Do Wholesale Markets Drive Widescale Storage Deployments?

PRESENTED BY

Andrew Levitt

PREPARED FOR

AMERICAN CLEAN POWER

ACP RECHARGE ENERGY STORAGE SUMMIT

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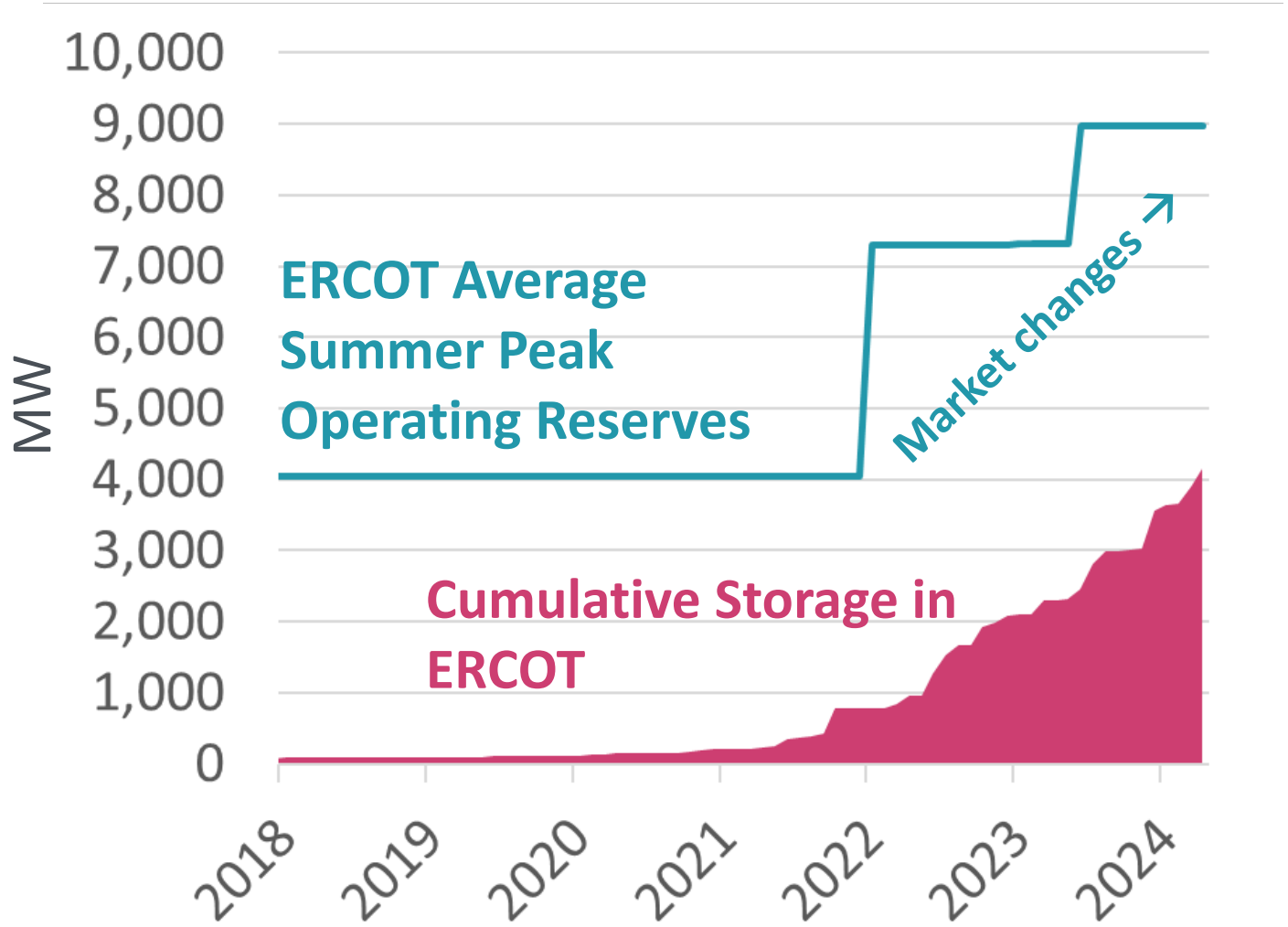
Brattle

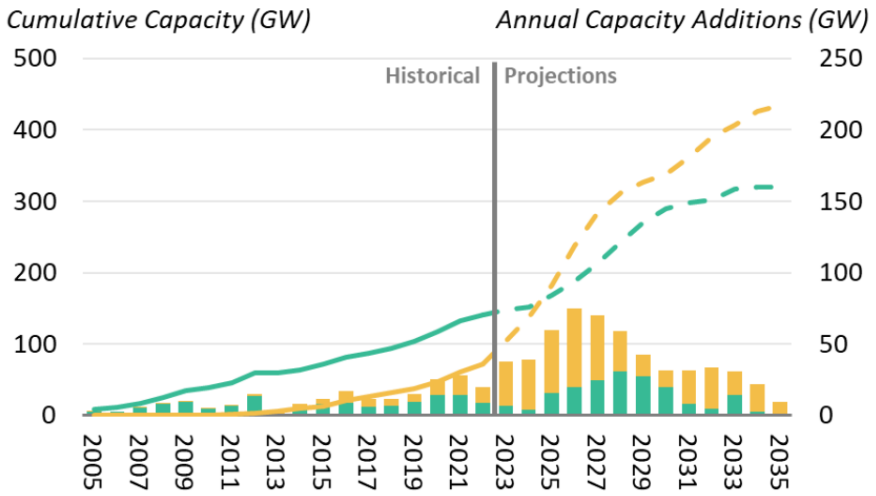
Wholesale Market Changes Can Drive Storage Deployments



Source: Potomac Economics, IMM Concerns with the AS Methodology, September 22, 2023
EIA, Form 860-M, April, 2024

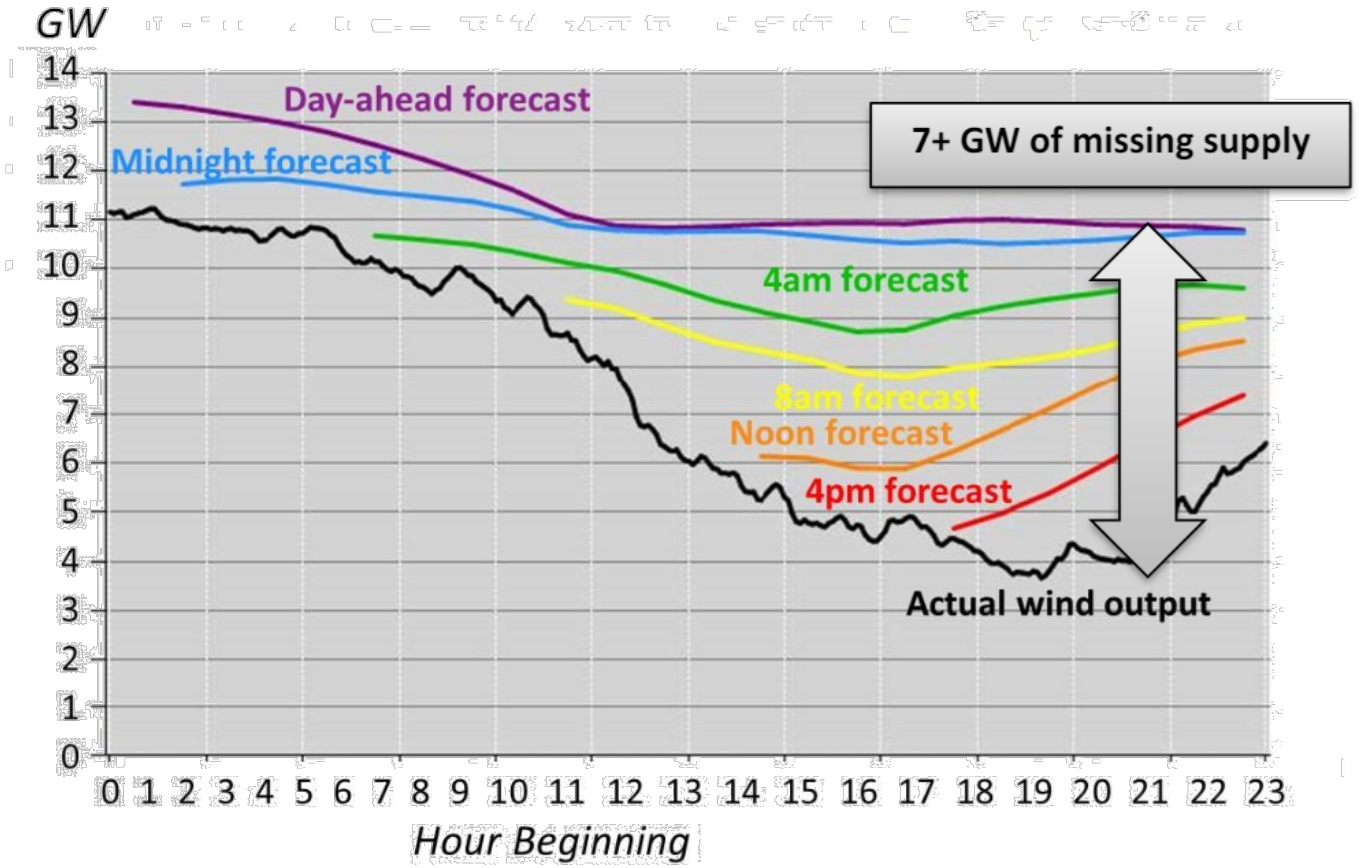
More Wind/Solar Growth Expected, Driving New Grid Needs

Wind and Solar Power Growth Will Continue



Notes and Sources: Lines represent total installed capacity, bars represent annual capacity additions; EIA, Monthly Energy Review, 2023, Table 7.7b; EIA, Annual Energy Outlook 2023, March 16, 2023, Table 16.

Uncertainty in Wind and Solar Forecast Drives New Grid Needs



Notes and Sources: Date of wind burn event was March 26, 2018. SPP, Market Working Group Meeting, March 17, 2020, Figure 24.

Reforms Complement Shifting Trends on A Low-Carbon Grid

Market	Shift in Trend w/ Decarbonization
Median Energy Price	↓
Energy Price Variability	↑
Scarcity Pricing in Energy	↑
Flexibility & Reserves	↑
Capacity	↑
Clean Attributes	↑
Adjacent Customer & Distribution Markets	↑
Interties & Geographic Diversification	↑

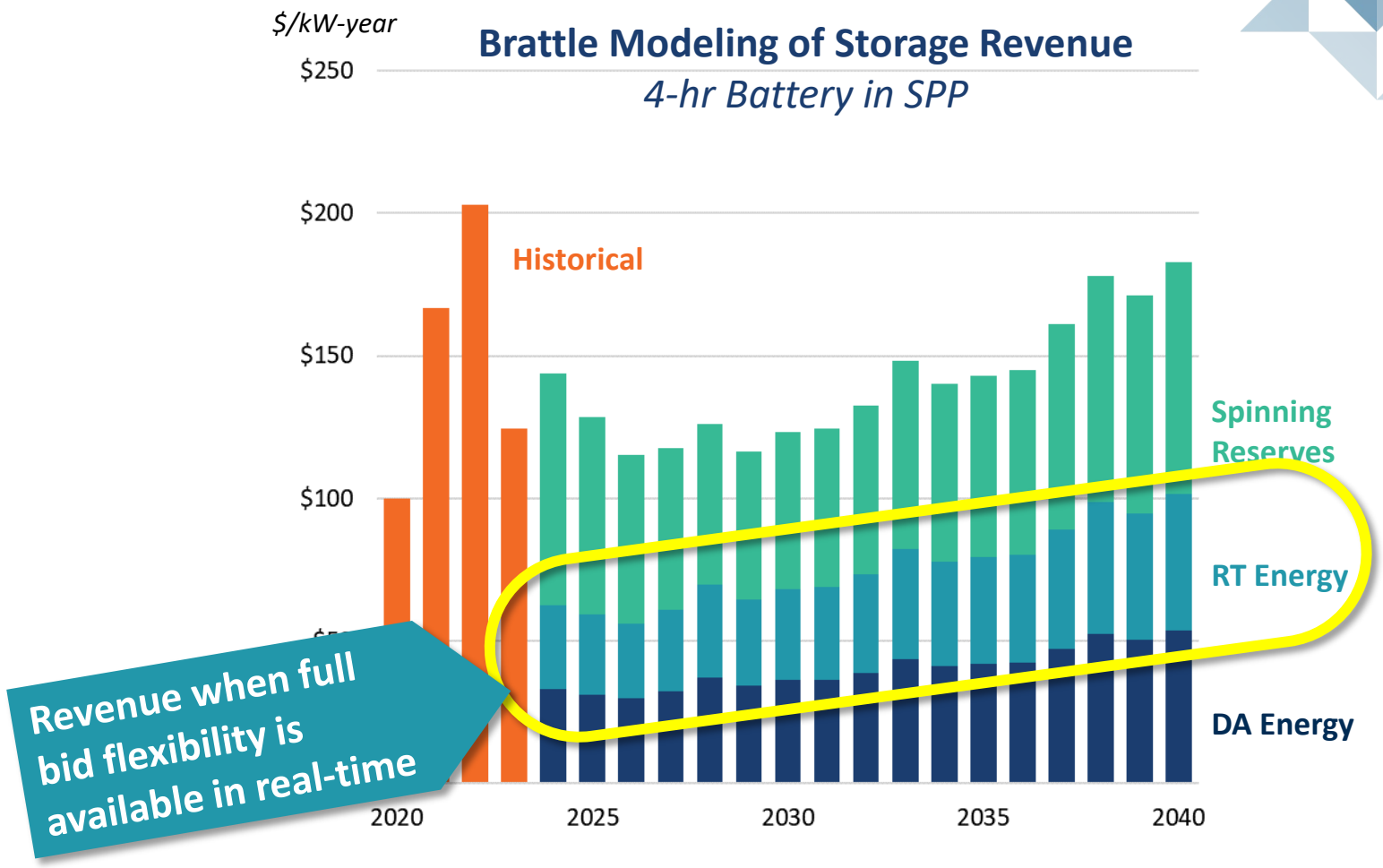
Market Reforms to Address Evolving Needs

- Complete energy pricing that reduces uplift
- Scarcity pricing aligned with system value
- New and bigger ancillary services
- More adaptable capacity markets
- Integration of clean policies and preferences into wholesale markets
- Expanded regional markets and interregional integration

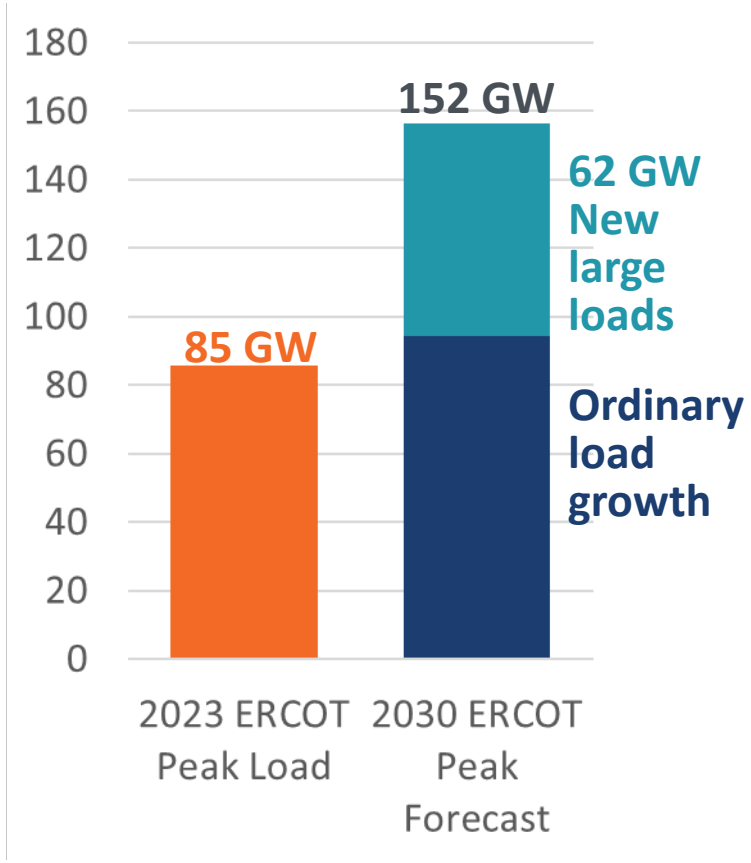
Example Wholesale Market Barrier and Reform: Bid Flexibility

Barrier: wholesale market rules can partly limit the ability of storage resources to pursue price arbitrage opportunities in the real-time market

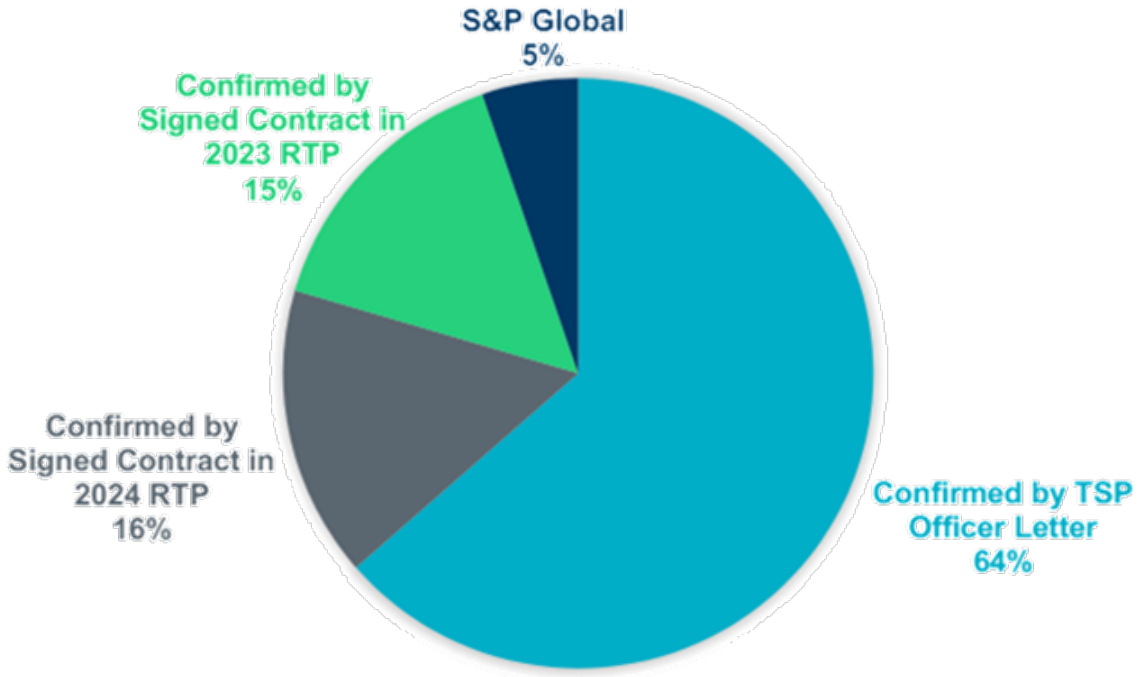
Reform: allow participants to change energy offer quantities and prices without unnecessary delays



Dramatic Load Growth Expected

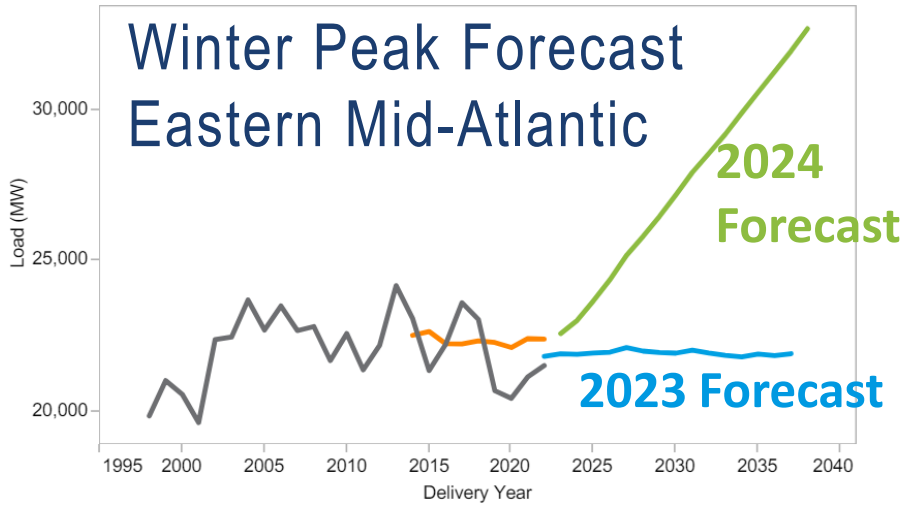


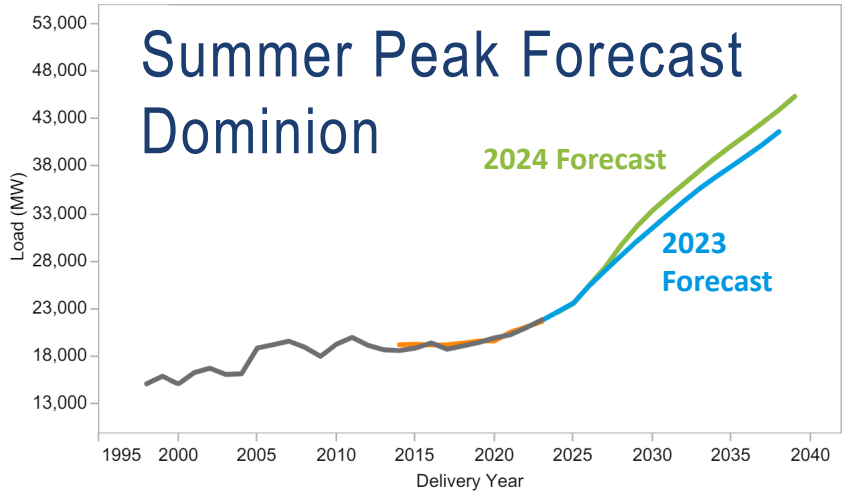
Approximately 62 GW of additional load will be added on top of the 2024 RTP bounded load level for study year 2030 with the breakdown as follows



Source: ERCOT, 2024 RTP Load Review Final Update, April 2024

Dramatic Load Growth Expected

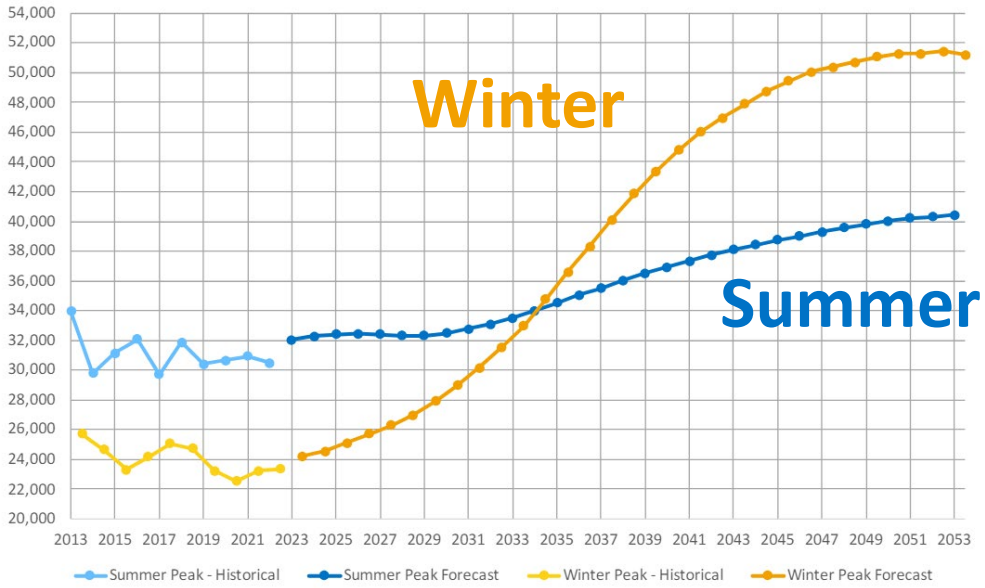




Growing load and tight supply conditions drive:

- More frequent scarcity prices in energy
- Higher ancillary service prices
- Higher capacity prices

NYISO Baseline Peak Forecast



Load Growth Amplifies Importance of Reform

Market	Shift in Trend w/ Load + Decarb
Median Energy Price	↓
Energy Price Variability	↑
Scarcity Pricing in Energy	↑↑↑
Flexibility & Reserves	↑
Capacity	↑↑↑
Clean Attributes	↑↑
Adjacent Customer & Distribution Markets	↑
Interties & Geographic Diversification	↑↑

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Thank You!

Additional Slides

About the Speaker

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Andrew Levitt is an expert in wholesale electricity policy, with a focus on evolving system needs. He has worked with utilities, regional transmission organizations (RTOs), and regulators to address wholesale electricity policies in light of a changing operational and infrastructure environment.

His experience includes the development of capacity value accreditation rules for renewable and storage; foundational market access rules for hybrids and storage; a new reactive power compensation approach; and an initial design concept for a capacity market overhaul.

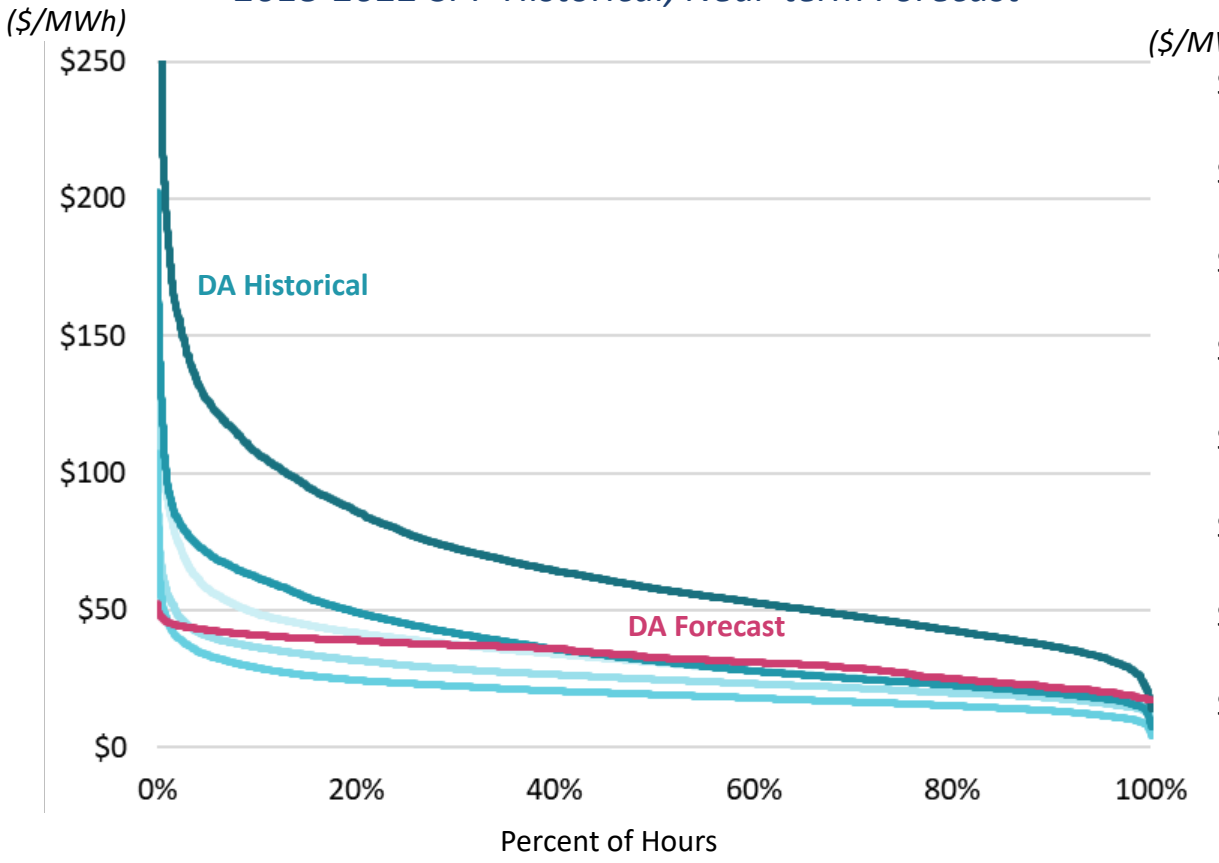
A lecturer in Johns Hopkins University's Energy Policy and Climate program, Andrew is also a frequent speaker and panelist at industry conferences. His research has been published by the Institute of Electrical and Electronics Engineers (IEEE) and *Energy Policy*, and he is the co-author of a chapter that appeared in *Future of Utilities – Utilities of the Future*.

Prior to joining Brattle, Andrew was Senior Lead Market Designer at PJM. He received an MMP from University of Delaware, the Center for Carbon-Free Power Integration, and a BS in physics from University of Toronto.

Fundamental price forecasts seldom reflect volatility observed in real-world prices, thereby understate storage valuation in Resource Planning and Valuation studies

Historical vs. Fundamentals Energy Price Duration Curves

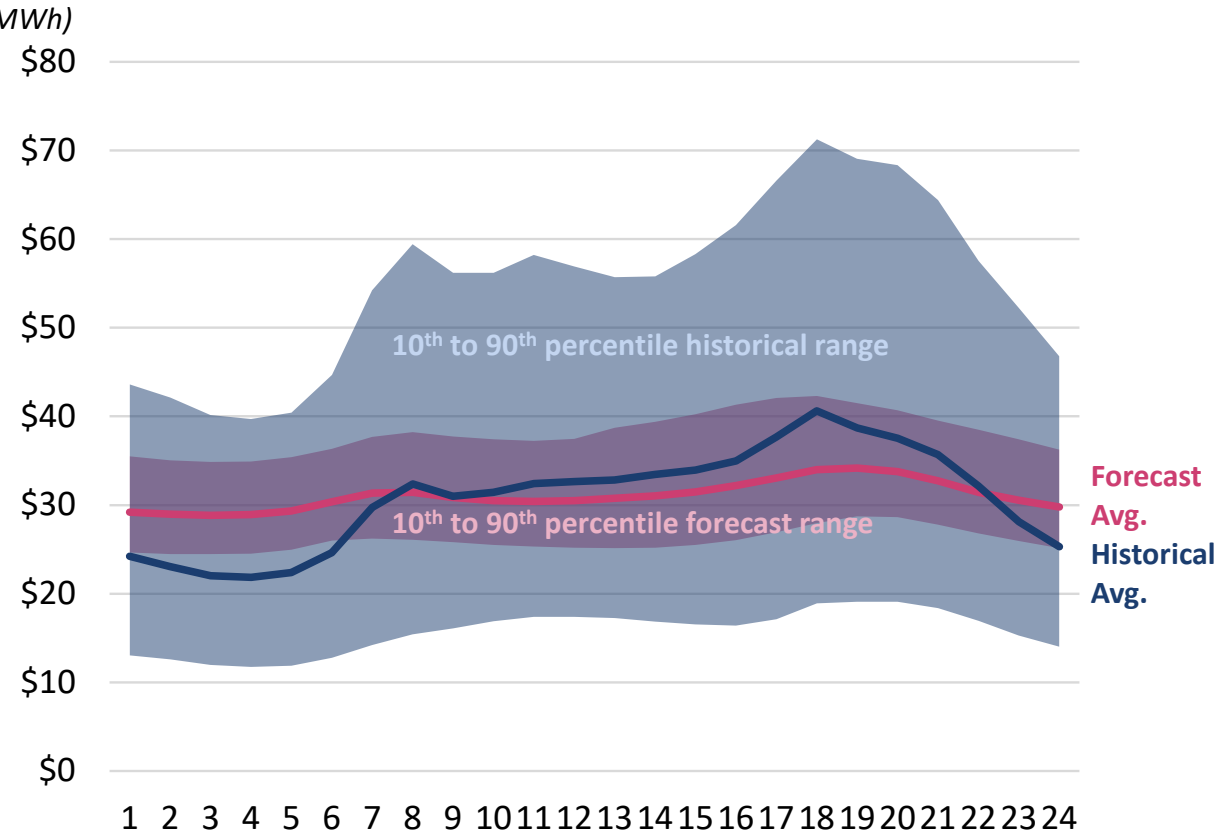
2018-2022 SPP Historical, Near-term Forecast



Note: Each shaded line represents a different year of historical DA energy prices.

Daily Historical vs. Fundamentals Energy Price Shapes

2018-22 SPP Historical, Near-term Forecast



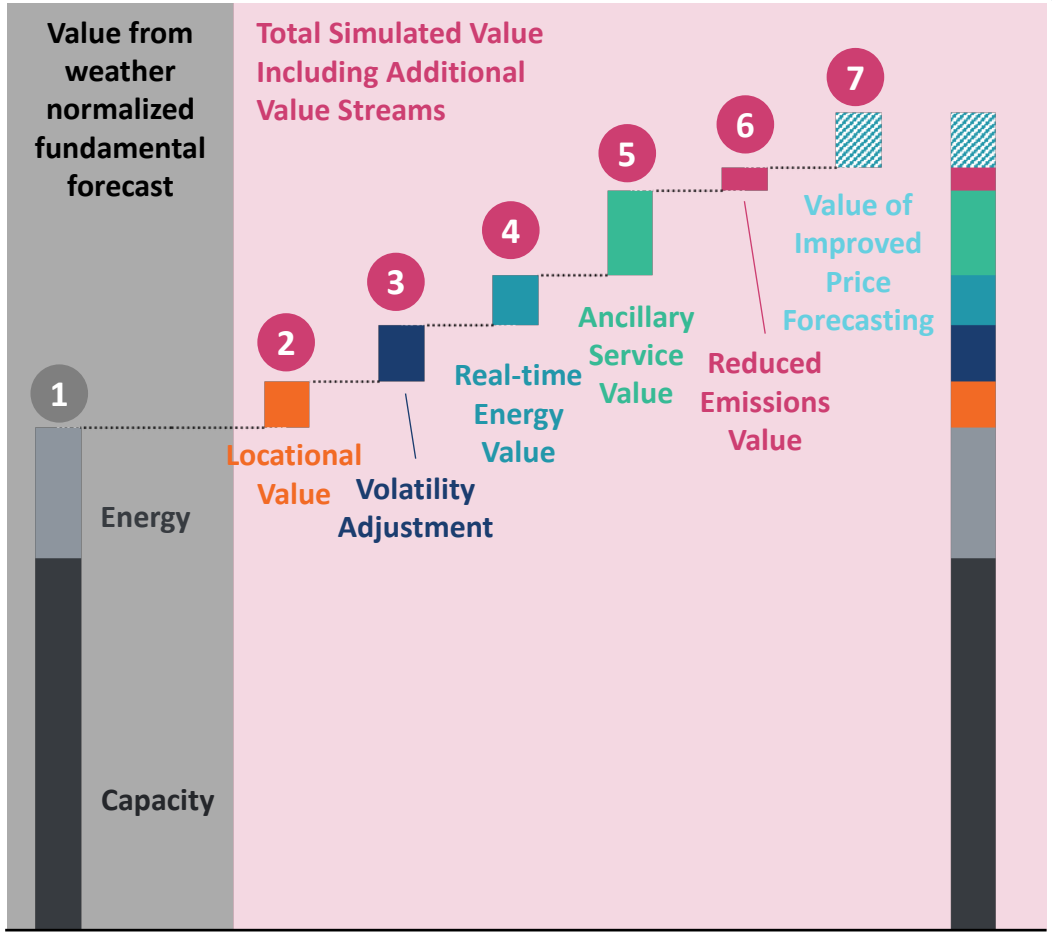
Note: Historical prices are adjusted such that the average historical price is equal to the average forward price in order to isolate volatility differences from price level differences.

Brattle's bStore Value Stack

Brattle's bStore model captures future storage revenues by reintroducing historical value streams into the forward looking revenue estimates

1. Simulated value from typical weather normalized fundamental forecast
2. Locational value from placing assets at specific locations on the electric system with different locational marginal prices due to congestion and losses
3. Value associated with volatility in real-world prices relative to fundamental forecast, captured from 5-min scale historically observed prices
4. Ancillary service value, from spin. Batteries react quickly to dispatch instructions and are good at providing these products
5. Real-time energy value. Batteries react quickly to real-time price changes and earn revenue through real-time energy arbitrage
6. Value associated with grid emission reductions. Charging during low marginal emission hours and discharging during high emission hours can reduce overall grid emissions
7. Additional realizable value associated with perfect foresight into the market. Brattle dispatches batteries with imperfect foresight to reflect real-world conditions, but dispatchers over time could extract additional value with experience and data analytics that improve forecasting capability

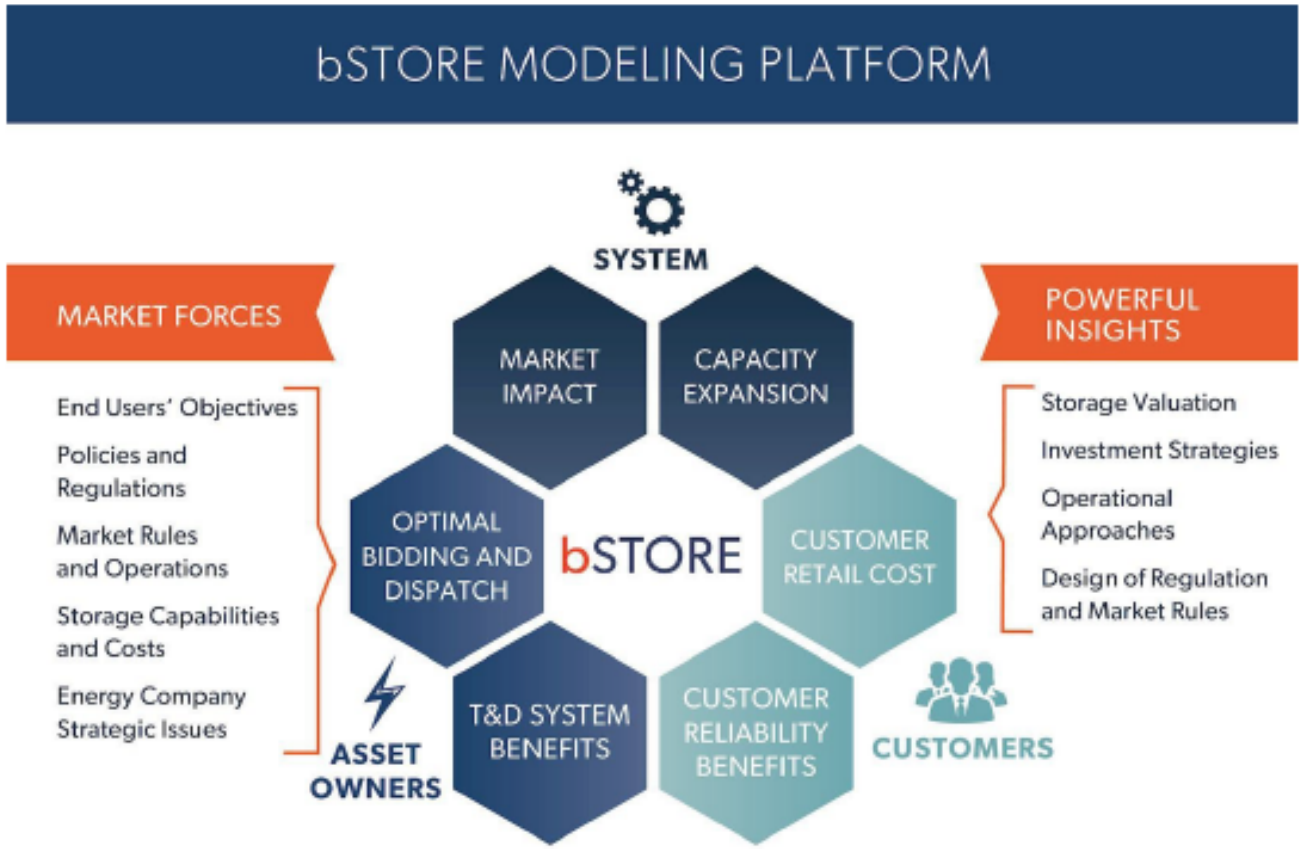
Full Storage Value Stack ($/kW-year)



Brattle's bStore Model

Brattle's bSTORE modeling platform can estimate storage revenues across all value streams considering real-world price volatility

- Using historical and forecasted prices for a range of market products, we simulate the dispatch of storage projects to optimize value across potential revenue streams
- Foresight into future market prices is assumed to be limited and modeled as such, reflecting realistic price forecasting ability of the battery operator
- We simulate dispatch of the batteries to capture multiple revenue streams, accounting for tradeoffs and limitations on the extent to which the revenue streams are additive



Source: The Brattle Group's bSTORE website