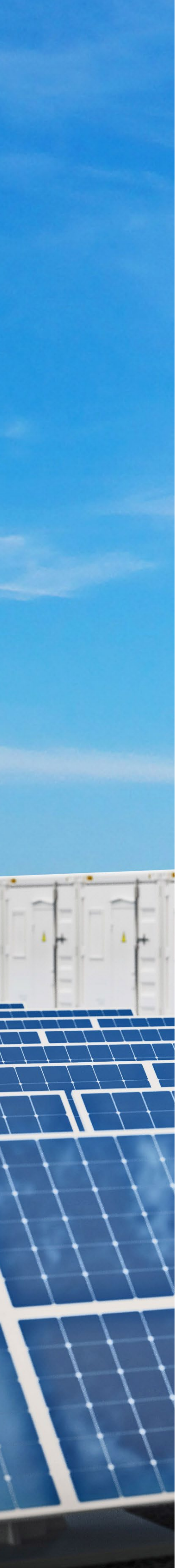


Energy Storage for Resilience

Reliability and Resilience Exist on a Continuum

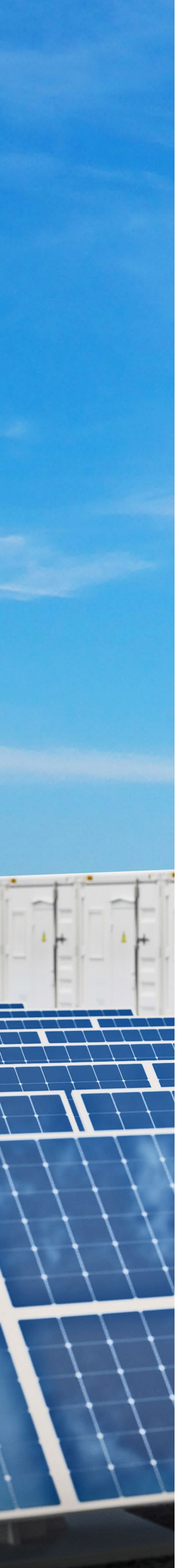


At the end of the day, reliability and resilience are the same thing: customer outages



Obstacles to Resilience

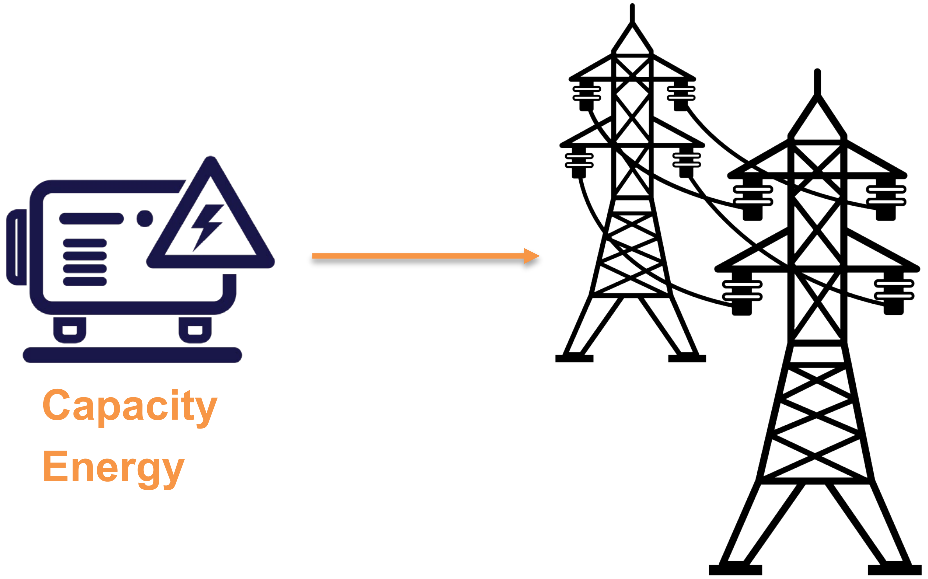
- **Traditional grid planning processes are designed to meet two objectives: reliability and cost.**
  - NERC reliability standards enable us to prospectively define tangible planning outcomes
  - Reliability reporting metrics (IEEE 1366-2012) enable us to retroactively measure investment impacts
- **Resilience objectives are difficult to incorporate into existing planning processes.**
  - Absence of standards makes it difficult to set objectives, absence of metrics complicates our ability to measure current conditions or improvements
- **Standards and metrics form the “why” of planning and investment decisions by creating the benefits against which the costs of investments are weighed.**
  - Absent such standards and metrics, there is no agreed-upon process for measuring the benefits of reliability and equity investments, making them much more difficult to justify
  - No foundation for compensating resilience investments, which means that resilience investments will have to pay their way by providing other services



Energy Storage for Resilience

The advent of cost-competitive energy storage options has enabled us to go from:

Mission-critical resilience



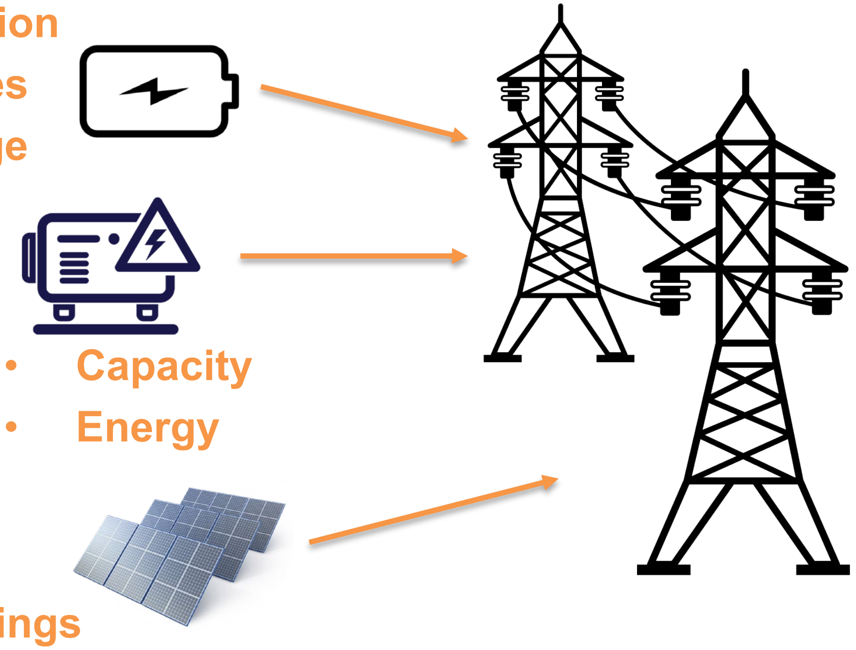
- **Capacity**
- **Energy**

- Limited opportunities for grid participation
- High cost
- Limited to facilities in which resilience is mission critical

to

Economic Resilience

- **Regulation**
- **Reserves**
- **Arbitrage**
- **…**

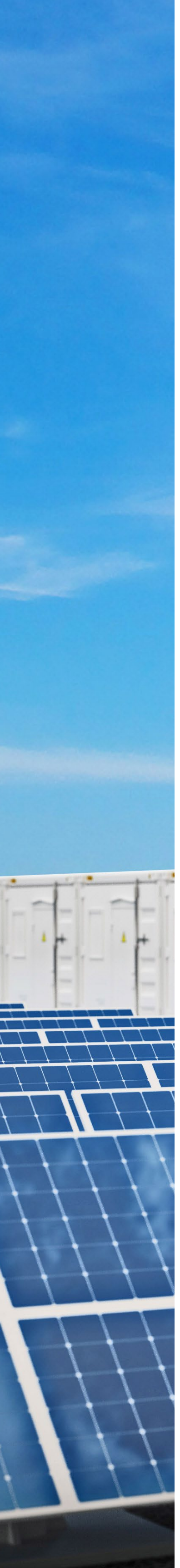


- **Capacity**
- **Energy**

- **Capacity**
- **Energy**
- **Fuel Savings**

- Increased opportunities for grid participation
- Offsetting revenues reduce system costs
- Viable resilience for broader range of facilities

Full report: [Planning Considerations for Energy Storage in Resilience Applications]



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Resilience is a Local Property

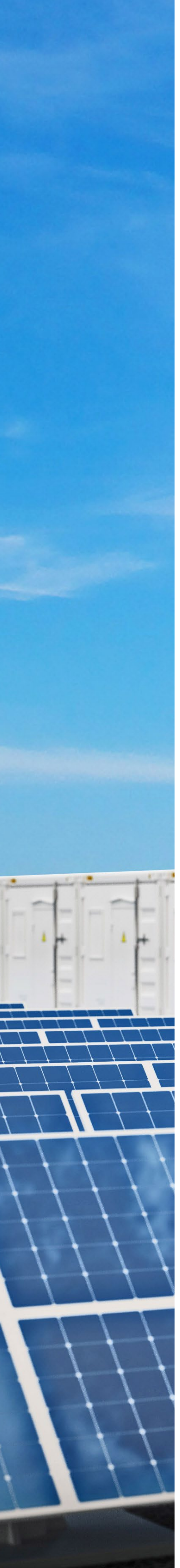
The nature of resilience events (low probability/high impact) make them difficult to address

- How do you harden the grid against a hurricane or a wildfire?

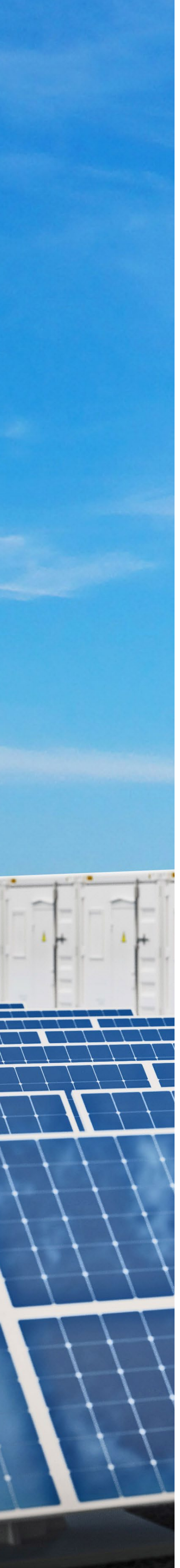
We may not be able to maintain service to all customers, but with distributed generation and energy storage, we can maintain certain loads

- How do we identify and prioritize those loads?
- Thought exercise: If the grid goes down, what loads to we need to keep up?

Thinking of resilience as a local property helps break down a big, existential problem into manageable pieces



Behind-the-meter Storage Programs



Behind-the-meter Storage Overview

- Relative to front-of-meter (FTM) projects, behind-the-meter (BTM) projects cost more on a per-unit basis but can offer targeted resilience benefits to critical loads and other customers
- Many states and utilities are developing shared investment models for BTM storage:

Benefits:
- Peak shaving
- Transmission deferral

Benefits:
- Bill savings (with TOU)
- Backup power

- Some programs have also begun offering tiered incentives to enable participation by low- and moderate-income customers, enabling these programs to also improve energy system equity

Paper: Equitable Design of Behind-the-meter Energy Storage Programs

Case Study: Green Mountain Power (VT)

- Green Mountain Power (VT)
  - Distributed storage through cost sharing with customers
  - Customers receive an incentive of $850/kW (3-hour battery) or $950/kW (4-hour battery)
    - Additional incentive of $100/kW for storage added to existing solar systems in transmission-constrained areas
  - Utility controls the devices; uses them for peak shaving
    - 2021: Saved $3M total
    - 2022: Saved $1.5M in one day by reducing annual peak (reduced capacity costs and transmission allocation)
  - All customers receive bill savings
  - Participating customers also receive backup power and time-of-use rate management

Green Mountain Power

Case Study: Eversource (CT)

Sector → Cost Test ↓	Residential	Non-Residential	Total
RIM	1.26	1.55	1.39
PCT	0.97	1.04	1.00
PACT	1.63	1.94	1.77
SCT	1.32	1.59	1.44
TRC	1.32	1.60	1.45

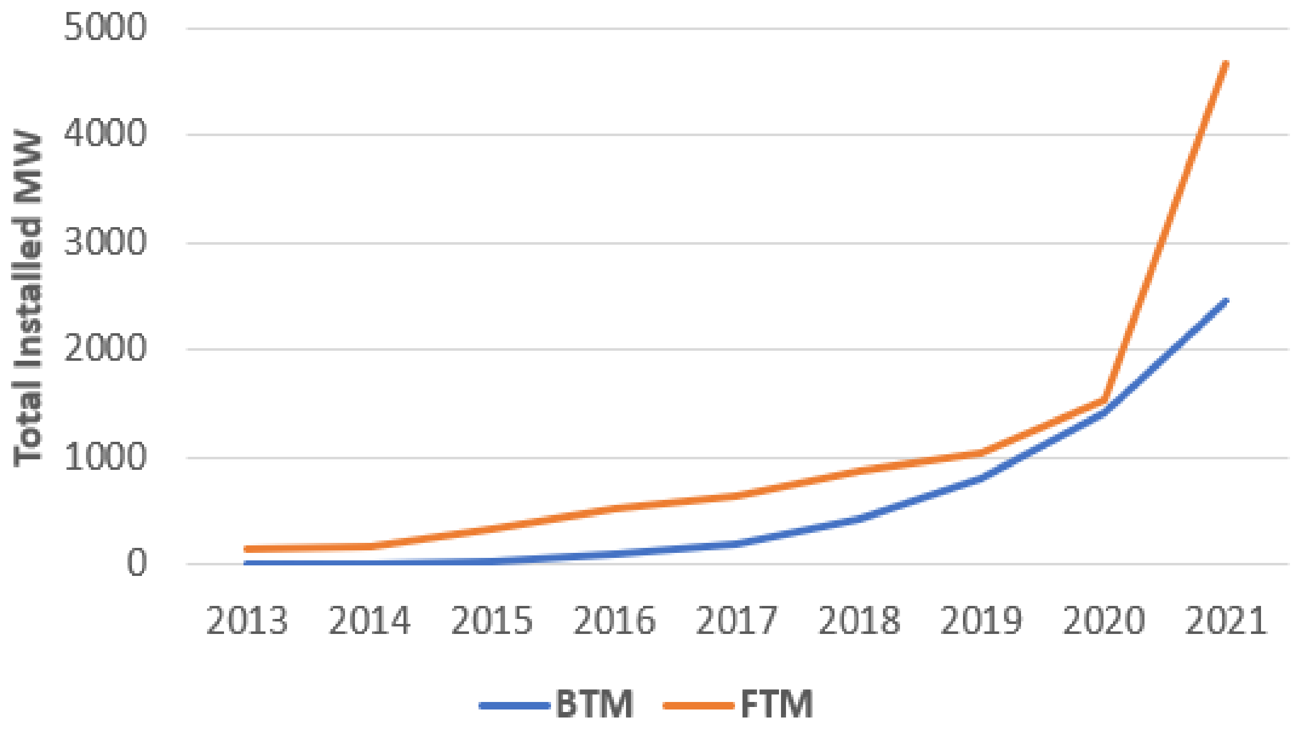
CT Public Utilities Regulatory Authority

The utility industry employs many cost-benefit tests. The Eversource program is cost-effective under any one of them.

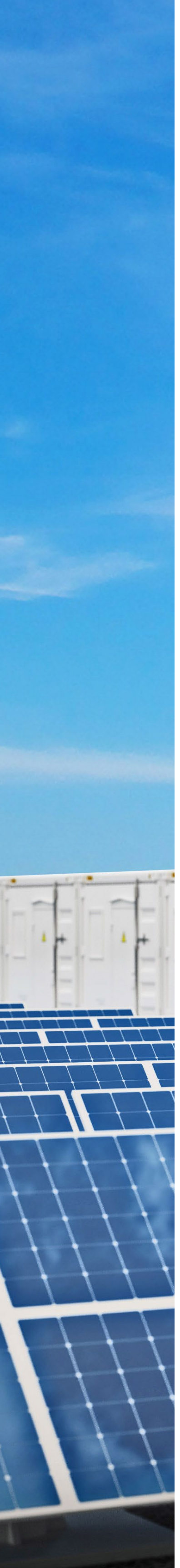
- **Eversource (CT)**
  - Batteries for Demand Response
  - Customers receive an incentive, in exchange for which they agree to enroll their device in Eversource's demand response programs
    - Customers receive $225/kW, based on the device's average output across all demand response events in a year
  - All customers receive the benefits of avoided generation costs
    - 2021: Program achieved a cost-benefit ratio of 1.45 (total resource cost test)
    - In other words, for every $1 spent on incentives, Eversource's customers saved $1.45
  - Participating customers receive backup power and time-of-use rate management

Policy drivers for BTM storage growth

- Multiple states have adopted binding (9 states) or non-binding (1 state) energy storage targets
- Some mandates and programs identify equity and resilience goals, leading states to target BTM investments
  - **CT**: 1,000 MW target includes 580 MW BTM carveout
  - **ME**: 400 MW target includes 15 MW BTM carveout
  - **IL**: No target, but storage programs include equity requirements
- As a result, BTM investments are accelerating



Cumulative installed FTM and BTM Energy Storage Capacity, U.S.

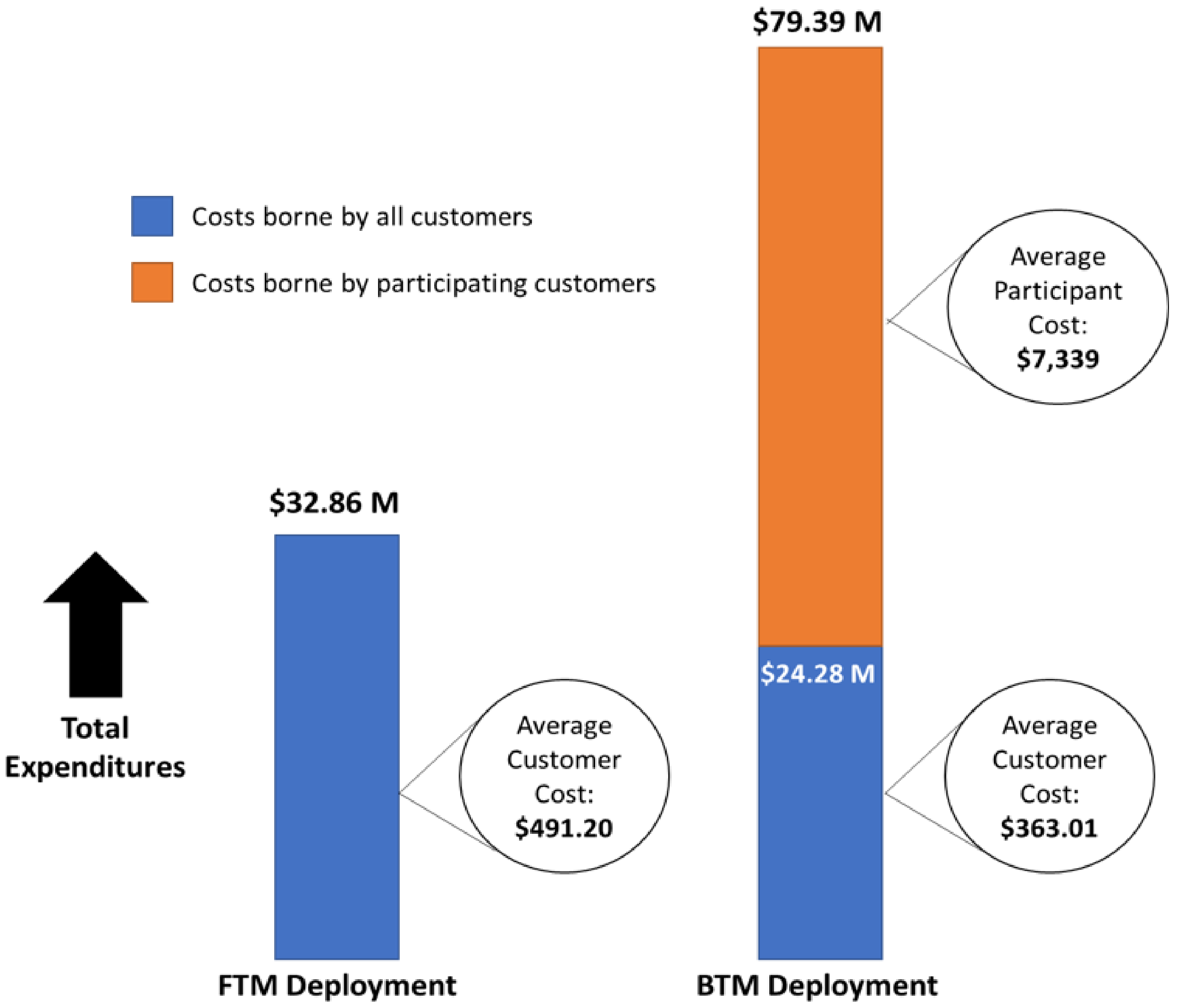


Summary of incentive programs

Source	Base Incentive	Low-income Incentive	Other Incentive
California	$200/kWh	$850/kWh	$1,000/kWh for low-income customers affected by public safety power shutoffs
Connecticut	$200/kWh	$400/kWh	$300/kWh for customers in designated underserved areas
Oregon	$300/kWh		
Maine	Pending		$200/kW for storage systems located at critical care facilities
Green Mountain Power (VT)	$850/kW (3-hour) $950/kW (4-hour)		Additional $100/kW for storage added to existing solar in transmission-constrained areas
Arizona Public Service	$500/kW		$1,250 additional flat incentive
Hawaiian Electric Company	$850/kW		
Rocky Mountain Power (UT)	$400/kW (residential) $600/kW (commercial)		$15/kW annual bill credit

- Average base incentive: $304/kWh
- Total cost of a BTM system: ~$1,000/kWh

Customer Impacts: Average Incentives



Cost of procuring 80 MWh of energy storage on an FTM or BTM basis

- BTM case reduces costs assigned to customers, but increases overall costs
- Customer resilience benefits vary

Customer Type	Cost of Outage (per kWh)	10-Year Benefit
Residential	$1.97	$256.10
Small Non-Residential	$143.31	$18,630.20

- Significant BTM participation needed for FTM equivalence
  - 7,380 BTM systems needed to equal an 80 MWh FTM system

Customer Resilience Benefits: Low Reliability

Details:

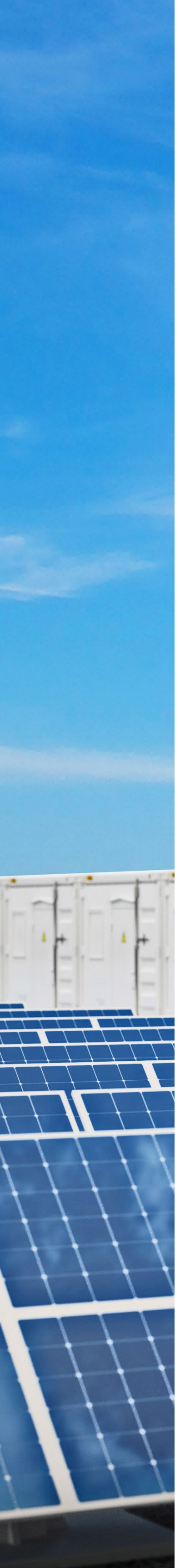
- Baseline case was based on average reliability scores (SAIDI and SAIFI) for U.S. utilities in 2020
  - 1.6 SAIFI, 390 SAIDI
- Sensitivity uses average scores for utilities with a SAIFI score more than 2 standard deviations above average
  - 4.94 SAIFI, 1857.1 SAIDI
- Inclusive of major event days
- Benefits calculated using ICE Calculator by Lawrence Berkeley National Laboratory

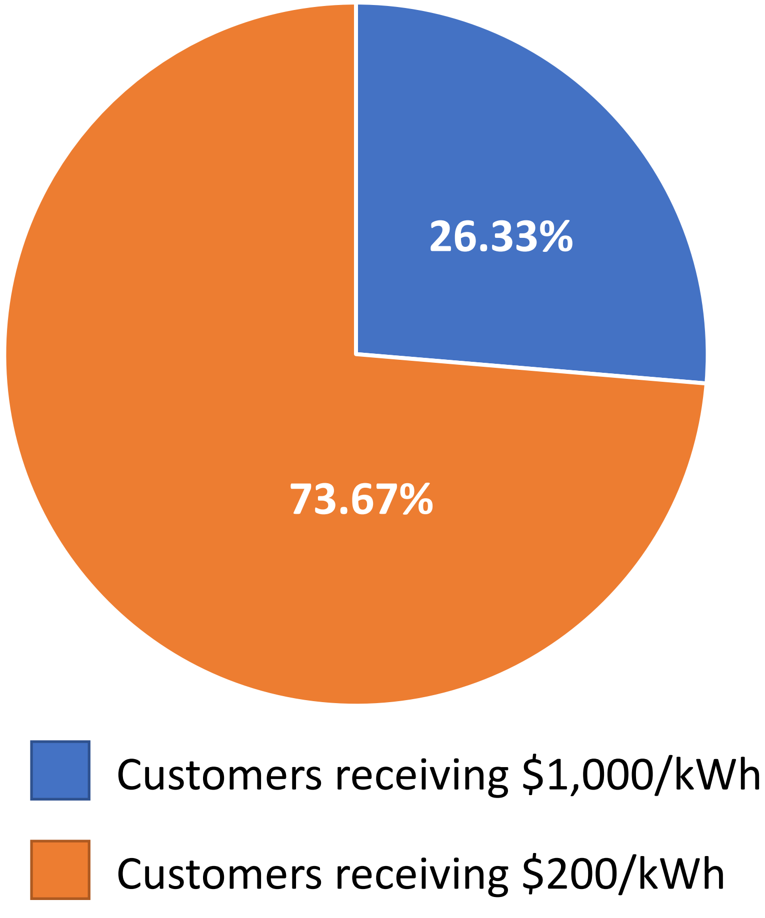
Customer Type	10-Year Benefit (Baseline)	10-Year Benefit (Sensitivity)
Residential	$256.10	$420.30
Small Non-Residential	$18,630.20	$34,769.19

Implications:

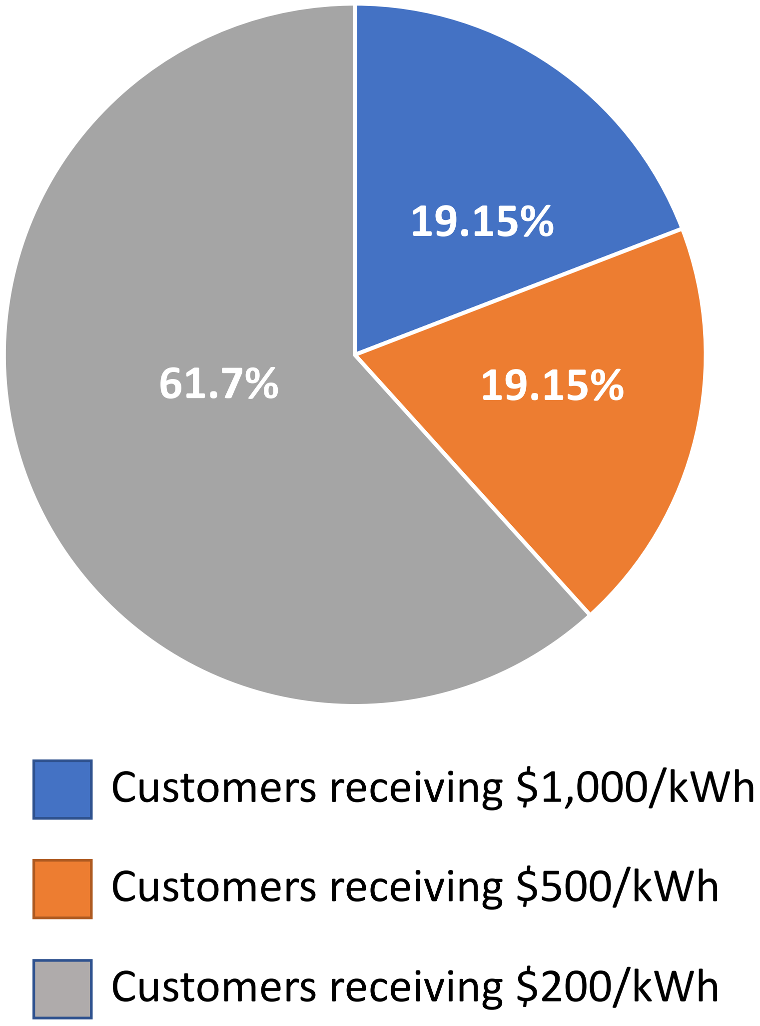
- Resilience provides limited financial benefit for average residential customer
- Businesses and residential customers with critical dependencies recoup investment several times over
- More storage capacity needed to “ride through” longer outages (average in this group was 6 hours)

Equitable Design of BTM Storage Programs





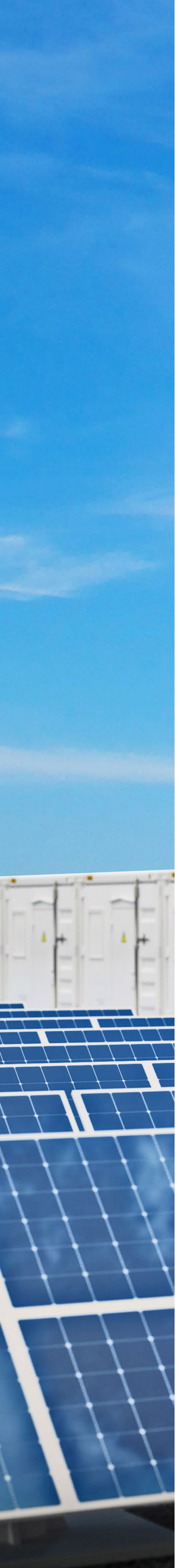
Program portfolio with two incentive levels



Program portfolio with three incentive levels

If we set the average incentive equal to the cost of FTM storage ($410.70) we can:

- Offer increased incentives to low- and moderate-income customers
- Keep all customers financially indifferent between FTM and BTM storage



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Thank you

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