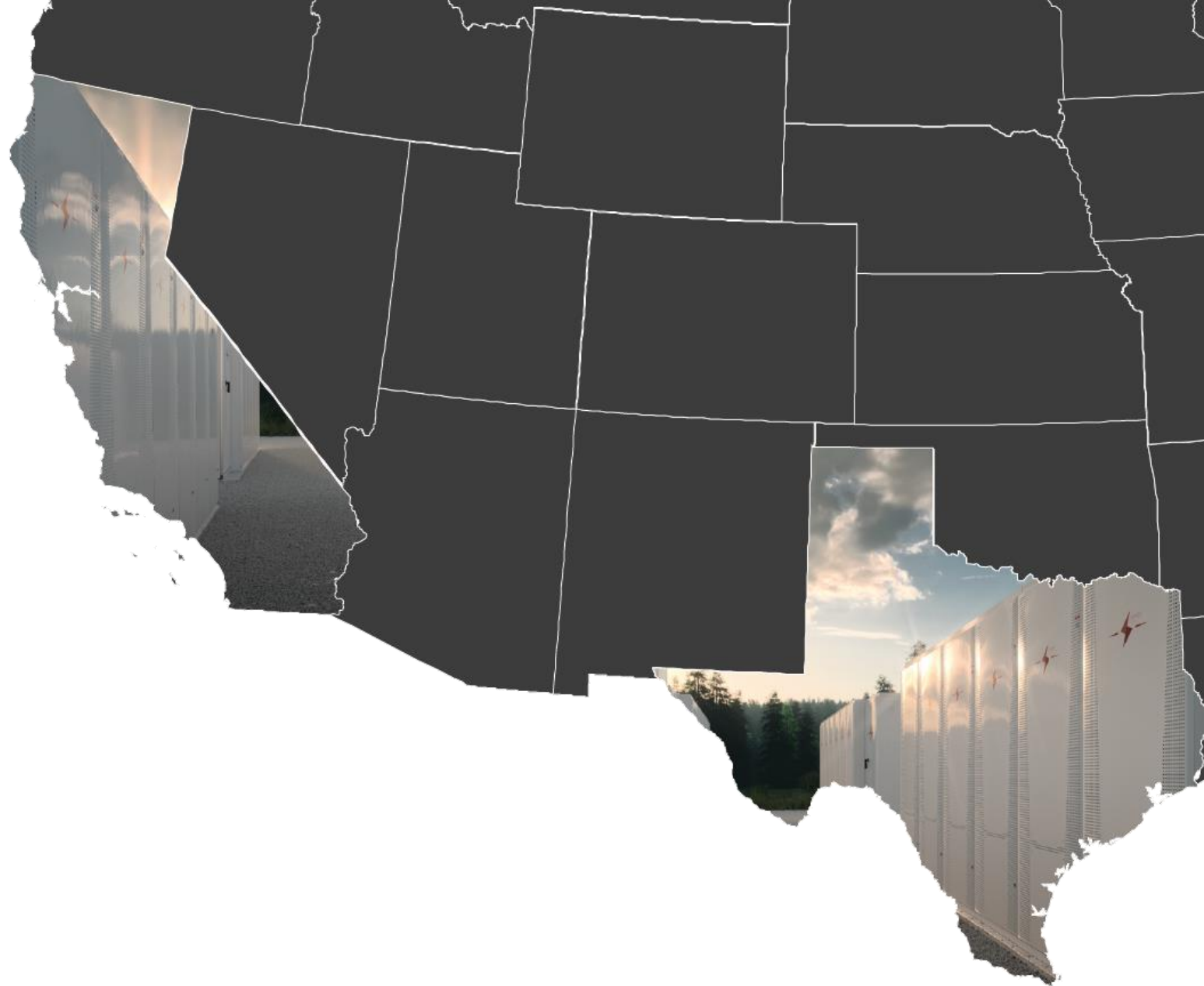


# Battery economics in CAISO & ERCOT

## Redacted Report



# Aurora provides data-driven intelligence for the global energy transformation

A U R  R A

Power markets



Renewables



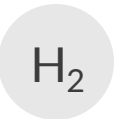
Storage



Electric vehicles



Hydrogen



Carbon



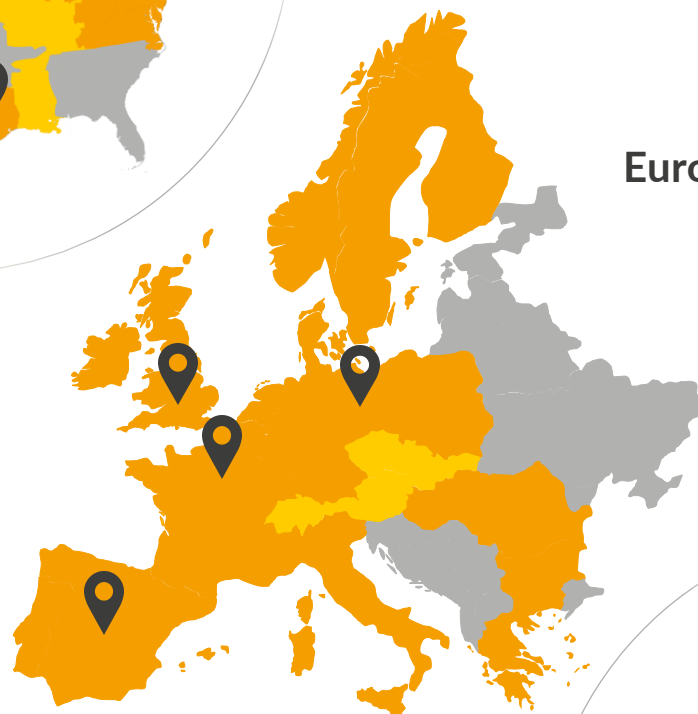
Natural gas



United States



Europe



Australia



 Regular detailed coverage  Analytics on demand



**7 Offices**

Oxford | Berlin | Madrid | Paris  
Sydney | Austin | SF Bay Area



**300+**

market experts, 35+ in the US



**550+**

subscribing companies



**120+**

transactions supported in 2021

# Aurora brings a sophisticated approach to the provision of analysis and insight to the energy industry

## Research & Publications

- Industry-standard market outlook reports and bankable price forecasts for power, gas, carbon and hydrogen markets
- Strategic insights into major policy questions and new business models
- Read and constantly challenged by 350+ subscribers from all industry sectors

## Commissioned Projects

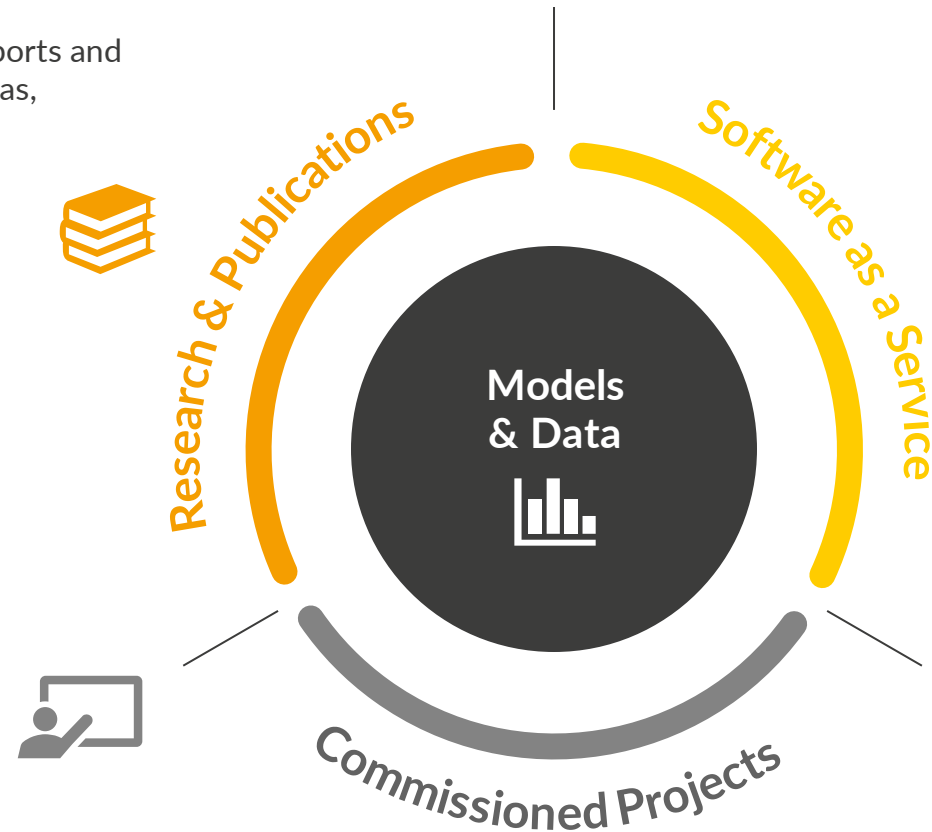
- Bespoke analysis, drawing upon our models and data
- Trusted advice for all major market participants proven in 500+ projects: transaction support, valuations, strategy & policy engagement

## Software as a Service

- Out-of-the-box SaaS solutions, combining cutting-edge sophistication with unparalleled ease of use
- **Origin** provides cloud-based access to Aurora's market model, pre-populated with our data
- **Amun** automates asset-specific wind farm valuations for over 30 leading funds, developers and utilities

## Models & Data

- Market-leading long-term models for power, gas, hydrogen carbon, oil and coal markets
- Continuous model improvements to reflect policy and market developments



- I. Modeling approach
- II. Battery storage in CAISO
- III. Battery storage in ERCOT

# Modeling storage is complex. Aurora's forecasts have underpinned the deployment of over 3 GW of operational battery assets globally

## What is the challenge?

- Modelling a consistent set of day-ahead, real-time and Ancillary service prices accounting for opportunity costs
- Understanding and modelling detailed rules in AS markets, including responding to market changes
- Capturing the role of weather in driving scarcity and AS procurement – annual averages are irrelevant to storage economics, esp. as renewables penetration increases
- Dispatching assets against multiple price series accounting for imperfect foresight, degradation, warranties, route to market, and asset characteristics

Future of the market  
(*difficult to model*)

Future of the asset in the market  
(*easier to model*)

## How do we address it?

- ✓ Integrated modelling of capacity expansion, power pricing and asset dispatch
- ✓ Consistent prices across day ahead, real time, and ancillary services at the hourly + sub-hourly level
- ✓ Ability to model different business models, trading strategies, market scenarios, and weather sensitivities
- ✓ Dispatch based on imperfect foresight, with "percentage of perfect" value capture in line with real-world outcomes
- ✓ Nodal modelling based on detailed representation of grid and power flows rather than statistics for more accurate representation of locational value

## Example transactions

2017



Sell-side advisory for UKPR's 500+ MW portfolio of peakers and battery storage, sold to Sembcorp for £216m

2018



Banked by Santander on first project financing of battery storage in the UK for 100 MW Zenobe portfolio



Sell-side market advisory for then-largest operational battery storage portfolio in Europe, STEAG's 90 MW bid into the FCR market

2019



Supported Pivot Power on sale of company and 2GW portfolio to EDF



Supported PE fund on \$50m acquisition of storage developer; bidding support for large developer for DS3 auctions

2020



AUS \$50m in debt financing for 50MW extension of Neoen's Hornsdale battery – first battery project financing in Australia

2021

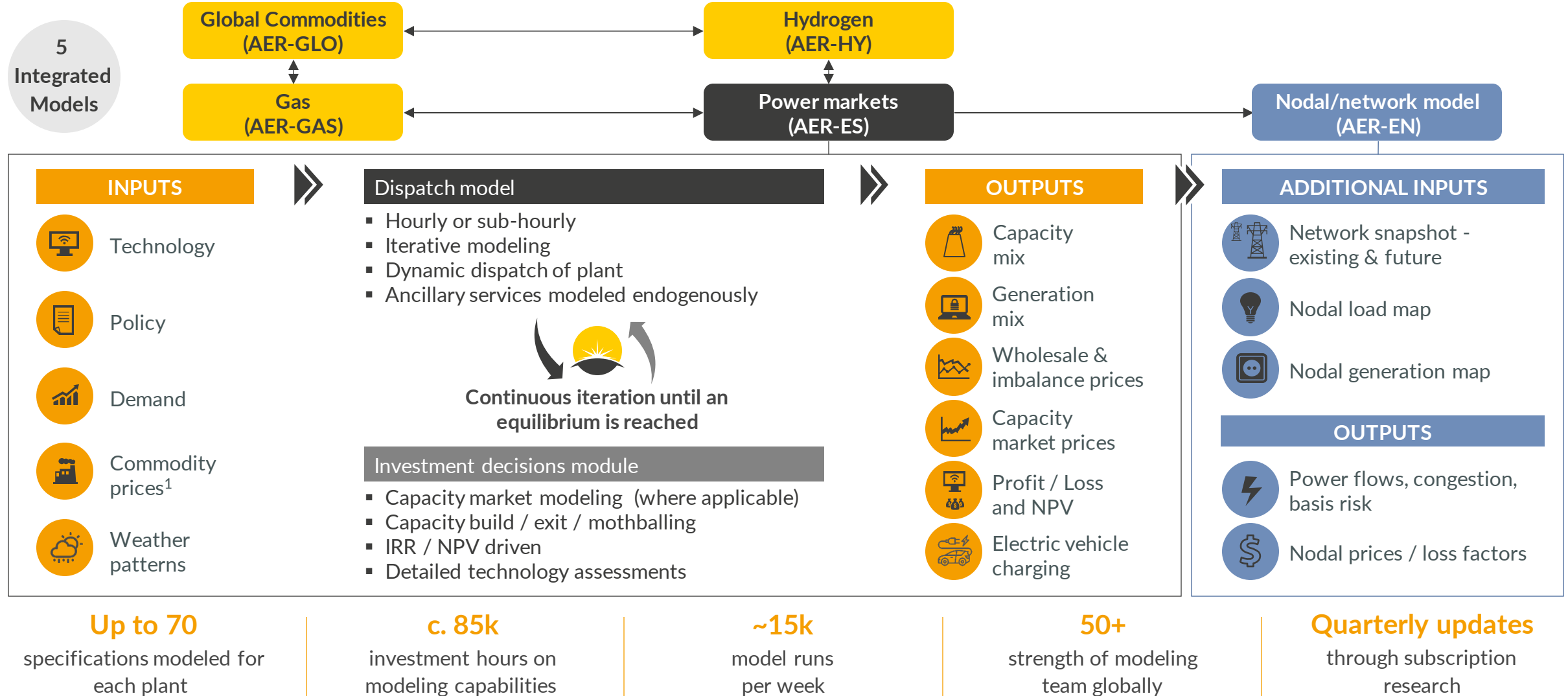


Sell-side advisory for successful sale of 400 MW of storage assets for Black Mountain to UBS Asset Management



Multiple buy- and sell-side storage transactions across ERCOT, CAISO and PJM totalling over 2.5 GW

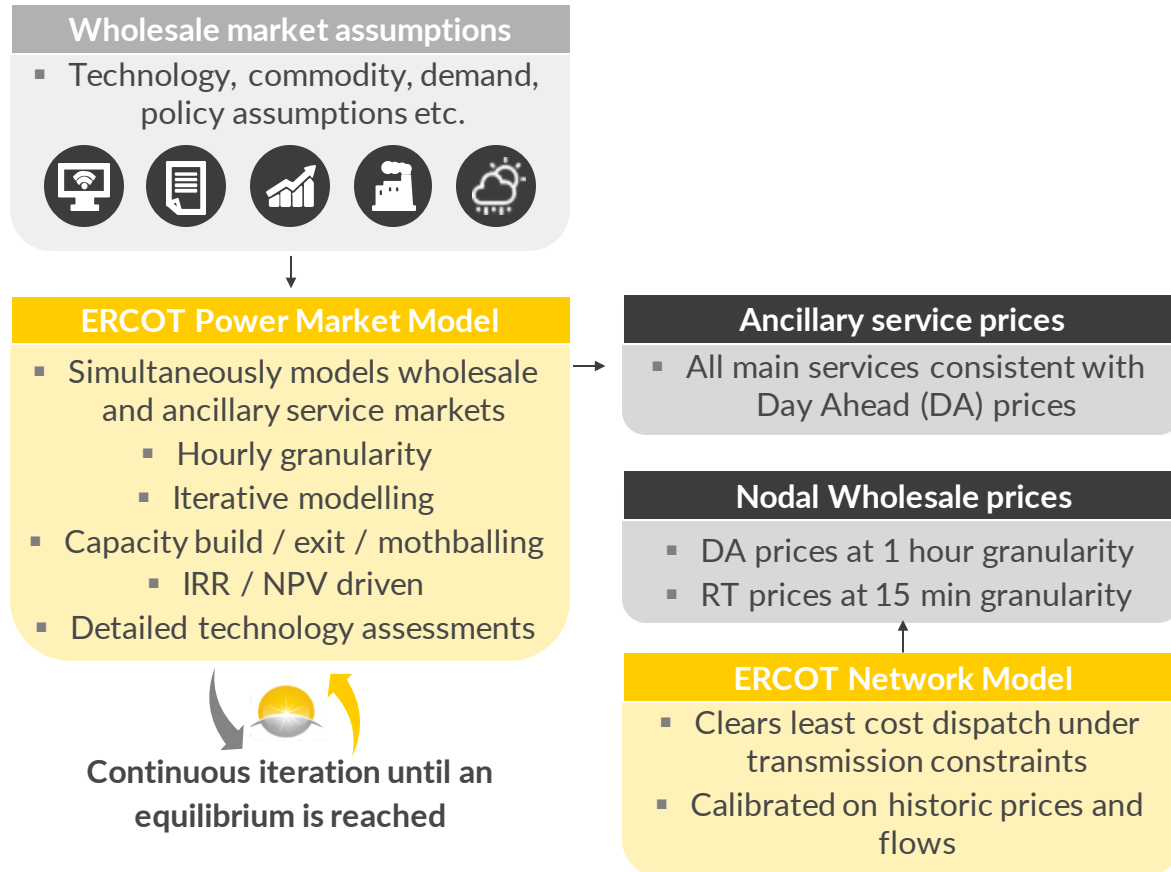
# Unique, proprietary, in-house modeling underpins Aurora's superior analysis, with integrated energy, ancillary, capacity, and power flow modeling



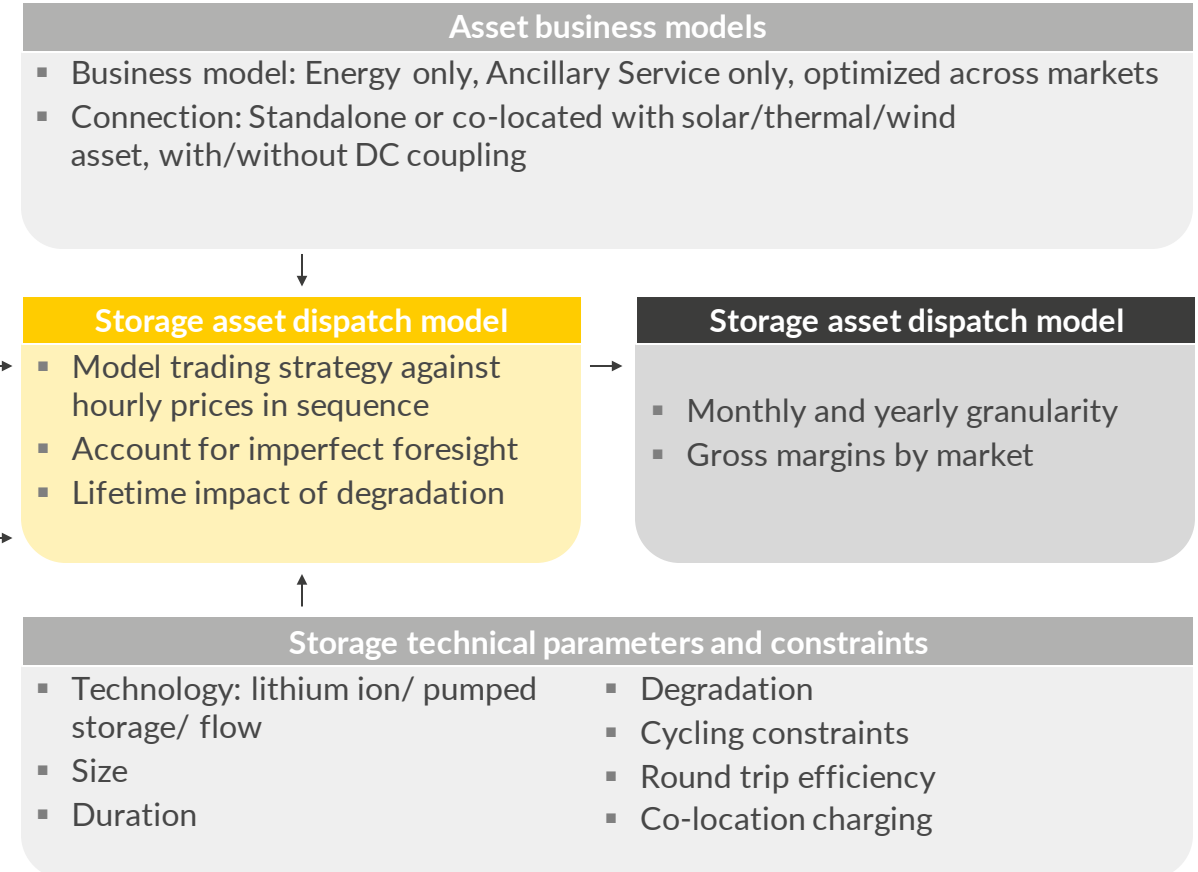
1) Gas, coal, oil and carbon prices fundamentally modeled in-house with fully integrated commodities and gas market model

# The battery dispatch model combines the outputs from the Aurora modelling suite into a consistent, nodal-calibrated, dispatch solution

## Step 1: Model consistent price series across markets



## Step 2: Model the battery asset dispatch



In-house model

Input

Output

# Agenda

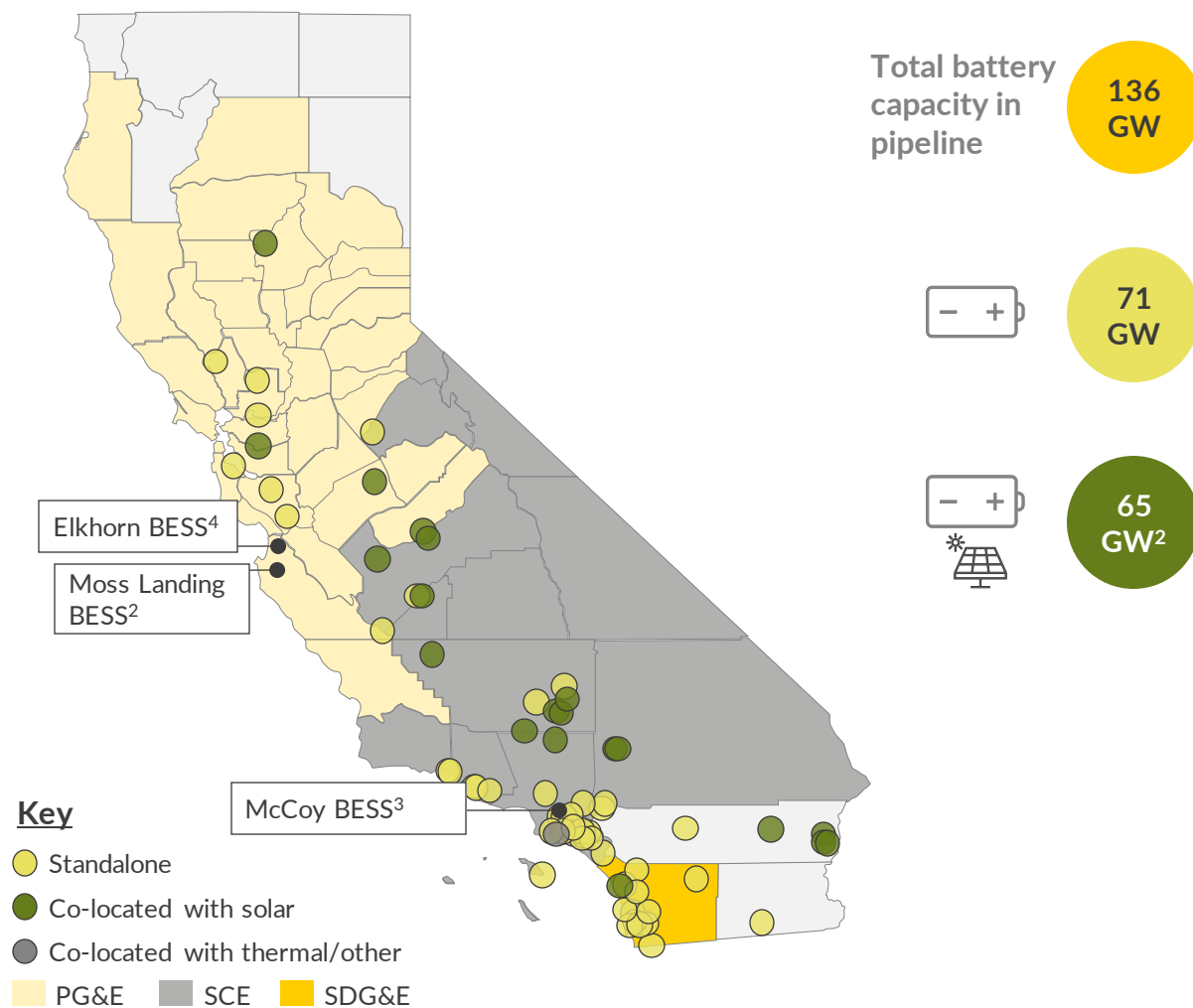
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- I. Modeling approach
- II. Battery storage in CAISO**
- III. Battery storage in ERCOT

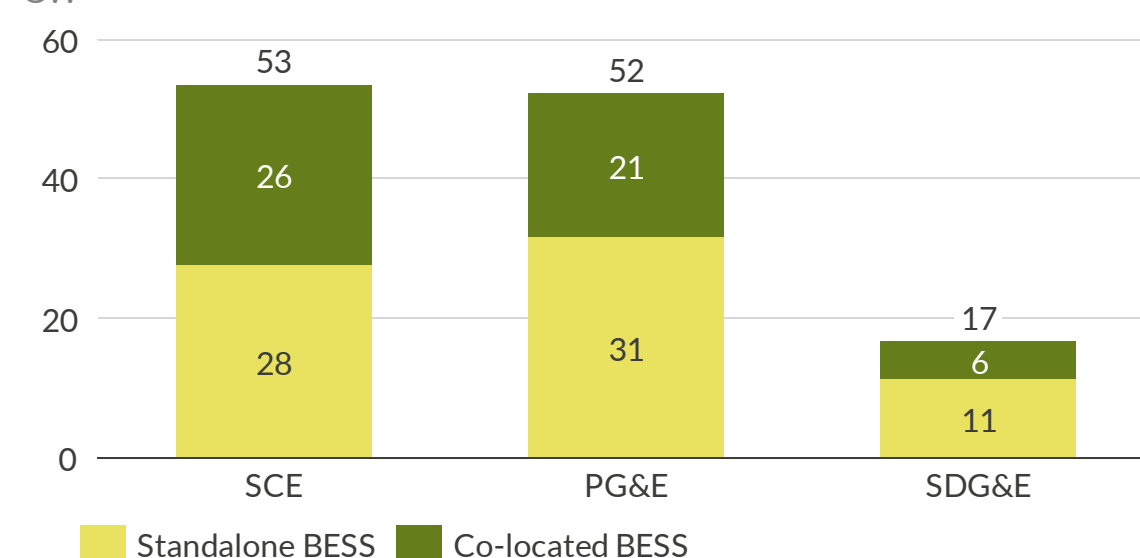


# CAISO has the largest installed battery capacity nationwide at ~3 GW and has 136 GW of prospective projects in the interconnection queue

Map of operational batteries in CAISO



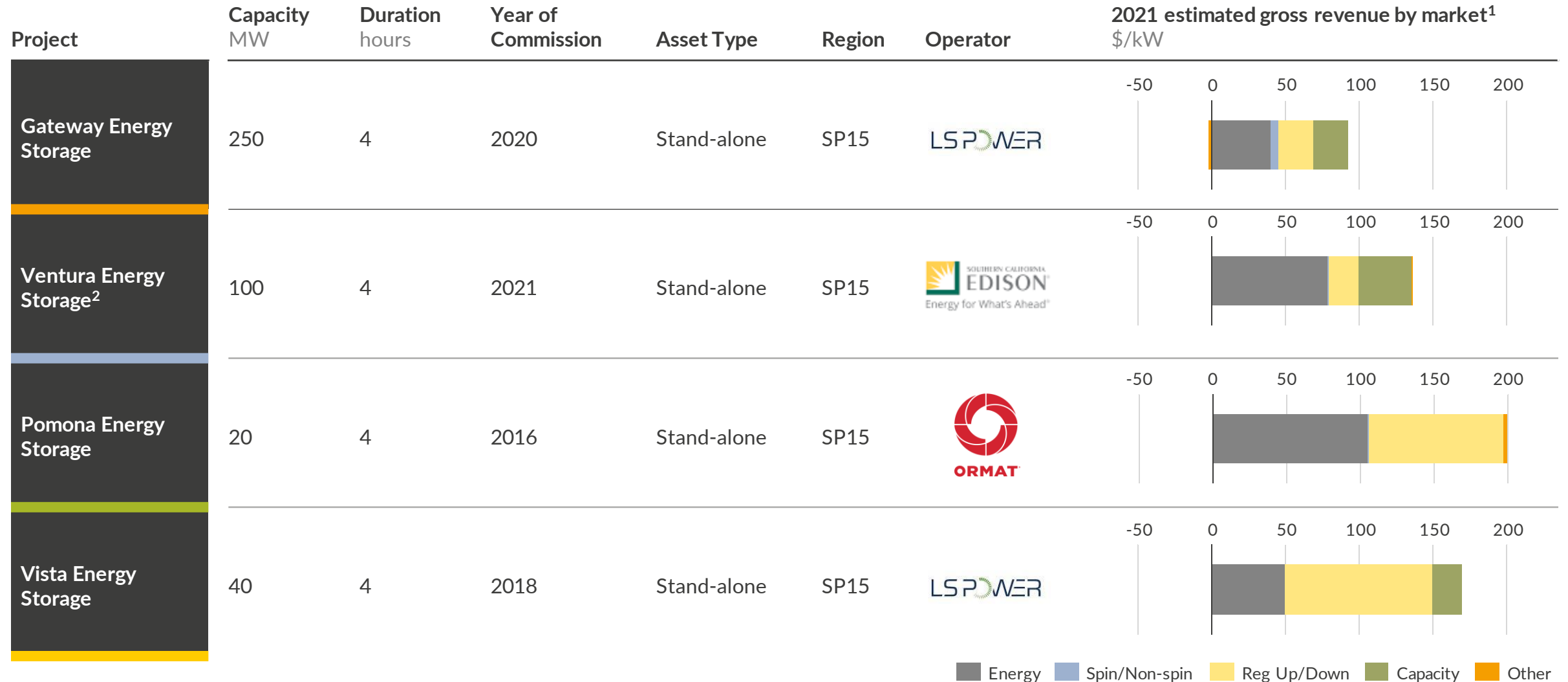
Total battery capacity in CAISO's generator interconnection queue<sup>1</sup>



- Currently, there is 1 GW of co-located and 2 GW of stand-alone storage capacity; in total these projects make up 11.6 GWh of energy storage volume
- Most stand-alone batteries are located in SP15, driven by energy prices in there being more volatile than in NP15 allowing for larger realized spreads
- More than 136 GW of battery storage projects are in the pipeline, 84 GW of which are located in southern California

1) Graph does not include interconnection applications for GLW, VEA, IID, DCRT, and DSLK utilities. 2) Moss Landing BESS is currently the world's biggest battery storage facility with 400 MW / 1,600 MWh capacity. 3) McCoy BESS is currently the second largest battery in California with 230 MW / 920 MWh capacity. 4) PG&E's Elkhorn battery, commissioned in June 2022 consists of 256 Tesla Megapacks and is the 3<sup>rd</sup> largest battery active in CAISO with 182.5 MW / 730 MWh capacity.

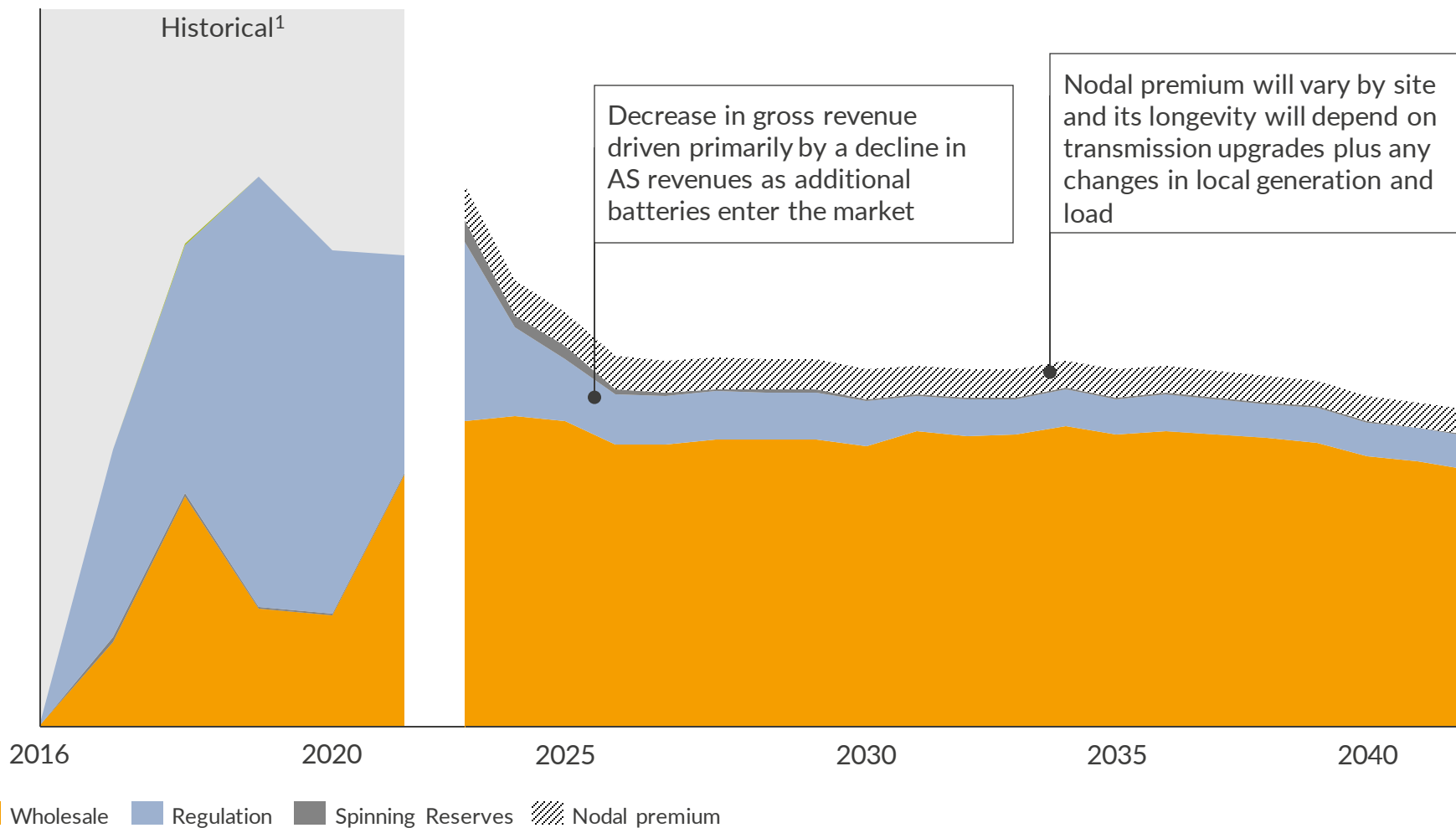
# These 4 projects illustrate the current operational use cases of batteries in CAISO



1) Other includes tolling energy, uplift, and other. 2) Ventura Energy Storage was commissioned in April 2021.

# Battery revenues are between \$120-220/kW/year over the forecast horizon as energy arbitrage becomes a larger portion of the total

Historic total annual revenue Pomona Energy Storage and forecasted 4-hour battery gross revenue in SP15  
\$/kW/year, real 2021



1) Includes nodal premium

## Outlook for battery gross margins

- Gross revenue for a 4-hour battery in SP15 declines from \$██████/kW/year between 2023-2025 to an average of \$██████/kW/year from 2030 onwards
- AS prices are expected to decline as the markets saturate with increased battery penetration
- In the long-term, revenue from wholesale arbitrage is expected to make up a larger proportion of a battery's gross margins, rising to ██████% by 2030
- Decreases in capex from 2023 onwards means assets become more economically viable with lower gross margins

# Regional differences are less impactful than duration and entry year decisions for asset profitability

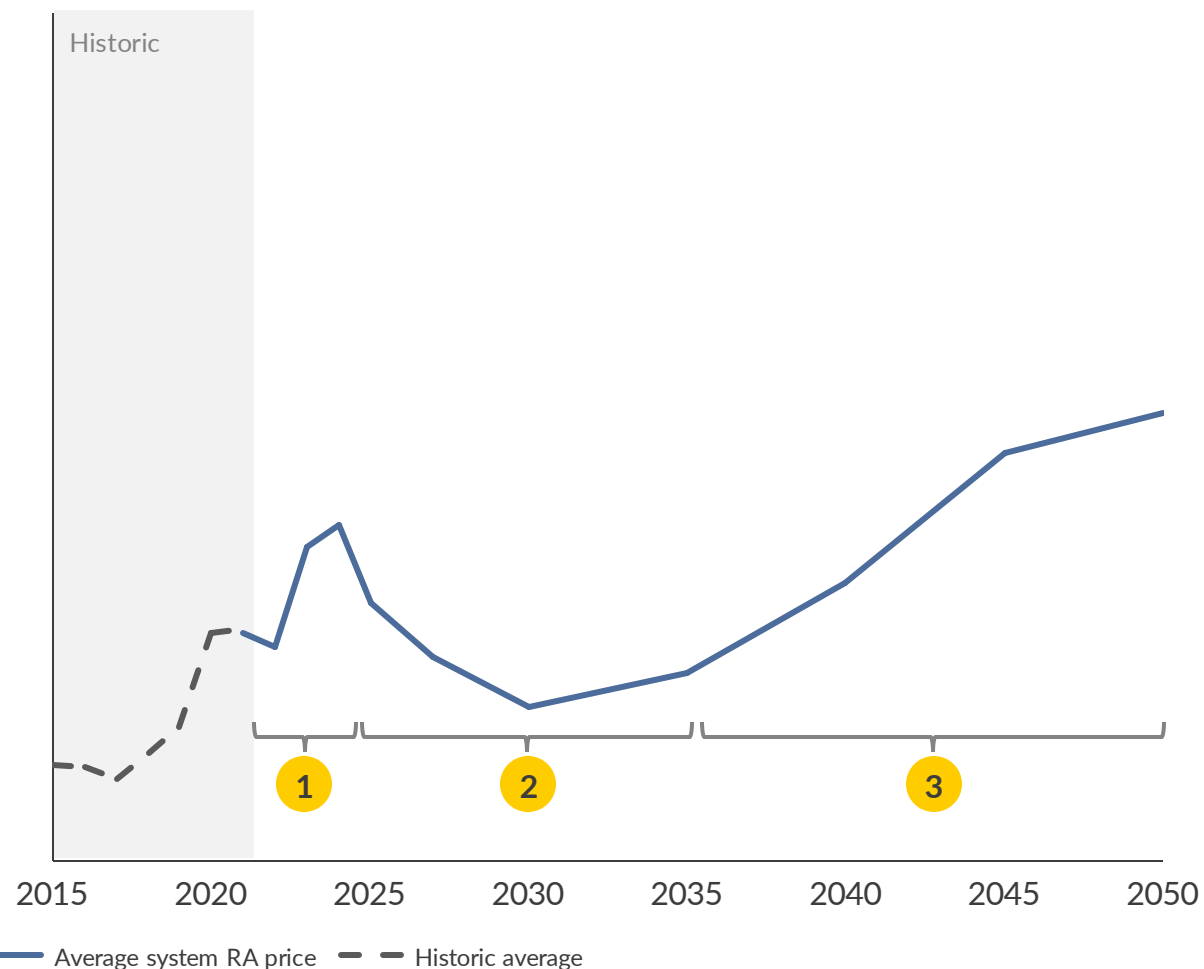
Evolving nodal upsides differentiate the regions and can cause their relative profitability to shift over time and between durations. 4-hour batteries remain the most profitable, and near-term declines in CAPEX will further accentuate short-duration profitability.

Entry Year	Scenario	Duration	Present Value of Margins <sup>1,2</sup> (\$/kW)			IRR (%)			Payback Period (yrs)		
			NP15	ZP26	SP15	NP15	ZP26	SP15	NP15	ZP26	SP15
2023	Central	4 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%
		6 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%
		8 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%
2026	Central	4 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%
		6 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%
		8 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%

1) Discount rate of 11%, and 15% for high price periods (>\$500/MWh for WM prices or \$200/MW/h for AS prices). Does not include OPEX. 2) Batteries receive the weighted average system RA price, irrespective of duration. Longer duration batteries may require premiums on RA to make project economics stack up.

# System RA prices will continue to be driven by batteries, setting prices between \$ █ /kW-month as ELCCs and other revenue streams fluctuate

Forecast weighted average system RA price<sup>1,2,3,4</sup>  
\$/kW-month, real 2021



1

RA prices increase significantly due to transmission connection delays and supply chain cost increases. Existing uncontracted plants are able to sign contracts to capture short-term RA payments at a premium

2

As short-term issues are relieved, RA prices are expected to see a gradual decline into the 2030s. This is driven by 1) lower premiums due to connection queue issues being relieved, and 2) continuous declines in battery CAPEX

3

Expectations of ELCCs for storage dropping to 55% by 2050 outweigh CAPEX reductions, putting upward pressure on RA prices in the long-term

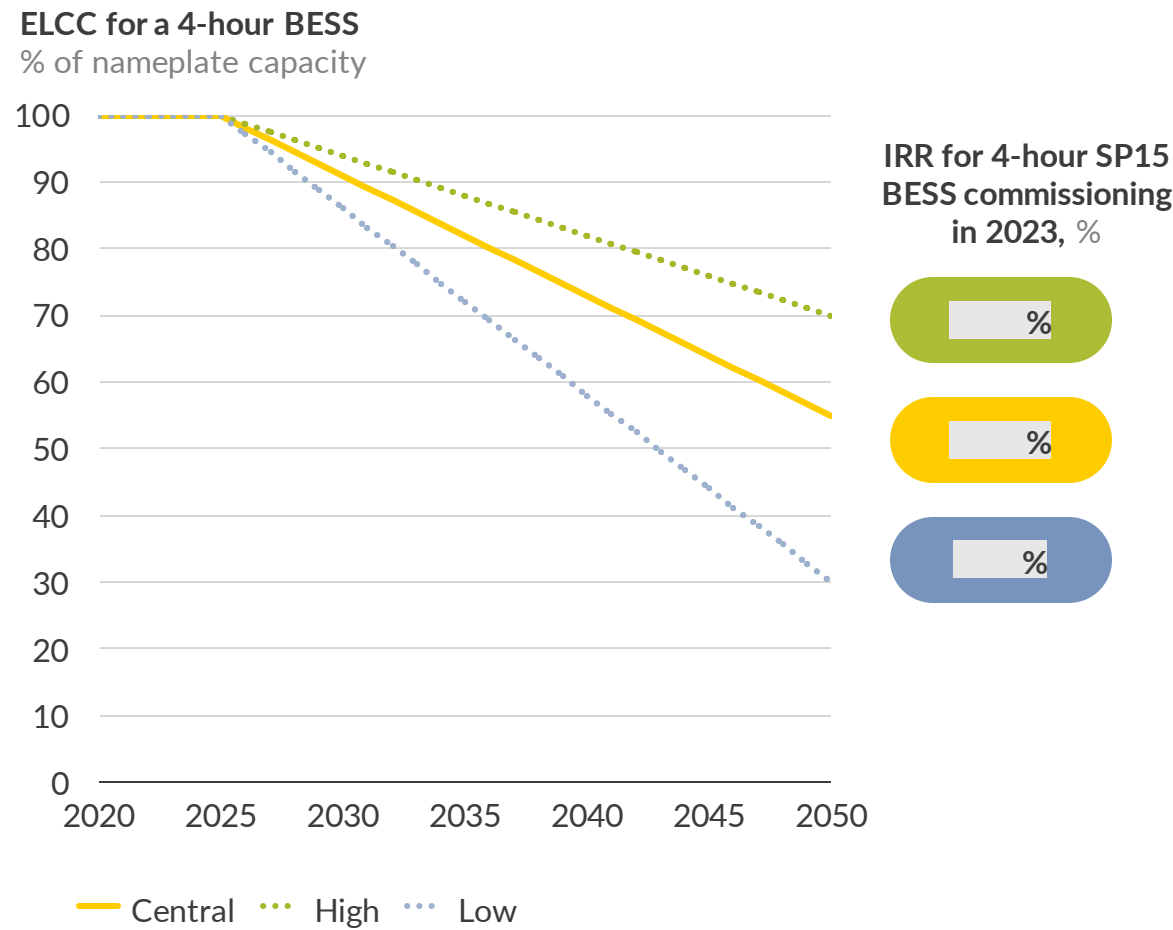
## Resource Adequacy

- BESS projects entering the market today are signing 10-to-20-year contracts for RA, with operational agreements varying by contract and LSE
- Although a long-term contract locks in a \$/kW-month price for the duration of the contract period, the eligible capacity under contract is subject to CPUC and CAISO's decision on its capacity attributes to the Resource Adequacy program
- Two 8-hour long-duration battery storage projects have been procured as part of CPUC's Mid-term Reliability requirement, with expected delivery dates in 2025 and 2026
- These two 8-hour assets are expected to have secured significant premiums on the average system RA prices
- Due to supply chain issues, many battery projects with RA contracts due for delivery in 2022 are experiencing delays or simply unable to deliver

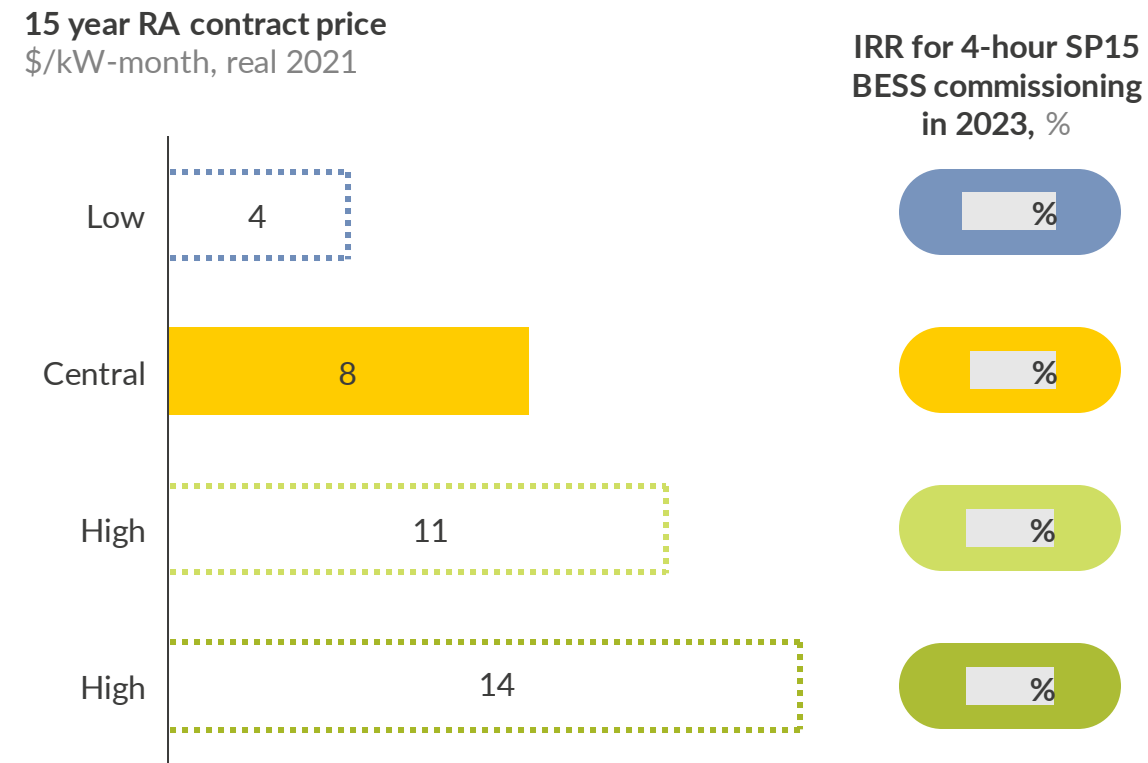
1) RA price by contract year – project deliver in the next year. 2) Based on NQC capacity. 3) Historic prices are nominal. 4) 11% WACC; 22-30% ITC is applied depending on entry years; assume the project RA contract length is 15 years; average ELCC reduces from ~100% to 45% by 2050; 1-year construction period; factor in CAPEX spending on cell upgrades through degradation.

# RA contract prices and future ELCC levels represent two areas for material upside in BESS business cases

1 Uncertainty around effective load-carrying capability (ELCC) levels for a 4-hour BESS represents a small but non-negligible upside for battery IRRs

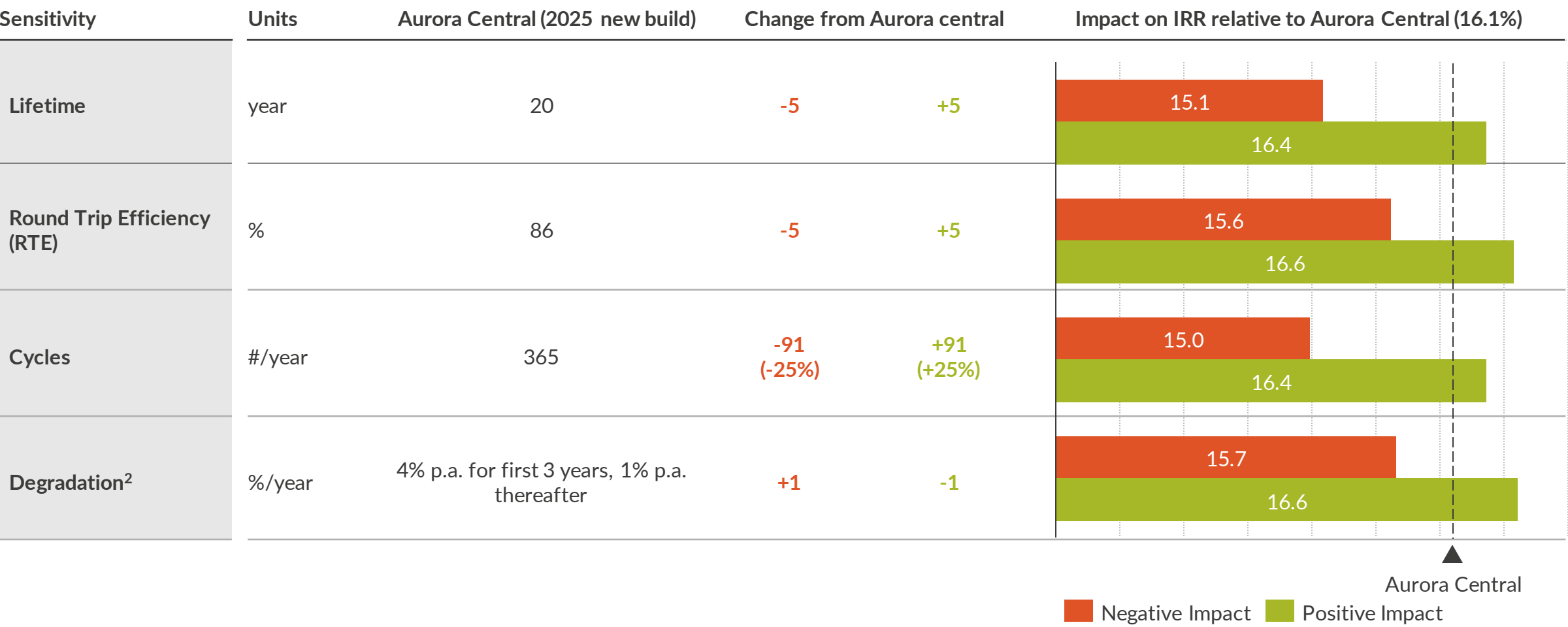


2 Current supply chain issues are creating scarcity in the resource adequacy (RA) market which potentially allow BESS assets to lock in the premium



# Lifetime, cycles, round-trip efficiency, and degradation can also impact project IRRs

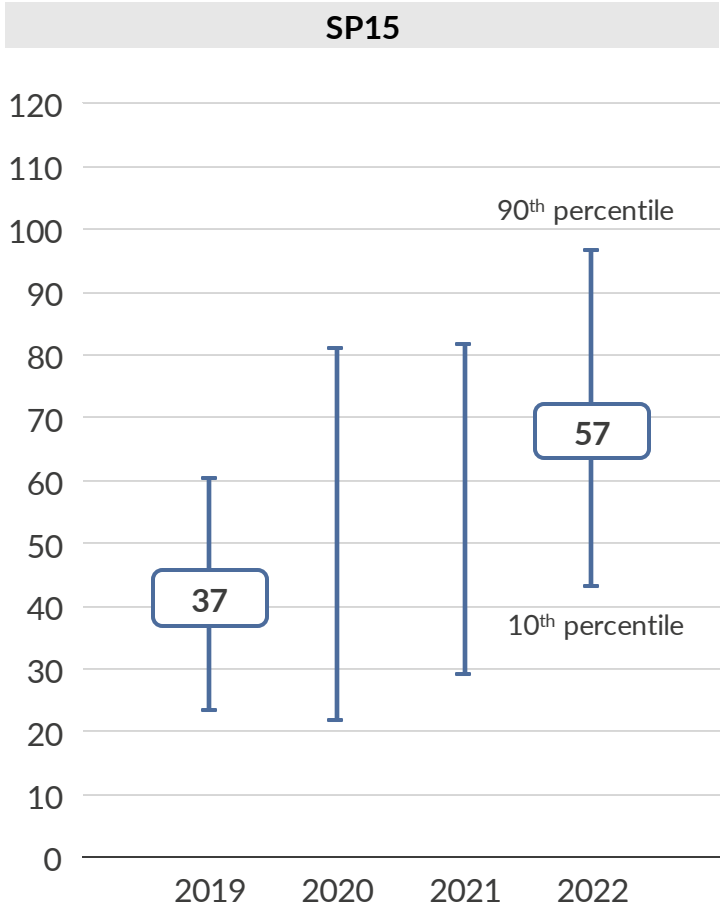
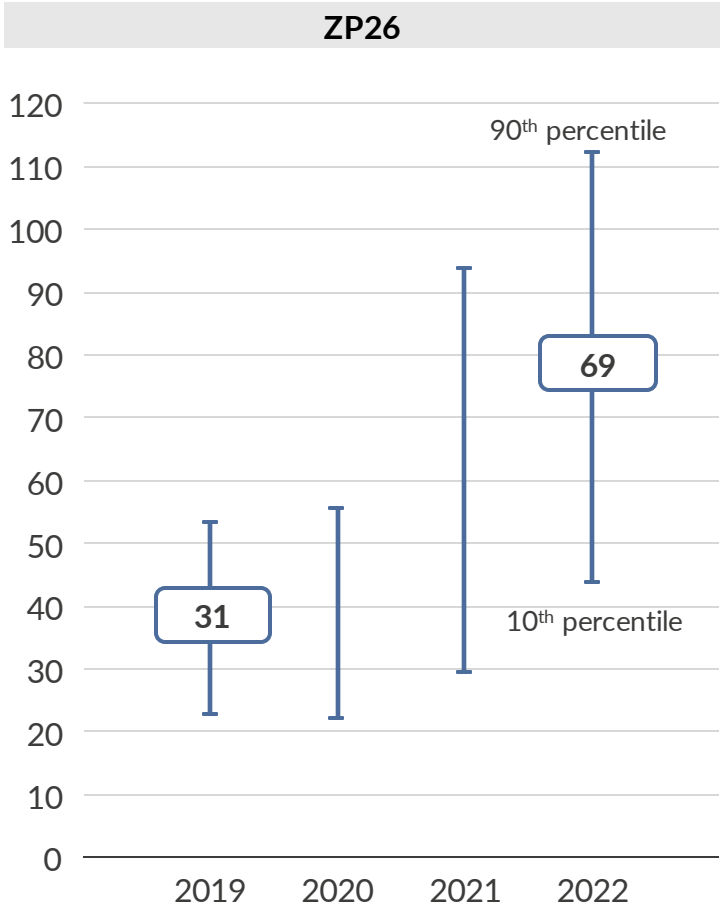
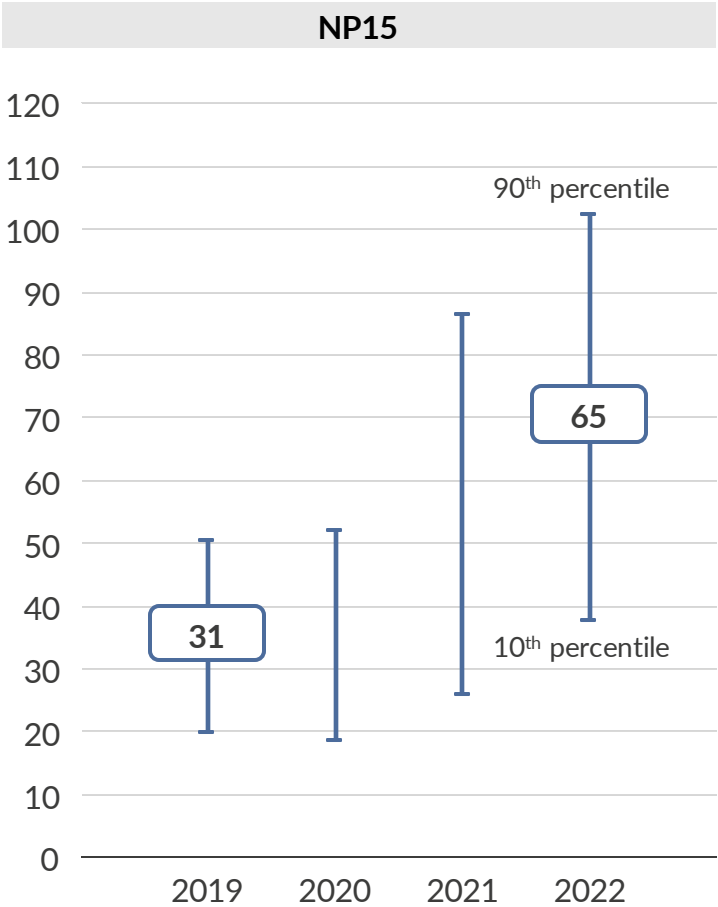
Sensitivity to technical parameters for 4-hour battery, 2023 entry, SP15<sup>1</sup>



1) Assumed 1 cycle per day unless otherwise specified. 2) In upside case, assumed 3% p.a. for first 3 years and 0.1% p.a. thereafter.

# The variability in nodal prices has significantly increased in recent years as renewables have built out and grid congestion has risen

Average historic daily 90<sup>th</sup> and 10<sup>th</sup> percentile nodal spreads by hub  
\$/MWh





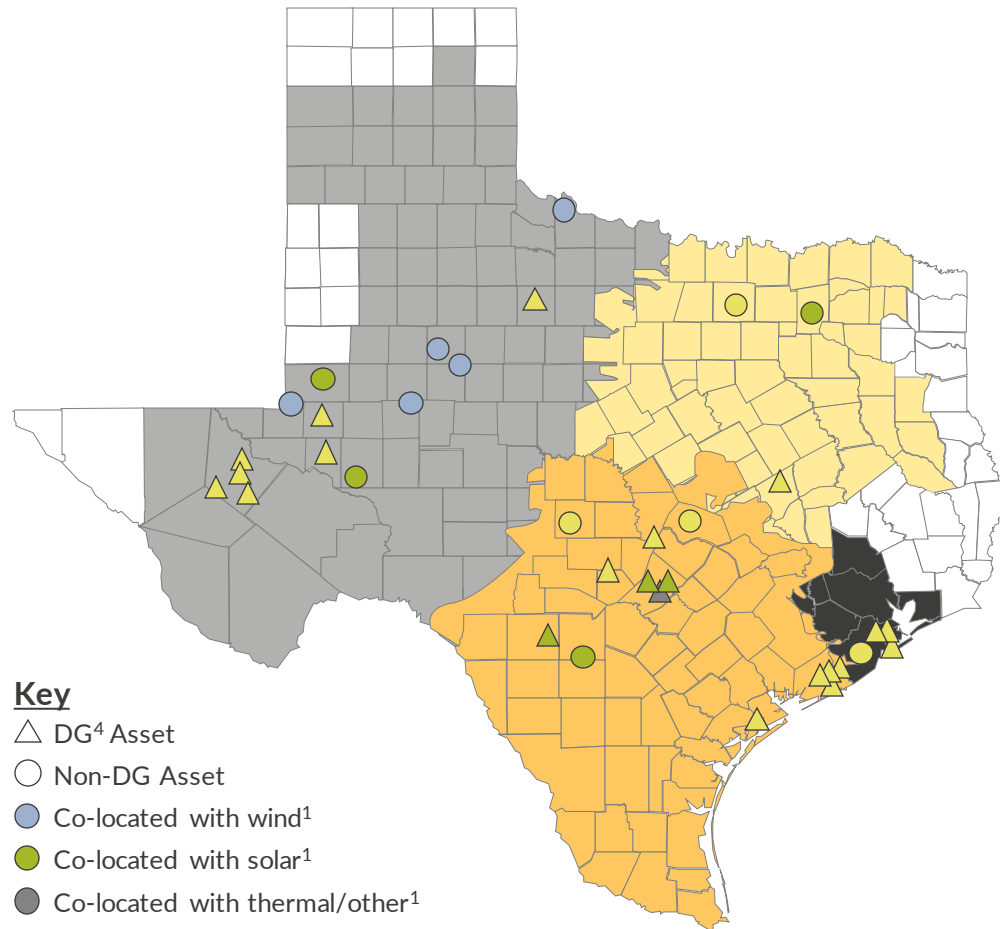
# Agenda

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- I. Modeling approach
- II. Battery storage in CAISO
- III. Battery storage in ERCOT

# 56 GW of prospective battery projects are in the pipeline with more than one quarter of projects co-locating with a wind or solar asset

Map of operational batteries in ERCOT as of June 2022<sup>2</sup>



## Key

- △ DG<sup>4</sup> Asset
- Non-DG Asset
- Co-located with wind<sup>1</sup>
- Co-located with solar<sup>1</sup>
- Co-located with thermal/other<sup>1</sup>
- Stand-alone

■ Houston ■ North ■ South ■ West

Total in pipeline<sup>2</sup>

56.2 GW

36.2 GW

36.2 GW

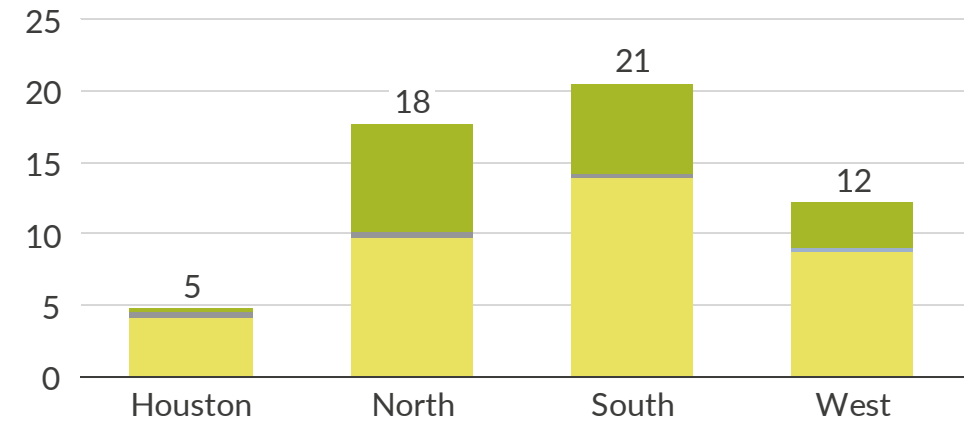
18.2 GW

18.2 GW

0.4 GW

0.4 GW

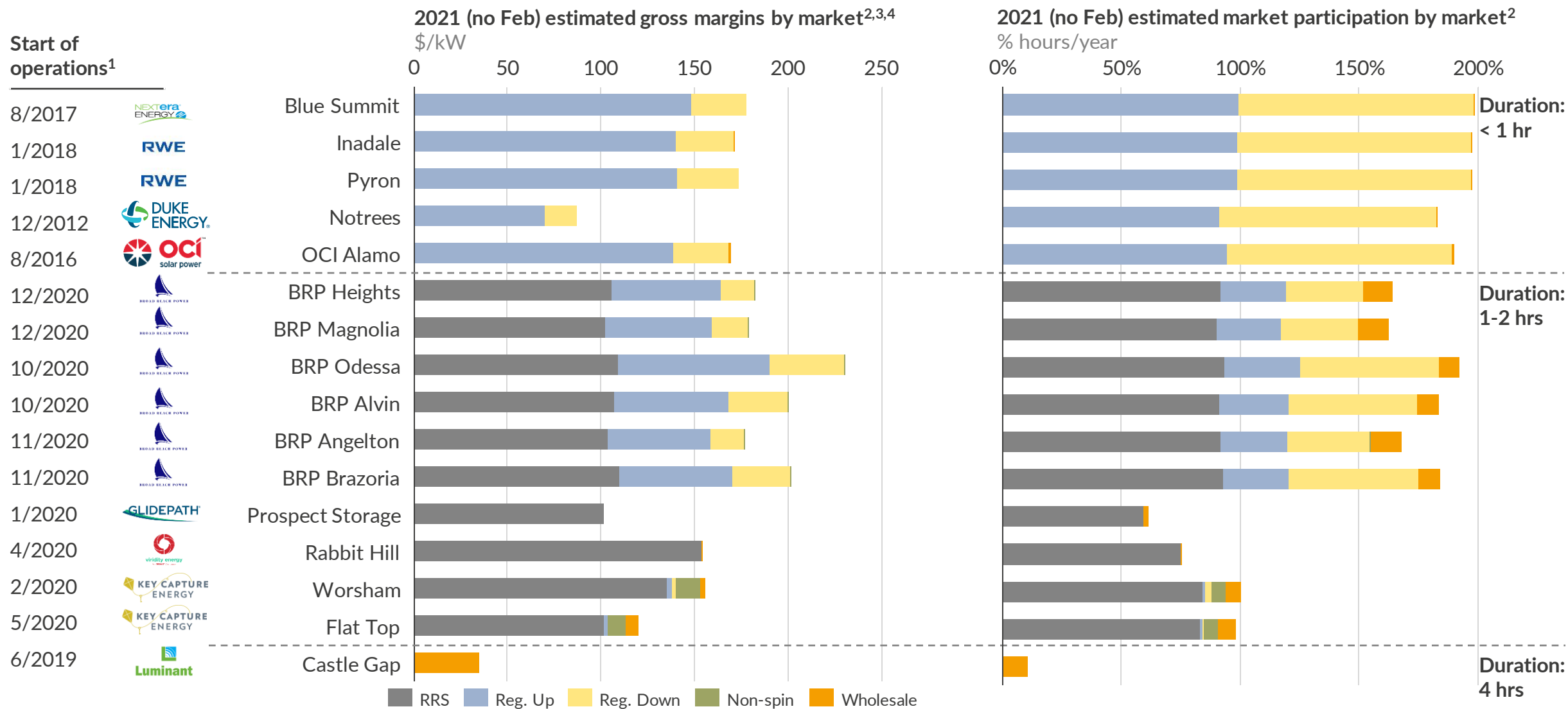
Cumulative battery storage pipeline for ERCOT zones with completion date before end of 2024<sup>3,5</sup>  
GW



- Currently, there is 206 MW of co-located<sup>1</sup> and 1126 MW of stand-alone storage capacity; totalling 1.3 GW of energy storage capacity in ERCOT<sup>6</sup>
- Most stand-alone batteries are located close to load centers with 6 in Houston, 4 in San Antonio and Austin, and others around DFW and the Permian Basin
- More than 50 GW of battery storage projects are in the pipeline, 32 GW of which are located in the South or West

1) Includes standalone resources on same site as another generator, does not include AC/DC-coupled resources 2) Does not include batteries under 10 MW in capacity or DG connected assets 3) As of June 2022. 4) Distributed Generation. 5) ERCOT does not have information to confirm if the co-located projects will be operated as AC/DC-coupled resources, or independently. This will be remedied by RRGR023, due in 2022. 6) Includes DG resources; future pipeline does not account for DG resources.

# In 2021<sup>4</sup>, high ancillary service prices drove margins above \$150/kW for some batteries, with BRP capturing the highest revenue in the fleet

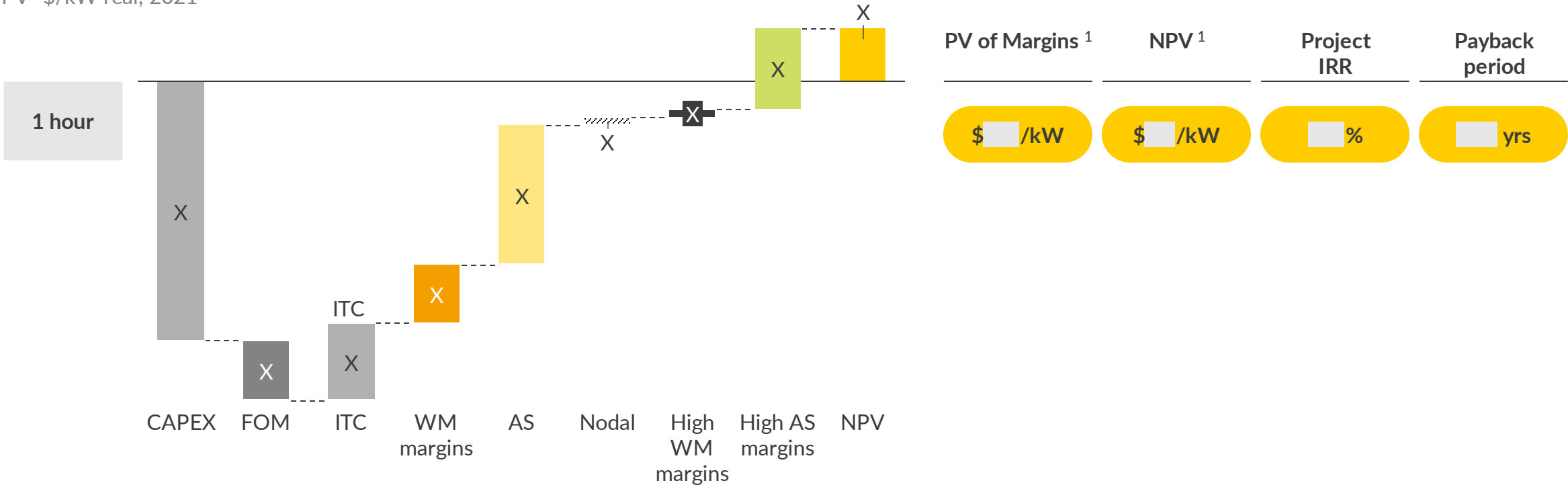


1) Self-reported from EIA 860M report, or ERCOT GIS. 2) Total market participation percentages can exceed 100% due to participation in multiple markets in the same period. 3) Energy revenues calculated at the batteries' trading hubs. 4) Excluding February 2021,

Sources: Aurora Energy Research, ERCOT, EIA

# A new build 1-hour battery in the West can achieve a positive NPV and an IRR of [redacted] %

Economics for new-build battery (West zone, 2023 entry year, no repower)  
PV<sup>1</sup> \$/kW real, 2021



- Wholesale margins make a small contribution for a 1-hour battery entering the market in 2023. Ancillary services will be the dominant revenue stream supporting the project
- High prices in the wholesale and ancillary markets contribute \$ [redacted] /kW to the Net Present Value, and are discounted at a higher discount rate than during low price periods

1) Discount rate of 11% for revenues and costs, and 15% for high price periods (>\$500/MWh for WM prices or \$200/MW/h for AS prices)

# Regional differences are less impactful than duration and entry year decisions for asset profitability

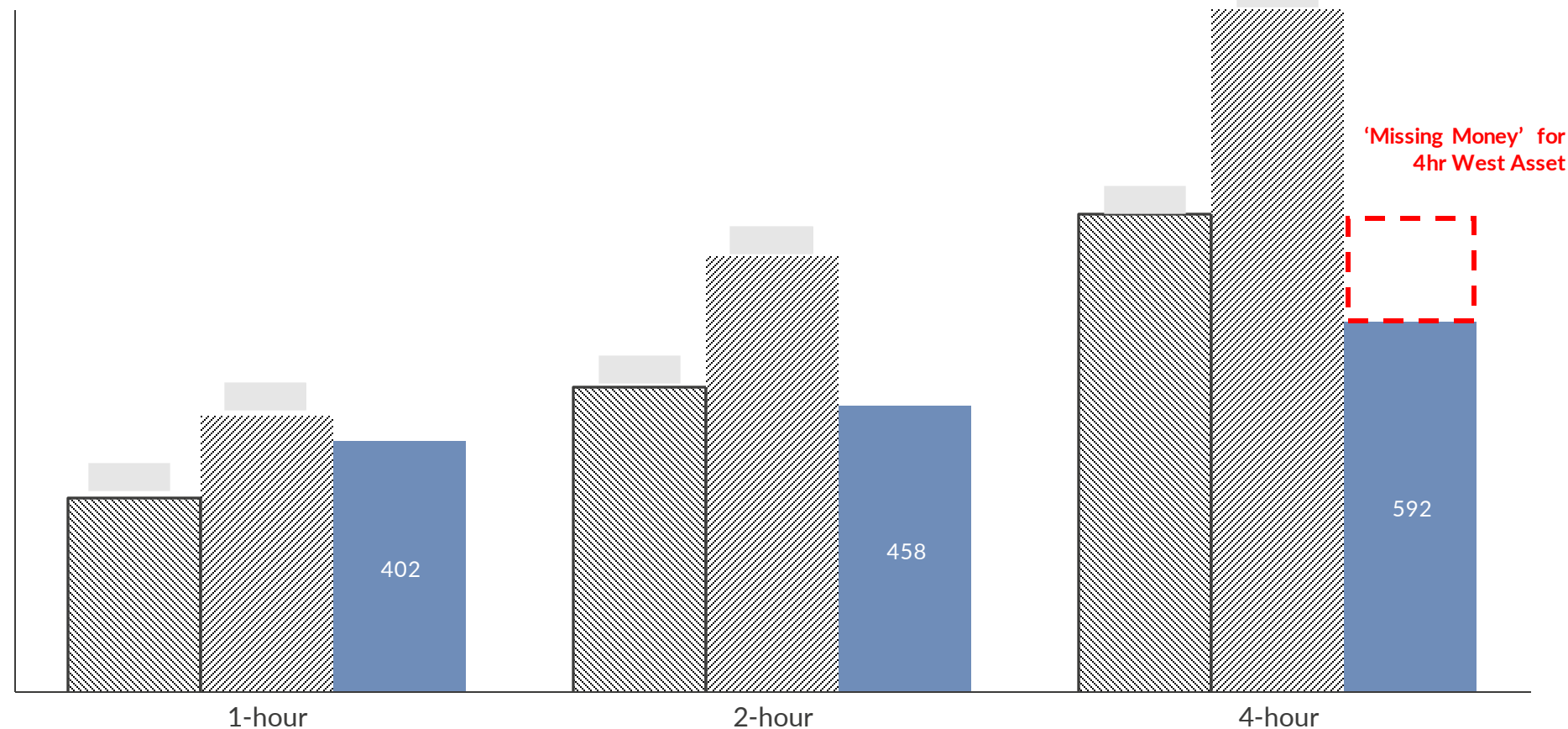
Evolving nodal upsides differentiate the regions and causes their relative profitability to shift over time and between durations. The West zone will emerge as the most profitable region for new build batteries, given the highest nodal premium, with an IRR of about 1% higher than other zones for 2026 entry. 1 hour batteries remain the most profitable, and near-term declines in CAPEX will further accentuate short-duration profitability.

Entry Year	Scenario	Duration	Present Value of Margins <sup>1</sup> (\$/kW)				IRR (%)				Payback Period (yrs)			
			Houston	North	South	West	Houston	North	South	West	Houston	North	South	West
2023	Central	1 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%
		2 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%
		4 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%
2026	Central	1 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%
		2 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%
		4 hour	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%	X%

1) Discount rate of 11% for revenues and costs, and 15% for high price periods (>\$500/MWh for WM prices or \$200/MW/h for AS prices)

# Increasing battery durations lead to lower marginal return, long duration fully merchant investment cases do not yet stack up

Present Value<sup>1,2,3</sup> of Gross Margins and Capex for West batteries of various durations (2023 Entry Year)  
\$/kW, real 2021



Capex, with ITC (2023) Capex, without ITC (2023) Present Value of Margins (West)

1) Discount rate of 11% for revenues and costs, and 15% for high price periods (>\$500/MWh for WM prices or \$200/MW/h for AS prices). 2) Aurora's in-house capex assumption, inclusive of recent 15% capex increases due to raw materials prices and supply chain issues.

Source: Aurora Energy Research

## Comparison of various durations

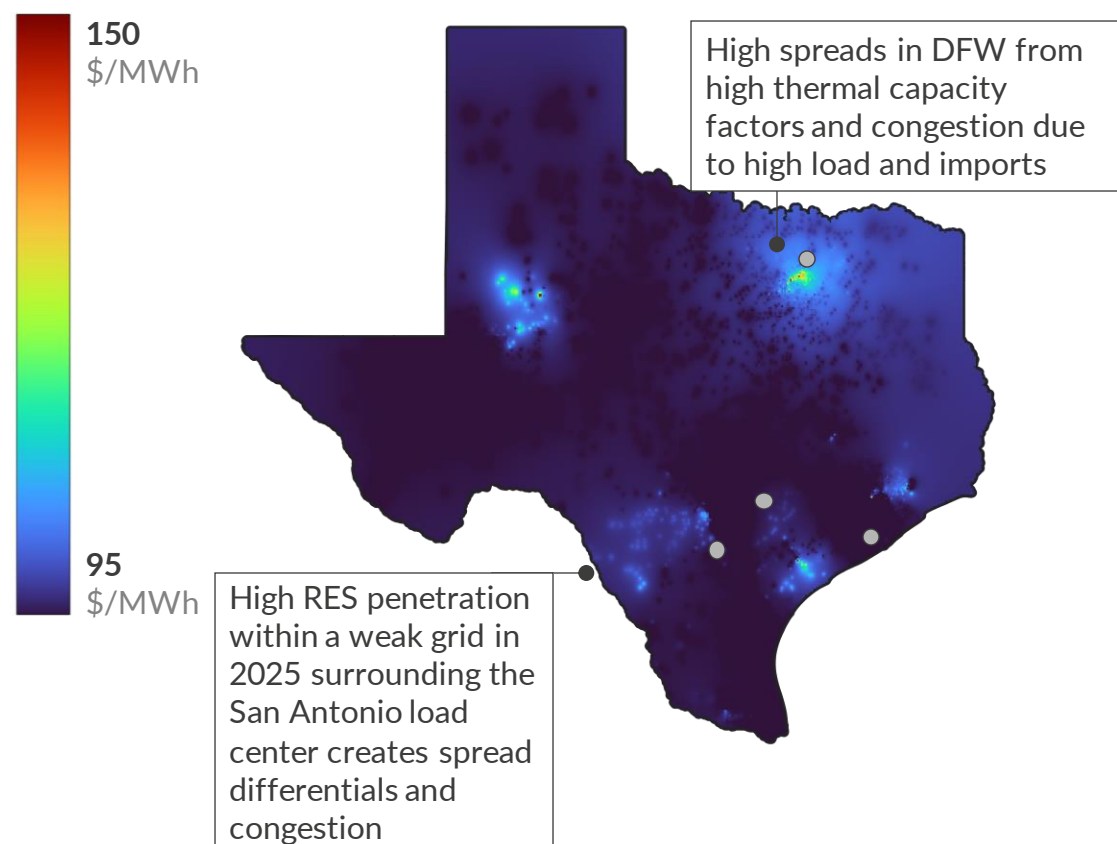
- The concept of 'missing money' is the difference between the battery's Capex and the Present Value of the battery's revenue
- Capex increases incrementally by   % moving from 1- to 2- to 4-hour batteries. Assuming a 30% ITC, this amounts to a \$ /kW additional cost for a 4-hour battery compared to a 1-hour battery
- However, battery revenues only increase by \$ /kW for a 4-hour West battery and by \$ /kW for a 4-hour Houston battery compared to their 1-hour counterparts
- These diminishing returns manifest in \$ /kW of missing money for a 4-hour West battery and \$ /kW of missing money for a 4-hour Houston battery, whereas their 1-hour counterparts both produce IRR's over   %

# Line upgrades, proximity to load centers and renewables deployment will impact the local spreads available to batteries

*Growing load and changing network landscape drives shifts in spread “hotspots”, although persistent value maintained in notable areas*

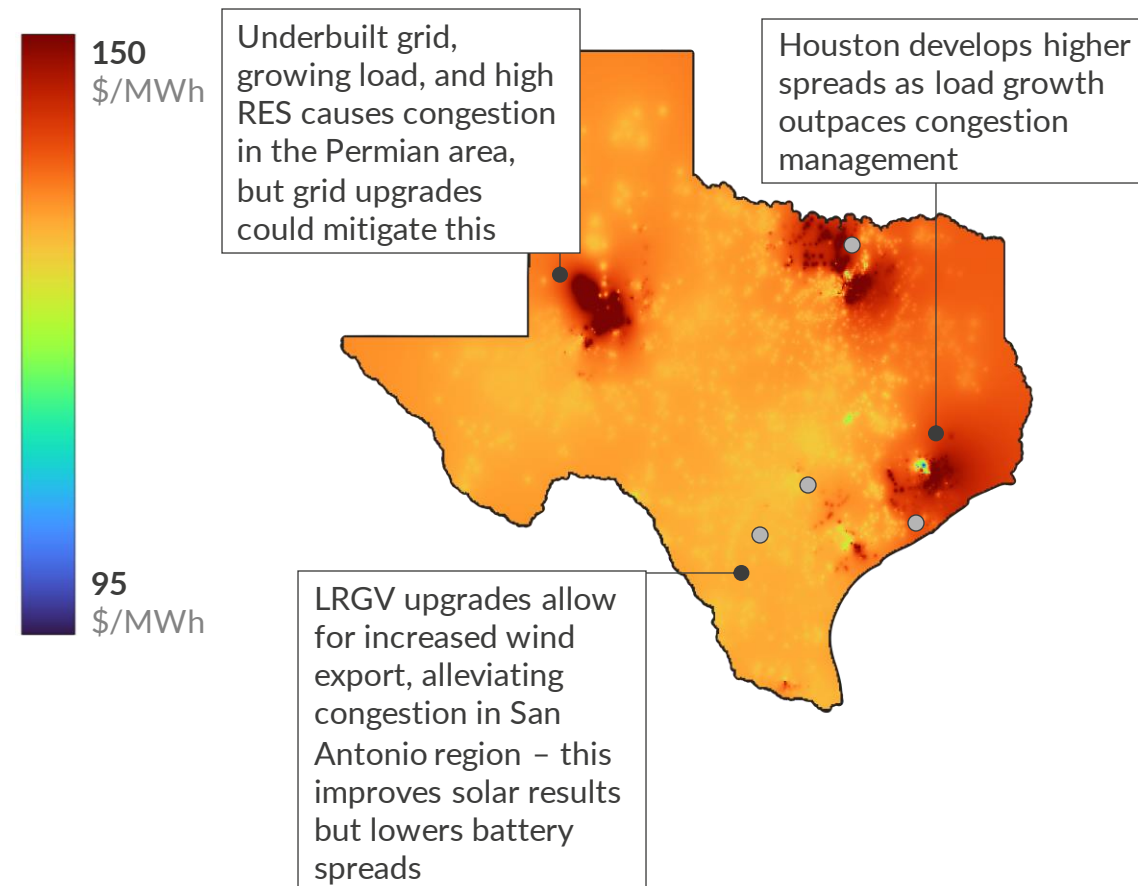
**Day-Ahead TB1 spreads with N-1 contingency grid conditions, 2025**

\$/MWh (real 2021)



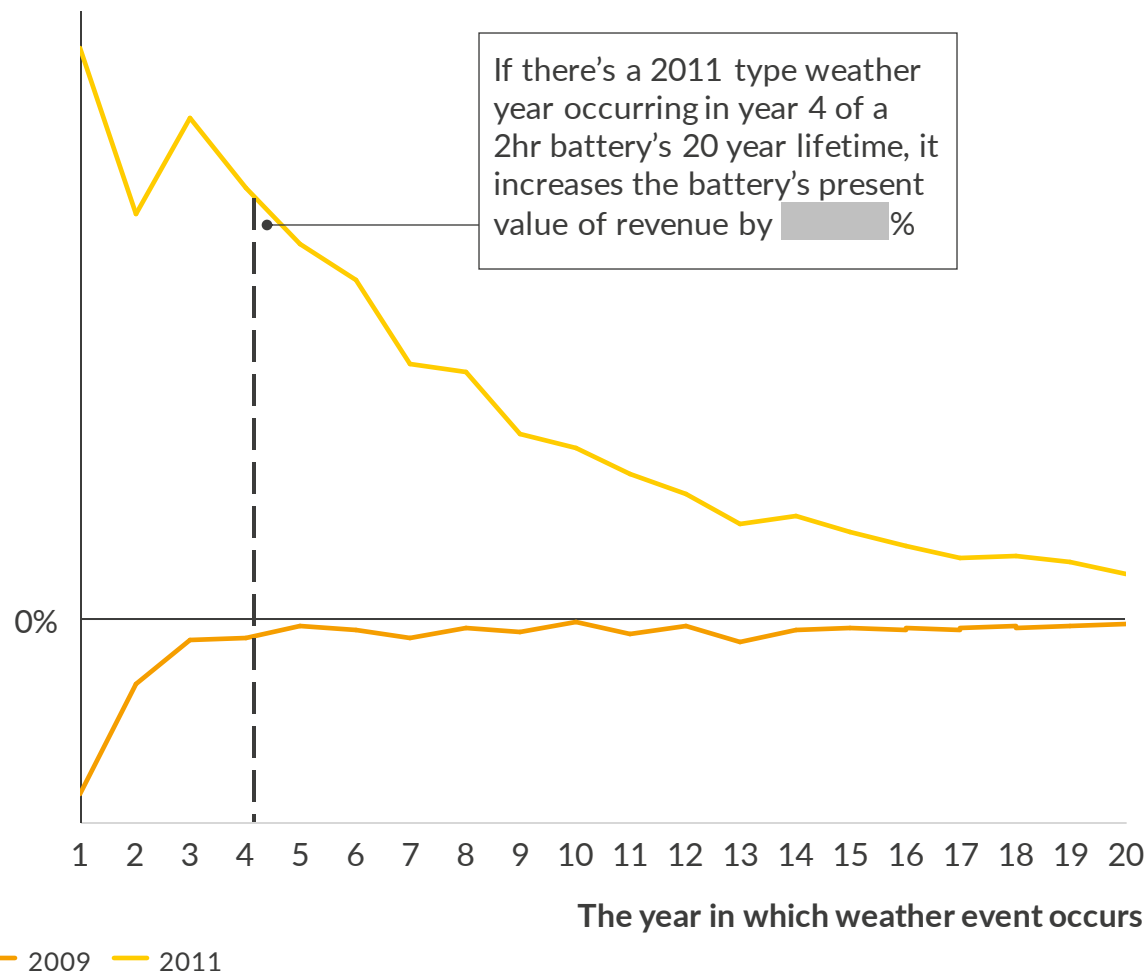
**Day-Ahead TB1 spreads with N-1 contingency grid conditions, 2030**

\$/MWh (real 2021)

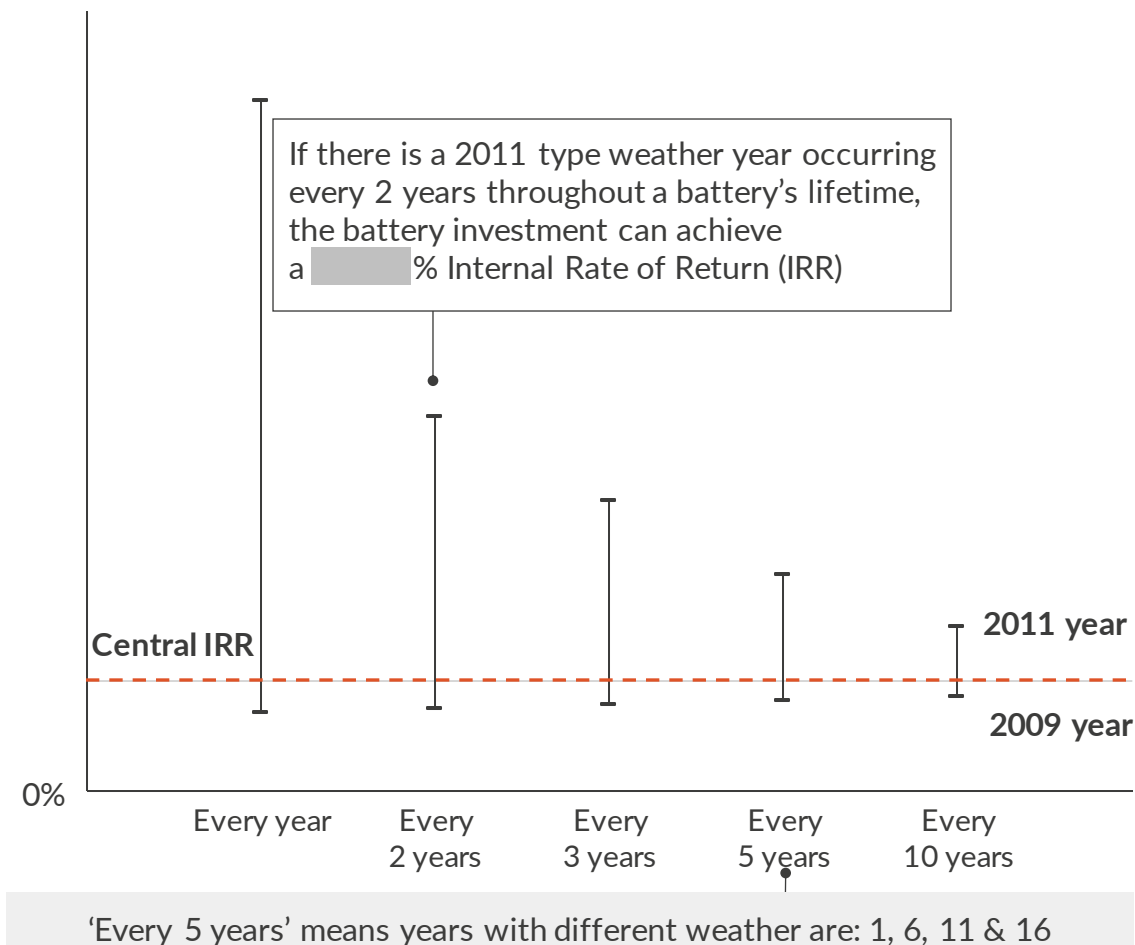


# The timing and frequency of weather events creates a significant range in potential upside

Impact on present value<sup>1</sup> of revenue from a weather event – 2hr North battery<sup>2</sup>  
%



2hr North Battery IRRs<sup>1</sup> with varying frequency of weather years occurring  
%



1). Assume a discount rate of 11%. 2) Does not take into account degradation and availability





# Aurora Service Offering



# US Power Market Forecast Services

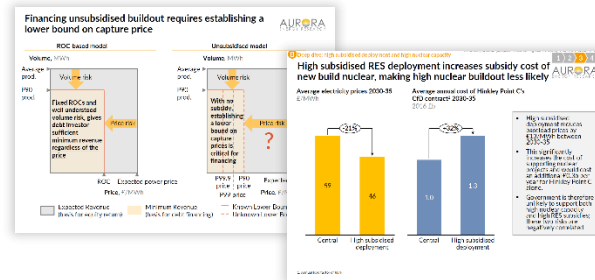
Key market analysis and forecasts for all participants in the PJM, CAISO, and ERCOT power market

## Quarterly data and market reports

- **All the latest trends and forecasts** – recent market developments and full policy and technology outlook
- **Key market outcomes to 2050** – monthly price forecasts, capacity and generation mix to 2050
- **Regional and technological detail** – prices by hub and generation by load zone
- **Scenario analysis** – 6 consistent scenarios that reflect key uncertainties
- **Investment case analysis** – costs and revenue streams under different scenarios
- **Data in Excel** – all forecast data easily downloadable in Excel format
- **Data online** – view forecasts and historical data on our online EOS platform

## Quarterly strategic insight reports and group meetings

- **In-depth thematic reports** on topical issues for the renewables industry
- **Four multi-client roundtable discussions** per year in person / virtual to network and discuss hot topics
- **Topics based on client demand** e.g.
  - *REC pricing and impact on power markets*
  - *Investment cases for battery storage and flex assets*
  - *Regional prices and grid bottlenecks*
  - *Implications of market reform for power pricing*



## Regular interaction through workshops and bilateral support

- **Bilateral workshops** to discuss specific issues on the market that are of particular interest to you
- **Ongoing support** from our experts to address any questions about Aurora's forecasts or the market more broadly – save time by speaking with one of our experts



**All intelligence for a successful business, based on bankable price forecasts**



# Flexible Energy Add-On Service Provides detailed power market analysis and investment case data for battery storage



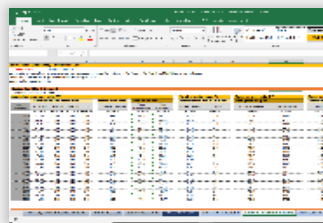
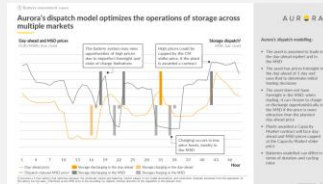
## Bi-annual Forecast Reports & Data

### Technology and Market Development Reports

- **Historical battery analysis** – Provides an analysis of existing battery storage assets' parameters and profitability metrics from both a wholesale and ancillary service perspectives (plus market specific capacity markets if applicable)
- **Market outlook** – Contains a market overview focusing on flexible capacity, Aurora's estimated battery build-out, and CAPEX trajectory
- **Standard battery investment cases** – Detailed costs and revenue streams for archetypal battery duration across various configurations, reflecting revenue-stacking opportunities

### Forecast Data and Databook

- Summary of battery KPI metrics
- Historical wholesale and ancillary services data
- Aurora's half-hourly/hourly wholesale, ancillary service price forecasts markets (RRS, Reg Up, and Reg Down), and real time prices to 2050 across key scenarios (Central, Low)



## Investment Cases

### Standalone Batteries and Co-locating

- Detailed data of each of the individual **54+ battery investment cases** that Aurora has modeled in ERCOT and CAISO
  - Gross margins, IRRs, and NPVs provided for battery storage investment cases
  - Cases consider 3 battery durations across all load zones with years of entry in 2023 and 2025
  - Gross margin data provided for all years out to 2050 in the supporting data book
- **Key sensitivities around nodal location, co-location, and weather year analysis** are also analyzed

## Ongoing Analyst Support

- **Bilateral workshops** to discuss specific content pertinent to the Flex/ Storage add-on
- **Ongoing availability** (access to market experts, modelers) to address any questions





# Appendix

Sample analysis

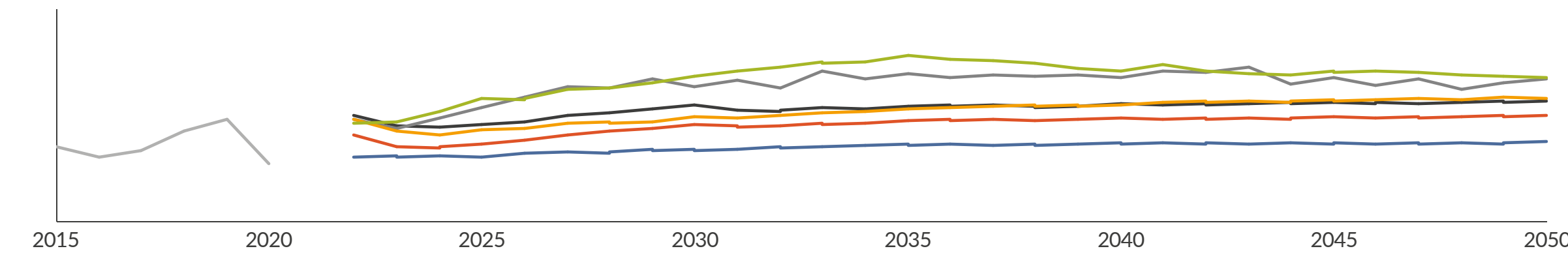


# We explore key market uncertainties through a range of scenarios

<b>Central</b>	Considers current policies alongside a view for future policy intervention, and our internally consistent central view of technological change and commodity prices. Assumes tax credits extended indefinitely, though with credit value declining over time
<b>Central &amp; CO<sub>2</sub> Price</b>	Central case with the addition of a carbon price from mid 2020s, increasing out to 2035 in line with decarbonization efforts
<b>Build Back Better</b>	Explores the effects of the passage of the Biden administration's Build Back Better plan, which aims to aid in the rapid decarbonization of the nation's energy sector. The plan includes extended and expanded tax credits for renewable energy, energy storage, nuclear energy, CCS, EVs and transmission
<b>Low</b>	Represents a downside case, incorporating low underlying demand and low commodity prices. This envisages a world with slower overall GDP and population growth while other assumptions, such as EV uptake, are maintained as in Aurora Central
<b>Green New Deal</b>	Explores a greater push for decarbonization in ERCOT. Alongside a carbon price, pollution standards hasten coal's exit, and there is increased power demand from space cooling/heating and transportation. Network upgrades allow for greater renewables build out in constrained regions of ERCOT
<b>Low Scarcity</b>	Stress tests the role of scarcity pricing on the value of power in ERCOT. This scenario sees a lower number of instances of scarcity and therefore lower prices, relative to Aurora Central

# ATC prices in the scenarios range between \$ [ ] and \$ [ ]/MWh in 2030 with the highest prices in the Green New Deal scenario

ERCOT-wide ATC price  
\$/MWh (real 2020)



Scenario	Brief description	Typical use case
Central	Aurora’s Central view of the market, current legislated and budget-funded policies	Equity financing, strategy analysis
Central & CO <sub>2</sub> Price	Central assumptions with additional carbon pricing	Test impact of carbon price
Build Back Better <sup>1</sup>	Immediate introduction of provisions included in the Biden administration’s Build Back Better plan	Test impact of introduction of Build Back Better legislation
Low	Low demand and commodity prices	Debt financing/sizing, strategy analysis
Green New Deal	Carbon pricing and other policies are enacted resulting in faster decarbonization of power sector and the wider Texas economy	Test impact of major shift to green economy
Low Scarcity	Central assumptions with increased firm margins	Test impact of oversupply or out-of-market reliability units on price formation





— Historical — Central — Central & CO2 — Build Back Better — Low — Green New Deal — Low scarcity ... Previous forecast

1) No previous Build Back Better scenario for comparison.

# We explore key market uncertainties for battery economics through a range of market scenarios

Scenario	Description	Battery capacity deployment, GW	
		2025	2030
<b>Central</b>	Considers current policies alongside a view for future policy intervention, and our internally consistent central view of technological change and commodity prices. Assumes tax credits extended indefinitely, though with credit value declining over time	10.3	25.7
<b>Low</b>	Represents a downside case, incorporating low underlying demand and low commodity prices. This envisages a world with slower overall GDP and population growth while other assumptions, such as renewables support mechanisms, are maintained as in Aurora's Central	11.3	20.6
<b>Persistent Scarcity</b>	Models persistent challenges to security of supply – e.g., low hydro availability, delays to inter-regional transmission, long interconnection queues, more cooling days, etc	9.7	25.1

# Summary of scenario input assumptions

As per Central scenario unless otherwise indicated		Aurora Central	Low	Persistent Scarcity
 Demand	Underlying Demand	X TWh in 2023 increasing to X TWh by 2050, driven by population and industrial growth		
	EVs	X million EVs in 2030 and X million in 2050		X million EVs in 2030 and X million in 2050
	Rooftop Solar	X GW in 2023 increasing to X GW in 2030 and X GW in 2050		
	BTM Battery	X GW in 2023 increasing to X GW in 2030 and X GW in 2050		
	Hydrogen electrolysis	No large scale demand for grid-connected hydrogen electrolysis		
 Commodities	Gas price <sup>1,2</sup>	Henry Hub forecast increased up to \$X/MMBtu in 2022 and California Citygate prices average \$X/MMBtu in 2030 and \$X/MMBtu in 2050	\$X/MMBtu in 2030 and \$X/MMBtu in 2050	\$X/MMBtu in 2030 and \$X/MMBtu in 2050
	Carbon price	Carbon price increases to \$X/ton by 2035 and levels off at \$X/ton	Auction reserve carbon price of \$X/ton in 2035 compounding X% annually on top of inflation	
 Technology	Renewables	Between 2022 and 2050, wind CAPEX falls by X%, solar by X%, and 4-hour batteries by X%; X GW off-shore wind in the Morro Bay call area starting in 2040		No Offshore or Wyoming wind
	Hydro	P60 hydro availability in CAISO		P90 hydro availability
 Policy	Pollution standards	Plants face increasing environmental costs at end of lifetime but are not mandated to close		
	Reliability	New entry determined by market economics; 22.5% PRM in 2024	Imports increase to X GW in 2023	X% PRM in 2024; Imports reduced to XGW in 2023
	Renewables incentives	Extension of PTC and ITC for wind and solar and introduction of ITC for batteries		No ITC applied for battery capex
	Transmission upgrades	CAISO 20-year transmission plan assumed, which enables a average cumulative 5.5 GW/year technical limit of new renewables <sup>3</sup>		Pipeline plant commission dates delayed average of 2 years due to delays in CAISO interconnection; new-build renewables restricted to reflect transmission bottlenecks; X% import and export transmission availability

1) Average of Northern and Southern California Citygate prices. 2) Scenarios assume an additional in-state transportation fee for Natural gas after the Citygate prices (\$1.57/MMBtu for PG&E and \$0.31/MMBtu for SoCal Gas). 3) Including additional transmission upgrades on Path 15 and Path 26 from the late 2030s to avoid significant disparity of SP15 and NP15 trading hub prices due to congested transmission lines.

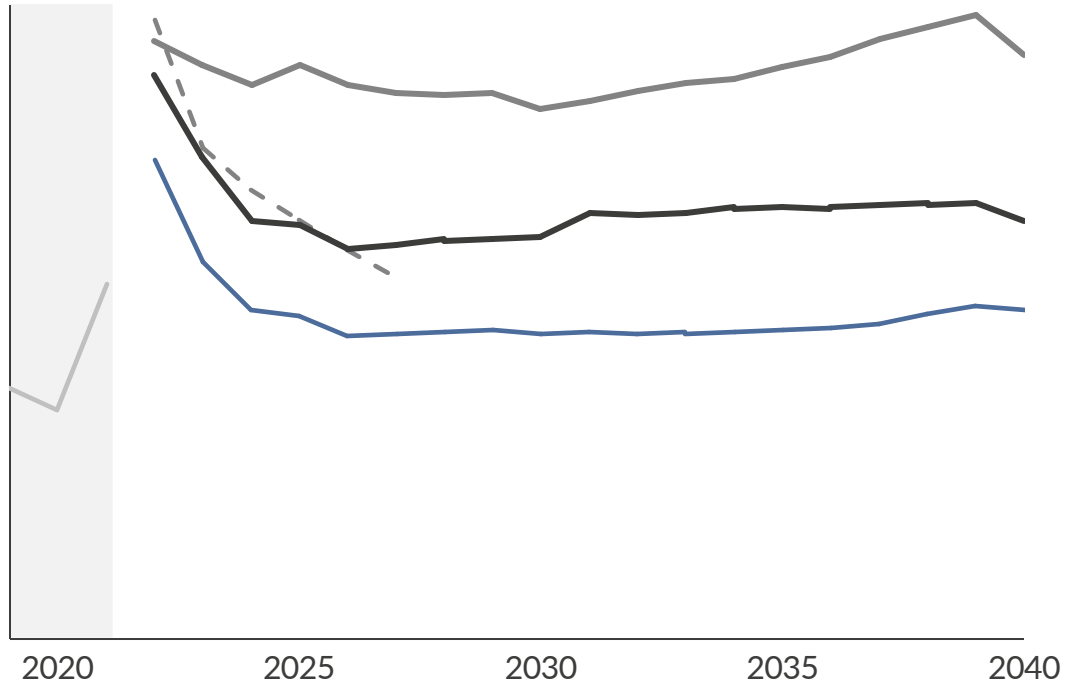
Sources: Aurora Energy Research

Redacted32



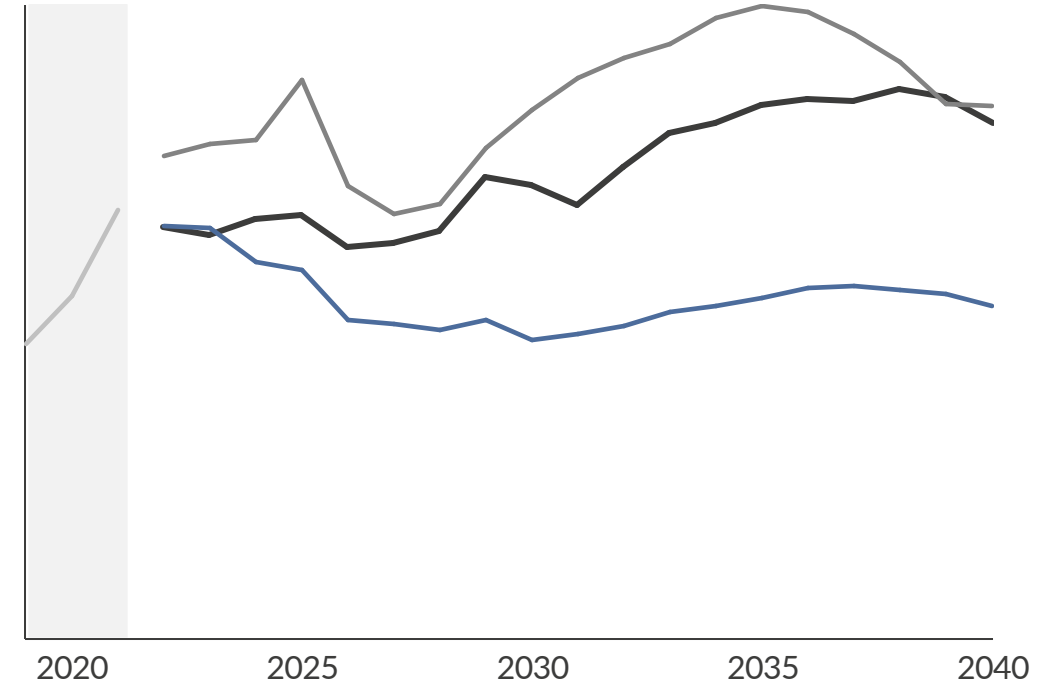
# ATC prices and 4-hour spreads vary by around [redacted] - [redacted] \$/MWh across these three market scenarios

CAISO-wide ATC<sup>1</sup> price  
\$/MWh (real 2020)



- Under Aurora Central, CAISO-wide ATC prices decrease from \$[redacted]/MWh in 2022 to \$[redacted]/MWh in 2030 as supply chain issues and interconnection delays are resolved

CAISO-wide average 4-hour daily spread  
\$/MWh (real 2020)



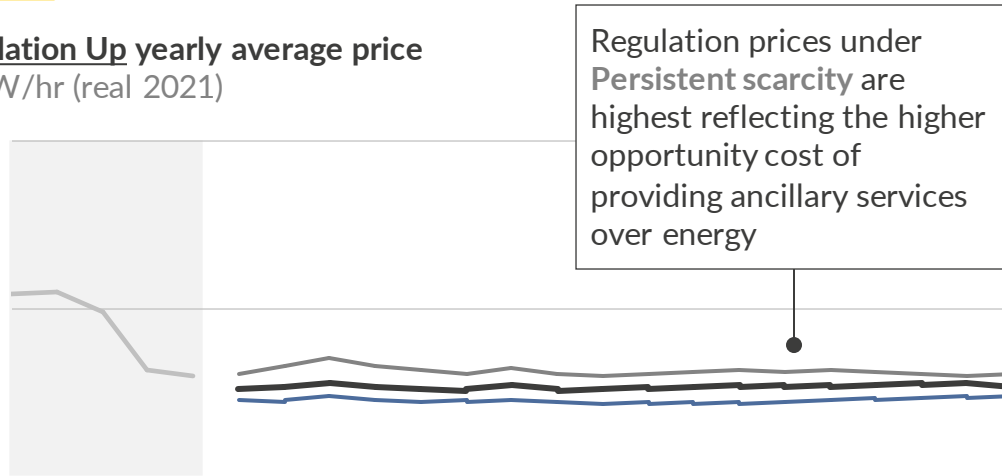
- Spreads are lowest under Aurora's Low scenario as lower natural gas prices result in lower prices in the shoulder hours, which eat away at spreads batteries are able to capture

— Historical    - - CAISO-wide futures    — Central    — Low    — Persistent Scarcity

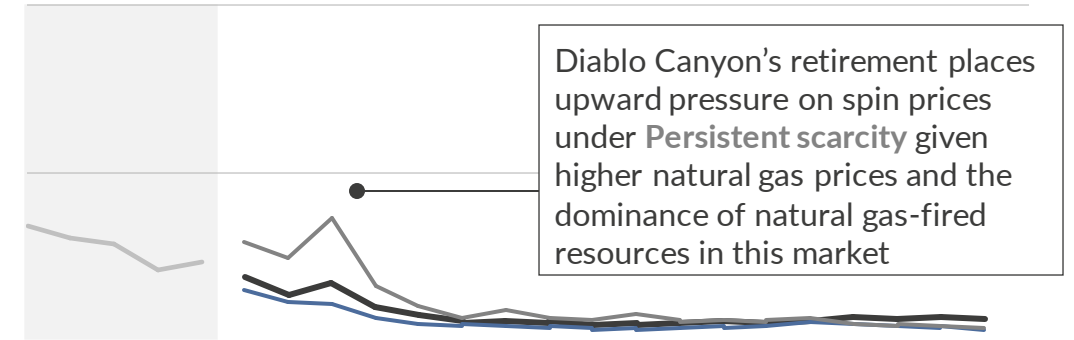
1) Around the Clock, also known as the Time Weighted Average (TWA)

# Ancillary service prices vary by up to \$ /MW across scenarios with the lowest prices in the low scenario

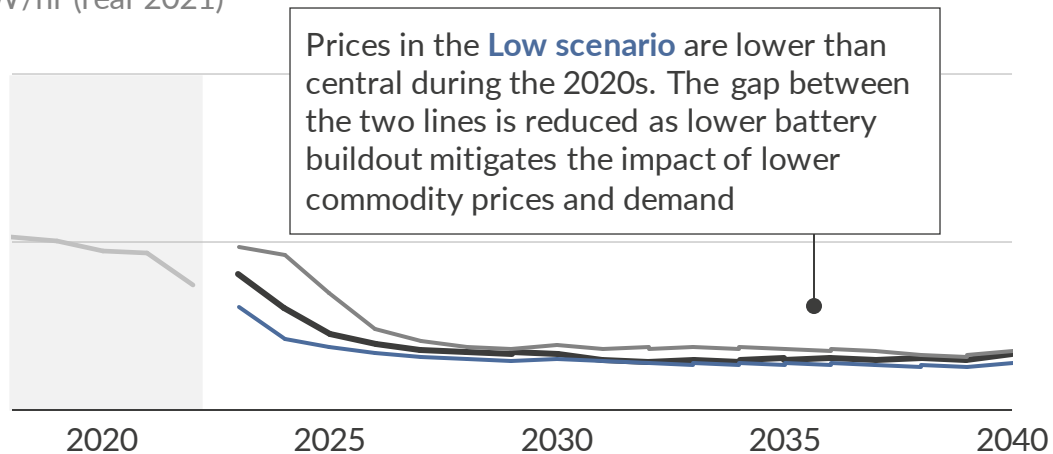
**Regulation Up** yearly average price  
\$/MW/hr (real 2021)



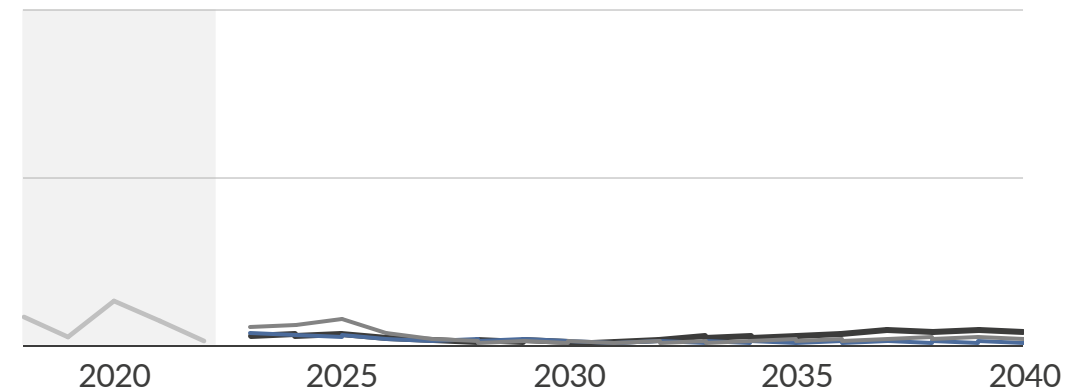
**Spinning Reserve** yearly average price  
\$/MW/hr (real 2021)



**Regulation Down** yearly average price  
\$/MW/hr (real 2021)



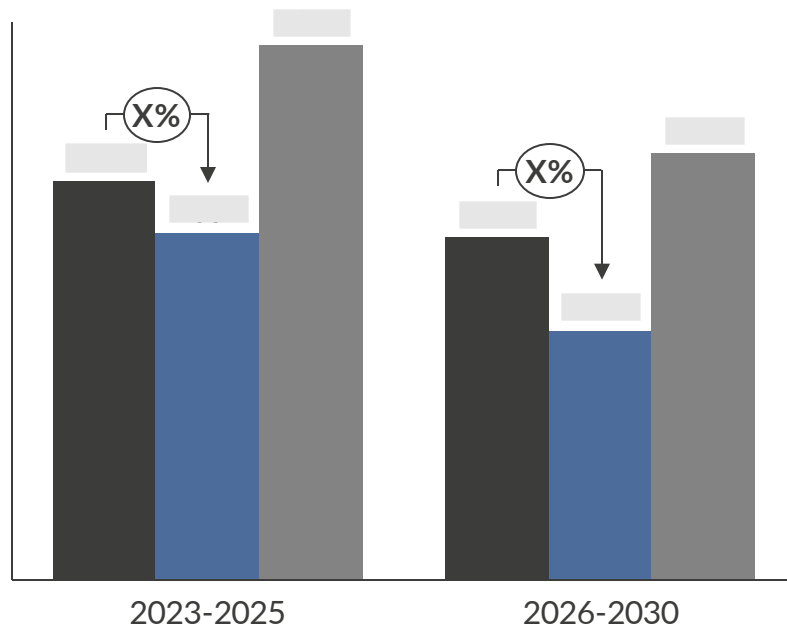
**Non-spinning reserve** yearly average price  
\$/MW/hr (real 2021)



— Historical — Central — Low — Persistent Scarcity

# IRRs vary by around [REDACTED] basis points across the scenarios, reflecting the inherent volatility in BESS investments

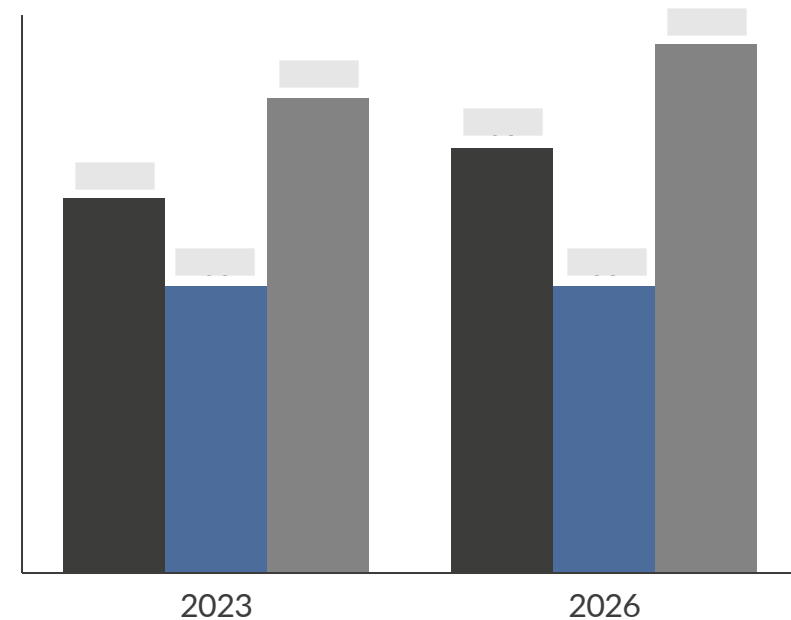
Average annual battery gross margins (4-hour duration, SP15, 2023 entry)  
\$/kW



- Gross margins are impacted by both the lower wholesale spreads and the lower ancillary returns.
- Margins are [REDACTED] % lower under the Low scenario, but [REDACTED] % higher under persistent scarcity

■ Aurora Central ■ Low ■ Persistent Scarcity

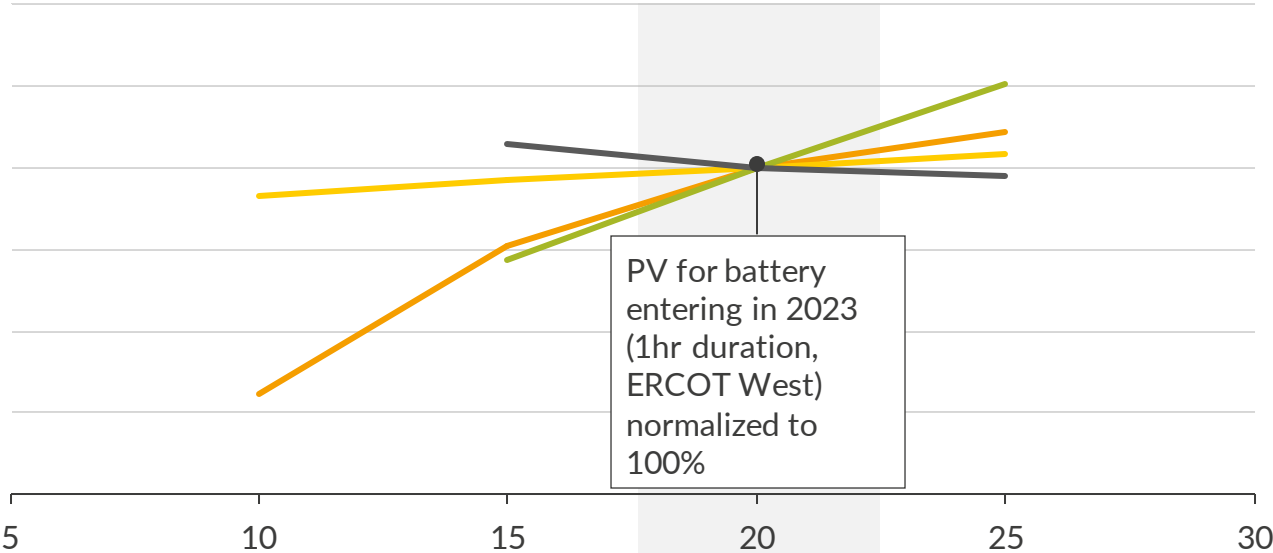
IRR for a new build battery by entry year (4-hour duration, SP15)  
%



- Project IRRs correspondingly fall with low returns being seen in the low scenario
- Under persistent scarcity, a new build battery in 2026 could see a significant upside, with IRRs at ~[REDACTED] %

# Lifetime, cycles and round-trip efficiency can influence PV of revenue by more than █ %

PV<sup>1</sup> of margins relative to central assumptions for new build battery (1hr, 2023 entry in West Hub)  
%



Lifetime	Years
RTE <sup>2</sup>	%
Cycles	#/year
Degradation <sup>3</sup>	% p.a.

	█ % pa, for 3 years, █ % pa thereafter	█ % pa for 3 years, █ % pa thereafter	█ % pa for 3 years, █ % pa thereafter

- Aurora selected 4 input assumptions to test the sensitivities for a change in the Present Value of revenues
- A change in the round-trip efficiency of the battery causes a relatively minor delta in the Present Value of revenue – until the efficiency drops below █ %. With an efficiency of █ %, the PV of the revenues are █ % of those with █ % efficiency as both arbitrage and ancillary revenues are impacted
- The impact of different cycling rates should be considered alongside degradation and lifetime as these measures are relatively interdependent

1) Discount rate of 11%, and 15% for high price periods (>\$500/MWh for WM prices or \$200/MW/h for AS prices). Does not include OPEX. 2) Round Trip Efficiency. 3) Assuming 365 cycles per year  
Sources: Aurora Energy Research

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