Beyond Lithium, Part 3: Form Energy's Iron-Air Battery

August, 6, 2026

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WEBINAR SPEAKERS

Beyond Lithium, Part 3: Form Energy's Iron-Air Battery

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Form Energy

Form energy

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President/Executive Director
Clean Energy Group
(Moderator)

CleanEnergyGroup

Beyond Lithium Webinar Series

- Beyond Lithium, Part 1: Hydrostor’s Advanced Compressed Air Energy Storage (4/8/2026)
- Beyond Lithium, Part 2: ESS Tech’s Iron Flow Battery (6/3/2026)
- Beyond Lithium, Part 3: Form Energy's Iron-Air Battery (8/6/2026)

www.cleanegroup.org/initiatives/energy-storage-policy-and-regulation/beyond-lithium

Thank You

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(August 18)

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BREAKTHROUGH, LOW-COST, MULTI-DAY ENERGY STORAGE

CEG Beyond Lithium Webinar

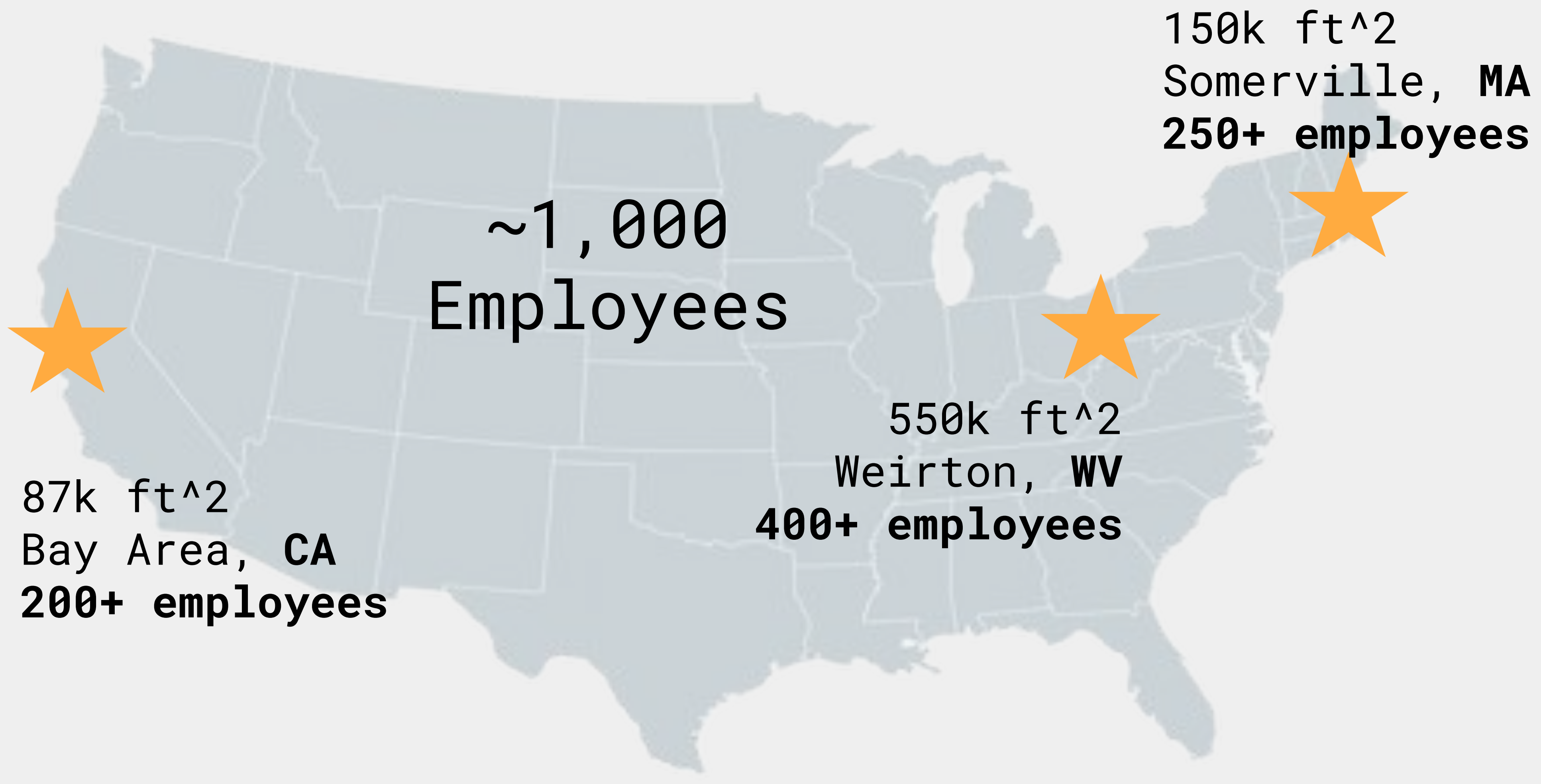
August 6, 2026

Energy Storage for
a Better World

INTRODUCTION

Form Energy at a glance

- American company founded in 2017
- Developing, manufacturing, & commercializing a 100-hour, iron-air battery
- Enabling a reliable, cost-effective, and stable electric grid
- Employing nearly 1,000 people
- Partnering with leading utilities and entities on >80 GWh of projects
- Operating >800,000 ft^2 of R&D, engineering, and manufacturing facilities in Somerville (MA), Berkeley (CA), and Weirton (WV)



OUR LEADERSHIP

Led by energy storage veterans with decades of cumulative experience and **100s of MWs** of storage deployed

TESLA ENERGY
A123 SYSTEMS
NEXTera ENERGY
DEPARTMENT OF ENERGY UNITED STATES OF AMERICA
AQUION ENERGY
SUNPOWER®
24m
amsc
MIT Massachusetts Institute of Technology

OUR INVESTORS

$1.2B+ in venture capital from long-term, impact-oriented investors

T.RowePrice
GE VERNOVA
GIC
TEMASEK
CAPRICORN INVESTMENT GROUP
Prelude Ventures
TPG RISE CLIMATE
Breakthrough Energy VENTURES
CPP Investments
NGP
THE ENGINE VENTURES
ENERGY IMPACT PARTNERS
COATUE
ArcelorMittal

Form energy

Form Energy’s impact-oriented long-term investors

$1.2B+ in Venture Capital to date

T.RowePrice
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ENERGY IMPACT PARTNERS

Breakthrough Energy VENTURES
Prelude Ventures
COATUE
MACQUARIE
THE ENGINE VENTURES
NGP

eni next
VamosVentures
The Cap Table Coalition
CAPRICORN INVESTMENTGROUP
CPP Investments
GIC

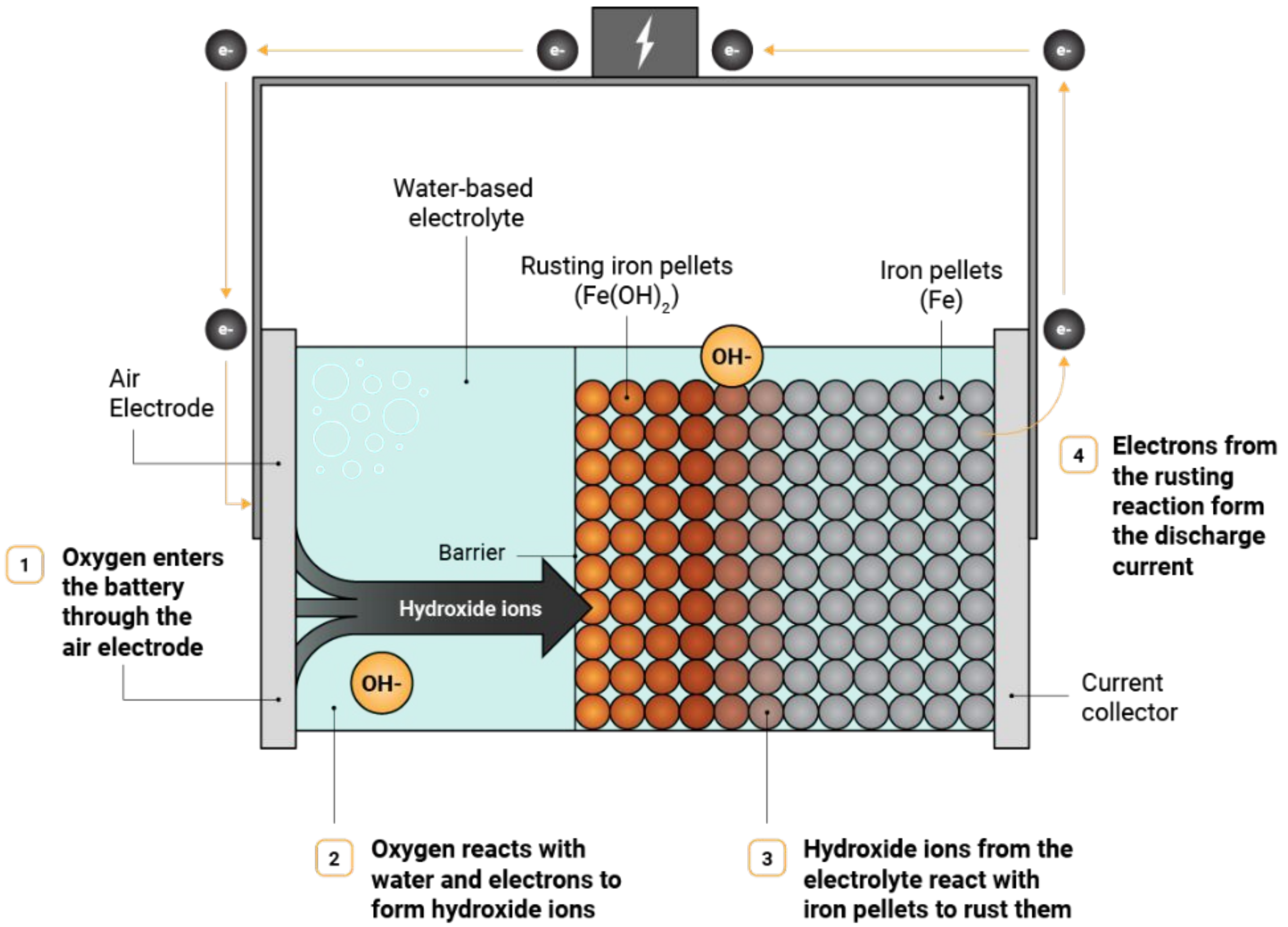
THE TECHNOLOGY

Breakthrough 100-hour, iron-air battery technology

Multi-Day	100-hour duration
Firm Capacity	~95% availability
Cost Competitive	Targeting $20/kWh at scale
Ready To Deploy	2026+ Deliveries

Principle of operation: Reversible rusting

Discharge



Water-based electrolyte

Rusting iron pellets ($Fe(OH)_2$)

Iron pellets (Fe)

Air Electrode

Barrier

Hydroxide ions

Current collector

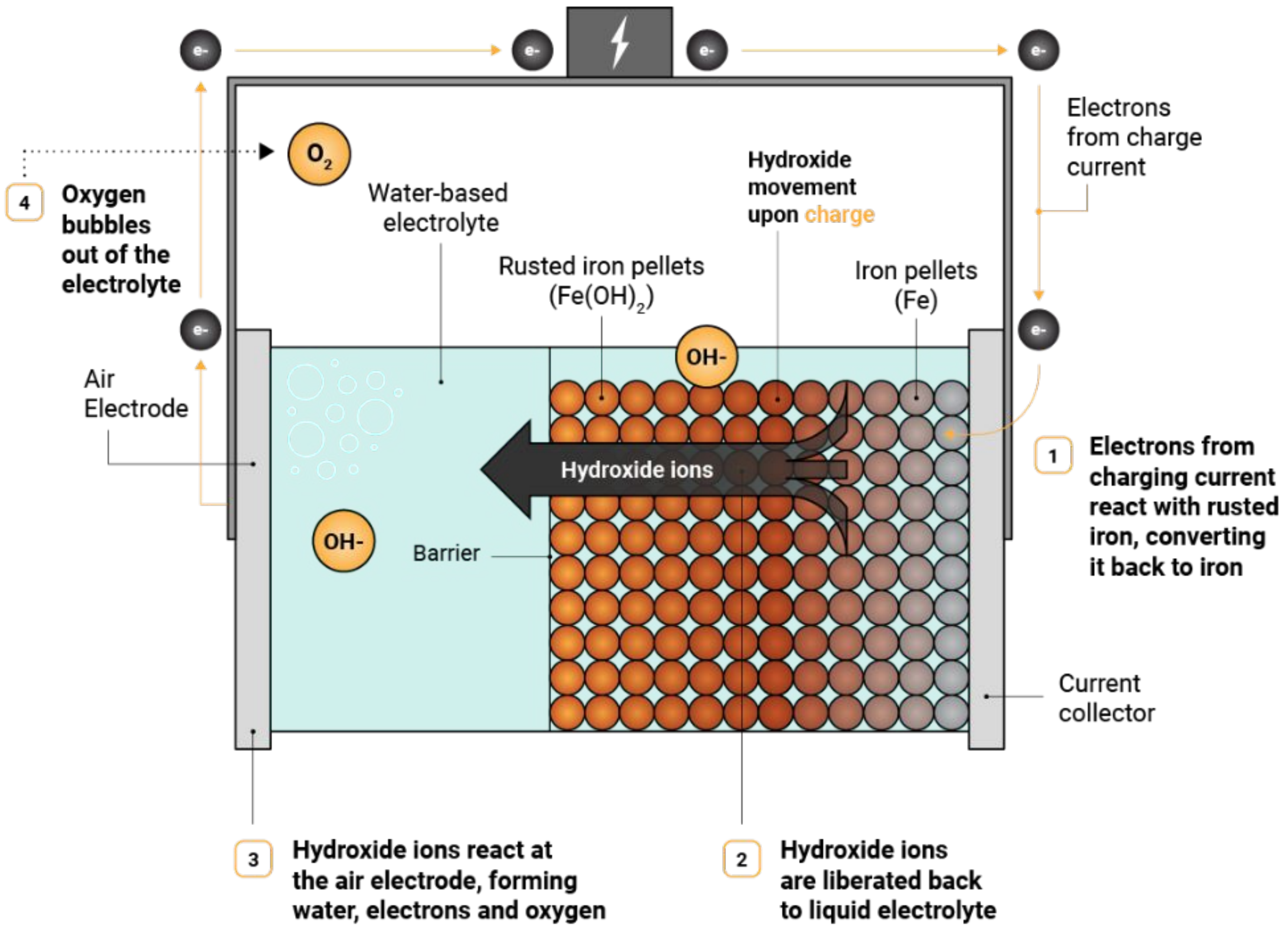
1 **Oxygen enters the battery through the air electrode**

2 **Oxygen reacts with water and electrons to form hydroxide ions**

3 **Hydroxide ions from the electrolyte react with iron pellets to rust them**

4 **Electrons from the rusting reaction form the discharge current**

Charge



O_2

Water-based electrolyte

Hydroxide movement upon charge

Rusted iron pellets ($Fe(OH)_2$)

Iron pellets (Fe)

Electrons from charge current

Air Electrode

Hydroxide ions

Barrier

Current collector

1 **Electrons from charging current react with rusted iron, converting it back to iron**

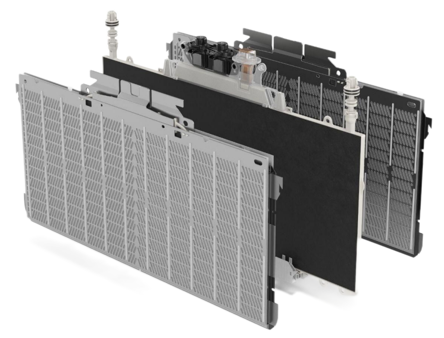
2 **Hydroxide ions are liberated back to liquid electrolyte**

3 **Hydroxide ions react at the air electrode, forming water, electrons and oxygen**

4 **Oxygen bubbles out of the electrolyte**

Form energy

Key components of an iron-air battery system



ELECTRODE STACK

Component parts of an electrochemical cell

CELL

Fundamental electrochemical unit

MODULE

Cells stacked horizontally

TOWER

Modules stacked vertically

PACK

Houses towers & auxiliary systems (e.g., thermal management)

POWER PLANT

Several blocks of packs and inverters – system delivered to customers

Form's battery uses a safe & stable chemistry, designed & tested to meet industry safety standards

Key Fire Safety Features

NO THERMAL RUNAWAY DEMONSTRATED

UL9540A testing under various severe conditions for full-scale cell did not result in uncontrolled heating, dendrite formation, fire, or thermal runaway.

SAFE COMPONENTS

Water-based electrolyte (natural fire deterrent).
Materials certified for safety and reliability.

STABLE REACTIONS

No dendrite formation.
Controllable discharge reaction.

Key System Standards & Design

- **Target Certifications**
  - Battery: NRTL certified to UL 1973
  - ESS: NRTL certified to UL 9540; UL 9540A tested
  - Inverter: IEEE 1547; UL 1741
- **Design Safety Codes & Standards**
  - Installation: NFPA 855
  - Electric: NFPA 70 (NEC)
  - Fire/Building: IBC-2024, IFC-2024
- **System Safety Design**
  - Monitoring, detection, alarms at BMS
  - Redundant fault detection & mitigation
  - Containment at cell, module, & system
  - Exhaust system coupled to modules & enclosure

Commercial-scale manufacturing at Form Factory 1

Top Facts

- Total Local Investment: $760 million
- Ground Breaking: 2023
- Production Start: 2024
- Jobs: 750 full-time jobs at scale (~400 as of May ‘26)

Why West Virginia

- Business friendly environment
- Access to river, rail, & hardened highways
- Strong local workforce

American Manufacturing

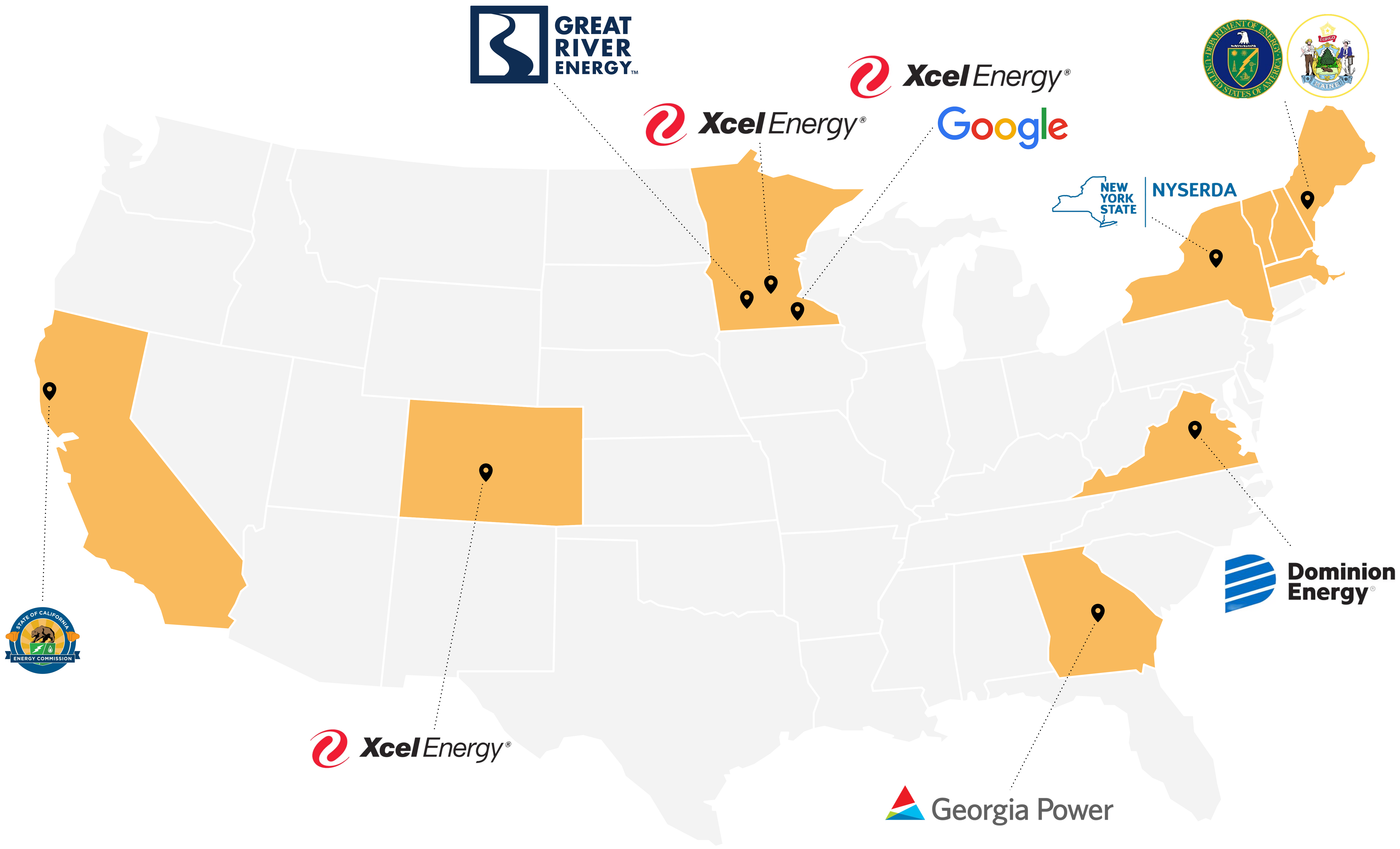
- Situated on the historic site of the former Weirton Steel mill, Form Factory 1 is demonstrating that the greatest manufacturing epoch isn’t behind us — it’s unfolding now.


2023


2024


TODAY

80 GWh of announced multi-day storage projects



Crusoe
US

FuturEnergy Ireland
IRELAND

Partners	RTO/ISO	Size
GREAT RIVER ENERGY	MISO-N	1.5 MW **150 MWh**
California Energy Commission	CAISO	1.5 MW **150 MWh**
Xcel Energy Northern States Power Minnesota	MISO-N	10 MW **1,000 MWh**
Xcel Energy Public Service Company of Colorado	SPP	10 MW **1,000 MWh**
Dominion Energy	PJM	5 MW **500 MWh**
Georgia Power	SERC	15 MW **1,500 MWh**
NEW YORK STATE NYSERDA	NY-ISO	10 MW **1,000 MWh**
US Dept of Energy (GRIP Program)	ISO-NE (Maine)	85 MW **8,500 MWh**
FuturEnergy Ireland	Ireland	10 MW **1,000 MWh**
Xcel Energy Google	MISO-N	300 MW **30,000 MWh**
Crusoe	TBD	120MW **12,000 MWh**
Confidential	Confidential	230MW **23,000 MWh**

~80 GWh

THE CHALLENGE

The Challenge: Grid reliability, safety, and security are at risk

Exponential increase
in load growth

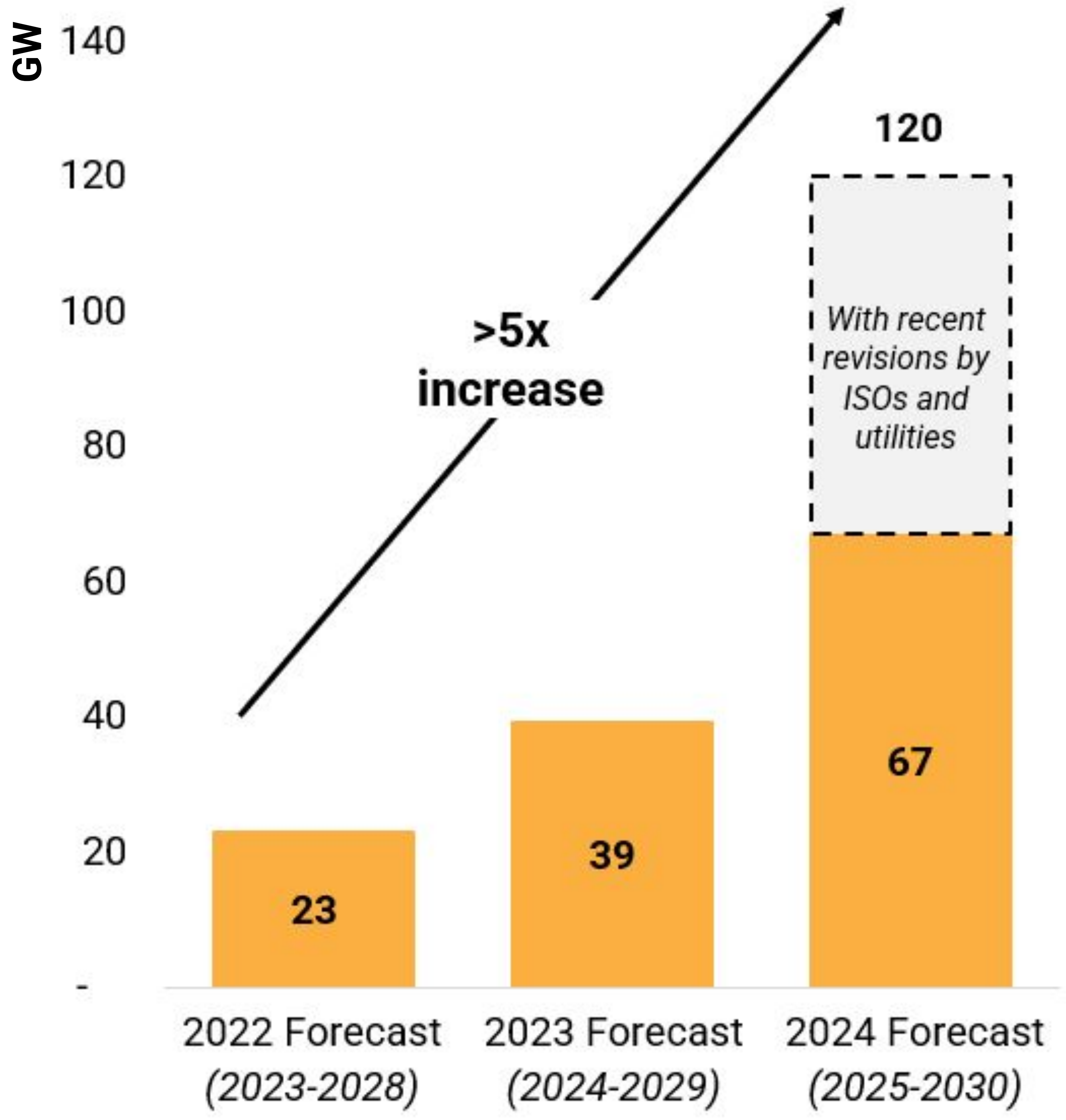
Growing share of
intermittent generation

Record number of
billion-dollar storms

Huge electricity load growth is placing increasing strain on the grid

Historic surge in load growth

5-Year Summer Peak Demand Growth (1)



More than half of North America now at risk of blackouts

NERC reliability risk area summary of the US, due to electricity demand rising faster than the rate of infrastructure buildout (2)

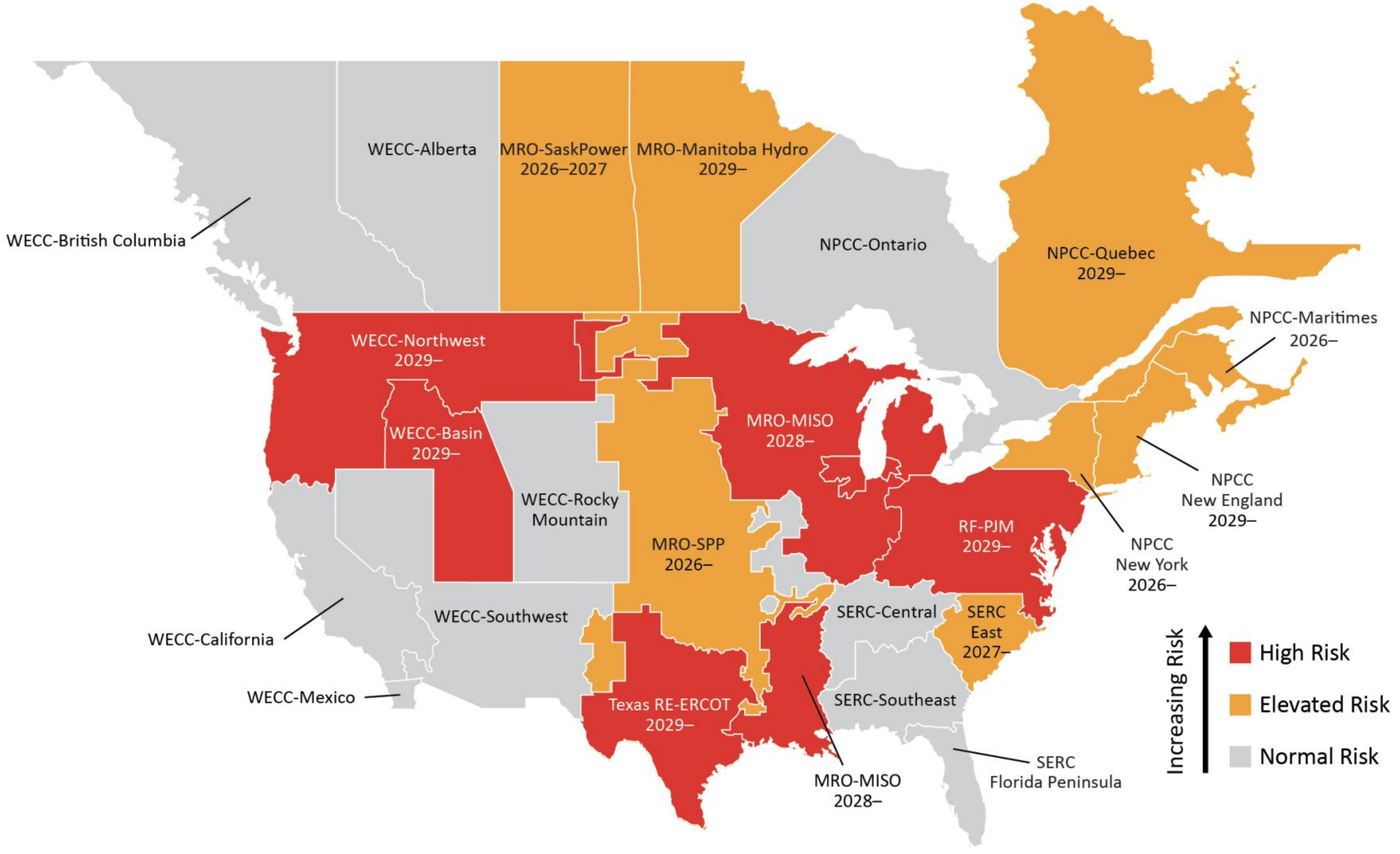


Figure 1: Risk Area Summary 2026–2030

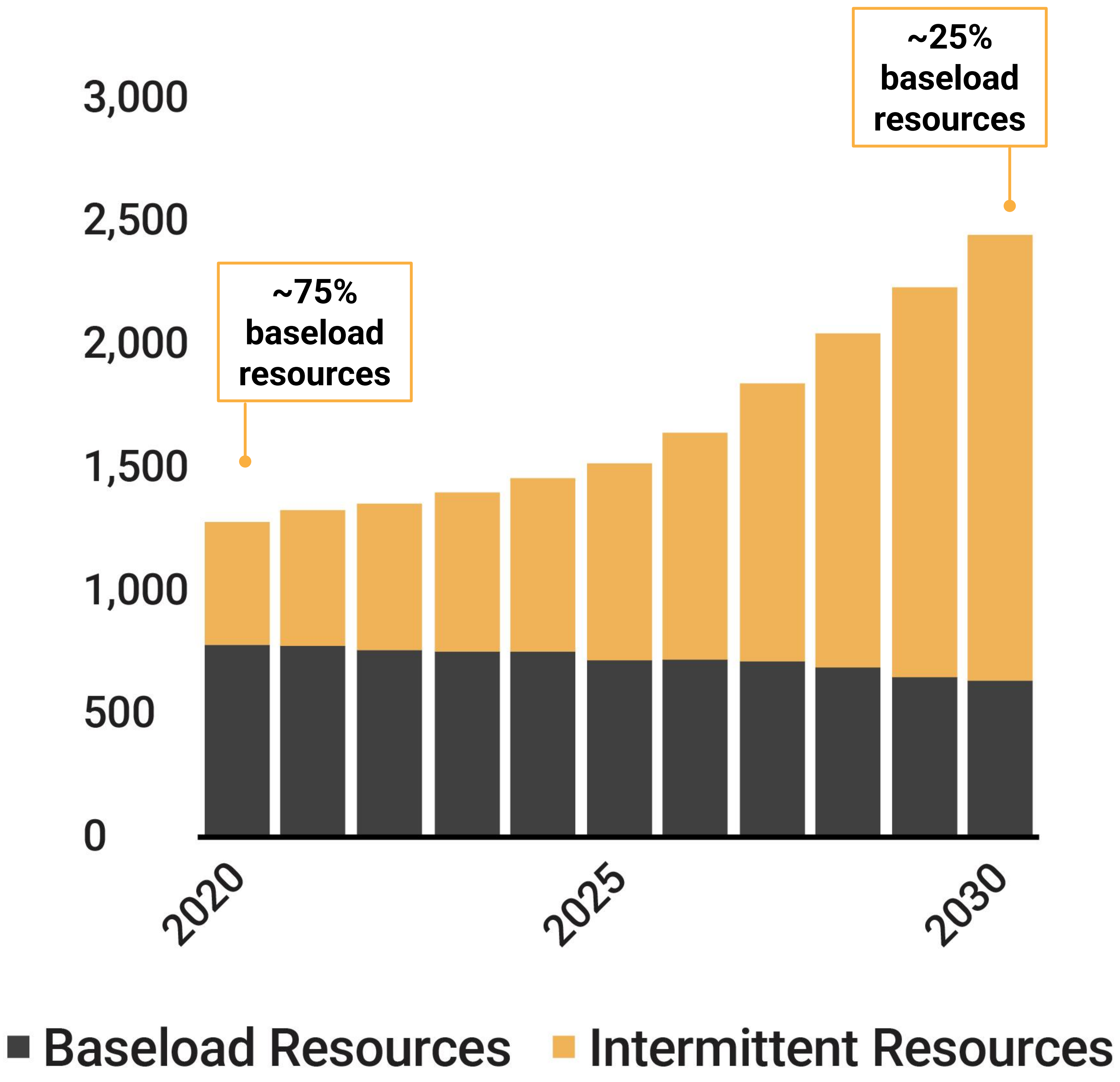
Shows highest risk classification that occurs in the first 5 years and states initial year of occurrence

Source: (1) Strategic Industries Surging. Grid Strategies (April 2025); (2) NERC. Long Term Reliability Assessmen (Jan 2026)

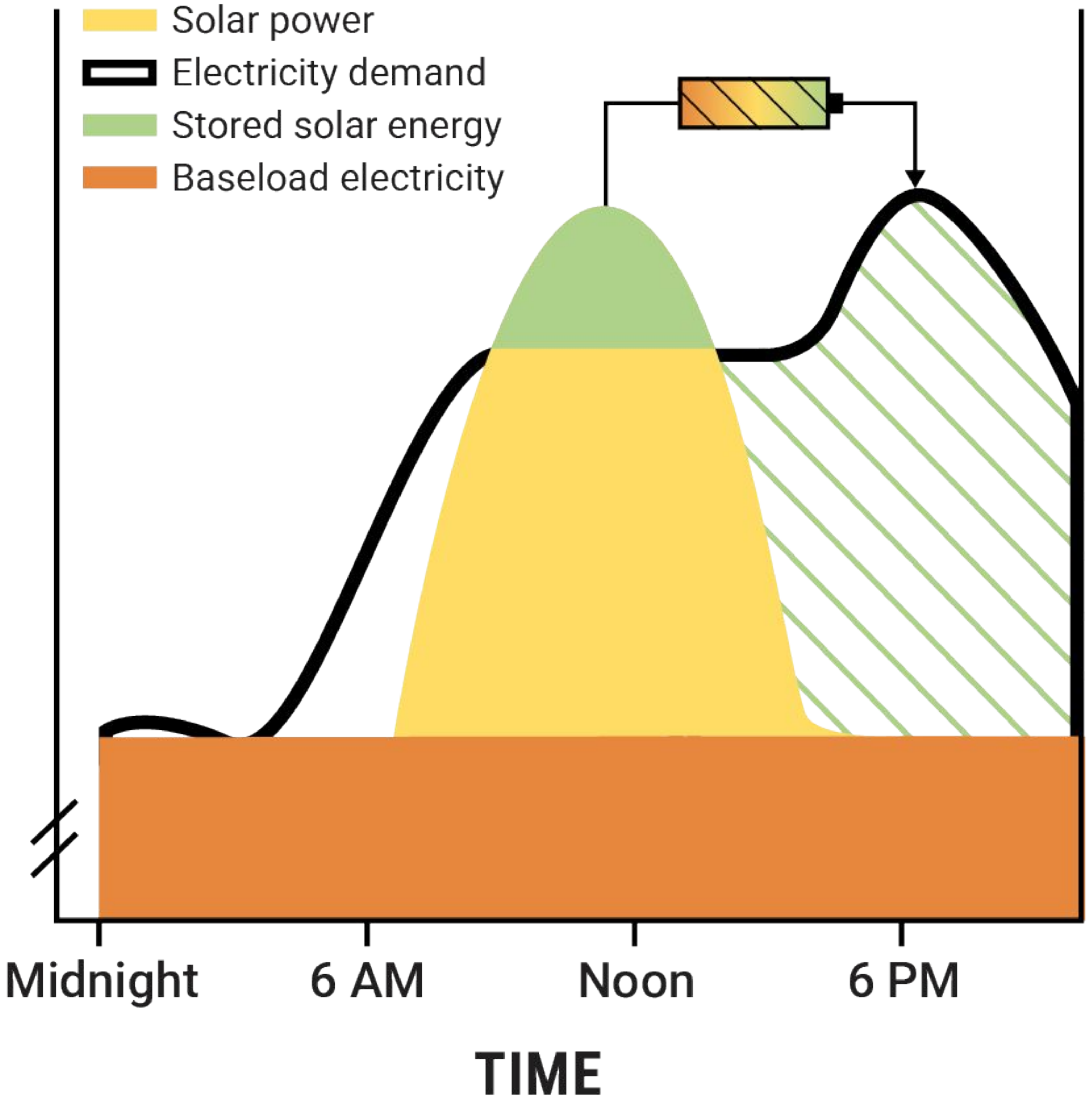
Renewables are the lowest cost & fastest-growing source of energy, but are intermittent

Renewables are seeing high growth

Total US Installed Capacity (GW)[1]



…but need firming up

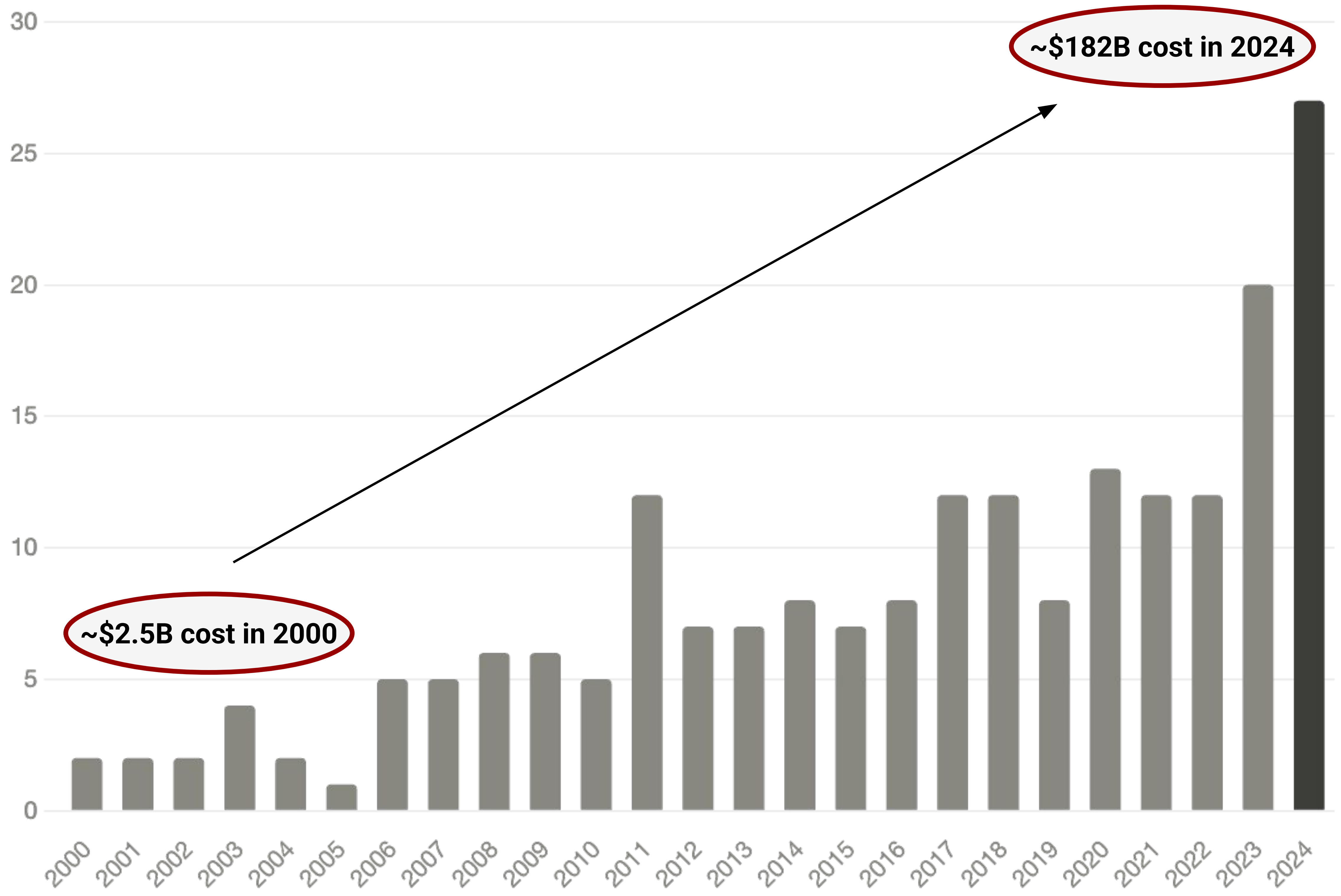


Source: 1) Bloomberg New Energy Finance (BNEF) – "New Energy Outlook 2024", 2) Conceptual diagram illustrating the CAISO "Duck Curve" mitigation strategy through battery storage.

Extreme weather events are on the rise, creating reliability strains on the grid for days on end

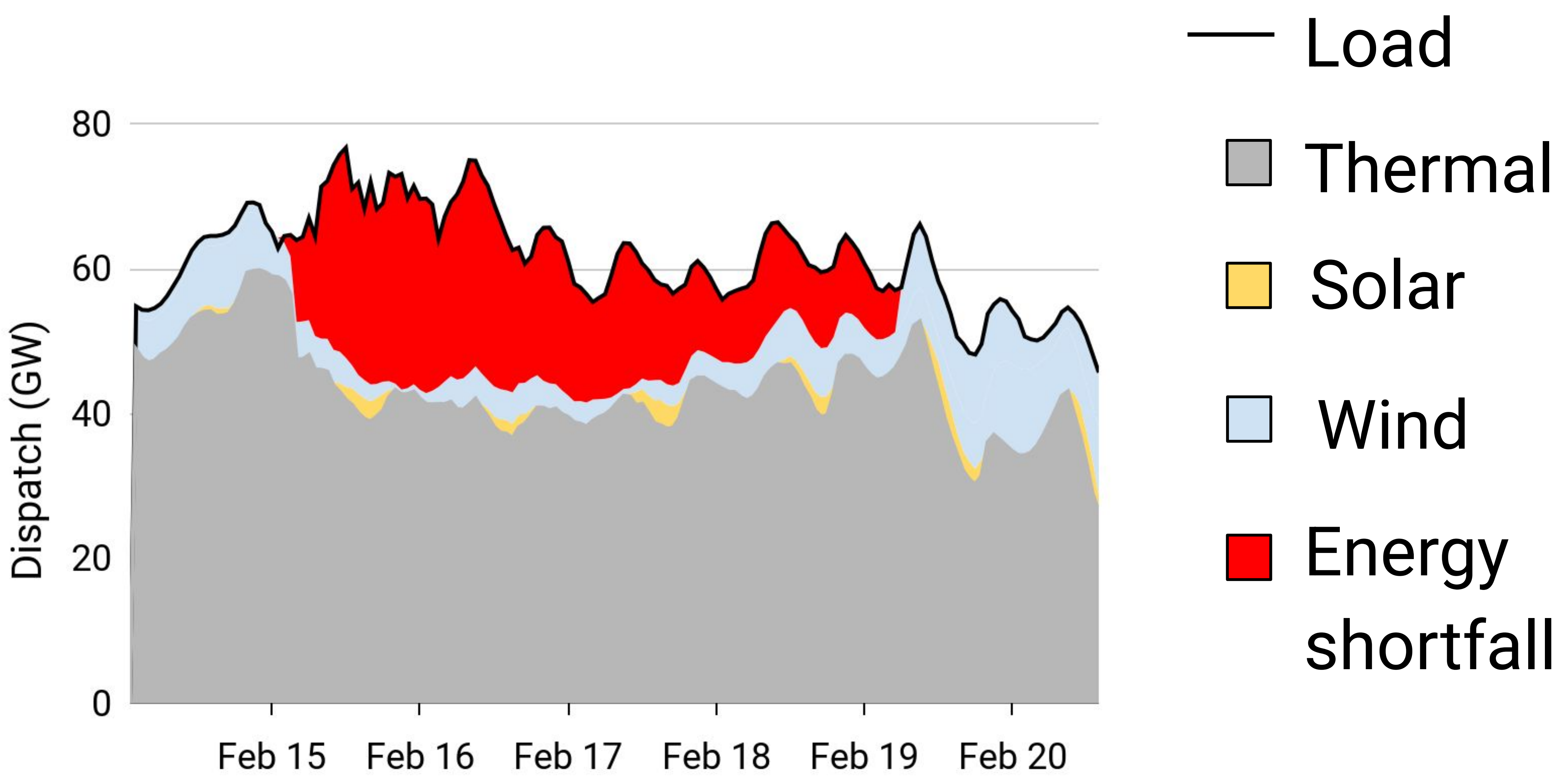
Extreme weather events are increasing

More than 10x more billion-dollar storms since 2000[1]



Extreme weather-related energy shortfalls last multiple days

ERCOT energy shortfalls during Winter Storm Uri[2]

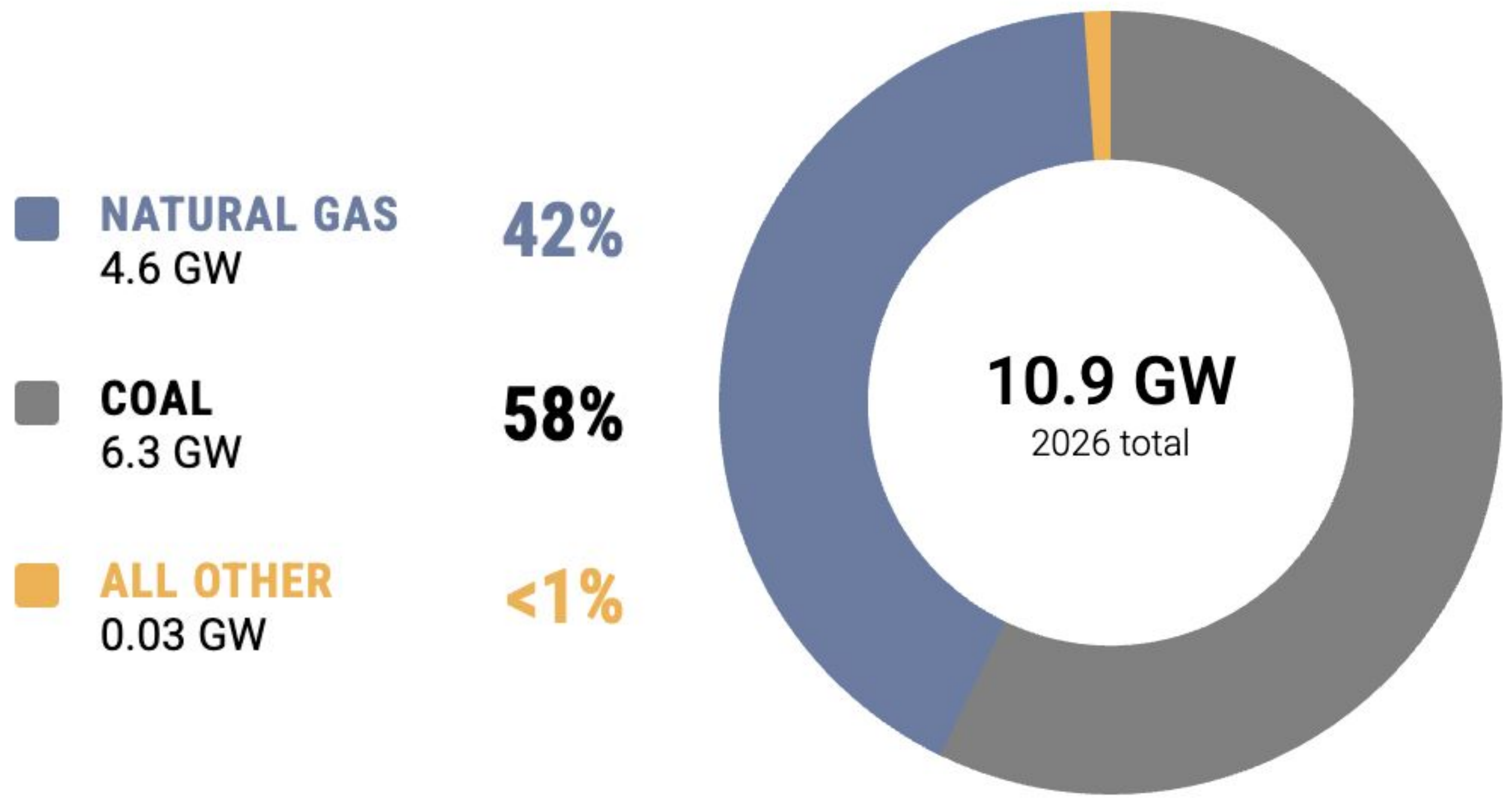


Source: 1) NOAA, 2024, 2) Historical ERCOT operational data during Winter Storm Uri from EIA-930

Thermal assets are retiring at a higher rate

Thermal resources - which have historically been used for reliability - are retiring

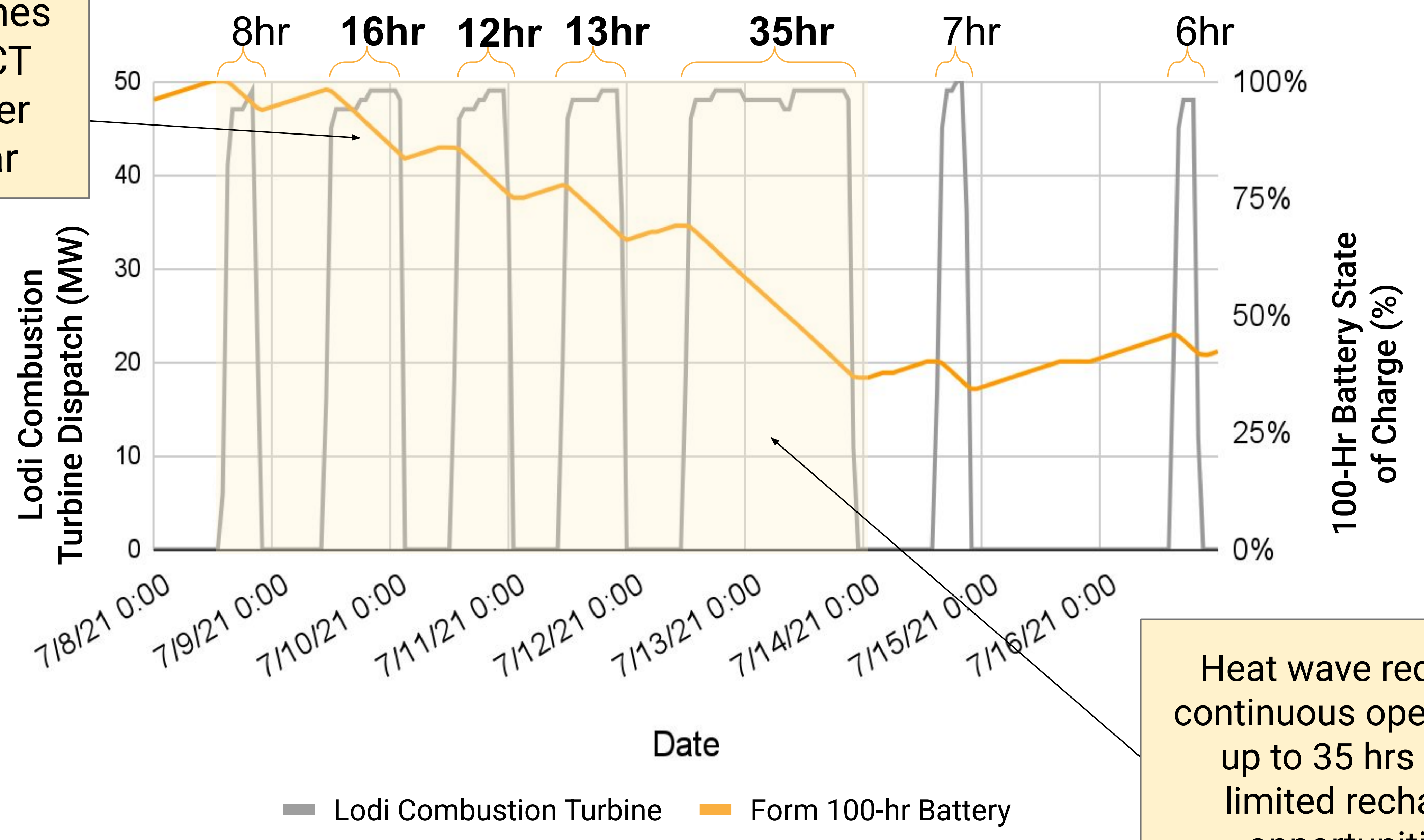
U.S. planned utility-scale electric generating capacity retirements (2026)



As more thermal assets retire, resources offering similar reliability benefits will be needed

State of charge of a 50 MW, 100-hour Form battery system replicating the dispatch of a 50 MW gas combustion turbine in CA

Multi-day storage dispatch matches 100% of gas-CT generation over the entire year



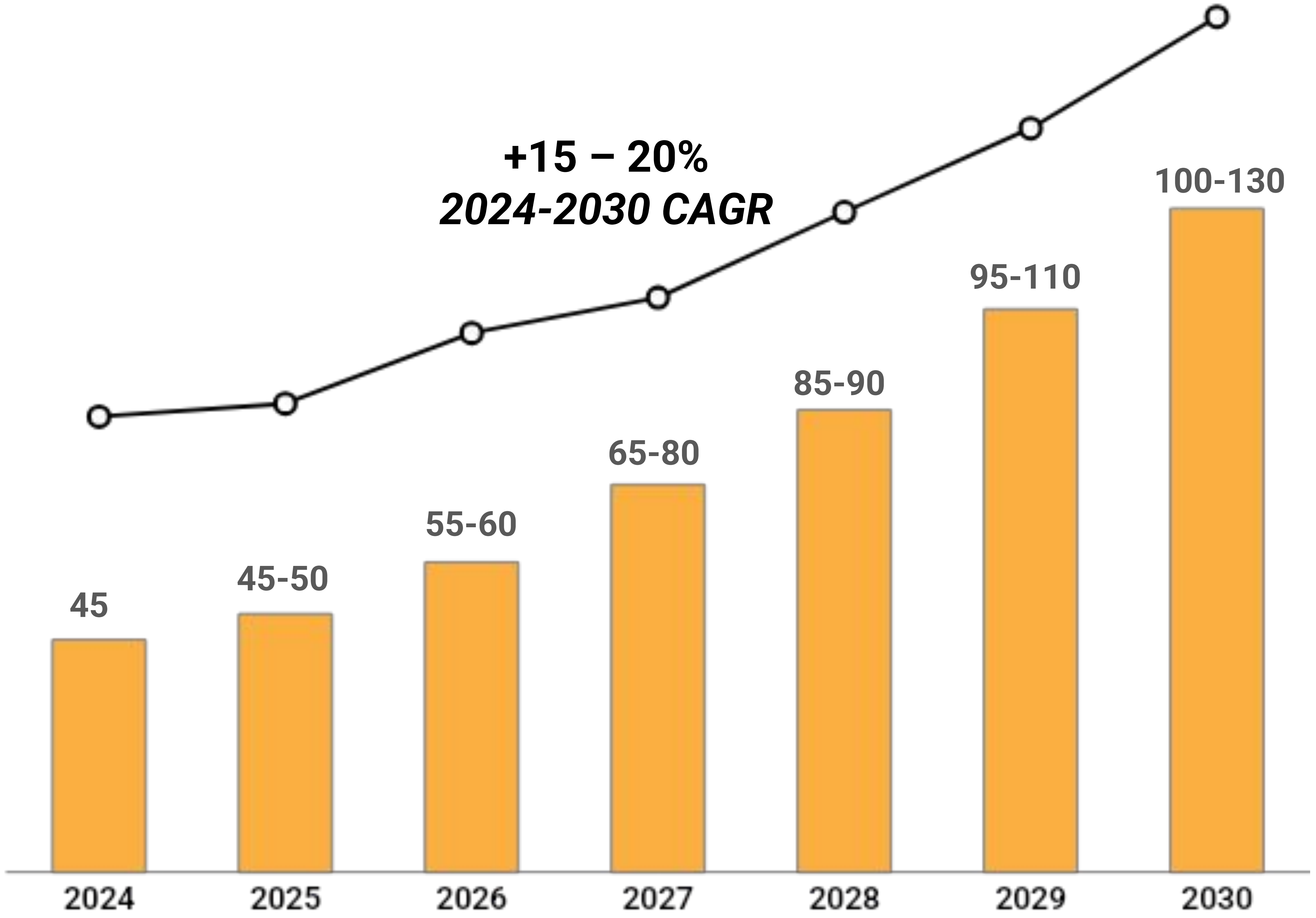
Heat wave requires continuous operations up to 35 hrs with limited recharge opportunities

Source: Energy Information Administration, 2026 (link); Formware^{TM} modeling of an iron-air battery matching historical generation of the Lodi CT2 generator in California.

AI data center demand is driving exponential load growth, further stretching the grid’s capacity

Data center demand is ushering historic load growth

Projected total U.S. data center power demand (GW) (1)



Data centers are the primary driver of U.S. load growth

Share of projected total U.S. energy demand growth, 2024 – 2030 (TWh) (1)

62% ● **Data center growth** *(cloud computing, big data analytics, AI and machine learning)*

15% ● **Electrification of transport** *(electric cars, buses, commercial vehicles, public transport)*

7% ● **Electrification of buildings** *(electric air and water heating systems, smart building technologies)*

1% ● **Electrification of industry** *(electric arc furnaces, industrial heat pumps, electrified chemical production)*

14% ● **Other factors** *(economic growth, automated agriculture, hydrogen production, etc.)*

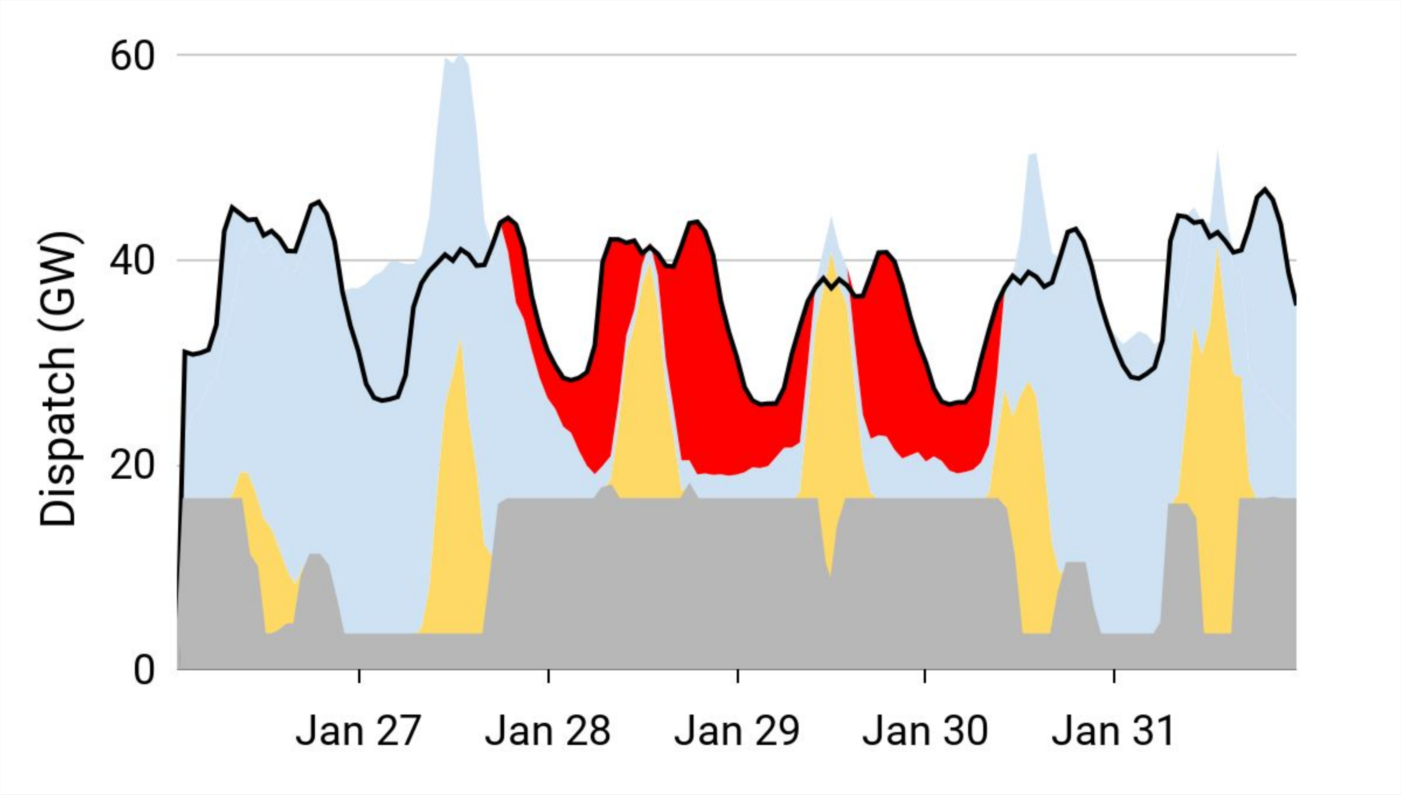
Source: (1) Boston Consulting Group, “US Data Center Power Outlook”, 2024.

THE OPPORTUNITY

The grid is vulnerable to multi-day reliability risks

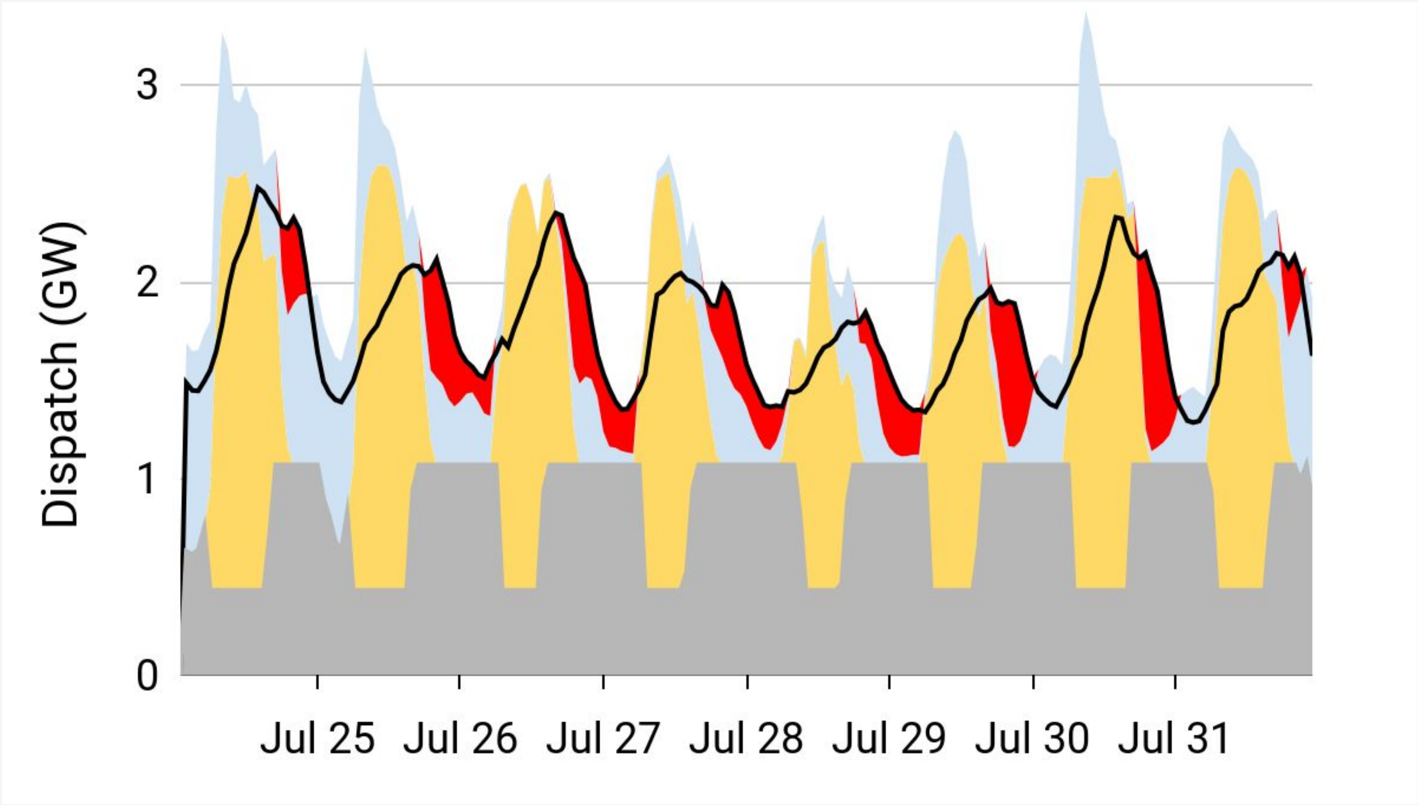
Examples

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



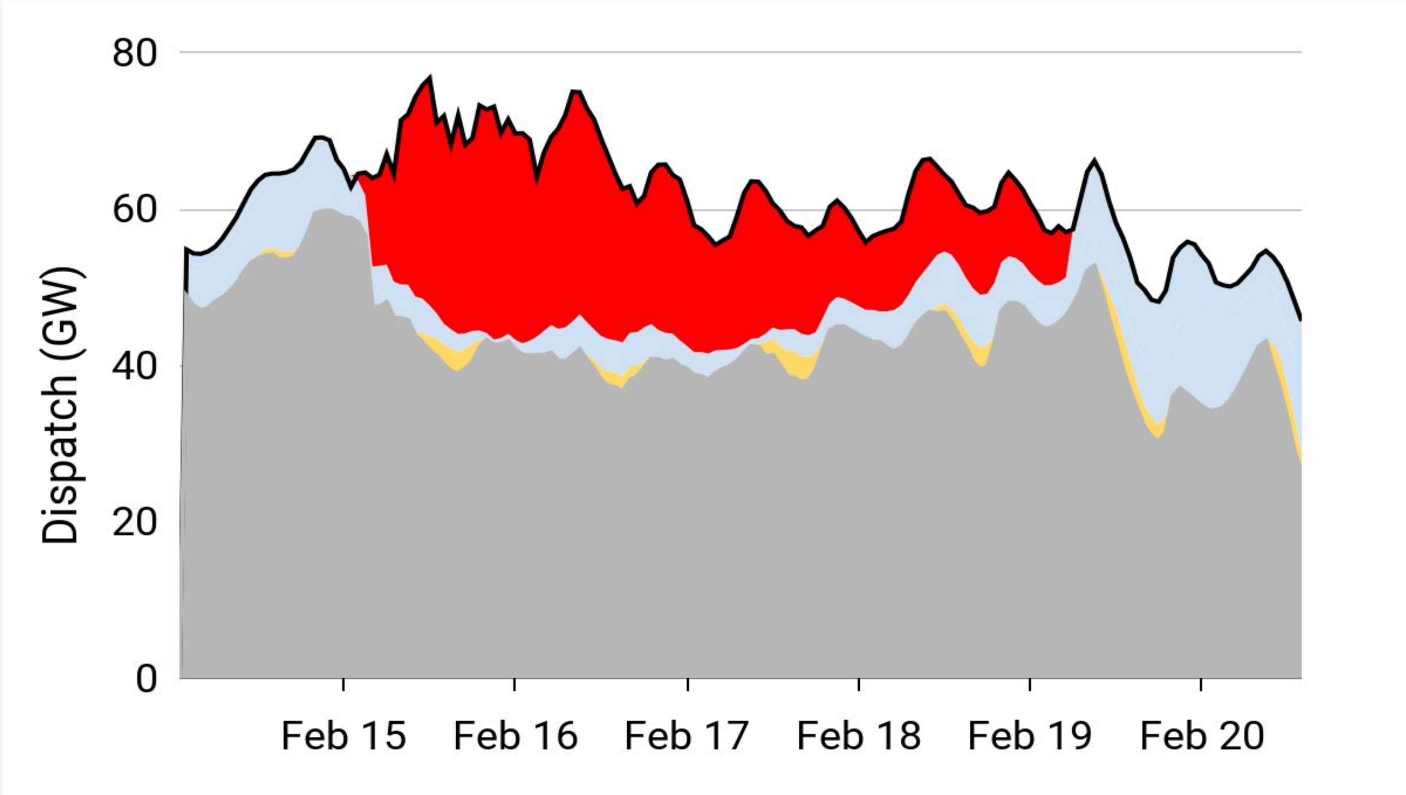
ISO-NE winter wind lull (1)

Energy scarcity for multiple 24-hour periods



WECC summer week (2)

Extreme weather events over several days



ERCOT Winter Storm Uri (3)

Challenges

Multi-day wind lulls and winter storms (fuel scarcity + demand surge) causing outages for 24+ hour periods

Multi-day heat waves + low solar creating reliability risks during peak hours when short-duration batteries can't fully recharge

Severe storms causing multi-day grid failures due to gas/coal outages and low renewable generation

— Load 🟥 Energy shortfall to be solved by Multi-day Storage ☐ Wind 🟨 Solar ▨ Coal & Gas

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[1] Full study available at Wilson *et al.*, "Clean, Reliable, Affordable: The Value of Multi-Day Storage in New England," September 2023.

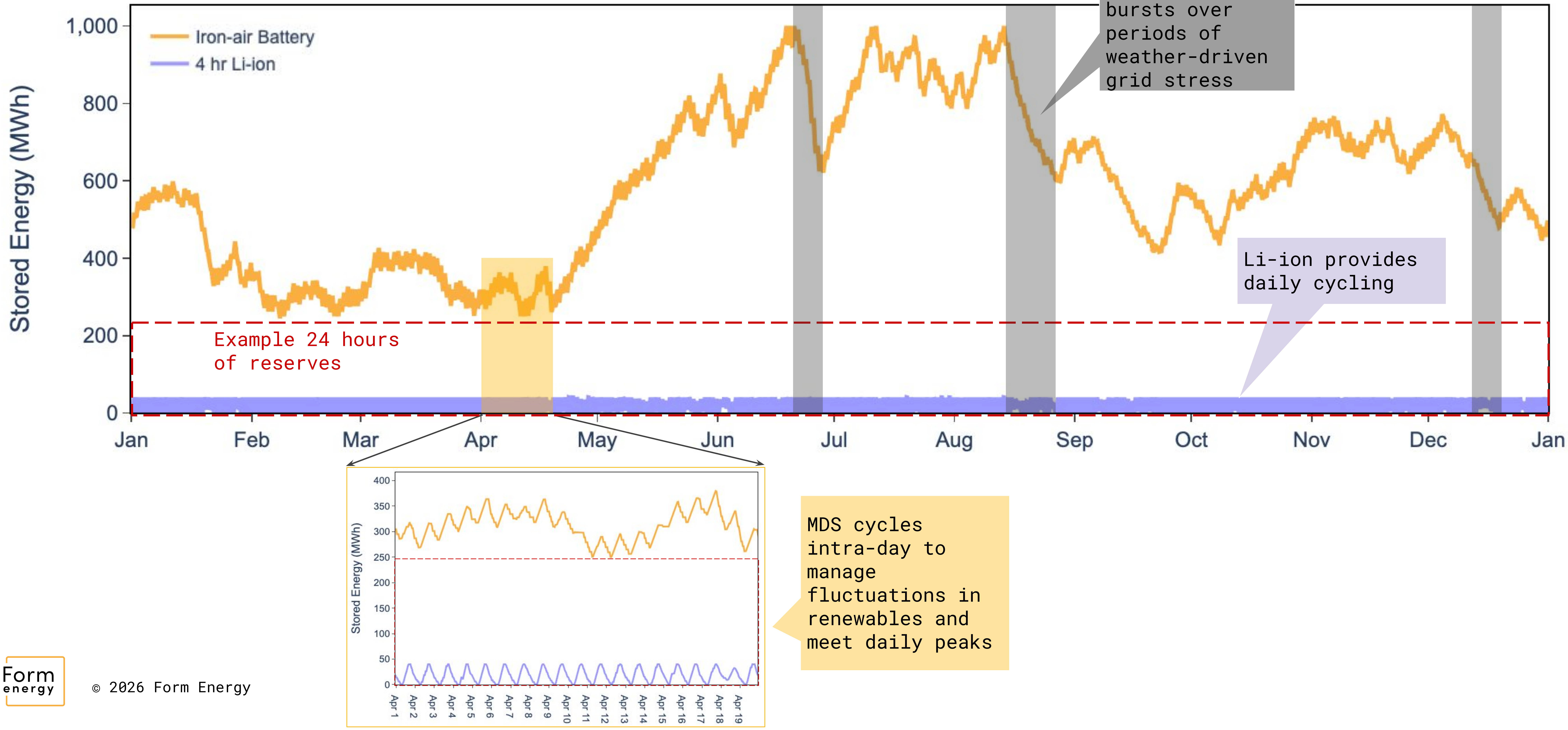
[2] Operational simulation in Formware^{TM} of 2035 WECC utility portfolio

[3] Historical ERCOT operational data during Winter Storm Uri from EIA-930

Multi-day storage acts as an energy reservoir for the grid on an hourly, multi-day, and seasonal basis, while also providing reserves

Stored Energy in Two Representative 10-MW Storage Systems

CAISO Example: MDS Providing 24-hr Reserves



MDS discharges in 24+ hour bursts over periods of weather-driven grid stress

Li-ion provides daily cycling

Example 24 hours of reserves

MDS cycles intra-day to manage fluctuations in renewables and meet daily peaks

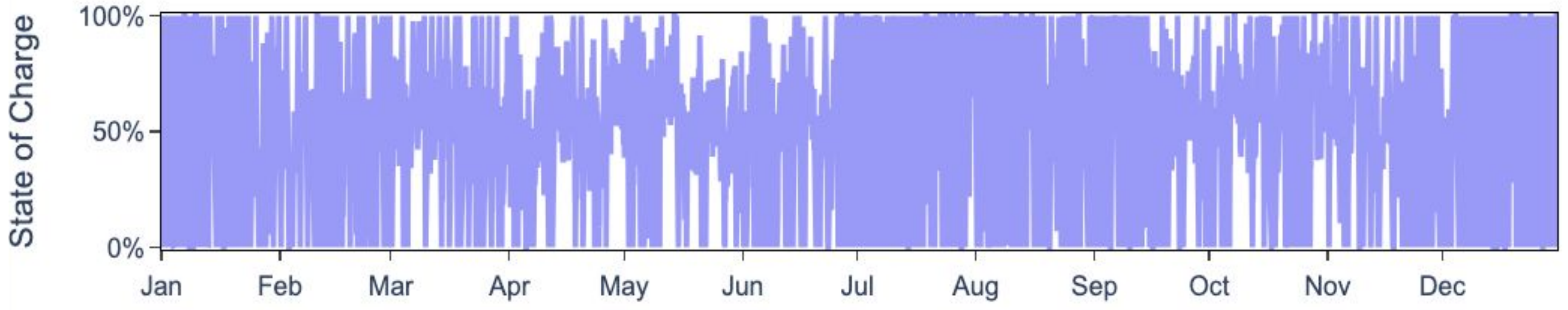
Multi-day storage and shorter duration technologies are designed to play distinct, complementary roles on the grid

Short-duration storage operations

Shifts energy from low-value to high-value periods **within each day**, i.e. high-efficiency diurnal cycling

~365 cycles per year (1,400 hours of discharge)

Example annual operations: 4 hour Li-ion battery

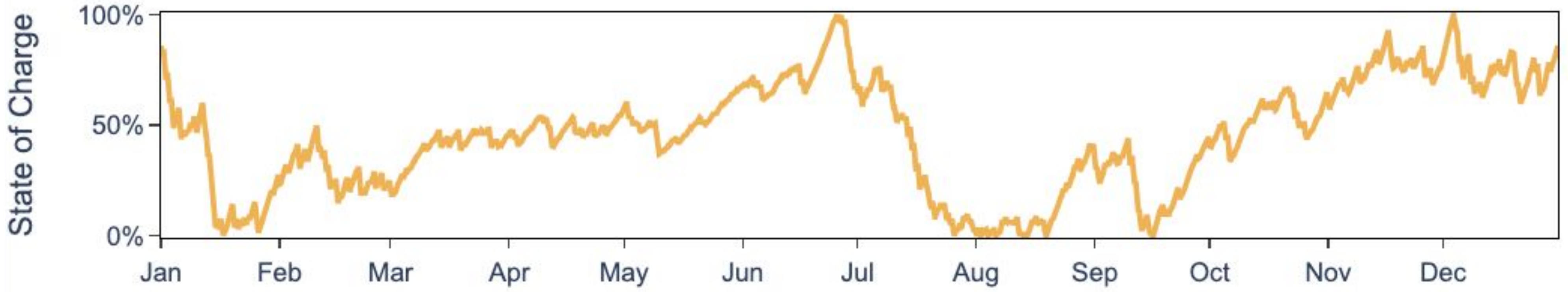


Multi-day storage operations

Shifts energy from low-value to high-value periods **across days, weeks, months, and seasons**

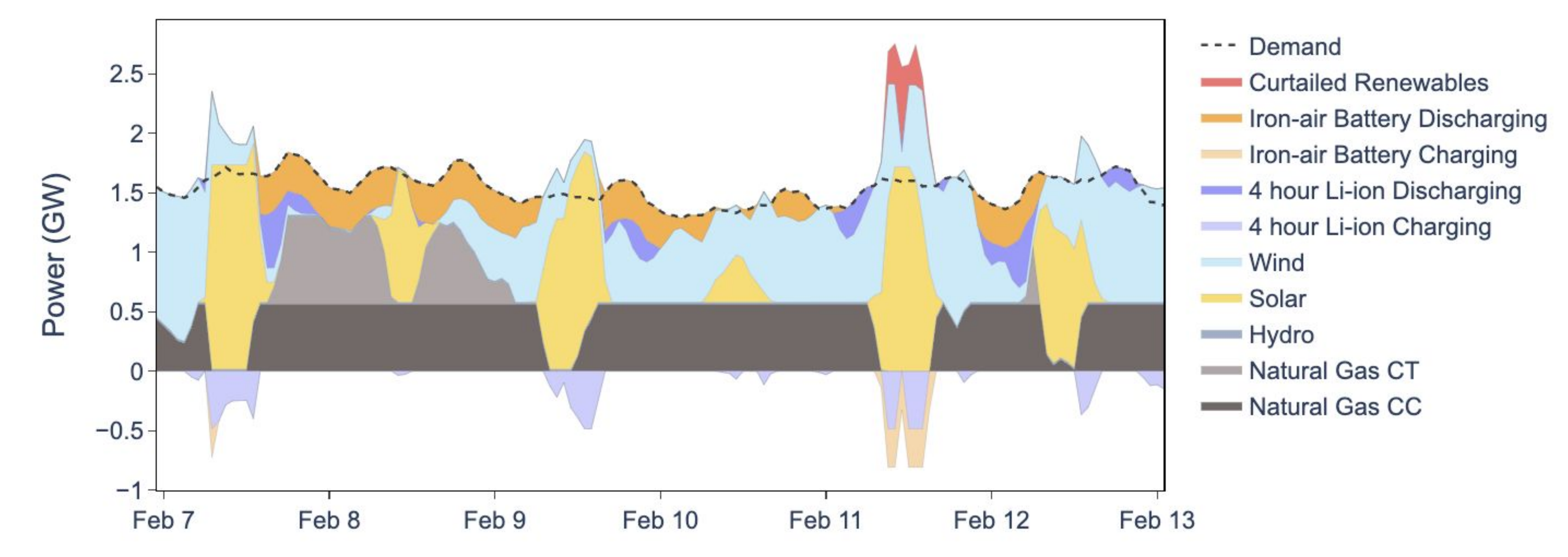
~8-13 cycles per year (800-1,300 hours of discharge)

Example annual operations: 100 hour iron-air battery



Complementary roles in maintaining reliability

Example: Winter week operations in MISO utility



Delivers **2-4 hour bursts of peaking capacity**, recharging during off-peak hours

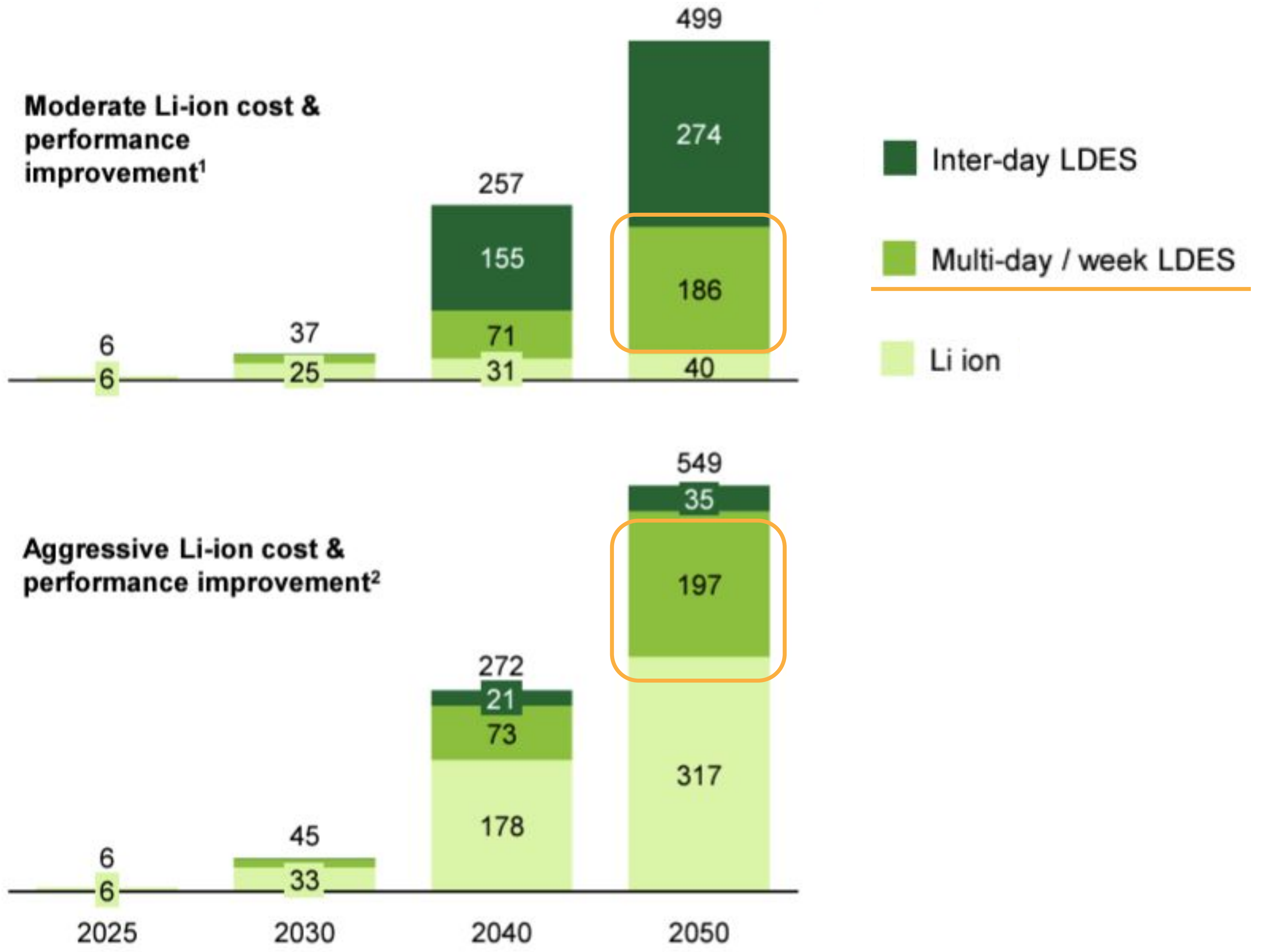
Delivers **firm energy over prolonged grid stress periods**, without having to recharge each day

Needs for Multi-Day Storage & Long-Duration Storage Nationally

From 2030 to 2050, 26-35% of total US storage needs will be from multi-day storage (DOE)

- **DOE Definitions**
  - *Inter-day LDES: 10-36 hrs*
  - *Multi-day LDES; >36-hrs*
- **2040-2050 US storage needs**
  - *88-92% is LDES in base case*
  - *34-42% is LDES in low li-ion cost case*
  - *Multi-day storage will comprise 28% to 37% of national storage needs from 2040-2050*
    - Needs are constant regardless of li-ion price sensitivity

DOE National Storage Capacity Scenarios (GW)



*DOE Pathways to Liftoff LDES report, p. 17

Policy drivers: 700GWh of state procurement with strong accreditation

~4 GW of Multi-Day Storage Carve-Outs

Virginia

1 GW MDS by 2035

+**1 GW** MDS by 2045

California

1 GW

MDS by 2031

Massachusetts

750 MW

MDS by 2030

>3 GW of Additional LDES Carve-Outs

New York

600 MW

8+ hr by 2030

California

1 GW 12+ hr by 2031

1.5 GW 8 hr by 2032

Rhode Island

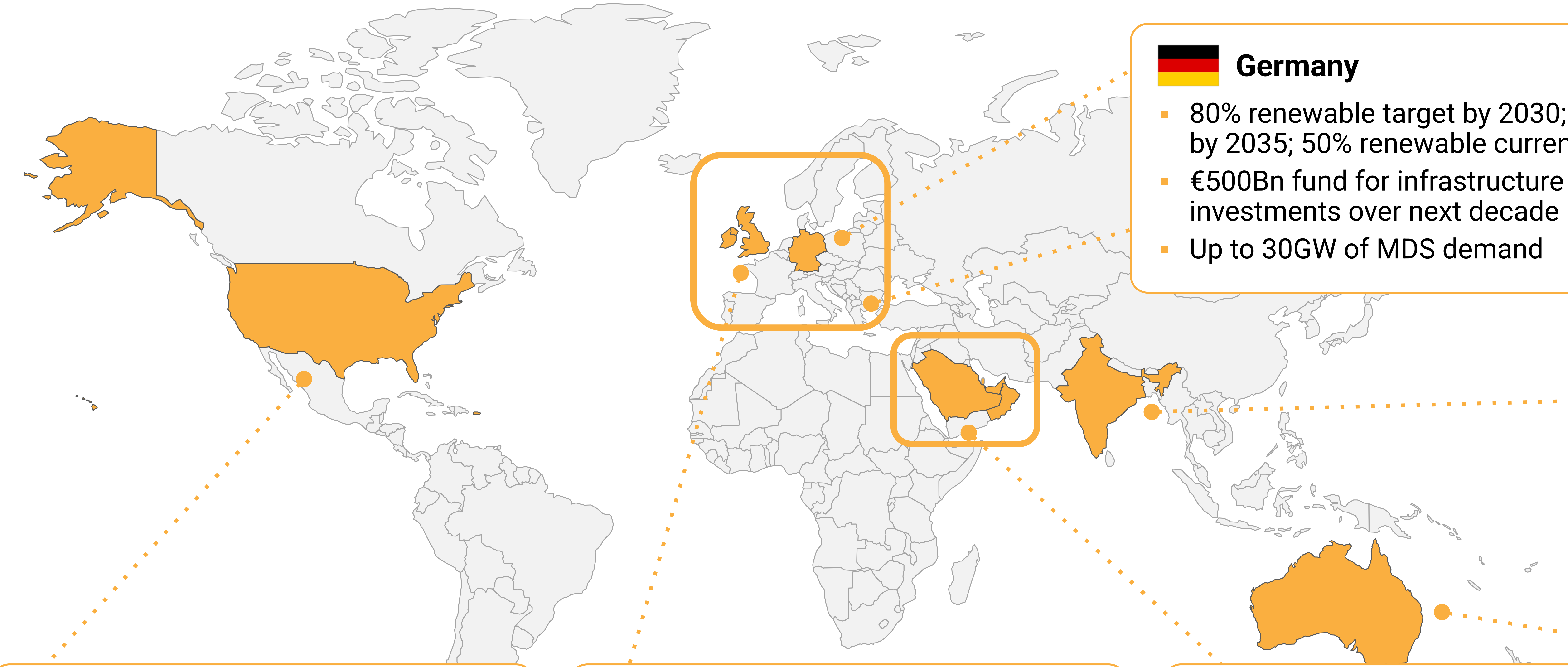
Portion of 600 MW

“LDES capable of displacing fossil fuel”

Utility / Agency	Storage Accreditation		
	100-hr	8-10 hr	4-hr
Portland General Electric	99%	44%	31%
PSE PUGET SOUND ENERGY	85%	-	25%
Platte River Power Authority	91%	76%	44%
Northwest Power and Conservation Council	100%	-	62%
SPP Southwest Power Pool	Pending	75%	47%
MISO	Pending	-	61%*
pjm	Pending	62-72%	50%
ISO new england	100%*	~50%*	~15%*

*Draft study results

Global policies creating strong demand for LDES internationally



Germany

- 80% renewable target by 2030; 100% by 2035; 50% renewable currently
- €500Bn fund for infrastructure investments over next decade
- Up to 30GW of MDS demand

European Union

- 90% GHG reduction target for 2040 to be legally endorsed
- Energy security (reduced reliance on imported gas), affordability and decarbonization are top priorities

India

- 50% renewables target by 2030
- 100 GW peak demand increase in last 10 years, 15% y/y growth in ’24
- Estimated total storage needs of 74 GW by 2031-32

United States

- >50% of U.S. states have 100% clean energy standards
- Domestic manufacturing incentives for clean energy technologies

UK & Ireland

- 95% and 80% carbon-free energy target in U.K. & Ireland, by 2030
- U.K. launching LDES auction with a Cap & Floor mechanism in 2025
- >10GW modeled demand by 2030

Middle East

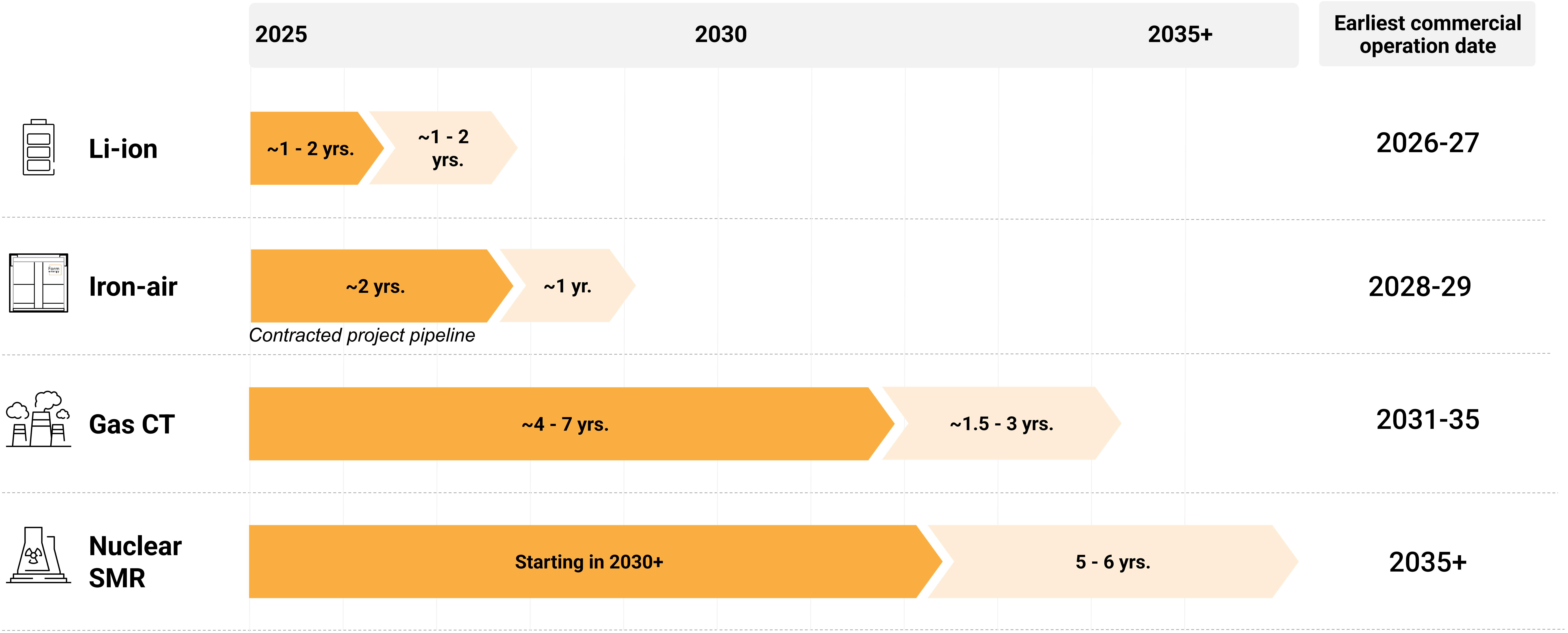
- 50% renewable by 2030 in Saudi Arabia and 50% by 2050 in UAE
- $100Bn renewables investment by 2030 in Saudi Arabia
- Exploring LDES deployments

Australia

- 82% renewable target by 2030
- Aging thermal generation, aiming for 9 GW of clean dispatchable capacity
- National Battery Strategy offers $500MM for domestic manufacturing

Form unlocks a fast, low-cost path to firm power

Forecasted deployment timelines by technology



	Manufacturing Lead Times	Installation	Earliest commercial operation date
Li-ion	~1 - 2 yrs.	~1 - 2 yrs.	2026-27
Iron-air	~2 yrs.	~1 yr.	2028-29
Gas CT	~4 - 7 yrs.	~1.5 - 3 yrs.	2031-35
Nuclear SMR	Starting in 2030+	5 - 6 yrs.	2035+

Contracted project pipeline

What would encourage deployment of multi-day energy storage?

PLANNING	Include MDS / LDES resources as options in utility modeling; model them correctly
RELIABILITY	Consider extended time frames of grid stress events in Resource Adequacy constructs, and consider resource interactions; accredit MDS resources
PROGRAM DESIGN	Consider duration (energy) in addition to capacity in energy storage programs
DEPLOYMENT	Use technology-inclusive RFPs; ensure appropriate market signals for needed services
UTILITY ENGAGEMENT	Utilities gaining knowledge of, experience with, and influence over beneficial new technologies

THANK YOU!

Form energy

Energy Storage for
a Better World