BREAKTHROUGH LOW-COST, MULTI-DAY ENERGY STORAGE

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Form energy

Energy Storage
For A Better World

CONFIDENTIAL

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

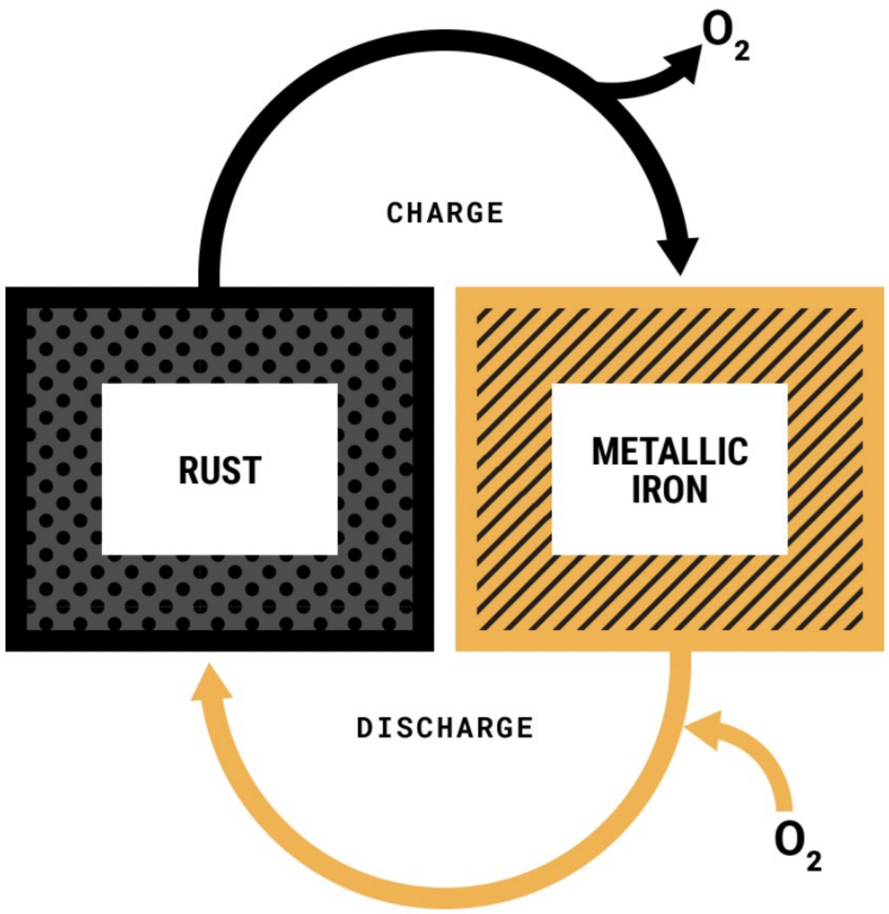
OUR INVESTORS: LONG-TERM AND IMPACT-FOCUSED

$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.

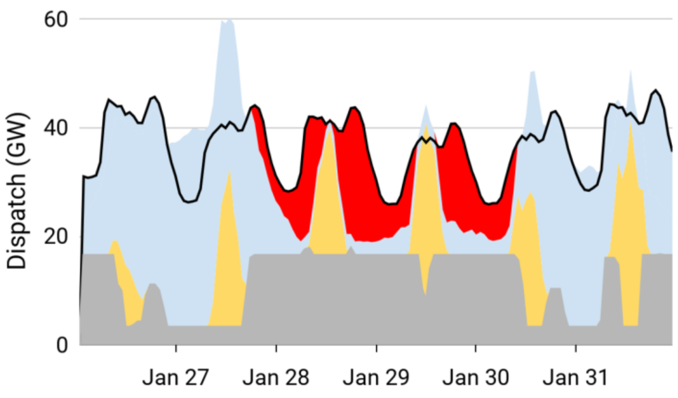
RELIABLE

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

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]

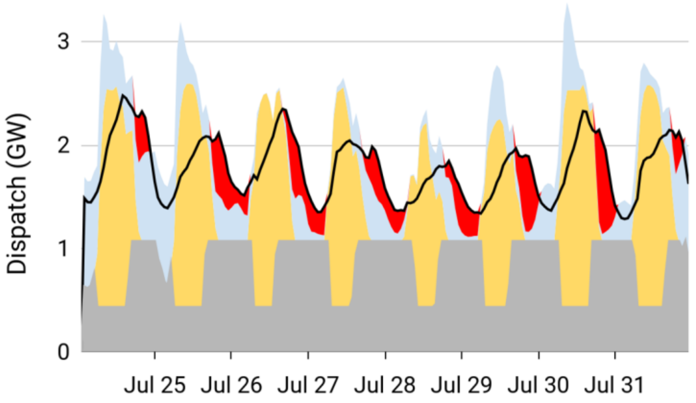


The challenge: Continuous periods of high net load or fuel shortages/price spikes can put the grid at risk of outage for 24+ hour periods.

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]

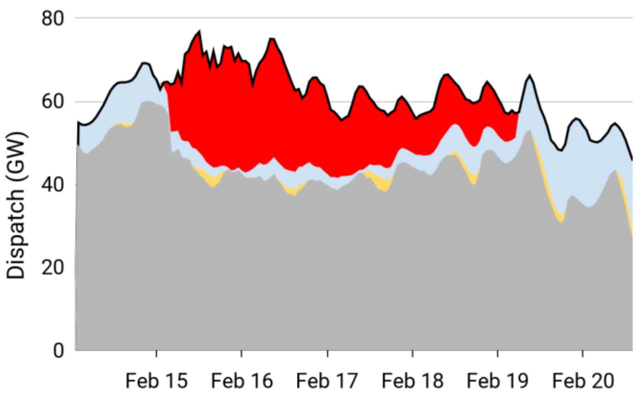


The challenge: Back-to-back days of high peak demand results in reliability risks during afternoon & evening hours. The system has insufficient energy to fully recharge short-duration batteries.

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

Best practice modeling approaches are essential to capturing both the value of multi-day storage and the grid's reliability needs

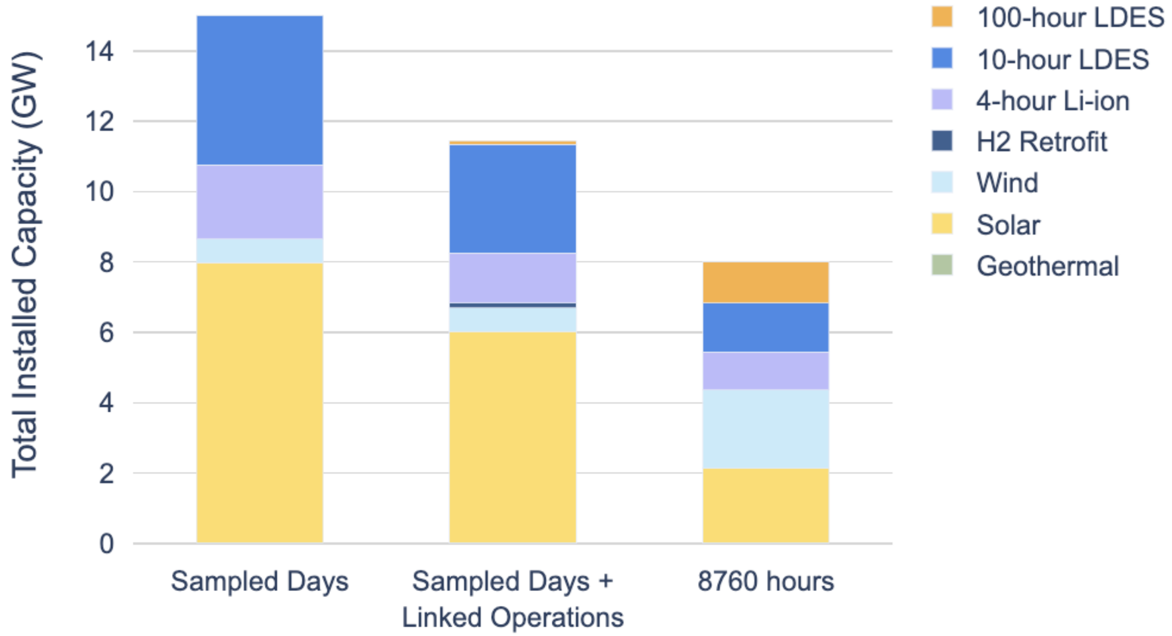
	1 Model 8760 hour grid operations	2 Use high fidelity weather data	3 Capture various weather scenarios
What?	Optimize resource portfolios with a chronology that includes all 8760 hours of the year	Use inputs which accurately reflect weather-correlated system conditions (load profiles, renewable profiles, fuel prices, etc.)	Evaluate the build and operational reliability of resource portfolios across a wide range of weather scenarios, including tail-risk events
Why?	Captures operational modes of MDS across daily, monthly, and seasonal time scales Includes reliability events that may occur outside typical days/weeks and last for several days at a time	Represents the realistic impacts of renewable lulls, temperature-driven demand surges, commodity price spikes, and other weather-correlated phenomena on grid operations	Ensures portfolios are designed to be least-cost and reliable across a range of grid stress conditions, including tail-risk events which have outsized impacts on customers

How?

Form Energy provides detailed resources to grid modelers on how to implement best practices, with specific recommendations for various commercial softwares (e.g. PLEXOS, Aurora, EnCompass, etc.)

8760 hour optimization produces most cost-optimal and reliable portfolios

2040 least-cost portfolio for a Southwestern utility



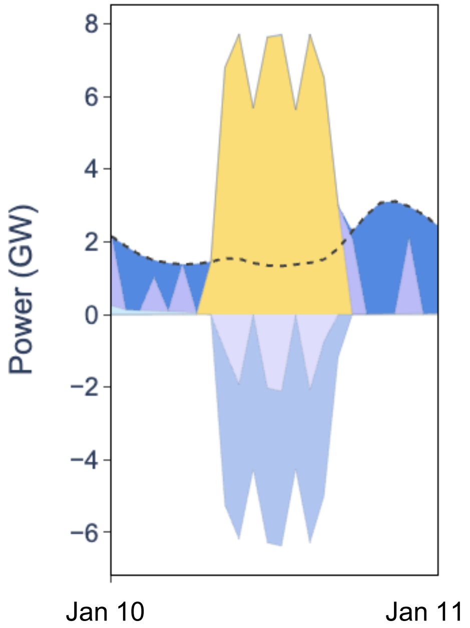
	Sampled Days	Sampled Days + Linked Operations	8760 hours
Annualized Portfolio Cost	$1.3 B/yr	$1.0 B/yr	$0.7 B/yr
Loss of Load in 8760 hr simulation	10 hours loss of load	37 hours loss of load	0 hours loss of load

- Capacity expansion for an example Southwestern utility, modeling 2040 portfolio
- Resulting portfolios were dispatched over all 8760 hours of this weather year to assess loss of load
- 8760 hour optimization produces most optimal resource portfolio in terms of cost, reliability, and resource build
- Sampled days methods may not fully capture the value of long-duration energy storage (LDES)
- Renewable build requirements significantly decrease when LDES operations are accurately captured

8760 hour optimization captures weather-driven variability in load and renewables

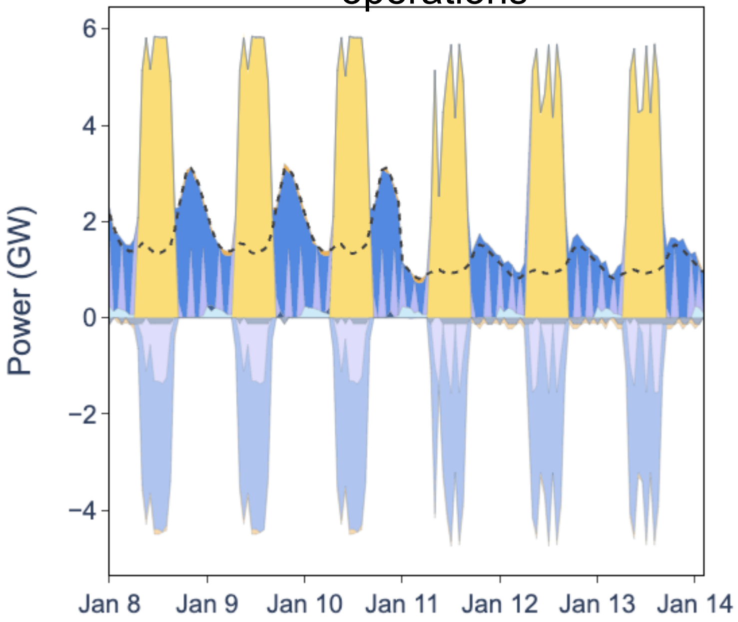
Example capacity expansion over a January week

Sampled day



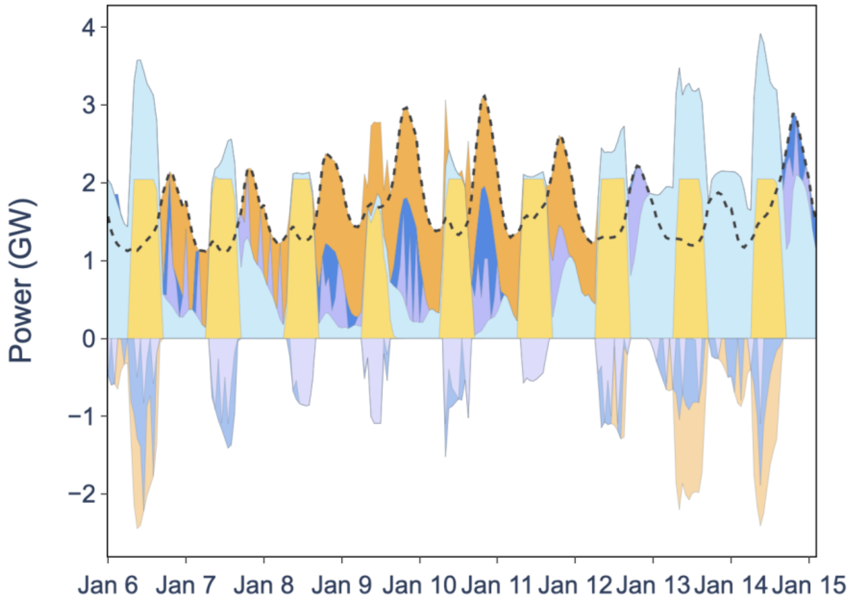
Captures only one day of system conditions

Sampled days, linked storage operations



Captures only 1-2 days of system conditions

8760 hour representation



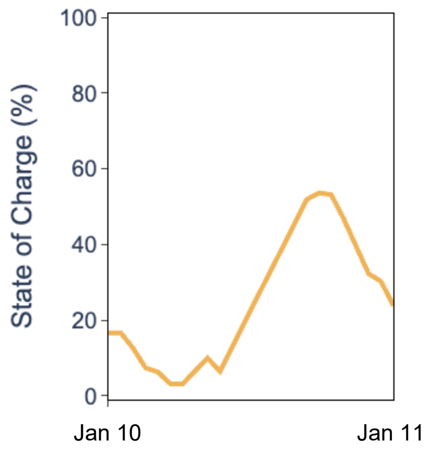
Captures hourly variation in load and renewable shapes during wind lull

- Load
- 100-hour LDES Discharging
- 100-hour LDES Charging
- 10-hour LDES Discharging
- 10-hour LDES Charging
- 4 hr Li-ion Discharging
- 4 hr Li-ion Charging
- Wind
- Solar
- Geothermal

8760 hour optimization captures full operational benefits of long-cycle resources

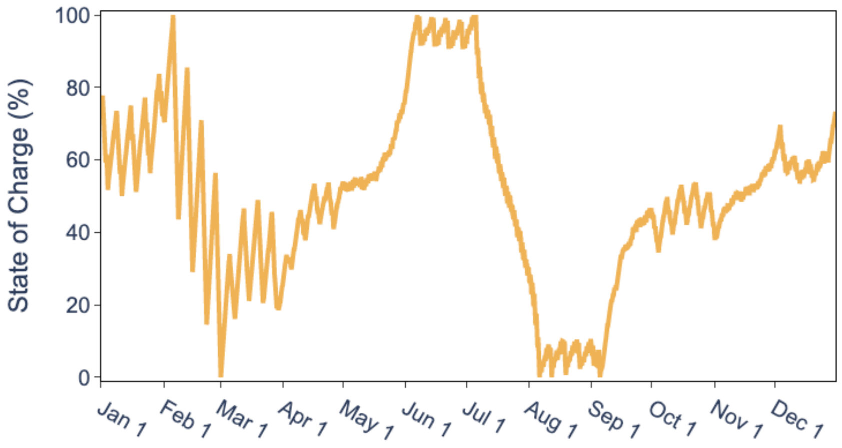
State of Charge of 100-hour battery over optimization horizon

Sampled day



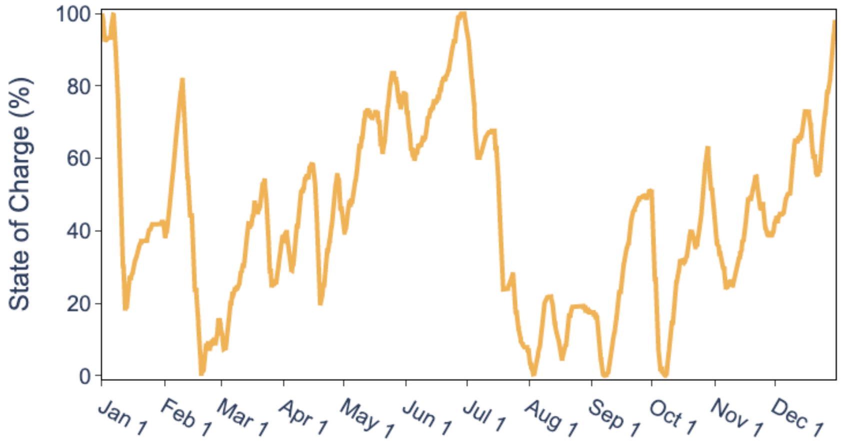
Storage can only shift energy within one day

Sampled days, linked storage operations



Some seasonal energy shifting

8760 hr representation

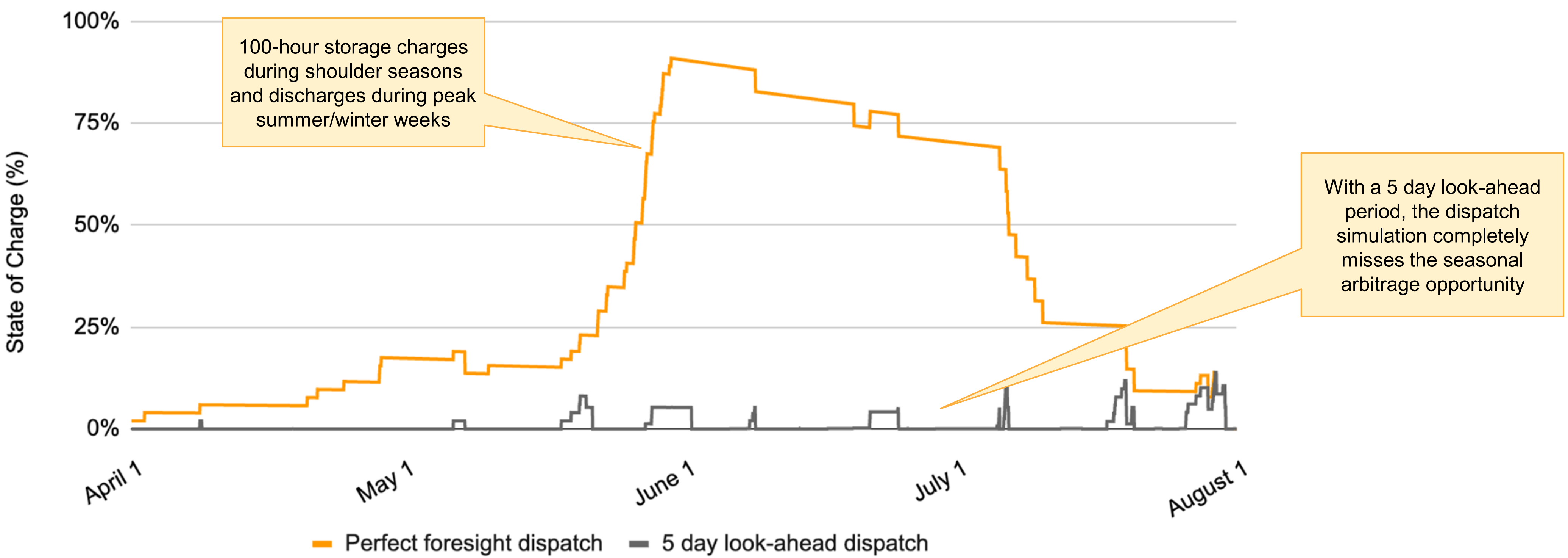


Energy shifting on daily, weekly, monthly, and seasonal time scales

In production cost modeling, limited look-ahead can greatly misrepresent seasonal operations of long-cycle technologies

Portfolio dispatch simulation must account for seasonal trends in cycling of multi-day storage and similar resources

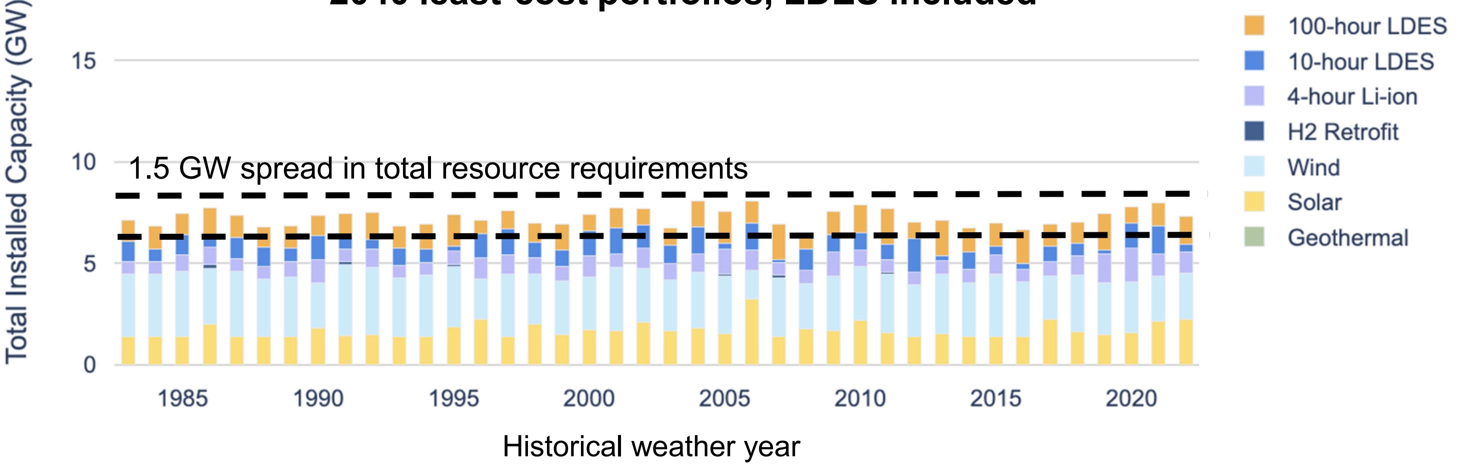
Simulated dispatch of 100-hour storage in production cost model



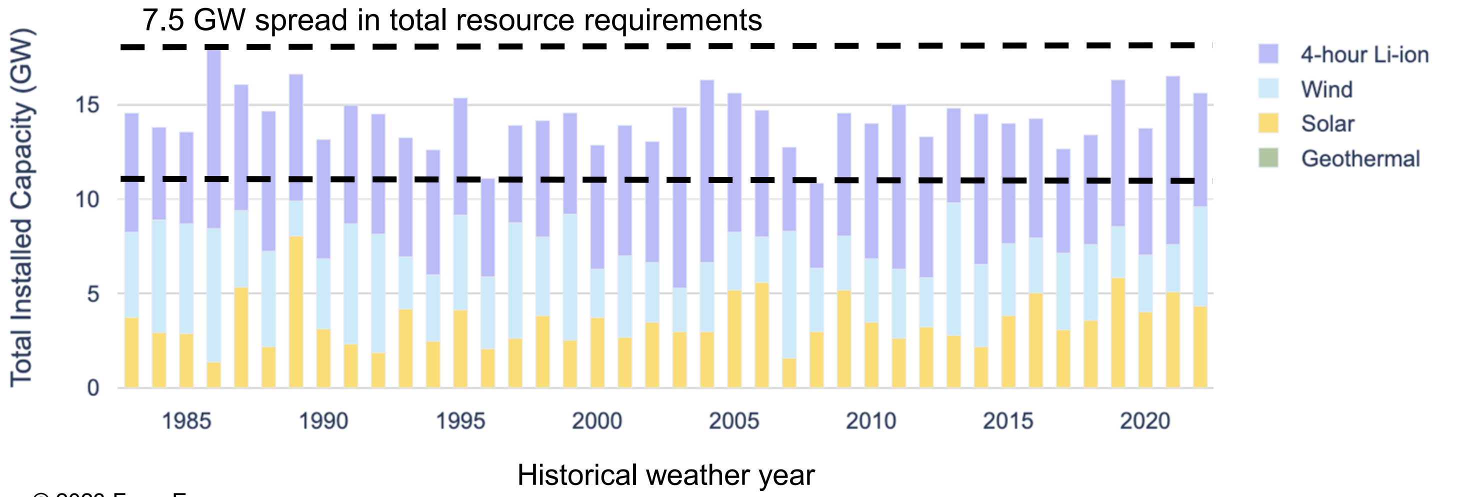
Modeling a wide range of weather years is critical to capturing resource variability

Southwestern Utility Case study

2040 least-cost portfolios, LDES included



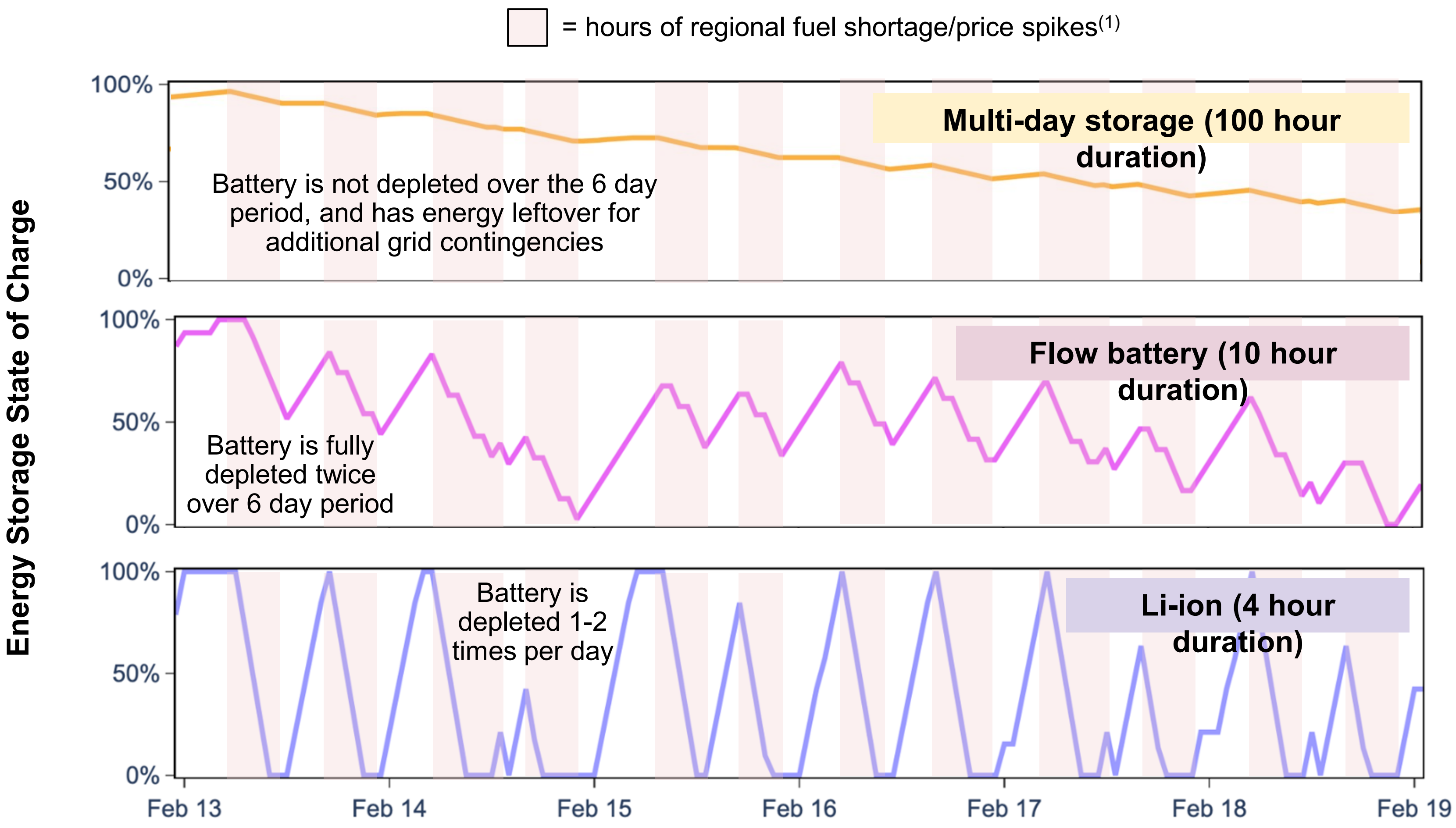
2040 least-cost portfolios, No LDES included



- Weather year selection can have a significant impact on resource planning outcomes
- Modeling a wide range of weather years helps to ensure that portfolio can maintain reliability across a diverse set of weather conditions
- Sensitivity of portfolios to variation in weather years was found to be higher in portfolios without LDES than portfolios which include LDES

Multi-day storage delivers clean, firm capacity during critical periods of energy scarcity in a way that shorter durations cannot

Dispatch of 100 MW storage assets simulated during 2015 ISO-NE polar vortex



Dispatch covers **100%** of scarcity hours

Dispatch covers **81%** of scarcity hours

Dispatch covers **63%** of scarcity hours

Note: (1) Based on 2030 fuel shortage scenario derived from ISO-NE Operational Fuel Security Analysis and simulated in Formware™.
More details in Wilson *et al.*, "Clean, Reliable, Affordable: The Value of Multi-Day Storage in New England," September 2023.

Thank you!

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