Bulk Energy Storage Technology Overview

Presentation to LIPA Board of Trustees

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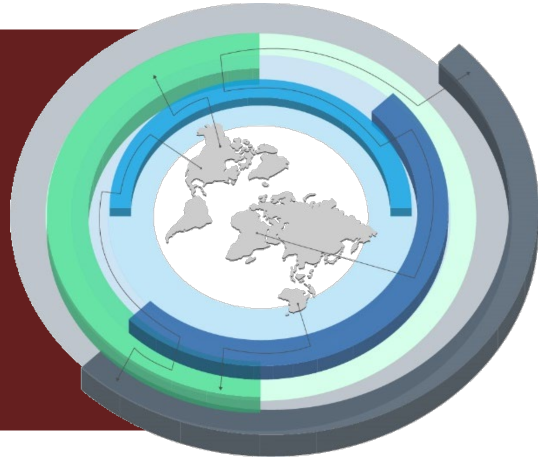
Agenda

- Energy storage background
  - Drivers for bulk energy storage
  - High level use cases
  - Benefits of a spectrum of energy storage technologies
- Review of emerging energy storage technologies
- Conclusions
- Discussion / Questions?

Please feel free to ask questions throughout

Energy Storage Background



Need for Energy Storage

Enabler

- Energy storage is an enabler for a low-carbon future. As more renewables are installed, it will be needed to help provide grid stability and reliability.

Need

- A substantial amount will be needed: 125–680 GWs of new energy storage is projected for the U.S. by 2050.* Globally, energy storage is also predicted to grow significantly.

** "Economic Potential of Diurnal Storage in the U.S. Power Sector," NREL, July 2021.*

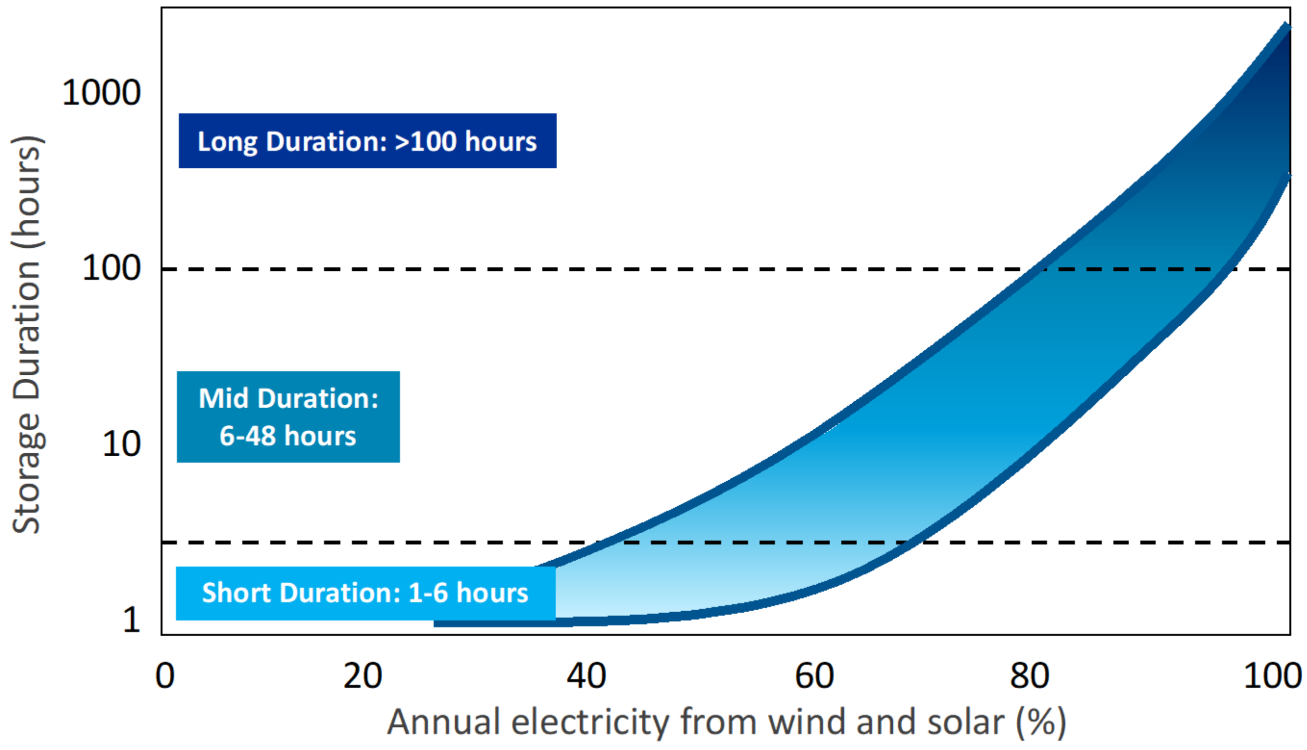
Options

- Energy storage comes in a variety of types and durations and will have different use cases

What types of energy storage will be needed?

Energy Storage Evolution

- **As intermittent renewables increase, the duration of energy storage needed also increases**
- **As storage duration increases, different types of energy storage are needed**



Adapted from "Long-Duration Electricity Storage Applications, Economics and Technologies," Joule, vol. 4, 2020.

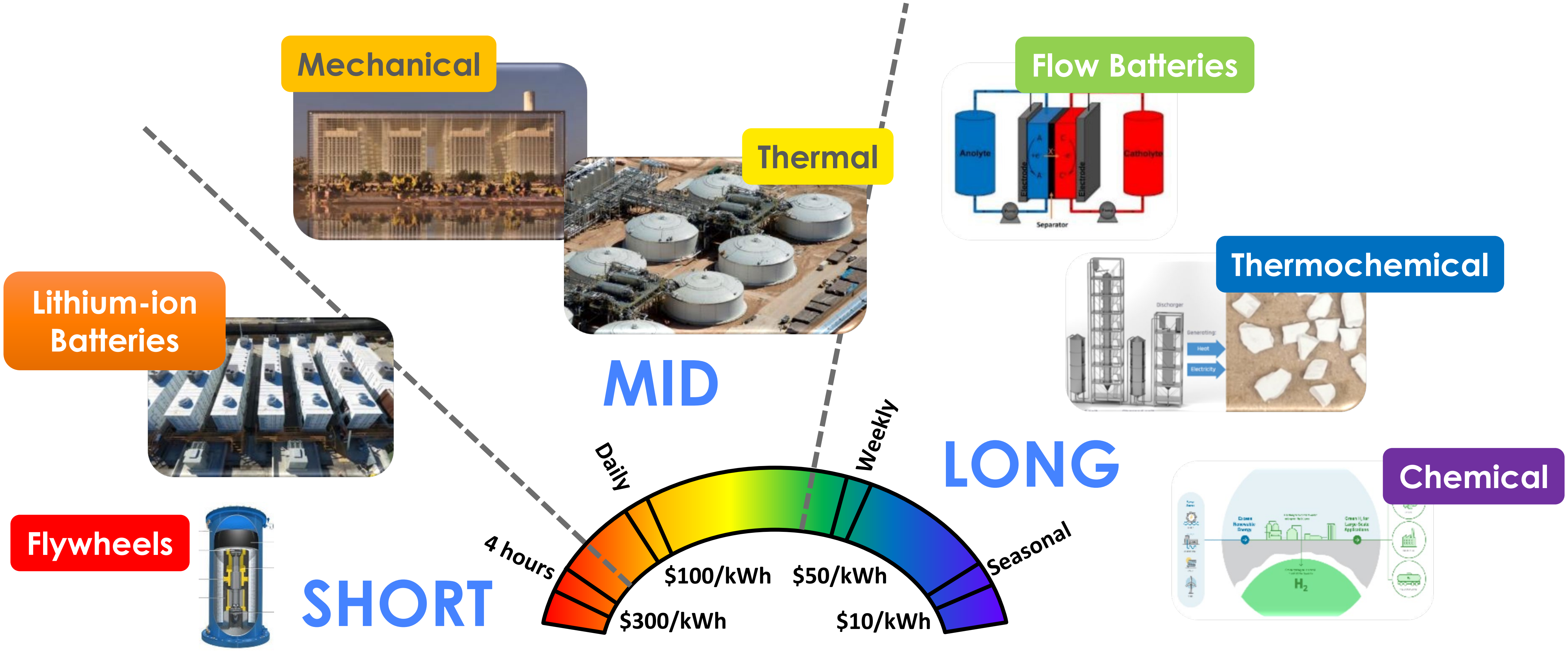
Different durations of energy storage will be required

Energy Storage Types

Electrochemical	Thermal	Mechanical	Chemical
Reversible chemical reaction generates an electrical potential difference	Energy storage achieved by heating bulk media	Kinetic or potential (compression or gravitational)	Reaction produces product that can generate heat or power

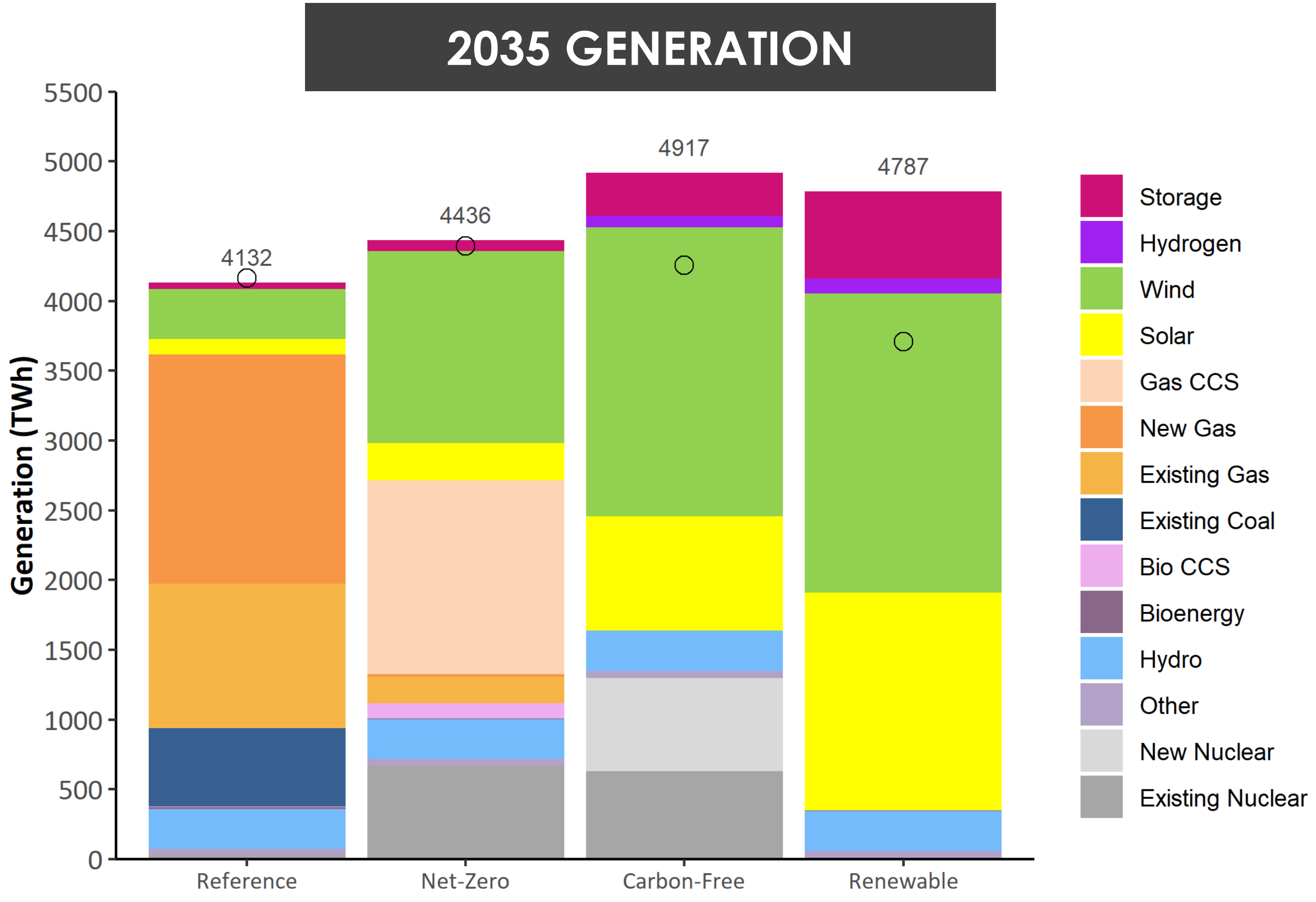
Different types for different purposes

Energy Storage Spectrum



Different technologies are best suited for each duration type

Energy Storage Can Play a Major Role



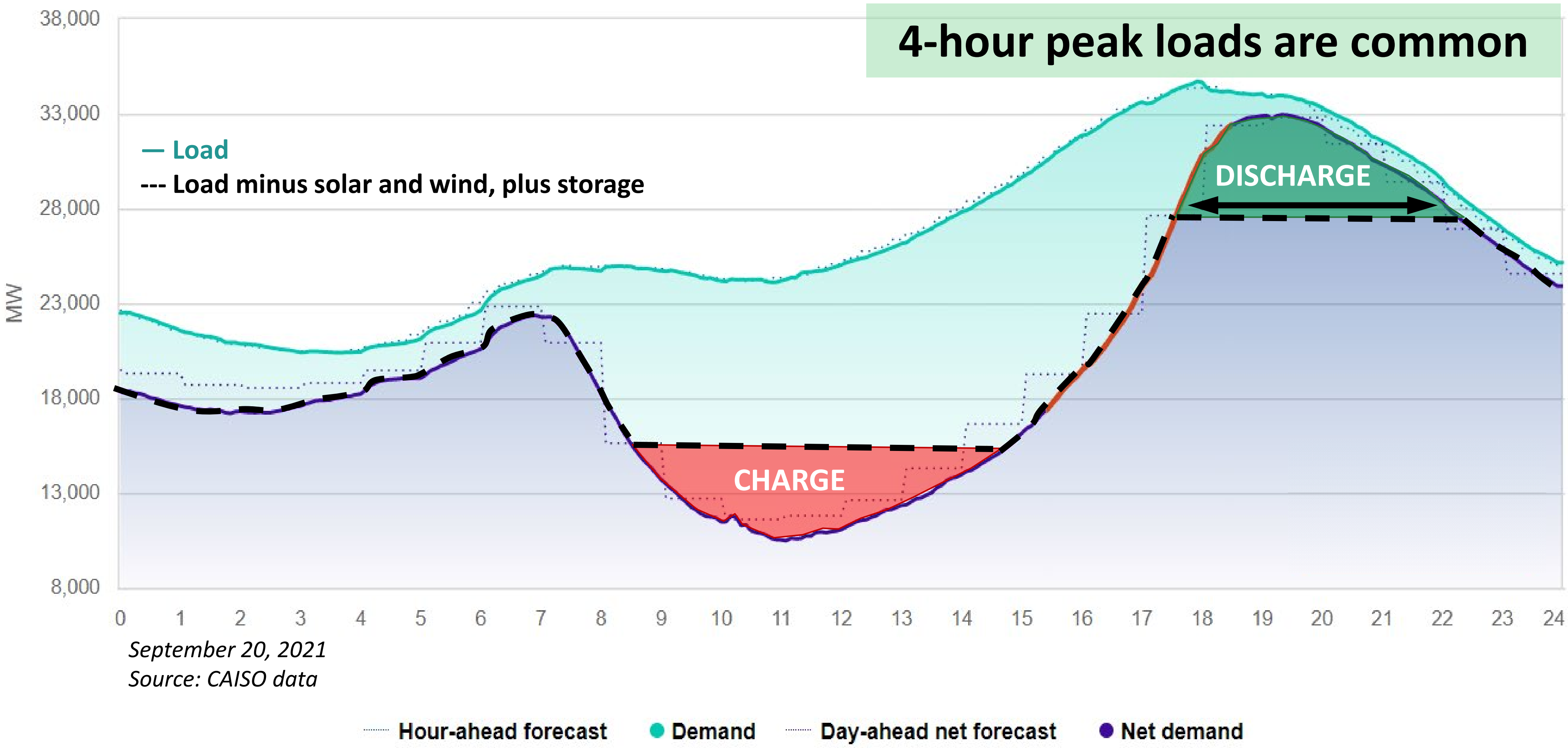
- **Reference:** Fossil continues to provide the majority of electricity
- **Net-Zero:** CO_2 capture and storage enables fossil to balance renewables
- **Carbon-Free:** Storage + H_2 important for balancing wind and solar and provide 9% of electricity demand
- **Renewables:** Storage + H_2 generation are 627 and 108 TWh and provide 20% of electricity demand

Based on an EPRI REGEN study done last year

LIPA's Energy Storage Roadmap

- Achieve LIPA's share of the State Climate Act targets
  - 10 MW of utility-scale storage in-service on East End
  - 2.5 MW planned for distribution substations
  - 175 MW of new utility-scale storage by 2025
  - 375 MW by 2030
- Use competitive procurements
- Uncover and reward locational and time values
- Streamline permitting and siting, lower soft costs
- Access to NYSERDA bridge incentives for customer-sited storage

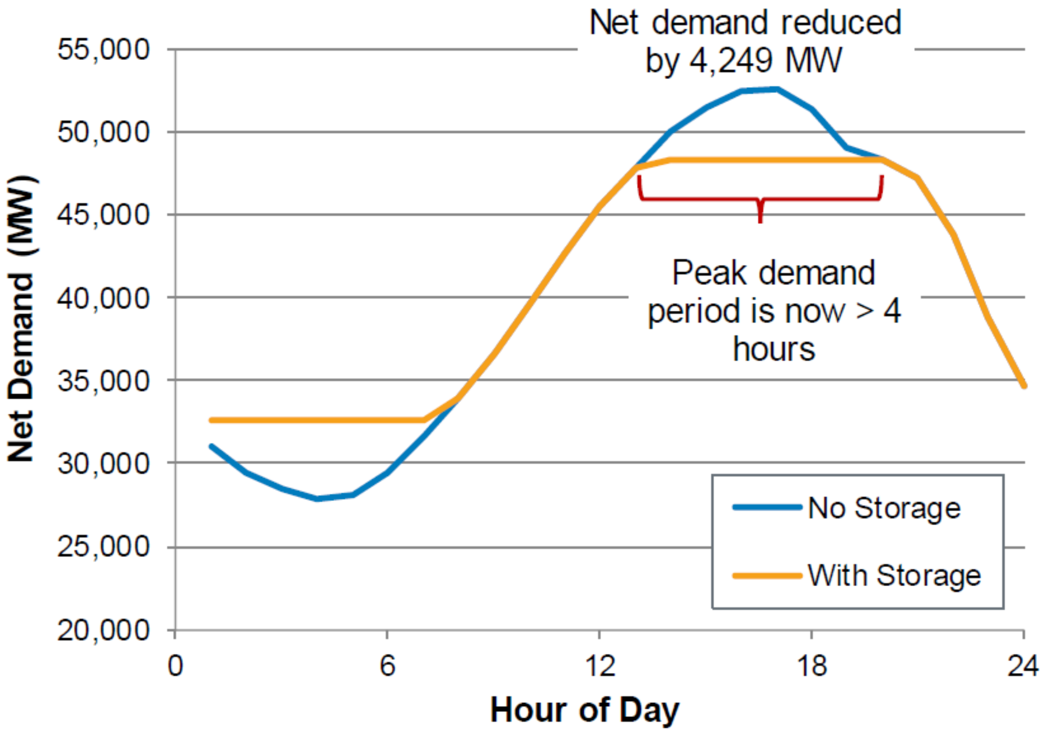
Storage Use Case: 4-Hour (short duration)

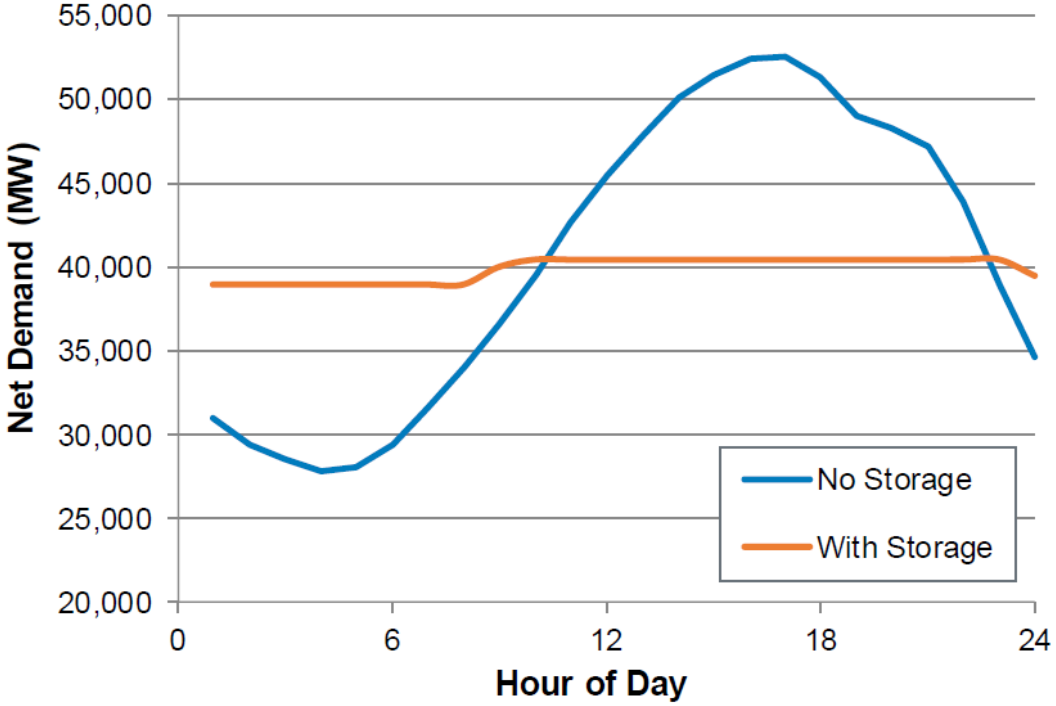


Daily peak loads served by 4-hour storage

Storage Use Case: Daily (short- to mid-duration)

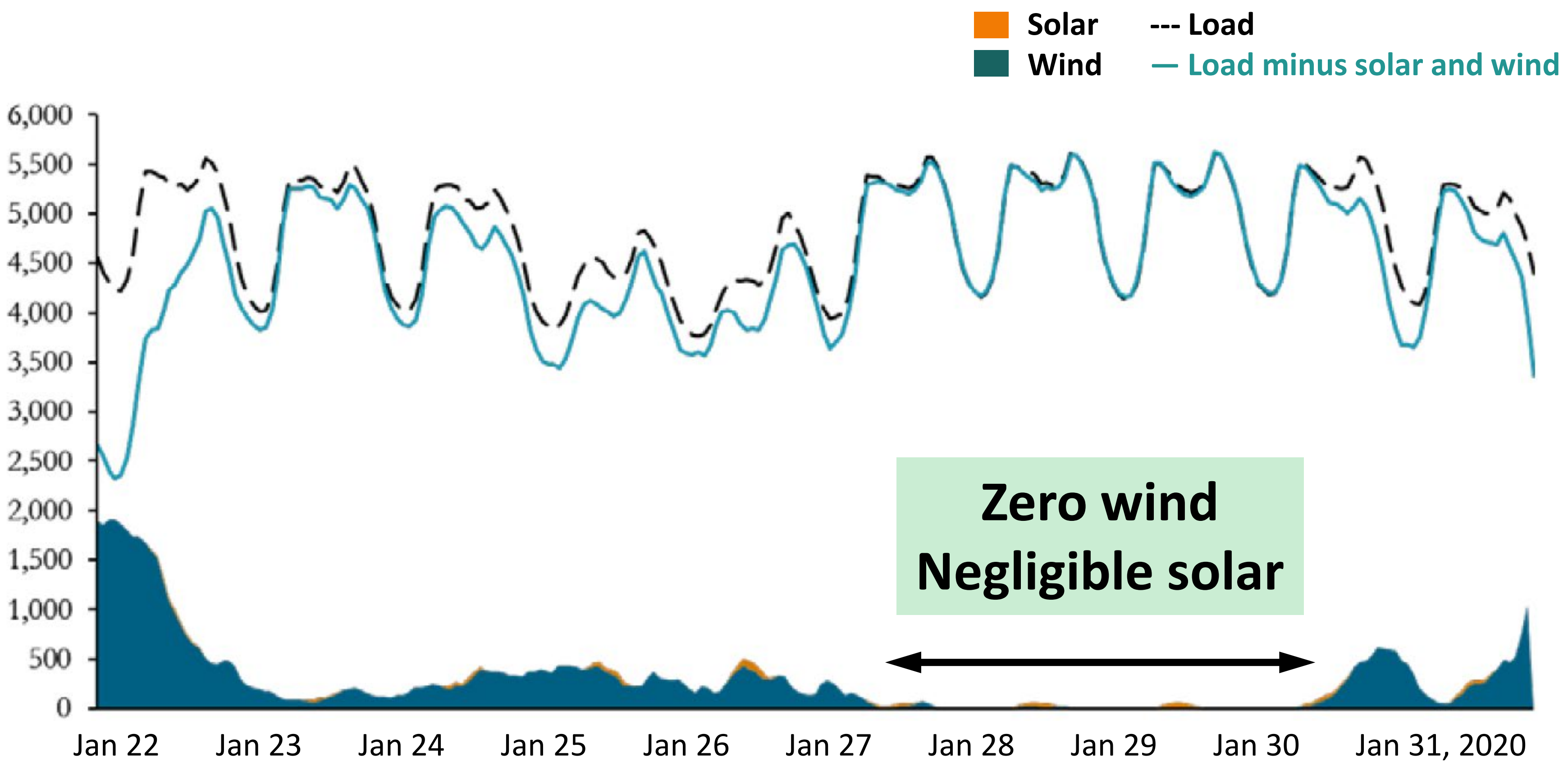
- Increased deployment of 4-hour storage broadens the peak load and drives the need for longer-duration storage up to ~12 hours





Source: Denholm et al., "The four phases of storage deployment," NREL, 2021.

Storage Use Case: Weekly (mid- to long-duration)



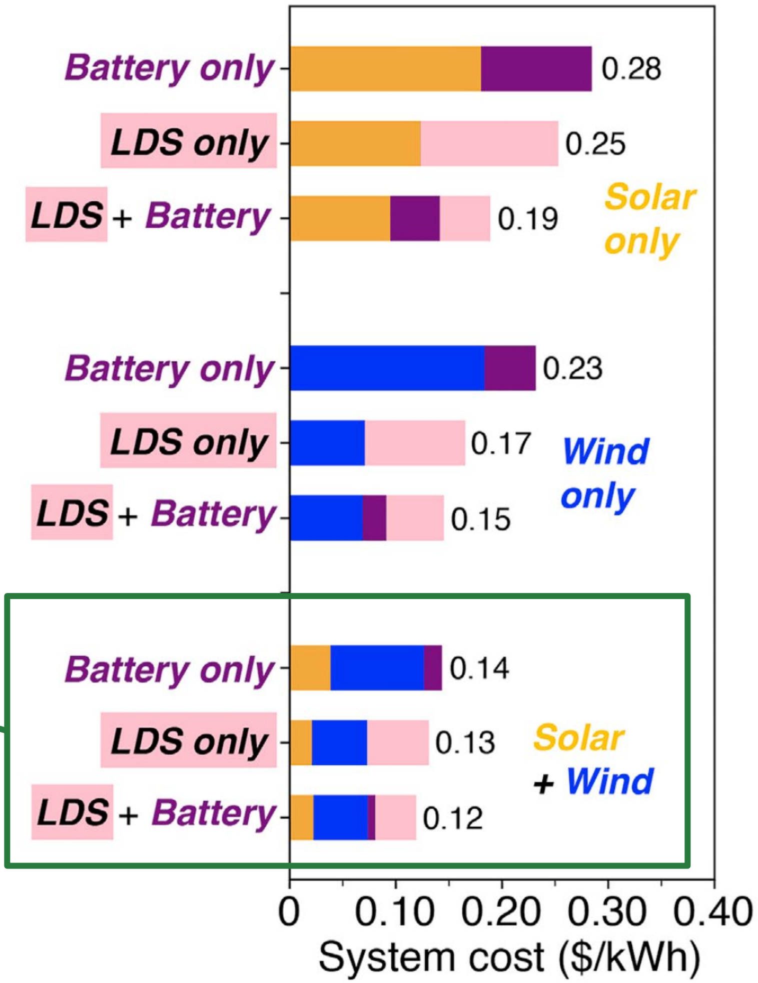
Source: Upper Midwest Integrated Resource Plan, Xcel Energy, 2020.

Multi-day renewable droughts are common

Energy Storage Spectrum Value

- A portfolio of energy storage durations and types is a **lower-cost solution** than a single-duration type

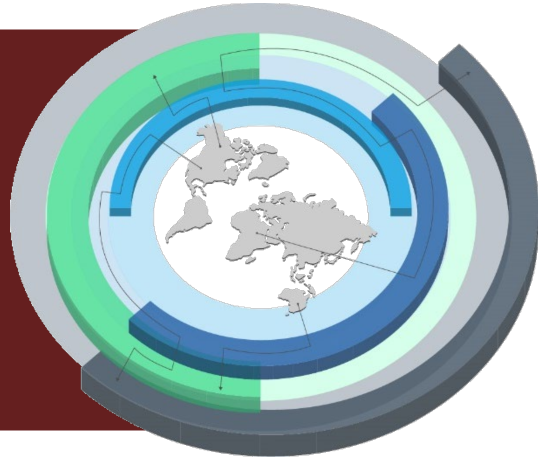
Renewables + short-duration storage + longer-duration storage = Lowest system cost



Source: Dowling et al., "Role of long-duration energy storage in variable renewable electricity systems," Joule, vol. 4, 2021.

A portfolio of energy storage technologies is optimal

Review of Energy Storage Technologies



Technology Readiness Level (TRL)

DEPLOYMENT	9	ACTUAL SYSTEM PROVEN IN OPERATIONAL ENVIRONMENT
	8	SYSTEM COMPLETE AND QUALIFIED
	7	SYSTEM PROTOTYPE DEMONSTRATION IN OPERATIONAL ENVIRONMENT
DEVELOPMENT	6	TECHNOLOGY DEMONSTRATED IN RELEVANT ENVIRONMENT
	5	TECHNOLOGY VALIDATED IN RELEVANT ENVIRONMENT
	4	TECHNOLOGY VALIDATED IN LAB
RESEARCH	3	EXPERIMENTAL PROOF OF CONCEPT
	2	TECHNOLOGY CONCEPT FORMULATED
	1	BASIC PRINCIPLES OBSERVED

Molten-Salt Thermal Energy Storage

How It Works:

Molten salt is heated and stored during off-peak hours; when energy is needed, salt is pumped to a steam generator to generate steam for a power cycle

Benefits:	Challenges:
• High specific heat capacity, density, and thermal stability and low vapor pressure • Non-flammable and non-toxic	• High cost of storage media • Operating within freezing and decomposition temperatures

Applications:

- Conversion of thermal energy to electricity in steam cycles using existing or decommissioned power units
- Application to other technologies that need TES, e.g., pumped heat energy storage

Vital Statistics

AC RTE:	35–41%	**TRL:**	9
Life:	30 years	**Installed Capacity:**	100s MWh (solar)

Crushed Rock Thermal Energy Storage

How It Works:

When charging, electrical resistive heaters are used to heat air and blow through a bunker of crushed rock. To discharge the system, air is blown through the hot rock to extract heat. Hot air is used to generate steam for a steam turbine generator.

Benefits:	Challenges:
• Small plant footprint • System inertia • Zero fire risk, inert, and low-cost material	• Cost of electrical and steam integration • Shorter plant lifetime than other TES solutions • high auxiliary power during discharge • Risk of thermal ratcheting in media

Applications:

Conversion of thermal energy to electricity in steam cycles using existing or decommissioned power units

Vital Statistics

AC RTE:	35–45%	**TRL:**	6
Life:	>20 years	**Largest Pilot:**	130 MWhth

Concrete Thermal Energy Storage

How It Works:

When charging, concrete is heated by resistive electrical elements using a heat transfer fluid. To discharge the system, air is blown through channels in the concrete to extract heat. The hot air is then used to generate steam for a steam turbine generator.

Source: Storworks Power

Benefits:

- Stackable, delivering a small plant footprint
- System inertia
- Zero fire risk, inert, and low-cost material

Challenges:

- Cost of electrical and steam integration
- Shorter plant lifetime than other TES solutions

Applications:

- Conversion of thermal energy to electricity in steam cycles using existing or decommissioned power units
- Can be heated via steam, flue gas, or directly with electricity

Vital Statistics

AC RTE:	35–45%	**TRL:**	5
Life:	20 years	**Largest Pilot:**	10 MWh-e

Liquid Air Energy Storage

How It Works:

Air is compressed and cooled to liquid state to allow above-ground storage at low pressure. When power is needed, the liquid air is pressurized, reheated at high pressure and expanded to produce power.

Benefits:	Challenges:
• Low fire risk and no toxic materials • Small plant footprint and mature components • System inertia	• Cost • Thermal management

Source: Highview Power

Applications:

Standalone energy storage or integration with existing power units

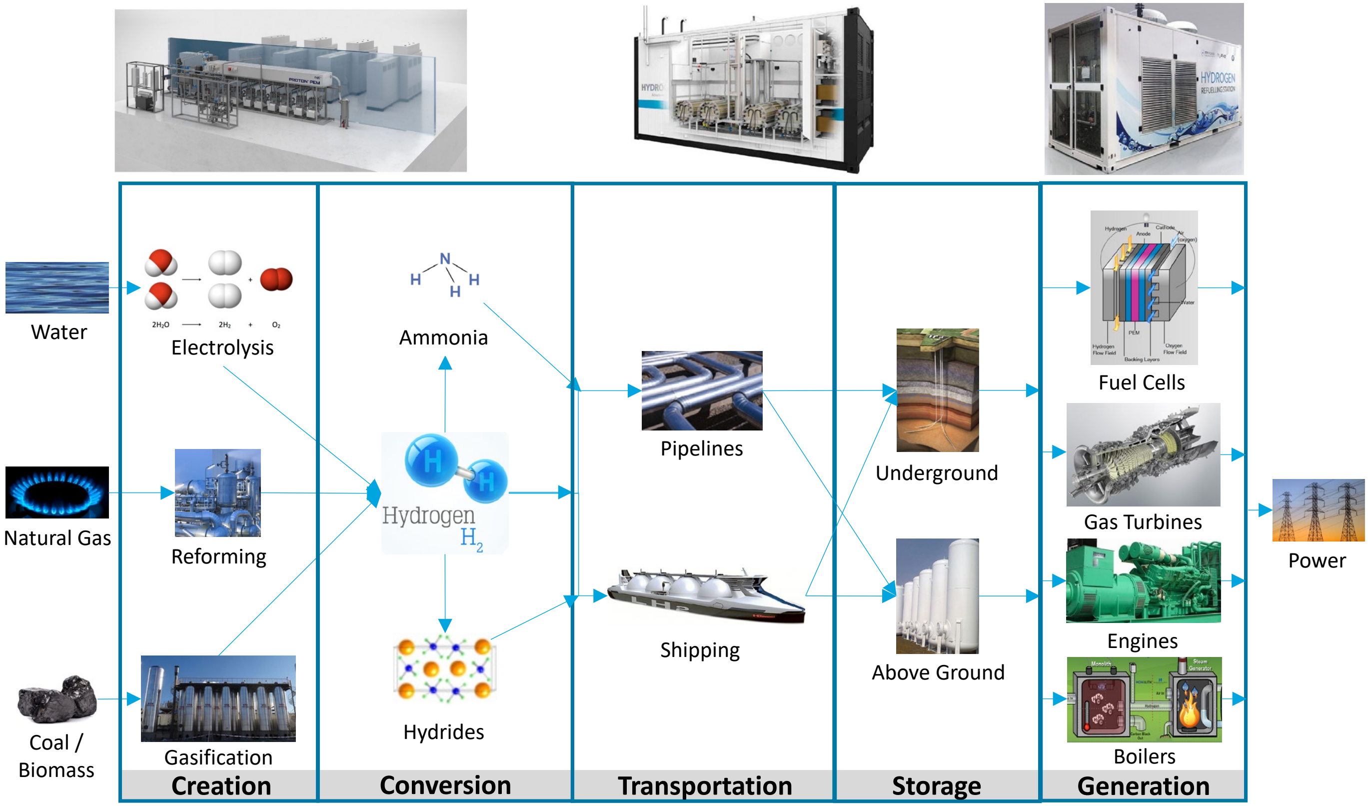
Vital Statistics

AC RTE:	50–60%	**TRL:**	7
Life:	30 years	**Largest Pilot:**	15 MWh

Low-Carbon Fuel Energy Storage

How It Works:

Low-carbon fuel (e.g., hydrogen, ammonia, bio-fuel) is produced through fossil conversion or electrolysis, stored and delivered, and then used for transportation or power generation (via boilers, engines, fuel cells, or turbines)



Benefits:

- Can provide longer-duration energy storage
- Potential to use existing infrastructure
- Can be applied to hard-to-decarbonize sources

Challenges:

- Potential storage and delivery issues
- Safety
- Cost
- Low efficiency

Applications:

Standalone, ultra-long duration energy storage (up to seasonal)

Vital Statistics

AC RTE:	20–25%	**TRL:**	5–9 (depends on application)
Life:	30 years	**Largest Pilot:**	Multiple

Conclusions

All Durations

- Consider all durations and types of storage available and emerging in the resource planning process

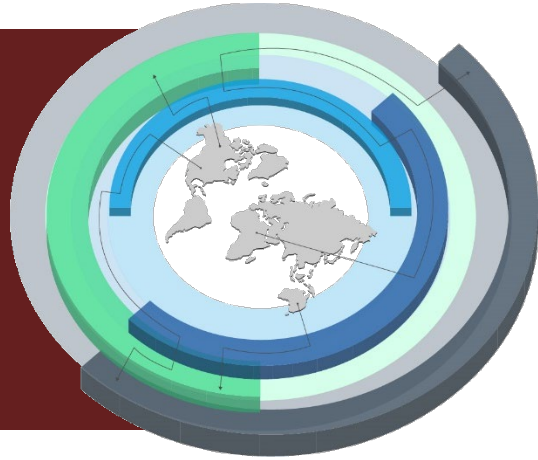
Portfolio

- A portfolio of energy storage technologies is better than deploying only one

Spectrum

- Ultimately, a spectrum of energy storage will be needed: short-, mid-, and long-duration

Discussion / Questions?

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