Multi-day Storage: Modeling Inputs and Modeled Outcomes

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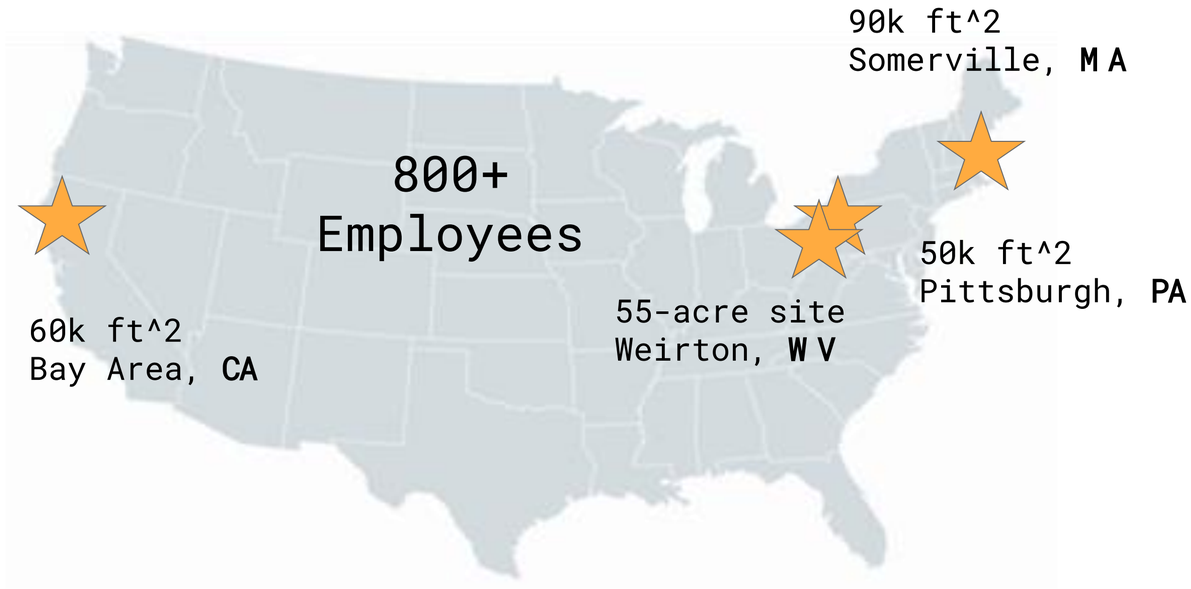
Form energy

Energy Storage
For A Better World

Rising to the grid's challenges with a team that will deliver



LED BY ENERGY STORAGE VETERANS

Decades of cumulative experience in energy storage

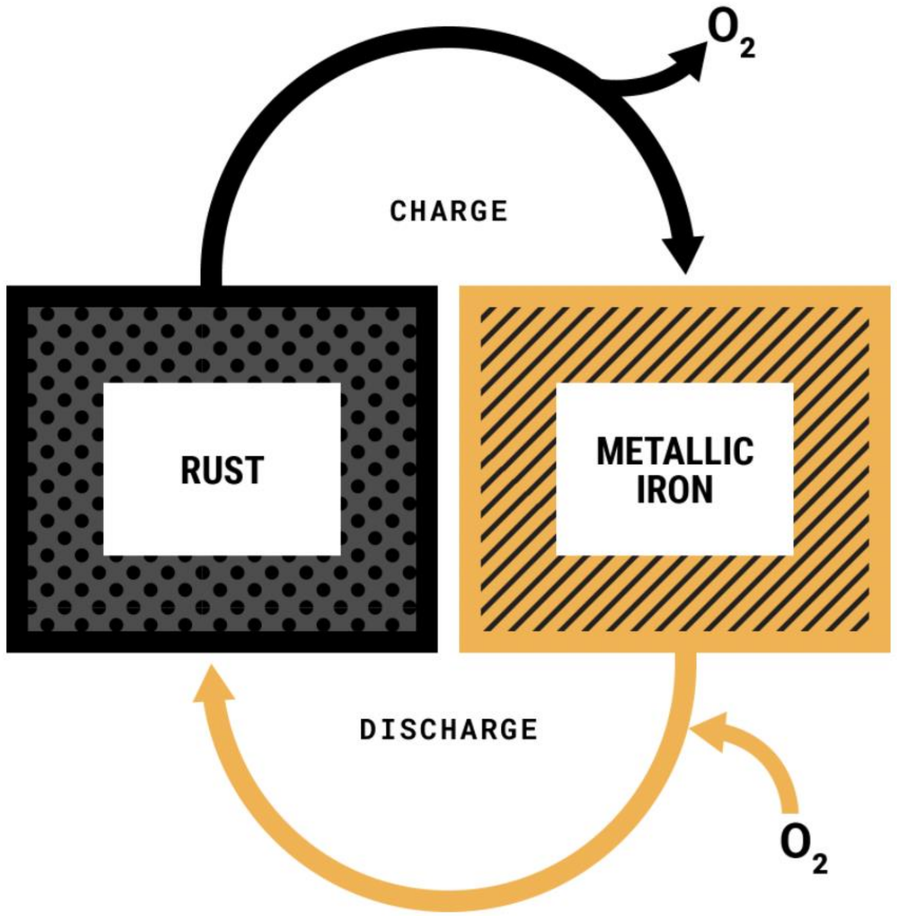
- 100's of MW of storage deployed

OUR INVESTORS: LONG-TERM AND IMPACT-FOCUSED

$820M in venture capital from top investors including: Breakthrough Energy Ventures (BEV), TPG's Climate Rise Fund, Coatue Management, GIC, NGP Energy Technology Partners III, ArcelorMittal, Temasek, Energy Impact Partners, Prelude Ventures, MIT's The Engine, Capricorn Investment Group, Eni Next, Macquarie Capital, Canada Pension Plan Investment Board, and other long-term, impact oriented investors

Rechargeable iron-air is the best technology for multi-day storage

Reversible Rust Battery
100-hour duration



COST
Lowest cost rechargeable battery chemistry.
Less than 1/10th the cost of lithium-ion batteries

SAFETY
Non-flammable aqueous electrolyte. No risk of thermal runaway. No heavy metals.

SCALE
Uses materials available at the global scale needed for a zero carbon economy. High recyclability.

RELIABLE
100+ hr duration required to make wind, water and solar reliable year round, anywhere in the world.

Over 5 GWh of Commercial Engagements

First-of-its-kind **1.5 MW /150 MWh** MDS project in Cambridge, Minnesota to come online in 2025

Two 10 MW / 1,000 MWh MDS systems; one in Becker, MN and one in Pueblo, CO. Both expected to come online as early as 2026

5 MW / 500 MWh MDS system in collaboration with the California Energy Commission in Mendocino County; online by 2026

10 MW / 1000 MWh MDS system in New York to come online as early as 2026

15 MW / 1500 MWh MDS system in Georgia to come online as early as 2026

5 MW / 500 MWh MDS system in Virginia to come online as early as 2025

Form Factory 1: Commercial-Scale Manufacturing

Transforming Weirton Steel Land for Battery Manufacturing in West Virginia

Form Factory 1, July 2024

- **Total Local Investment:** $760 million
- **Construction Start:** Early 2023
- **Production Start:** September 2024
- **Jobs:** Minimum of 750 full-time jobs

Location Benefits

- Close to our existing pilot manufacturing facility in PA
- Strong natural infrastructure
- Local manufacturing know-how

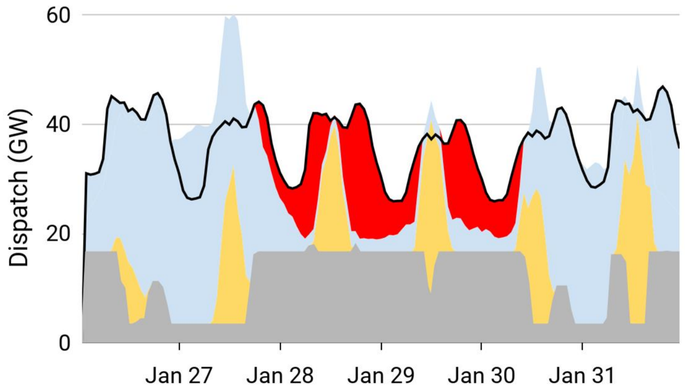
Factory Function

- Semi-to-fully automated cell, module, & enclosure assembly
- Ability to scale production in modular blocks

The grid is increasingly vulnerable to multi-day reliability risks driven by weather

Prolonged energy scarcity for 24+ hour periods

Example: ISO-NE winter wind lull[1]

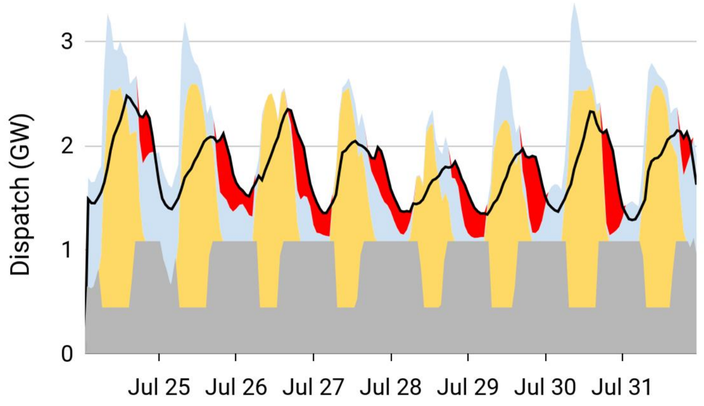


The challenge: Continuous periods of high net load or fuel shortages/price spikes can put the grid at risk of outage for 24+ hour periods.

Causes: multi-day wind generation lulls, winter storms (resulting in demand surges and fuel scarcity)

Back-to-back days with 8+ hours of tight conditions

Example: WECC utility during summer week[2]

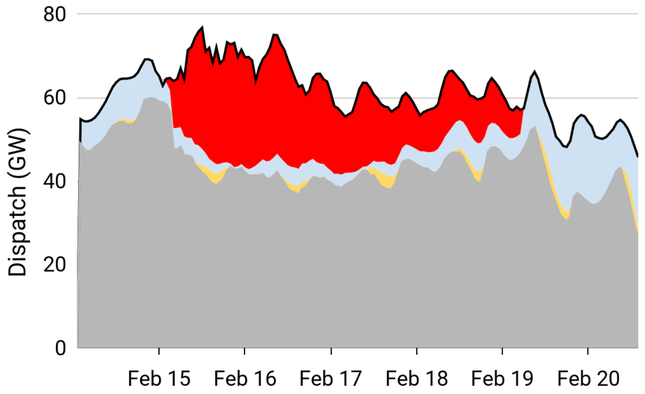


The challenge: Back-to-back days of high peak demand results in reliability risks during afternoon & evening hours. The system has insufficient energy to fully recharge short-duration batteries.

Causes: multi-day heat waves, multi-day stretch of low solar output

Extreme weather events lasting several days

Example: ERCOT Winter Storm Uri[3]



The challenge: Extreme weather events can result in prolonged grid failure, creating a need for firm energy reserves that can be dispatched for several days.

Causes: extreme storm conditions (e.g. Uri, Elliot, etc.) resulting in multi-day thermal outages, renewable outages, and/or limited regional import availability

[1] Full study available at Wilson *et al.*, "Clean, Reliable, Affordable: The Value of Multi-Day Storage in New England," September 2023.
[2] Operational simulation in Formware™ of 2035 WECC utility portfolio
[3] Historical ERCOT operational data during Winter Storm Uri from EIA-930

Modeling multi-day storage and broader grid volatility trends go hand in hand

Input assumptions that affect the selection and value of LDES/MDS resources in a weather-driven grid

- Capital and operating costs for different LDES technologies
- Capacity accreditation for storage assets that is a function of duration
- Volatility in hourly time series data
  - *Annual electric demand*
  - *Renewable profiles*
  - *Gas and other fuel prices*
  - *Market prices*

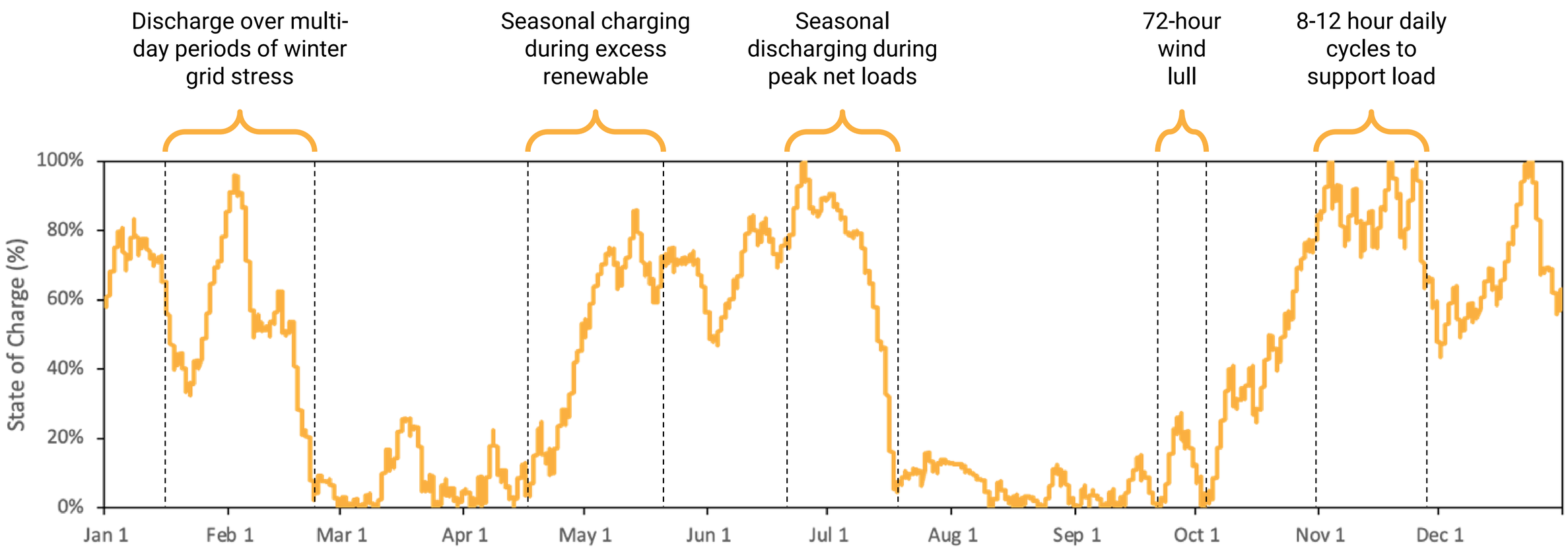
Best practices for modeling volatility on today's electric grid

- Implement an 8,760 chronology in capacity optimization
- Use weather-correlated inputs that reflect system conditions, e.g. load, renewable generation, commodity prices, etc
- Perform capacity expansion over multiple weather years
- Apply a dispatch scheduling method that incentivizes MDS to leverage opportunities for seasonal arbitrage

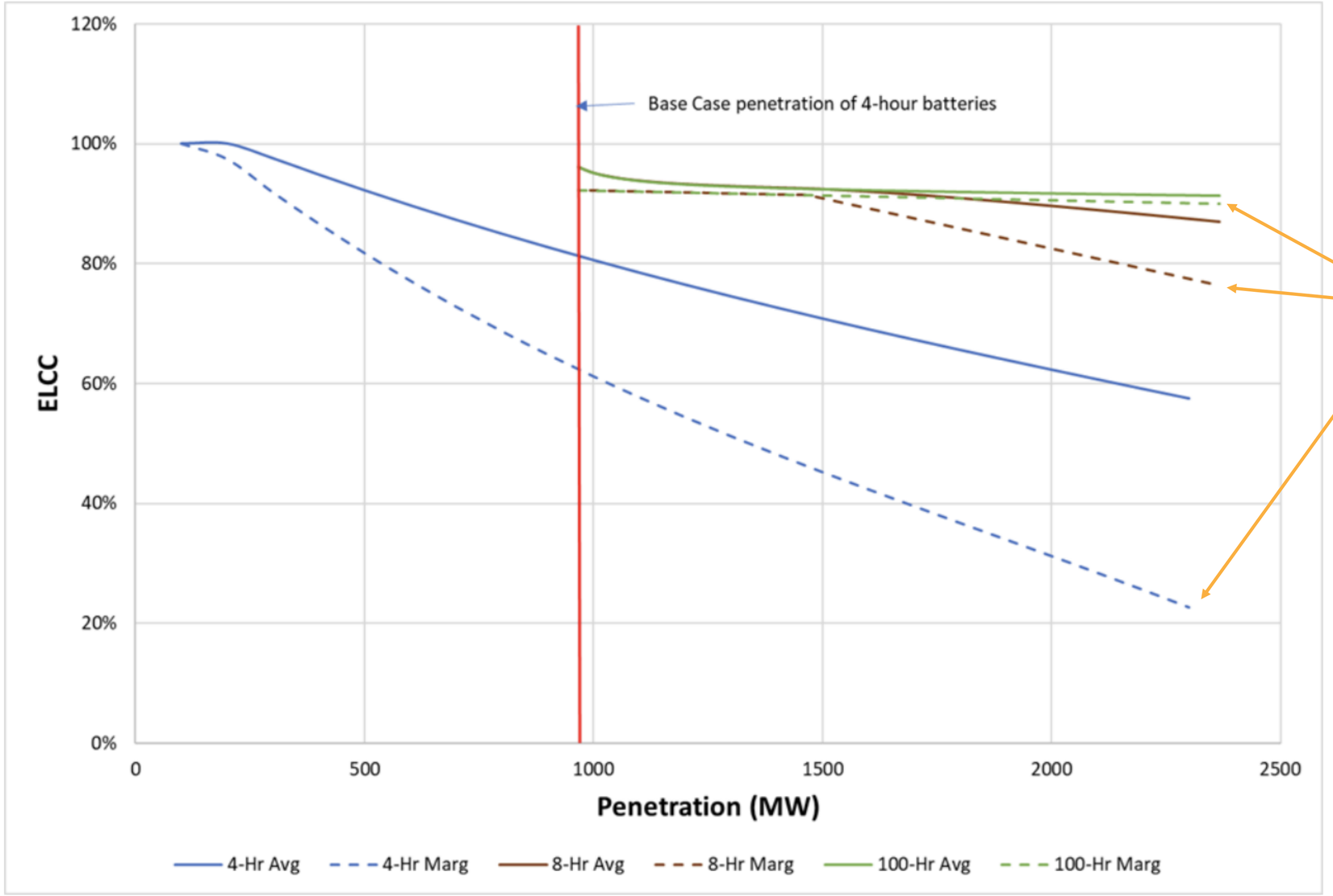
Inputs + Methods lead to least-cost, reliable portfolios that manage real world weather volatility with firm, flexible resources

Multi-day storage delivers flexible, firm capacity to the grid by cycling across weeks, months, and seasons

Example Operating Profile of 100-hour energy storage in a utility portfolio



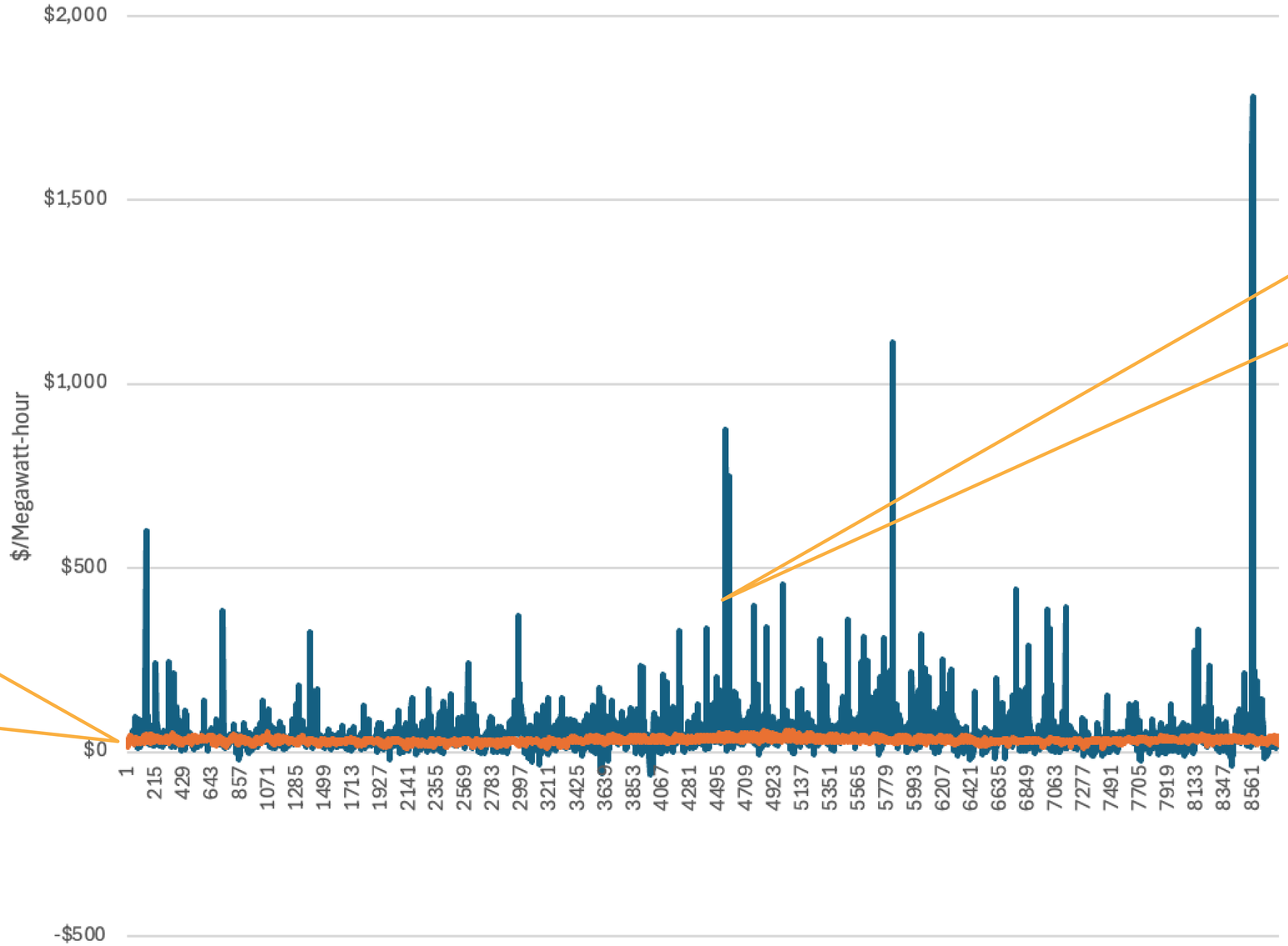
LDES and MDS technologies are often not yet accredited, yet have a higher ELCC than short-duration resources



Storage technologies with longer durations will keep a higher capacity accreditation, even while their penetrations increase.

Source: Astrape Consulting. 2023. Reserve Margin and Effective Load Carrying Capability (ELCC) Study. Prepared for Platte River Power Authority.

Forecasted commodity prices tend to exhibit less volatility than historical prices, understating the value of MDS in modeling efforts



MISO forecasted prices for 2025 at the Minnesota Hub exhibit low volatility, ranging from a low of **$11/MWh** to a high of **$59/MWh**.

Historical MISO prices at the Minnesota Hub are much more volatile, ranging from a low of **-$62/MWh** to a high of **$1,782/MWh** in 2022.

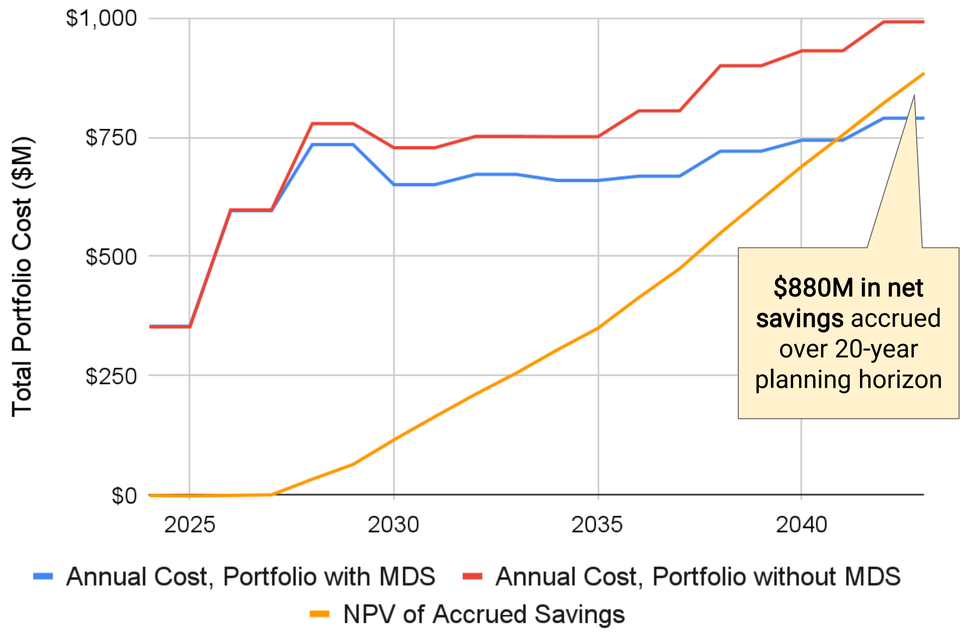
Forecasted prices for MISO's MN Hub for 2025 are taken from S&P Global.

Value of multi-day storage in utility resource portfolios

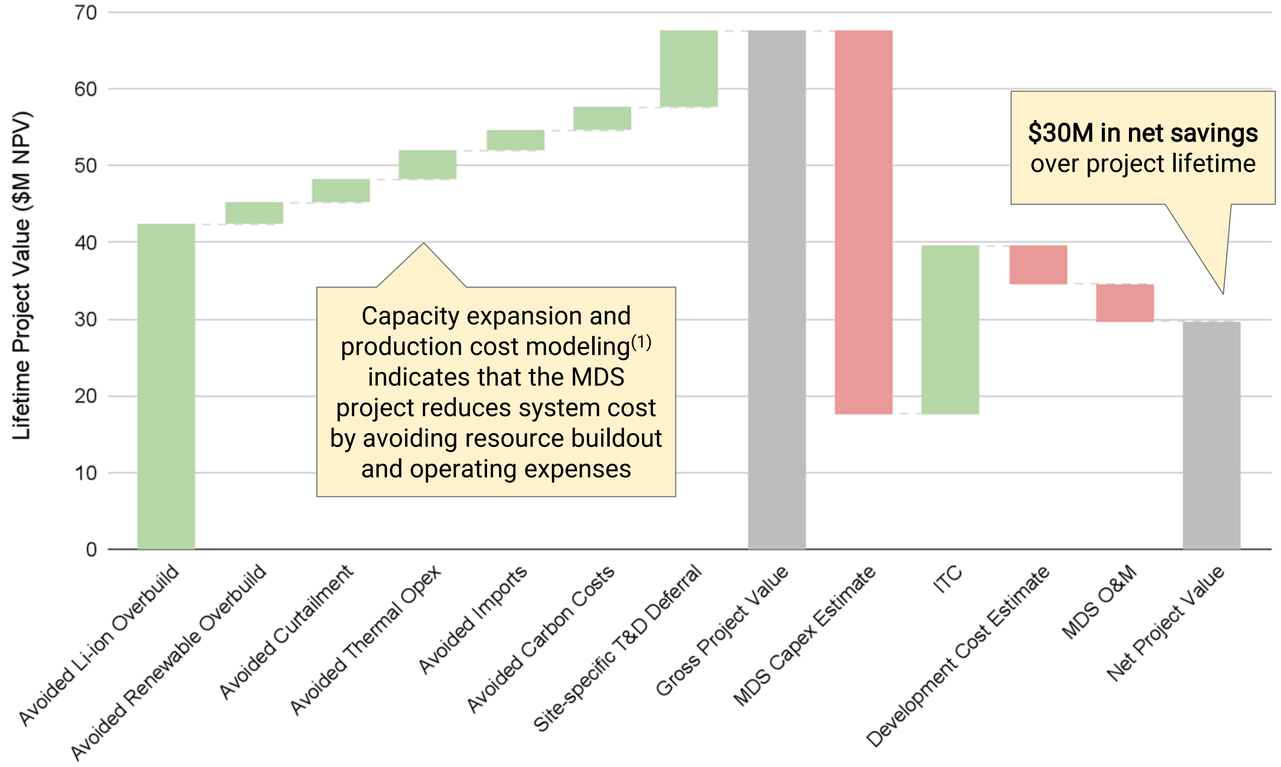
Multi-day storage reduces total cost of utility resource portfolio

Least-cost portfolio optimization for Mountain West utility selects MDS starting in 2027, with more than a gigawatt deployed by 2035

Long-term utility portfolio costs with and without MDS

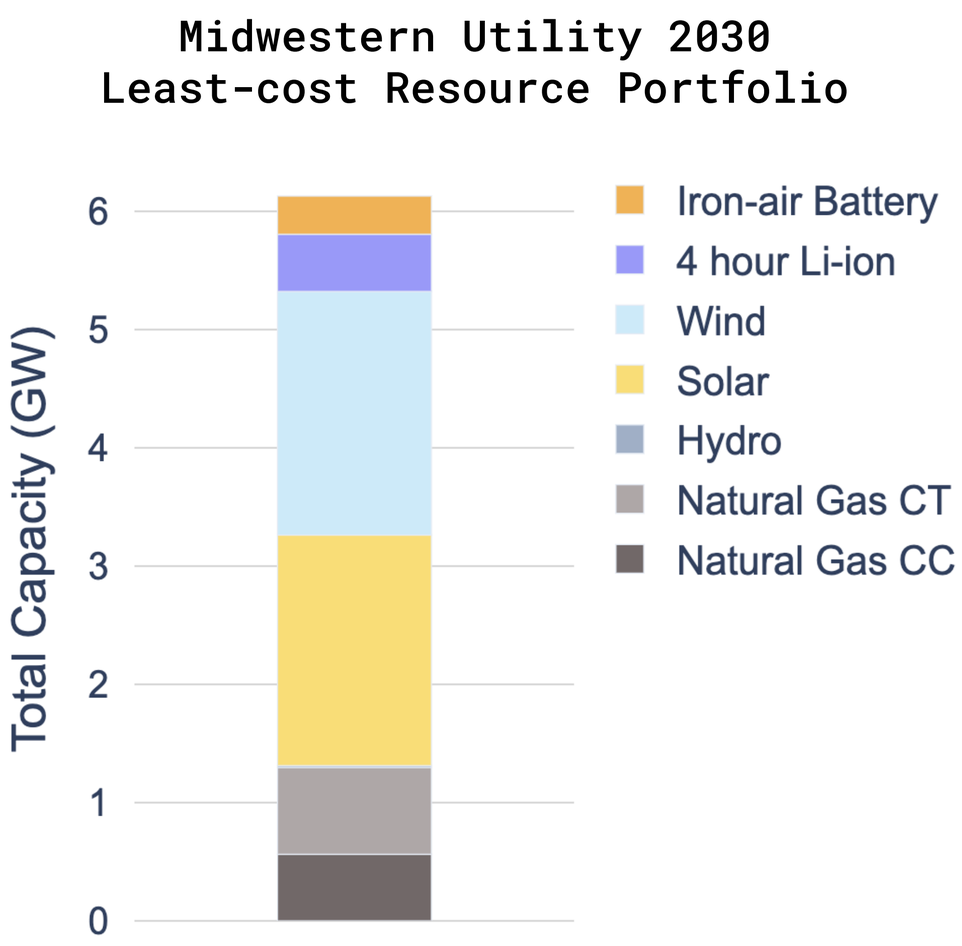


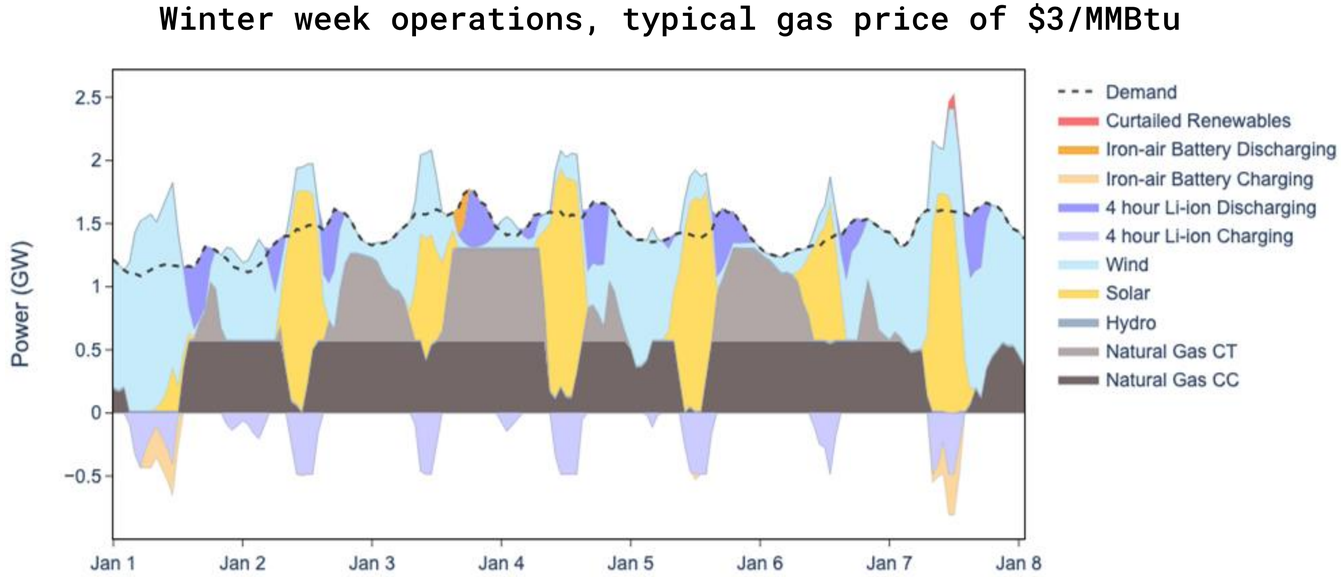
Value breakdown for a 25 MW MDS project in 2030

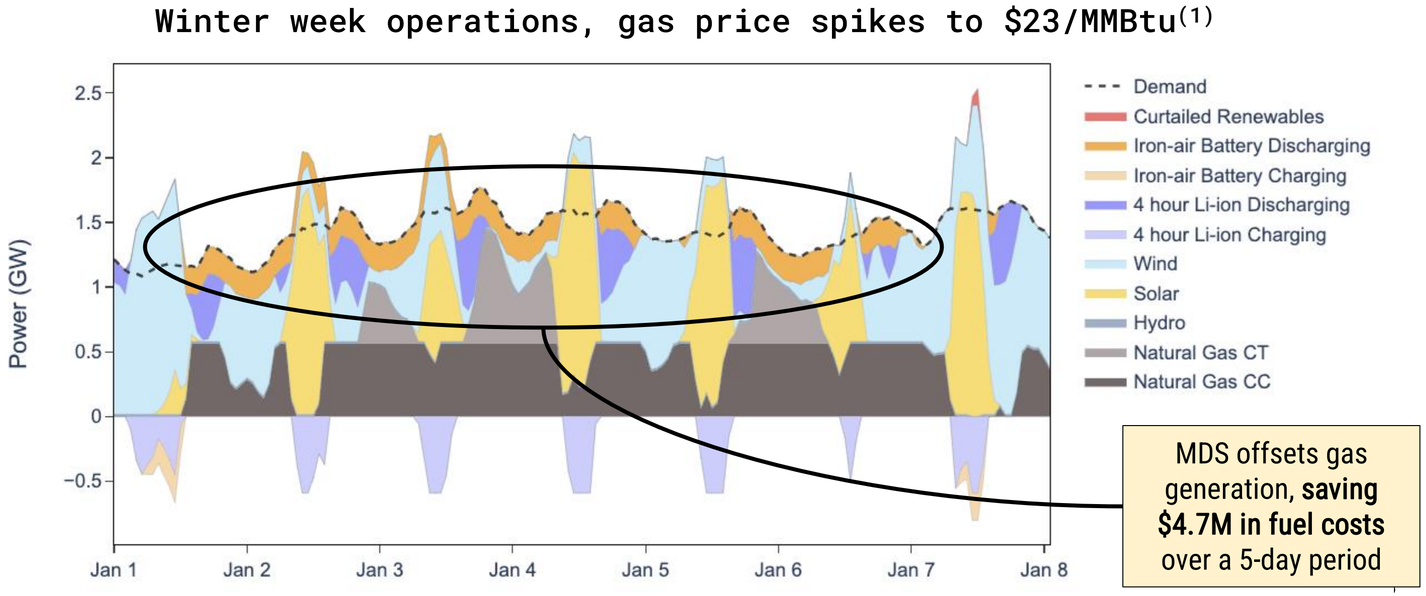


[1]Form Energy stresses the importance of implementing modeling best practices that capture year-round storage operations and weather variability. Commercially-available resource planning tools often struggle to accurately represent multi-day storage operations and its value within a resource portfolio. The presented analysis was performed in Formware™, which is designed to implement aforementioned best practices, such as portfolio optimization with 8760 hour temporal granularity.

MDS reduces portfolio operating costs during commodity price spikes





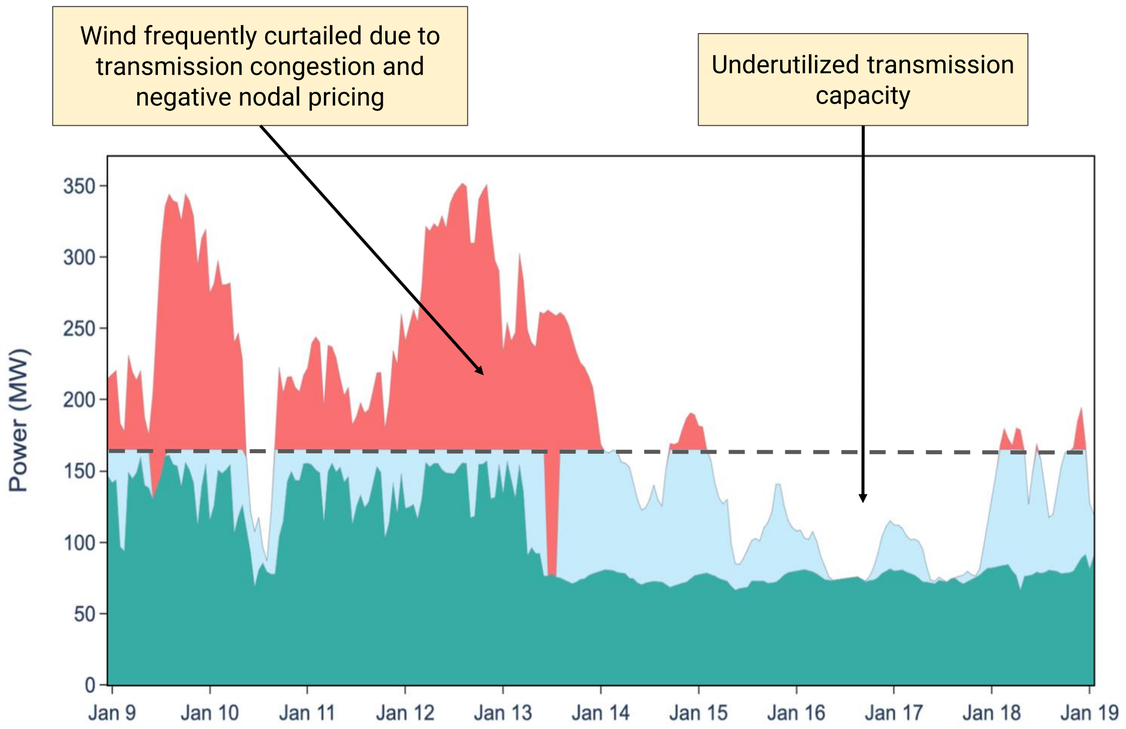


Note: (1) Average MISO-N natural gas spot price in February of 2021

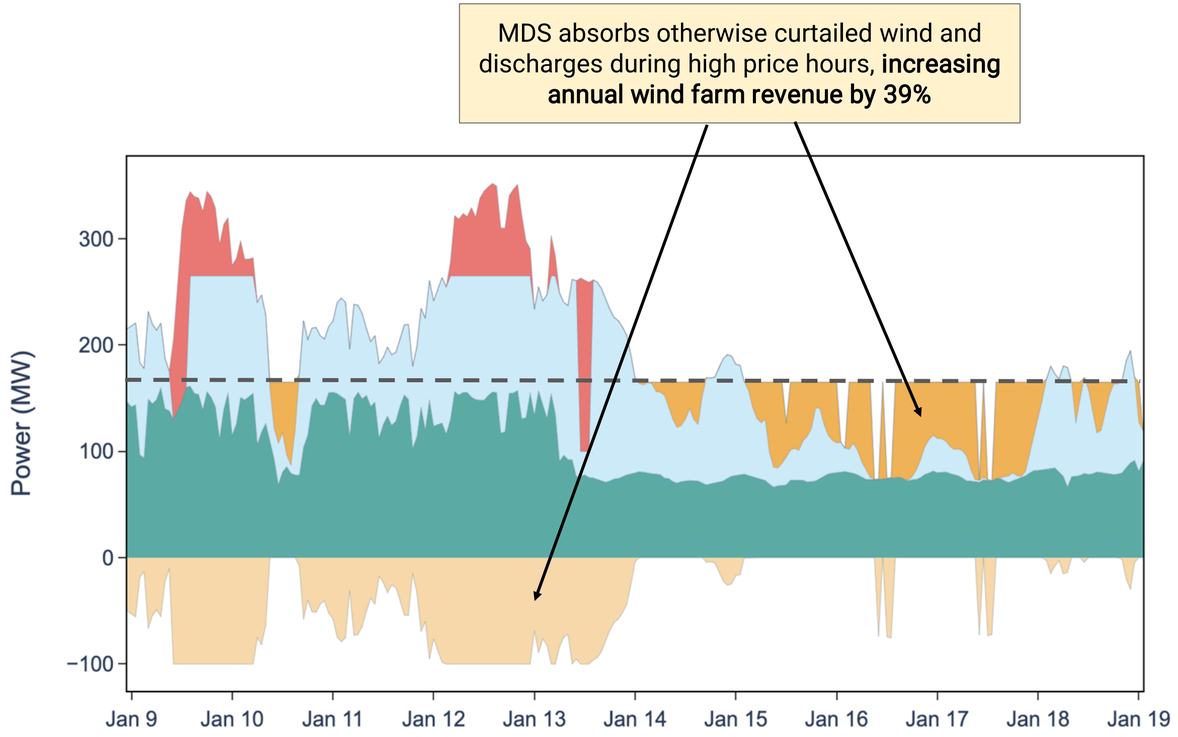
MDS balances generation from renewable assets to maximize revenue

Wind farm operations at transmission-constrained node in New England(1)

Without MDS



With MDS



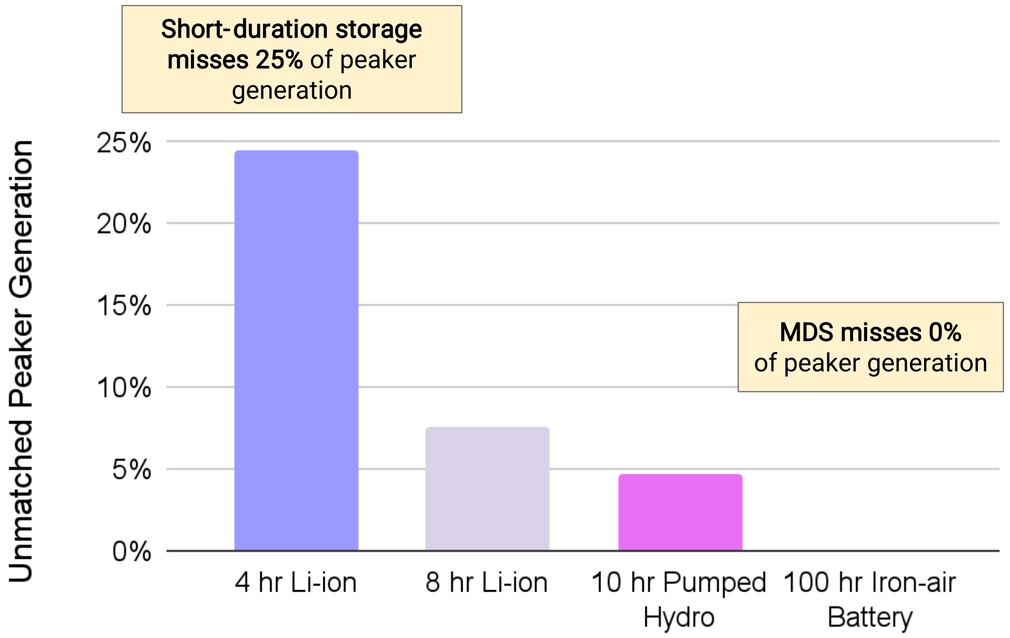
Dispatched Wind
Nodal Transmission Limit
Curtailed Wind
MDS Charging
Existing Transmission Congestion
MDS Discharging

Note: (1) Simulation based on historical weather conditions (wind generation, nodal pricing) across 5 historical weather years, 2018-2022. The displayed operations are from the 2022 weather year.

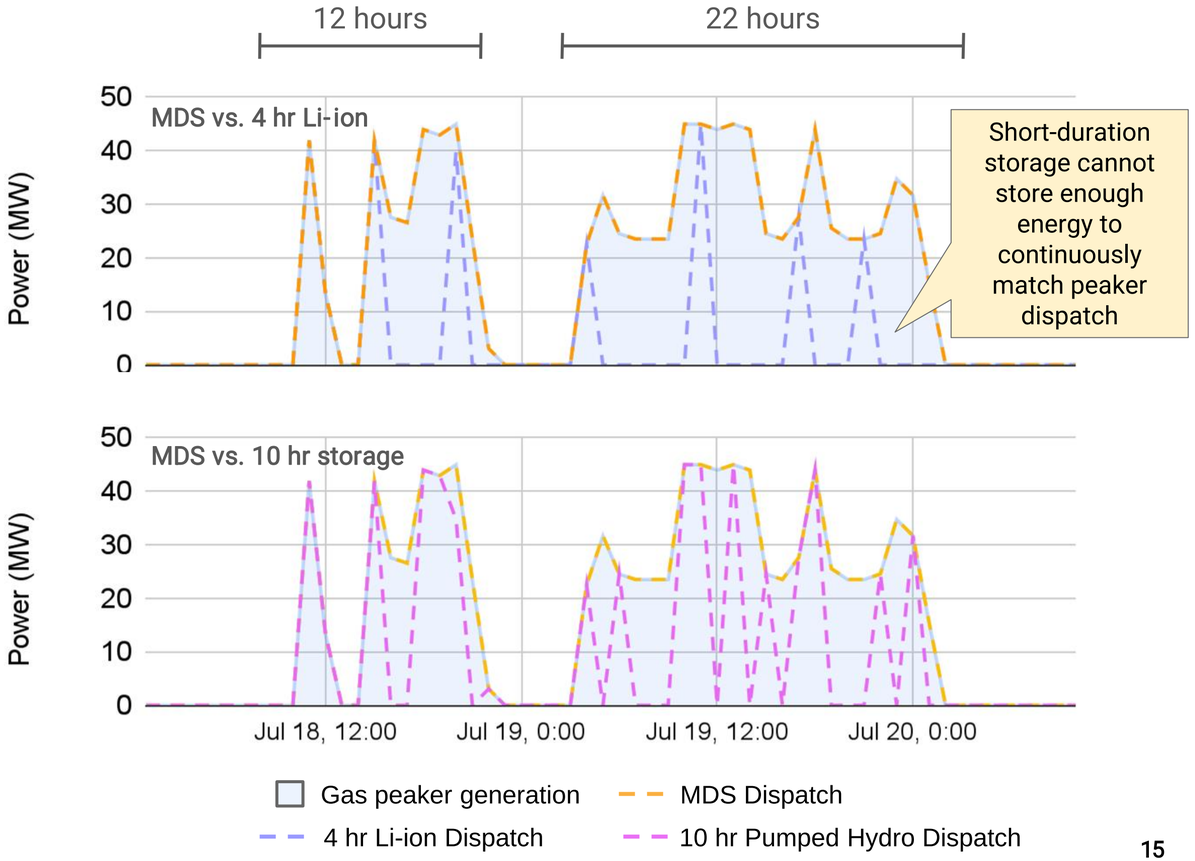
Unlike shorter duration storage, MDS can deliver the same dispatchability as thermal peaker plants during reliability events

50 MW storage projects dispatched to match the
2023 operations of a 50 MW gas peaker (WECC utility)

Ability to match peaker operations



Example Summer Week Operations



Thank you!

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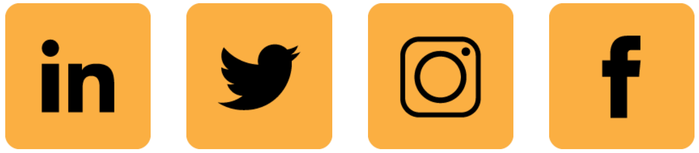

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