Beyond Four Hours: Potential Market Drivers for Deploying Long-Duration Energy Storage

DOE-OE Peer Review
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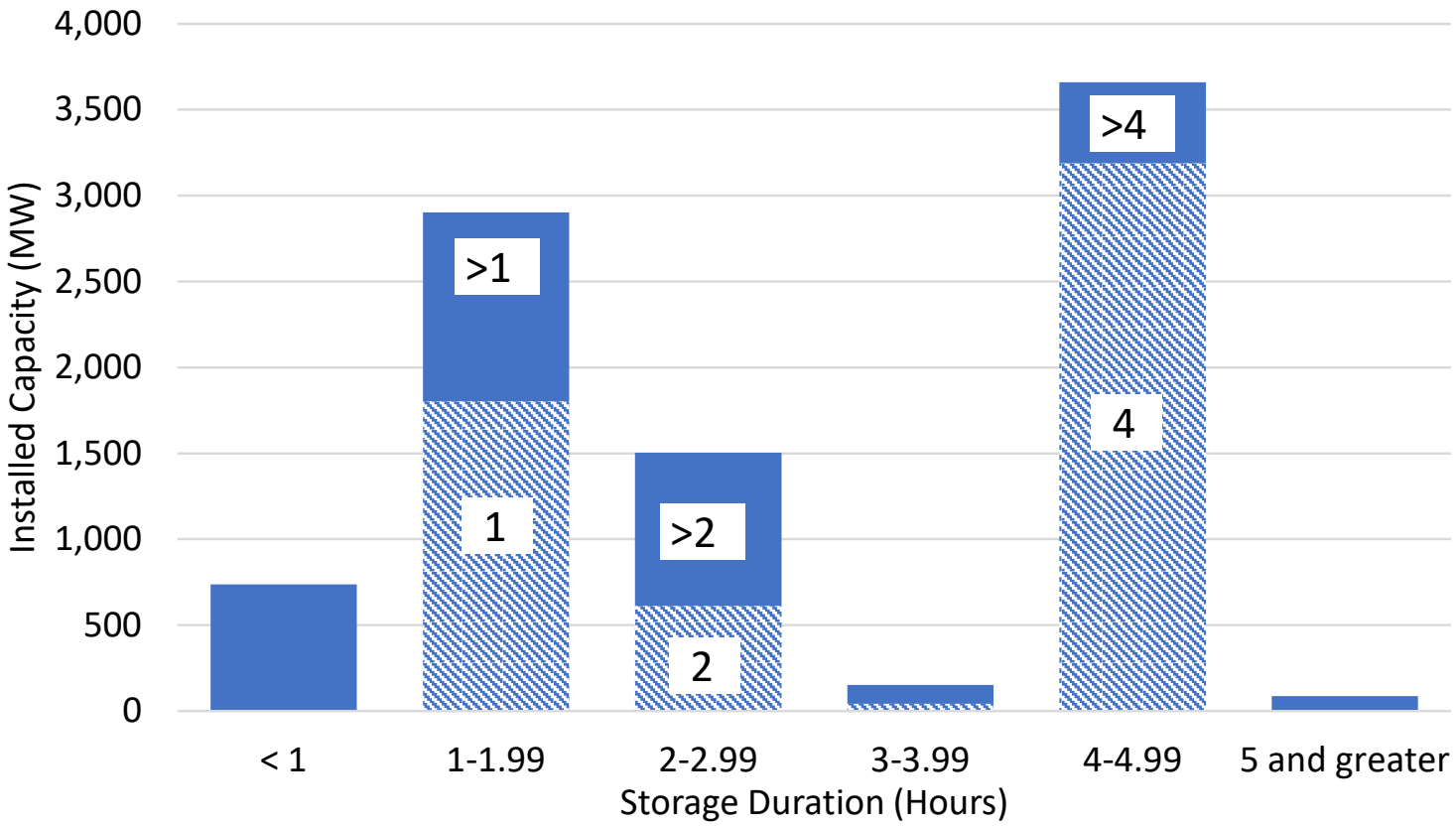
Motivation - Recent Storage Installations

Year	Power (MW)	Weighted Avg. Duration (Hours)
2010–2014	210	0.7
2015	150	0.5
2016	200	1.3
2017	130	2.2
2018	220	2.3
2019	190	2.7
2020	500	1.2
2021	3,380	2.9
2022	4,160	2.7
Total	**9,140**	**2.6**



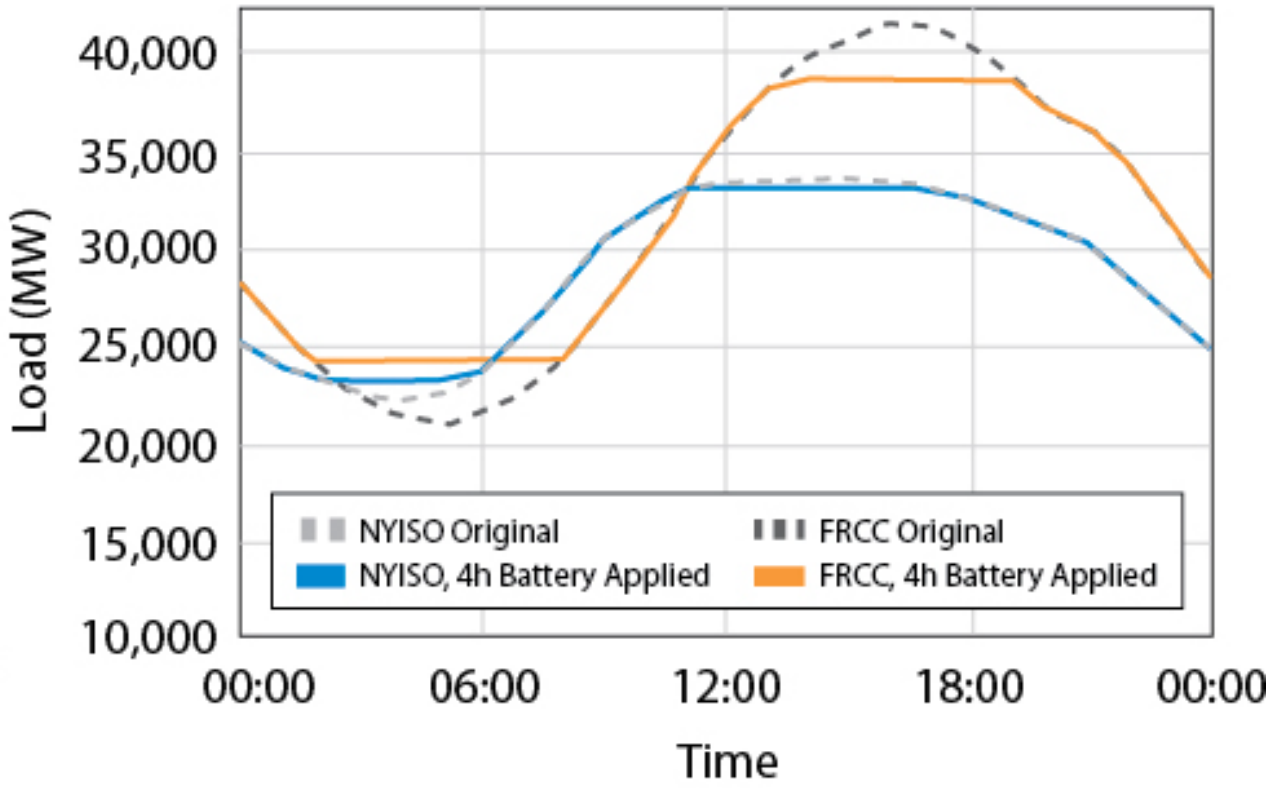
99.8% of capacity in 2021-2022 listed as Lithium-Ion. As of June 2023 another 1,763 MW of batteries competed and 7,165 under construction. Of the completed projects, only about 20% include duration data, but the average of these was below 2 hours.

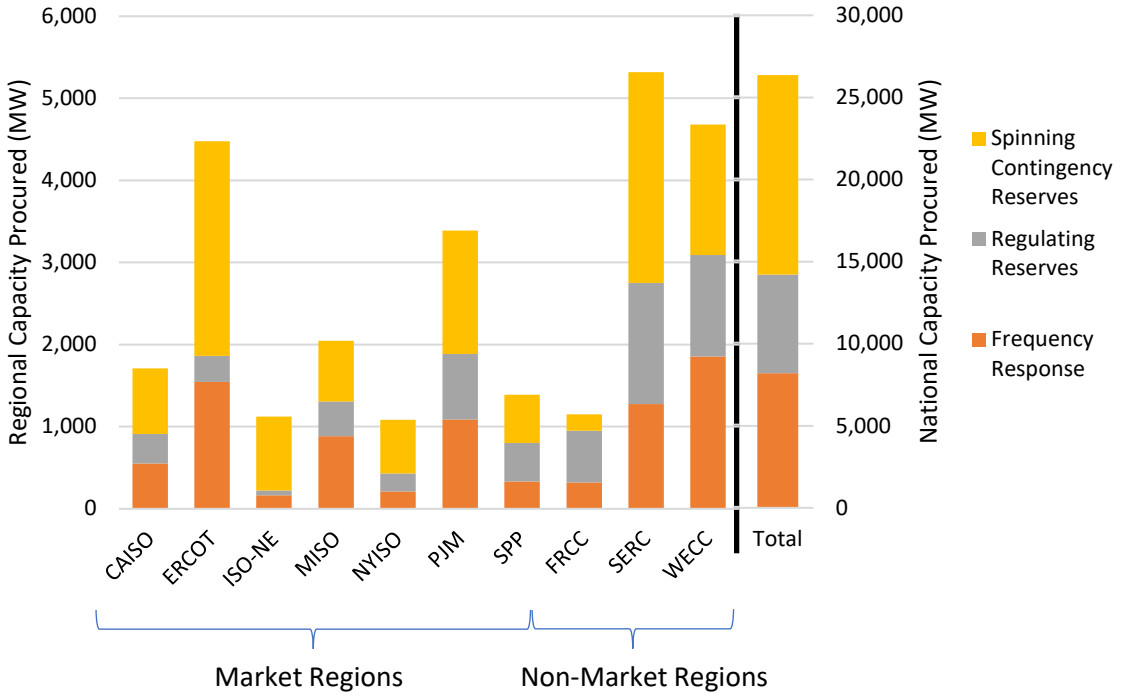
Less than 7% of total capacity has a duration that exceeds 4 hours.

BUT WHY???

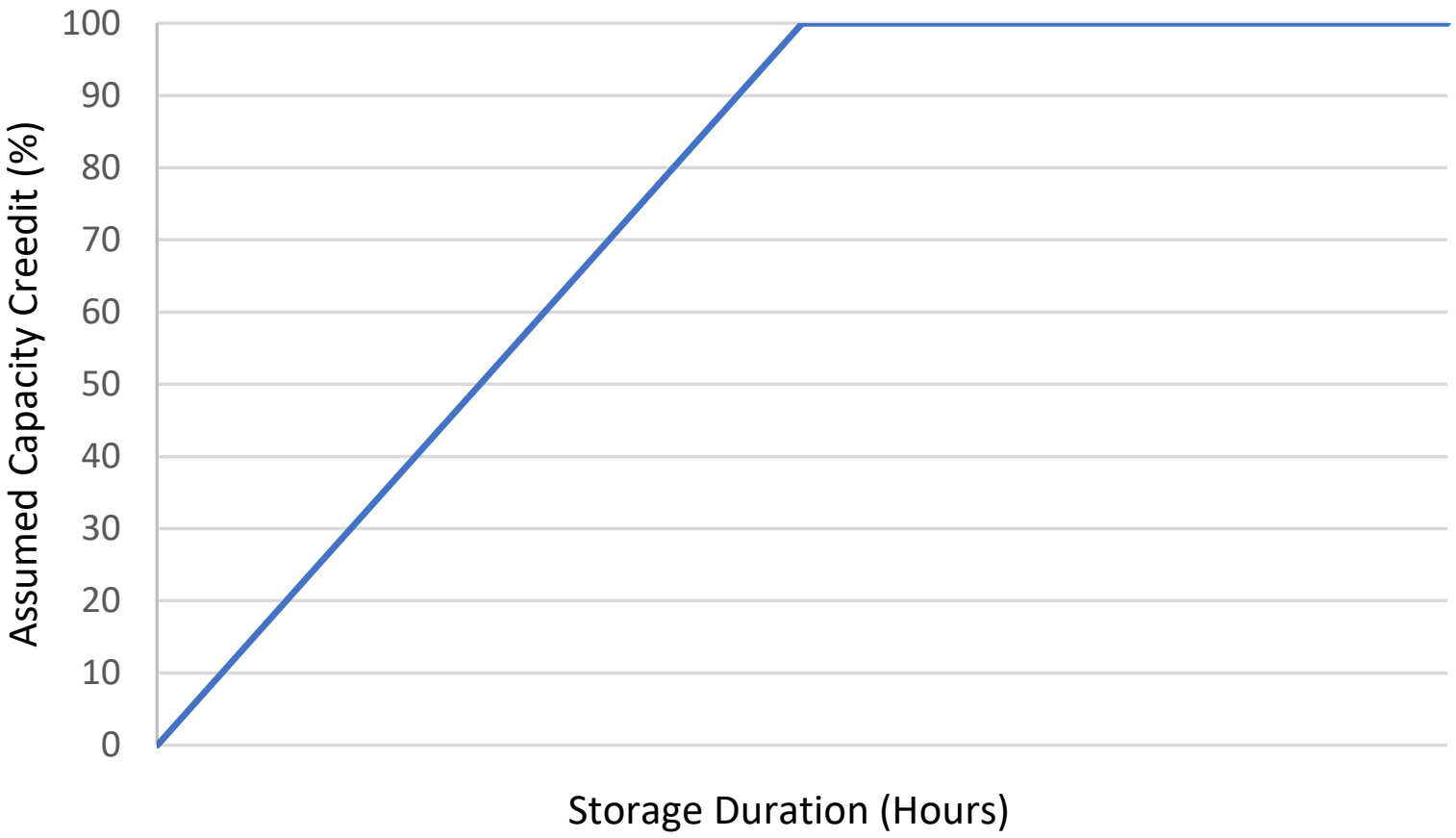
Primary Sources of Storage Value In Today's Grid

1) Ancillary services
2) Capacity value
3) Energy time shifting value





The Four-Hour Capacity Rule

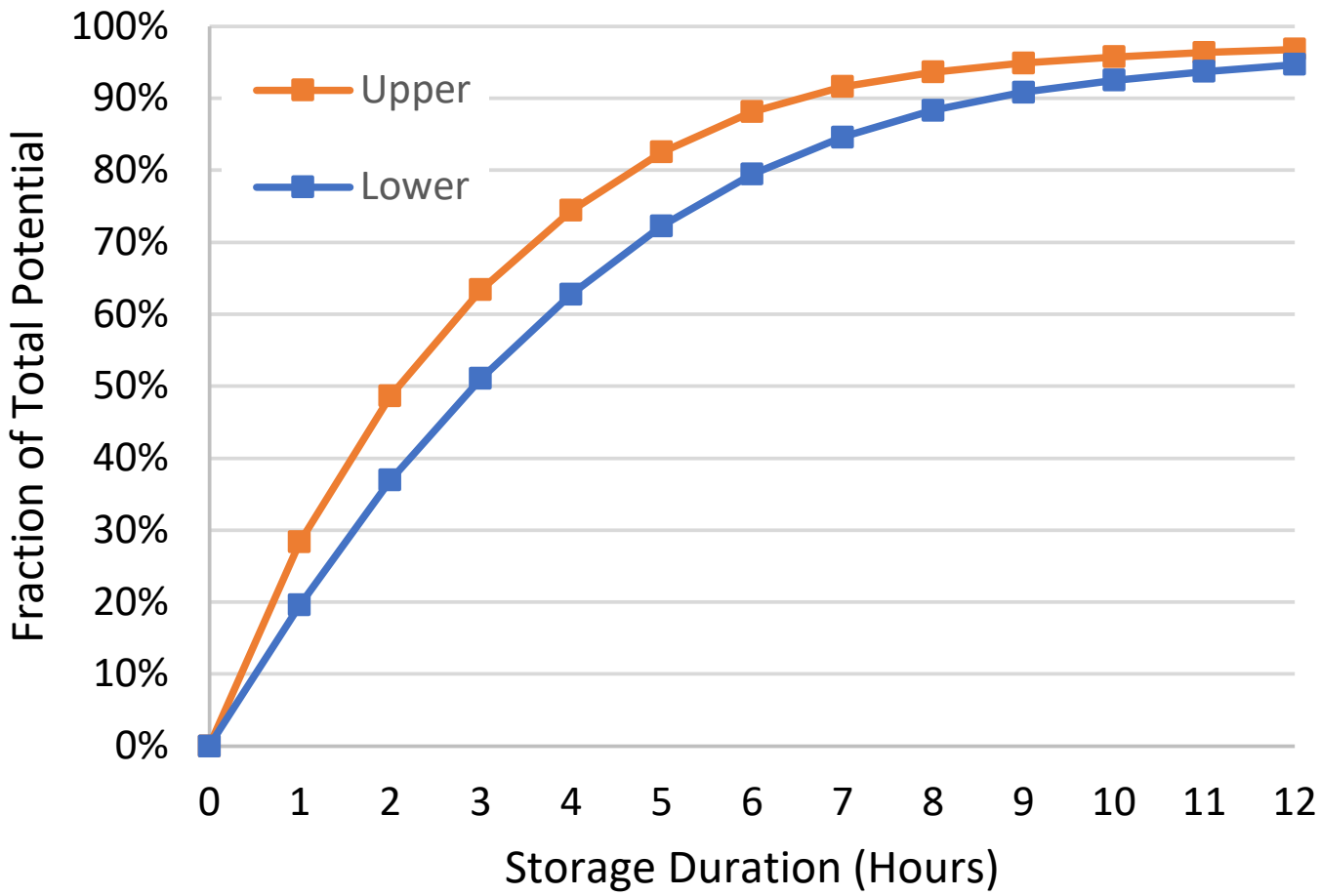


Market Operator	Duration Minimum (hours)
ISO-NE	2
CAISO	4
NYISO	4
SPP	4
MISO	4
PJM	ELCC based

Many regions have implemented a 4-hour requirement for resource adequacy

So the marginal value of adding a fifth hour is **zero**.

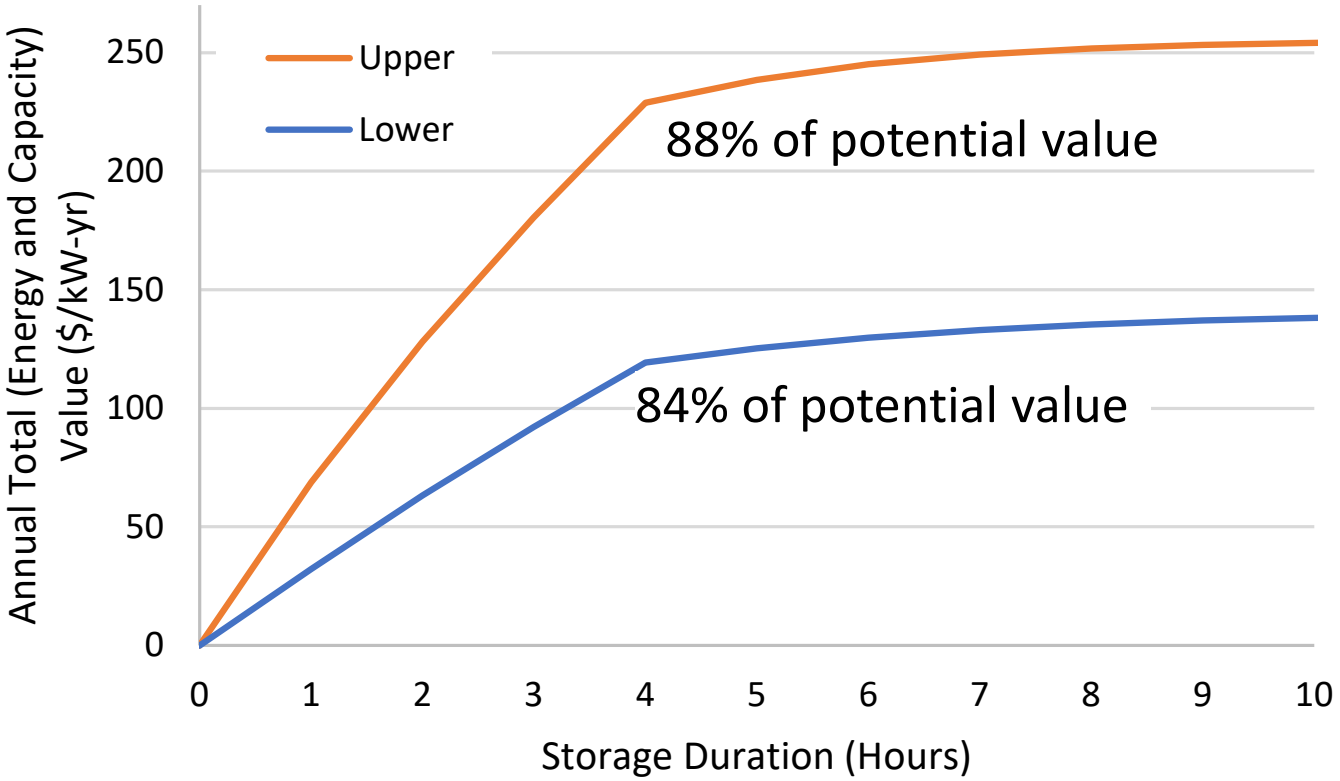
Energy Shifting Value

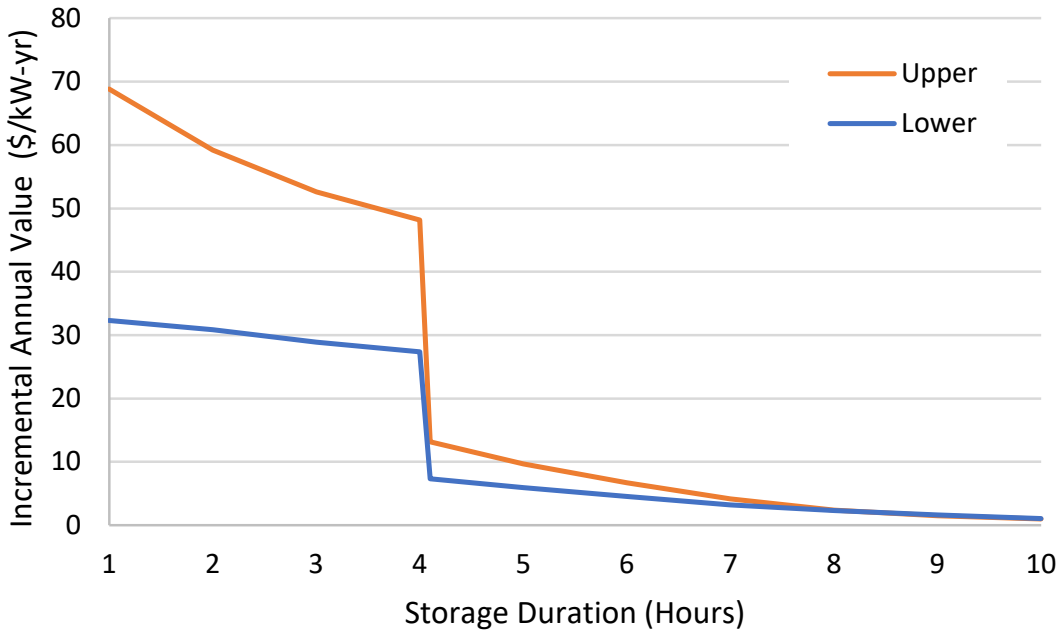


Example of the total value of energy time-shifting using a range of wholesale market prices

Bottom line

- Four hour storage captures most of the value in locations with a four-hour capacity rule



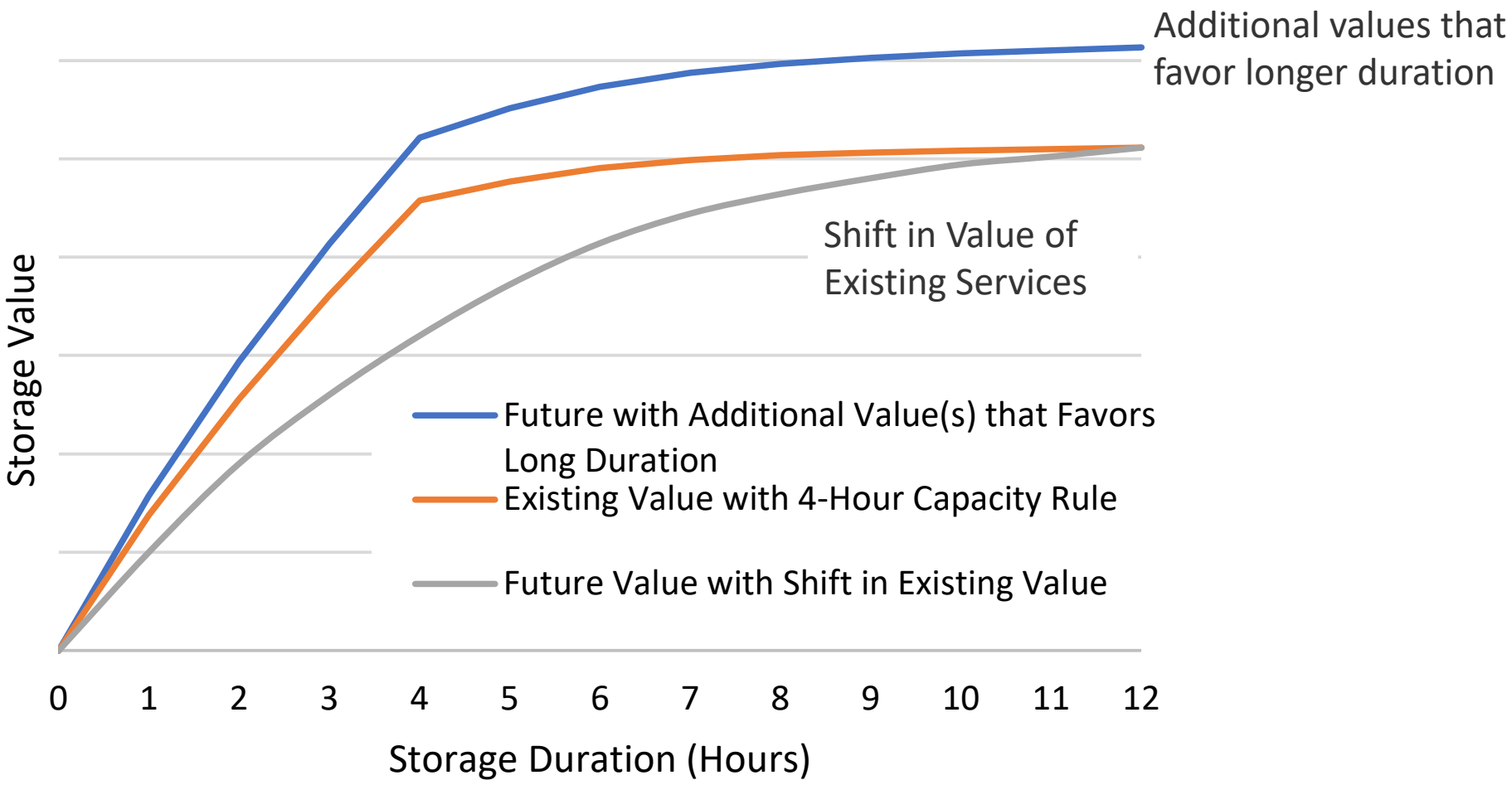


To Summarize

1. Nearly all of the monetizable benefits of storage can be achieved with durations of 4 hours in today's grid.
2. Li-Ion beats every other technology on life-cycle costs at 4 hours and less

- So..when will this change?

Framework for Moving Beyond Four Hours



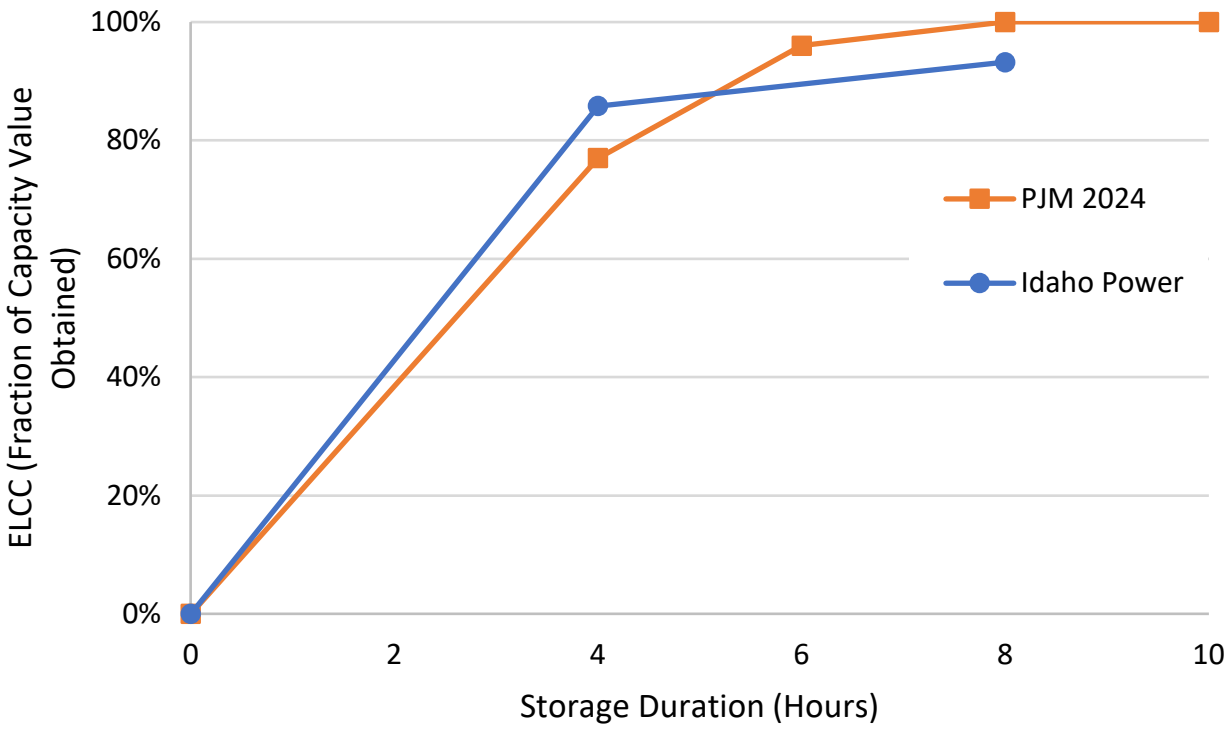
Changes in Value that Favor Longer Duration

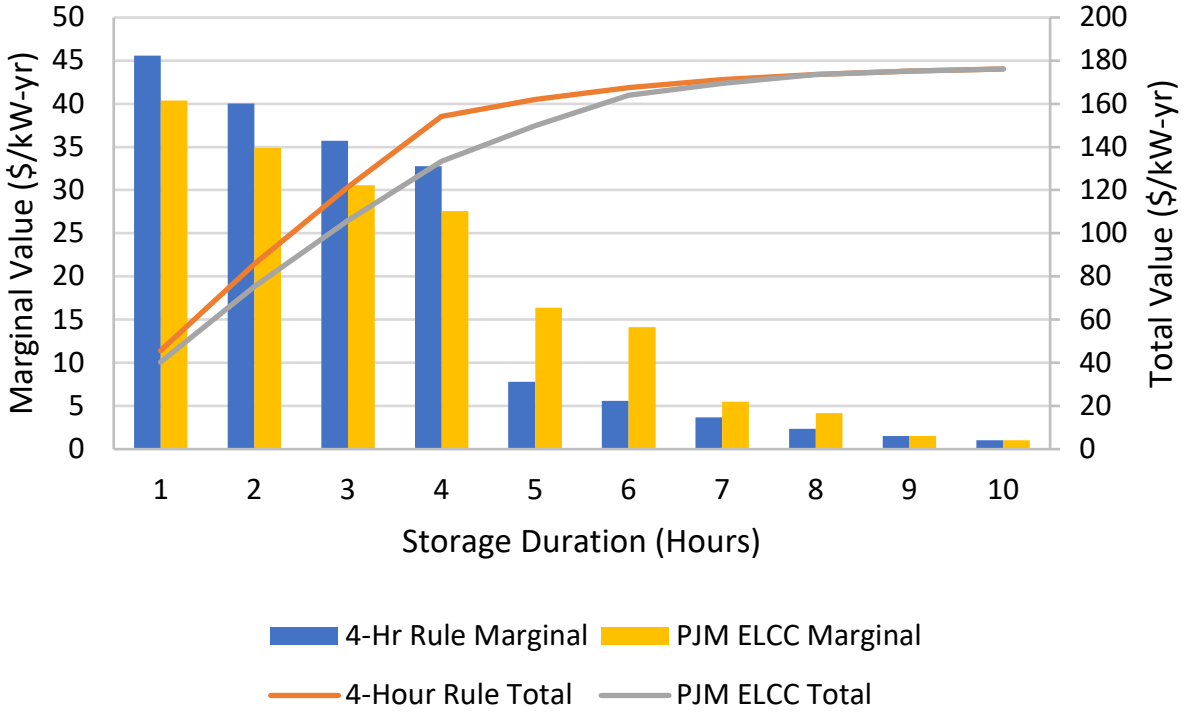
- Shift in Value
  - Capacity
  - Energy
- Additional Values
  - Transmission
  - Resilience

Shift in Capacity Value

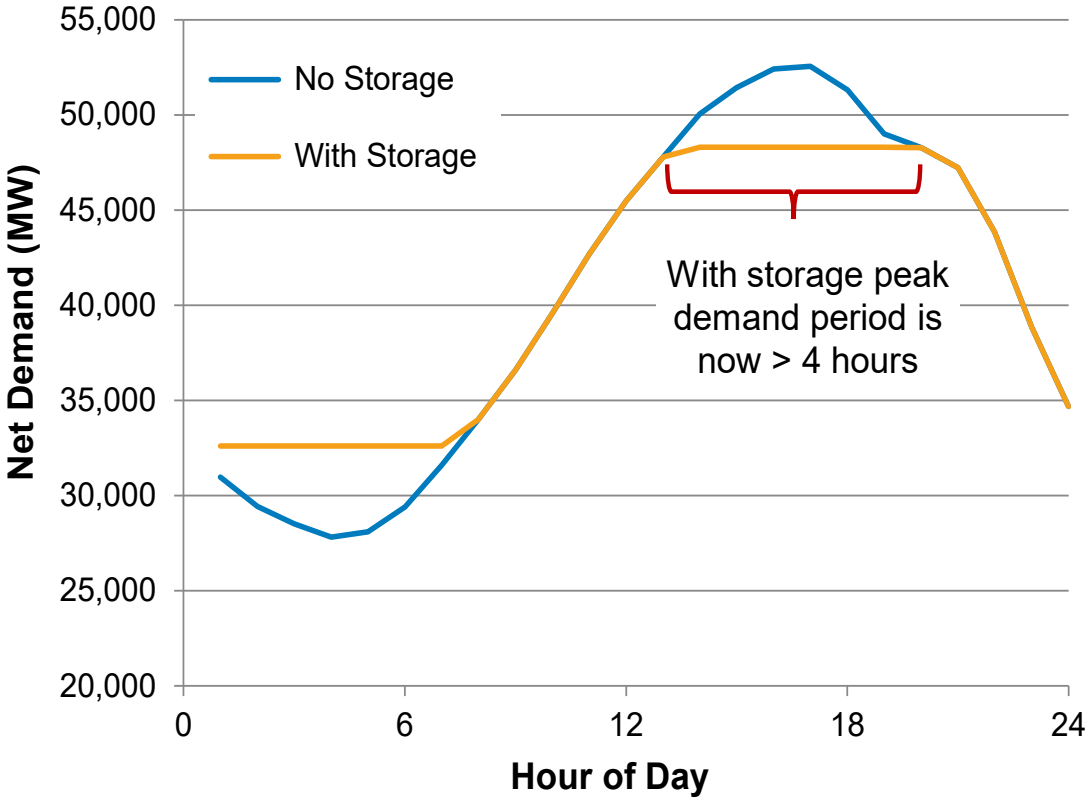
- Perhaps the most likely shift in value will occur due to declining capacity credit for short duration storage.
- Two likely causes:
  - Use of non-linear derates
  - Shift to longer-duration winter peaks

ELCC/Non-Linear Derates

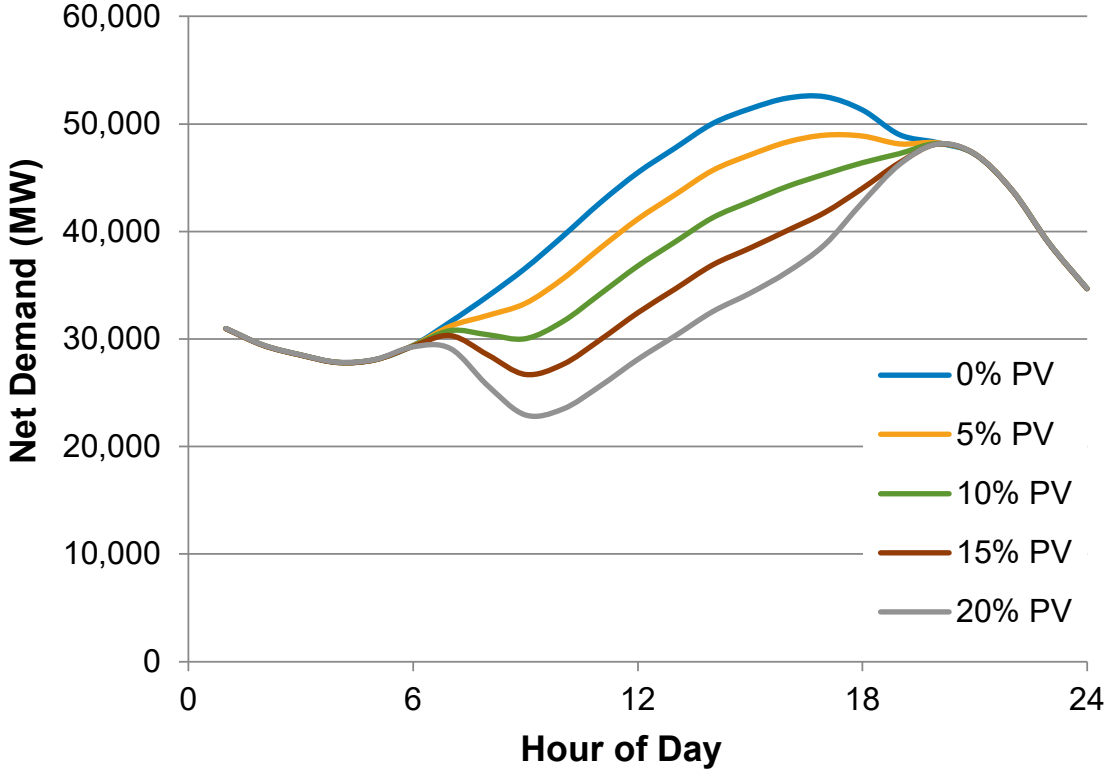




Transition to Longer Duration Peaks? (But Probably Not in the Summer)

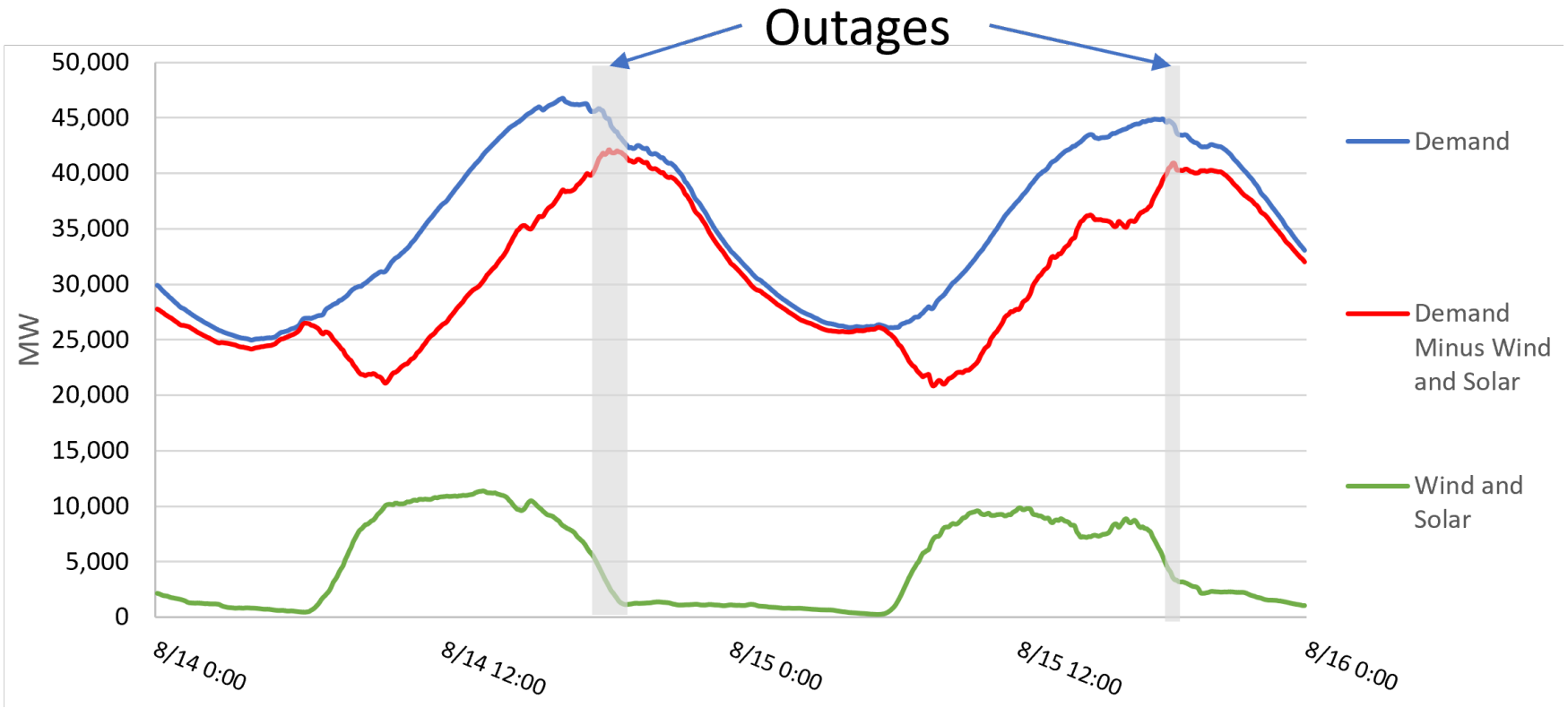


Simulated impact of increased 4-hour storage deployment on net load shape



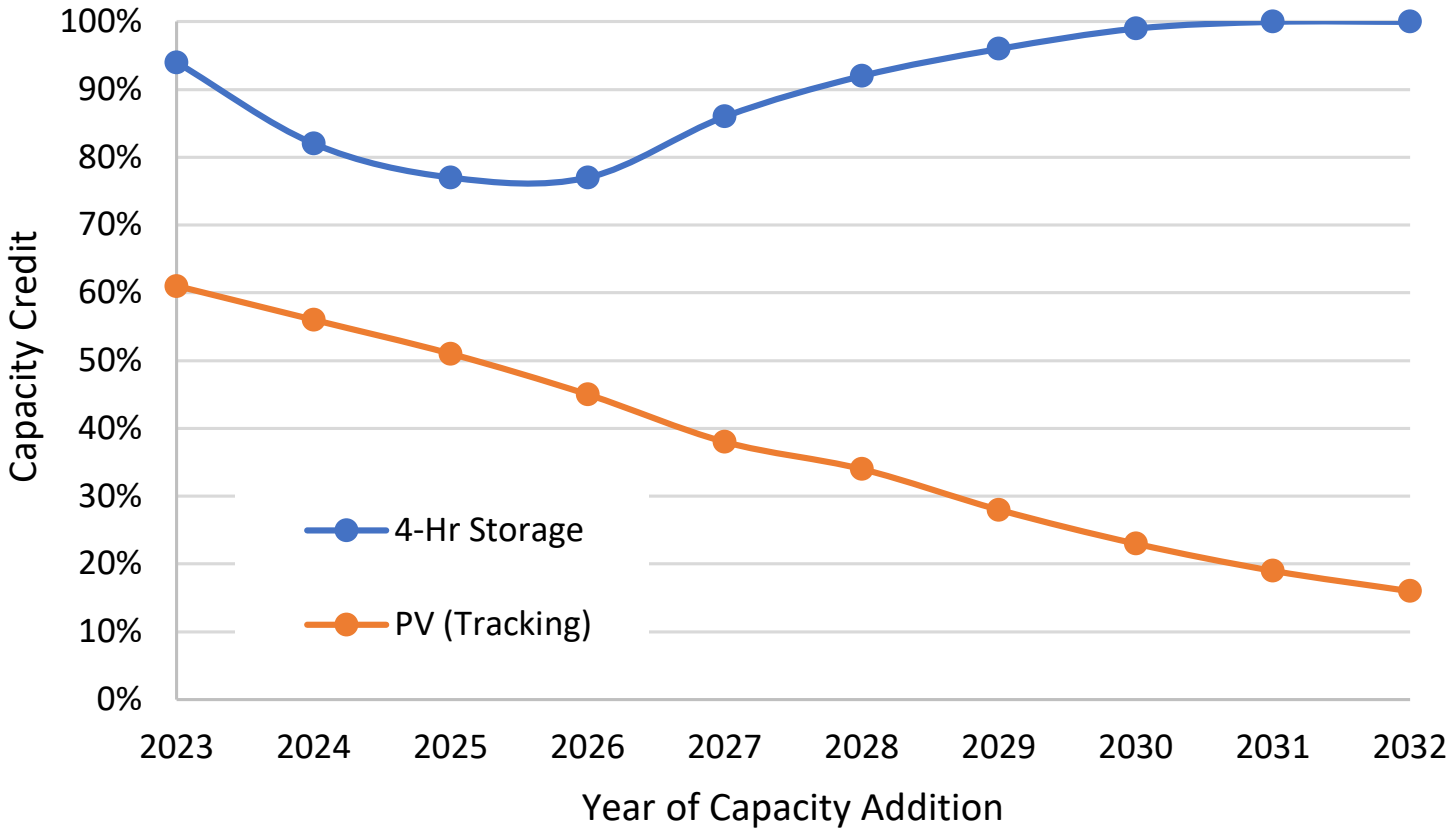
PV increases opportunities for 4-hour storage as peaking capacity – California Example

And Four Hours Should be Enough For Now….



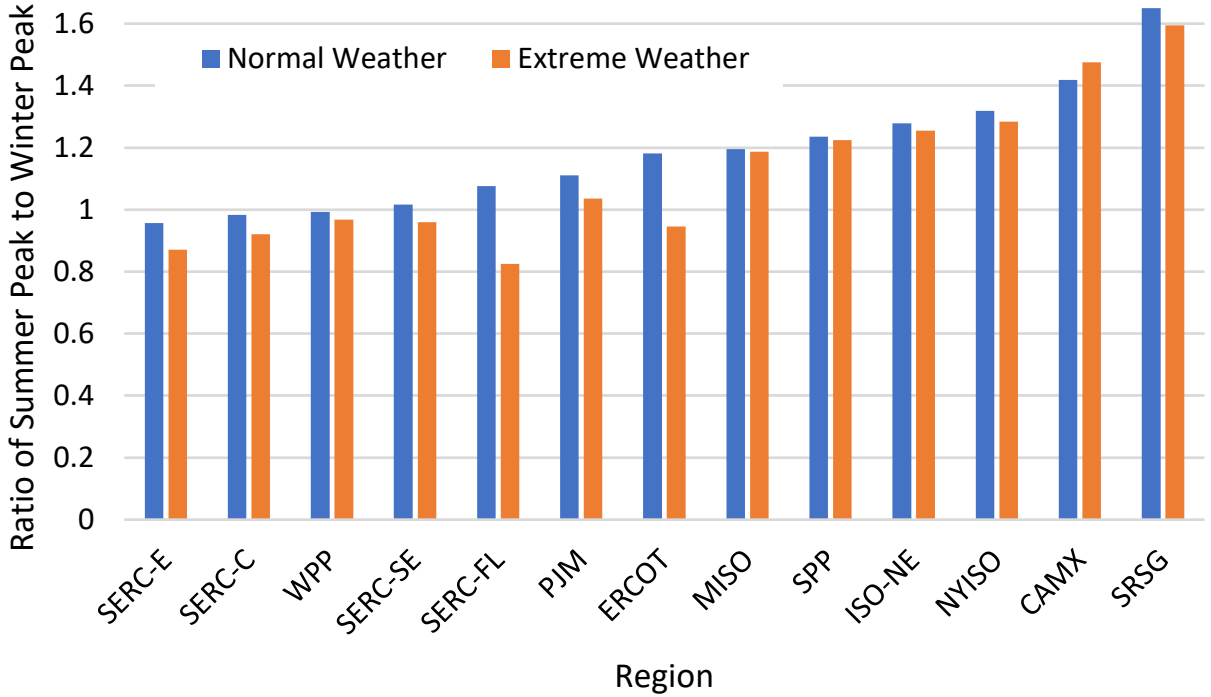
CAISO 2020 outages could have been addressed with 2.5 hours of storage

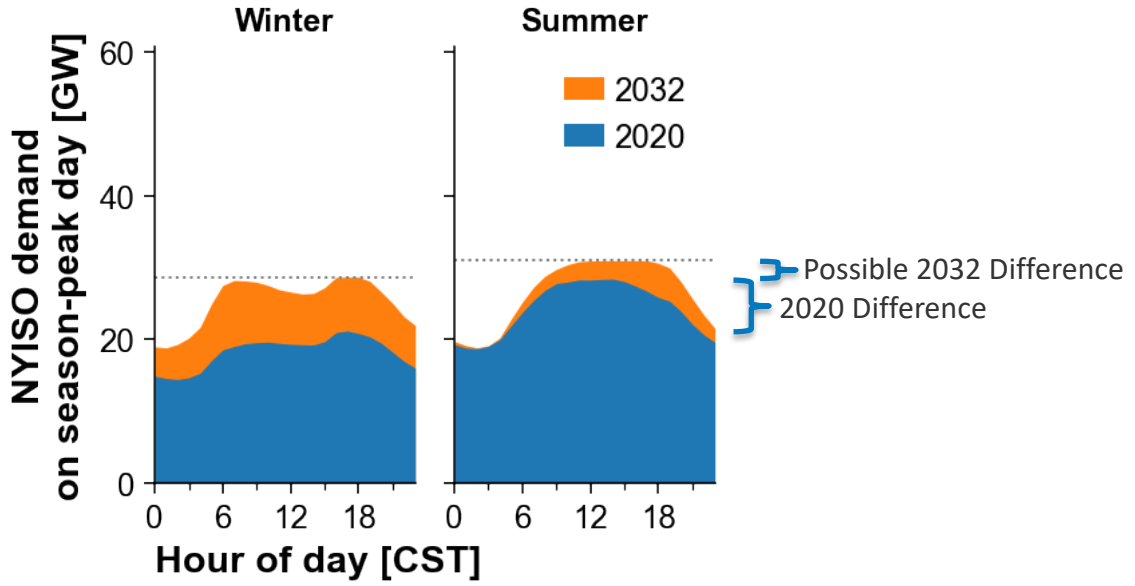
Four Hour Storage Maintains Summer Capacity Value



PJM Analysis by Astrape

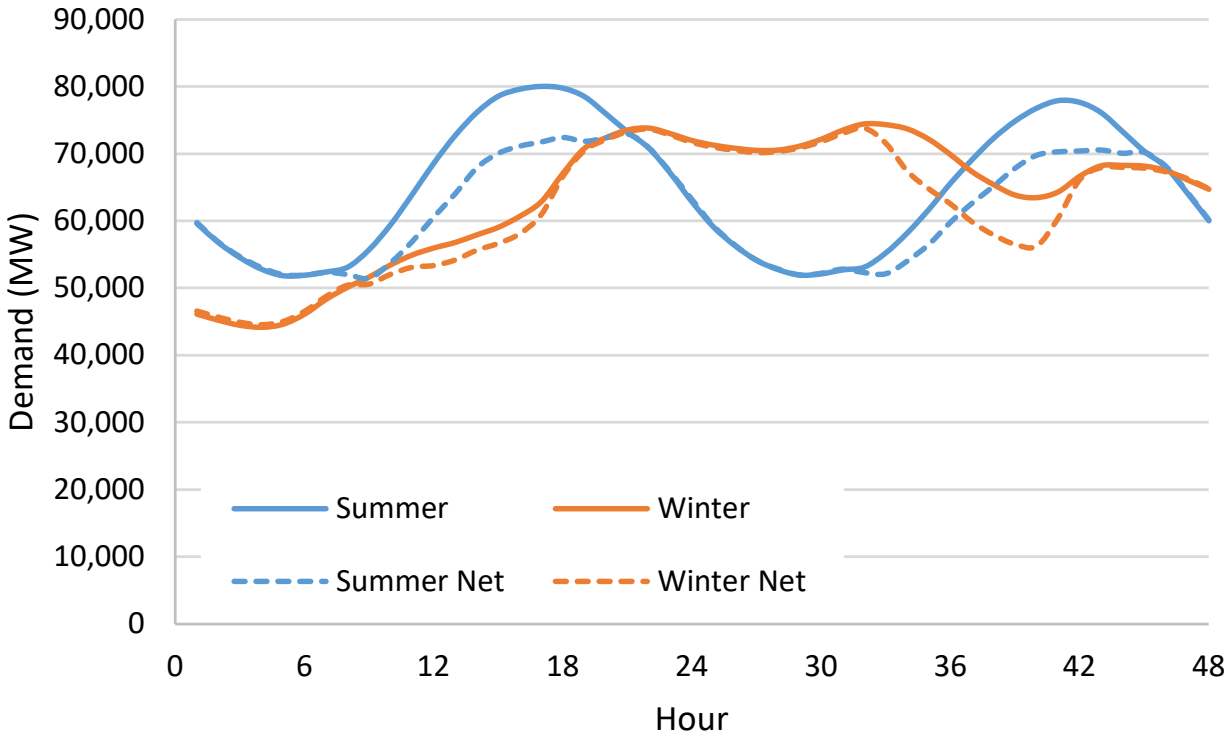
But Winter Peaks are Coming! (or already here…)



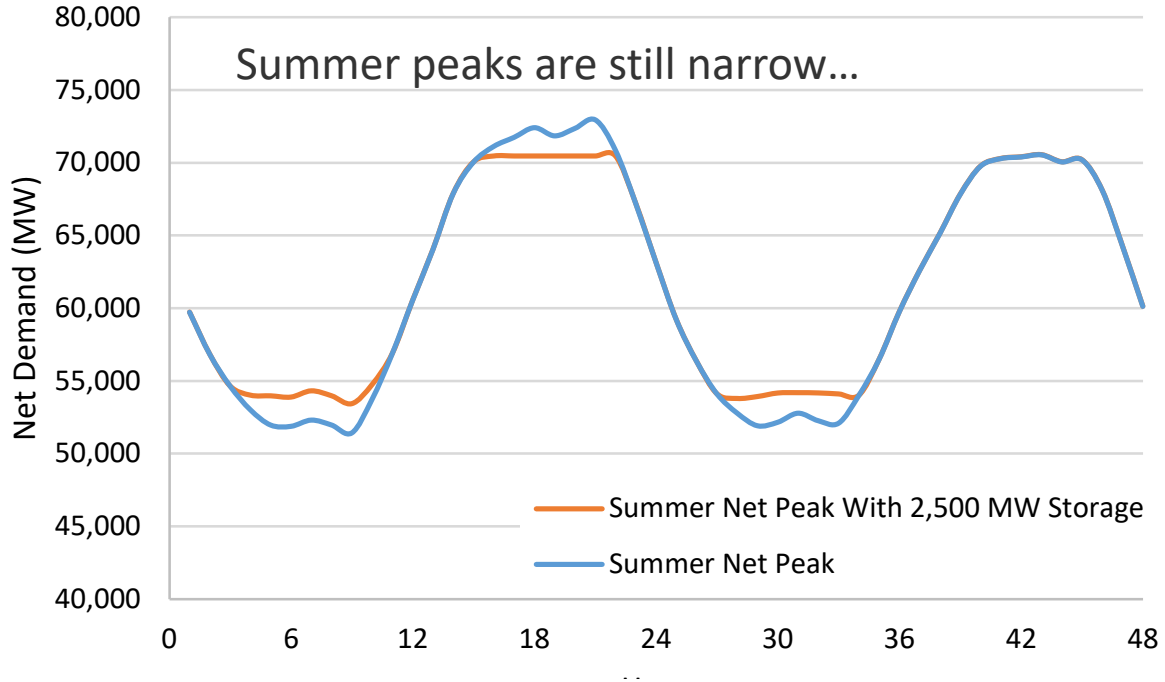


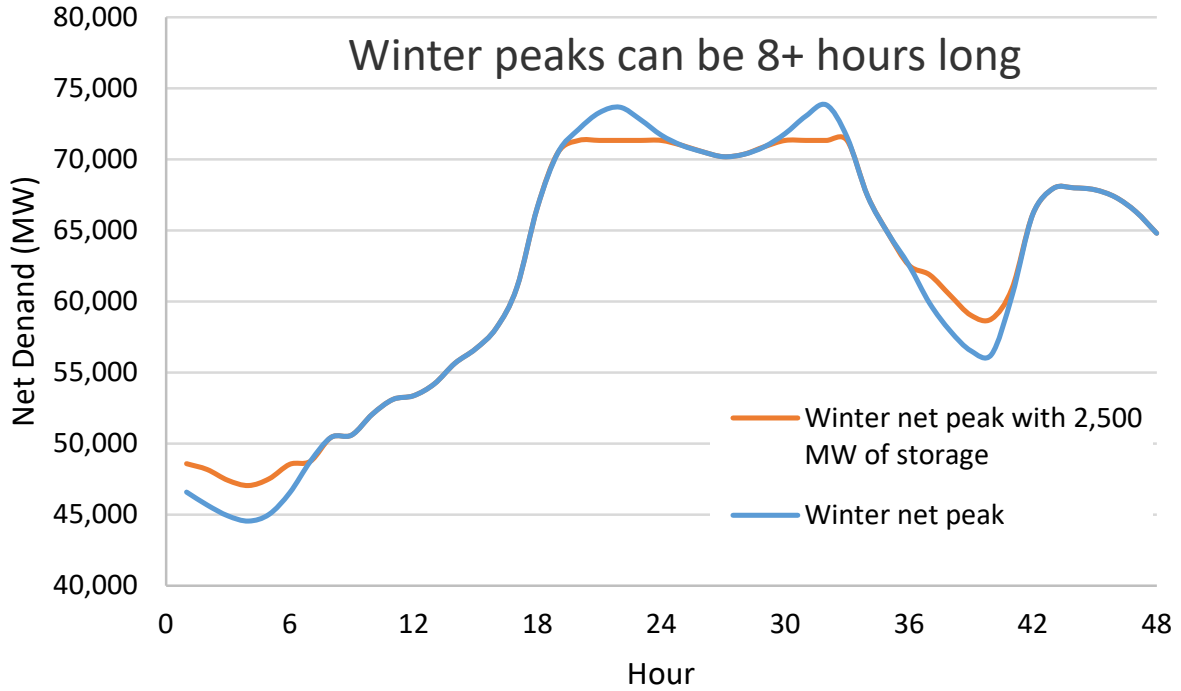
The Southeast is now winter peaking !!

Transition to Longer Winter Peaks

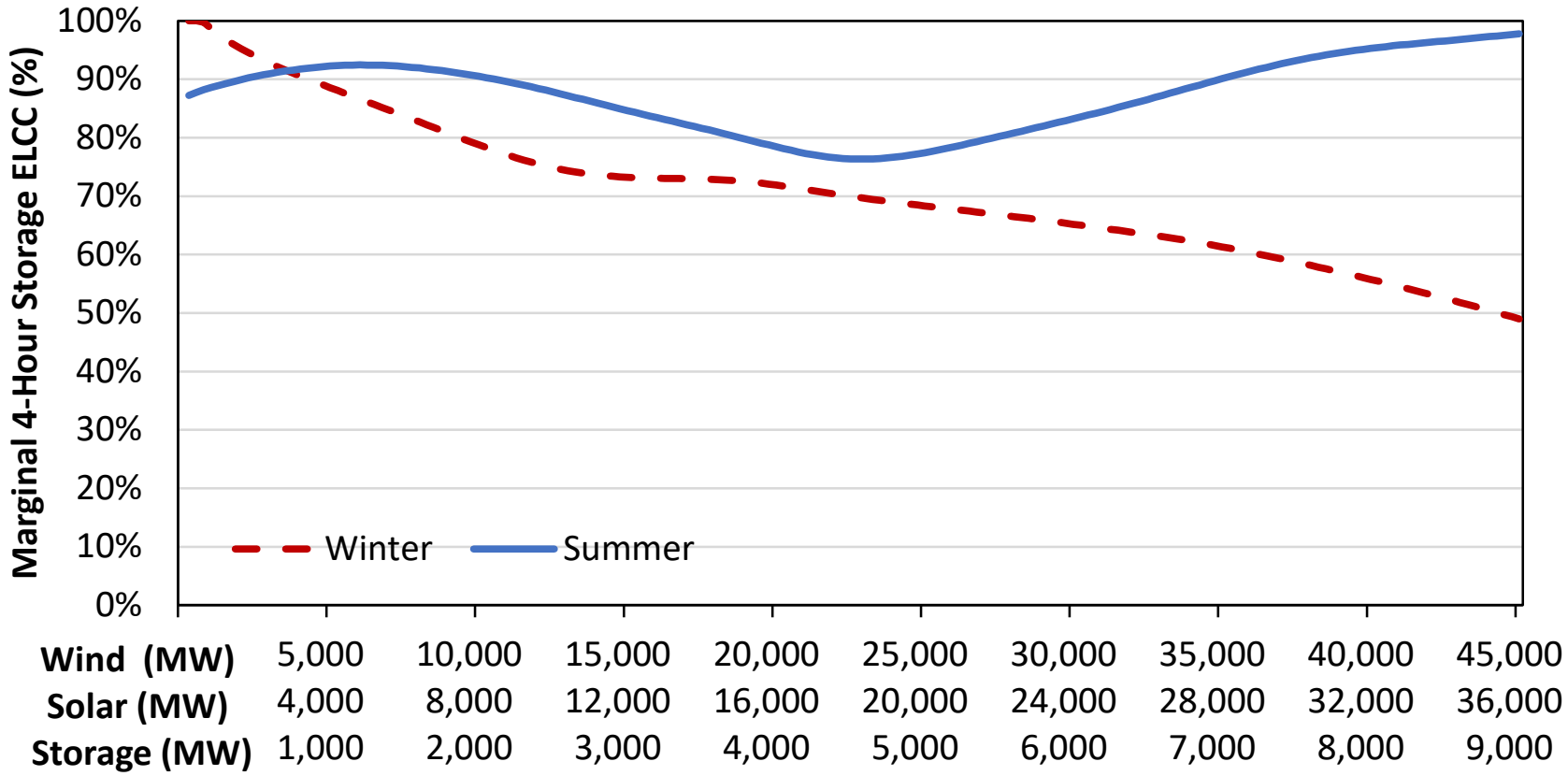


2022 ERCOT load data – net winter peak with the impact of PV

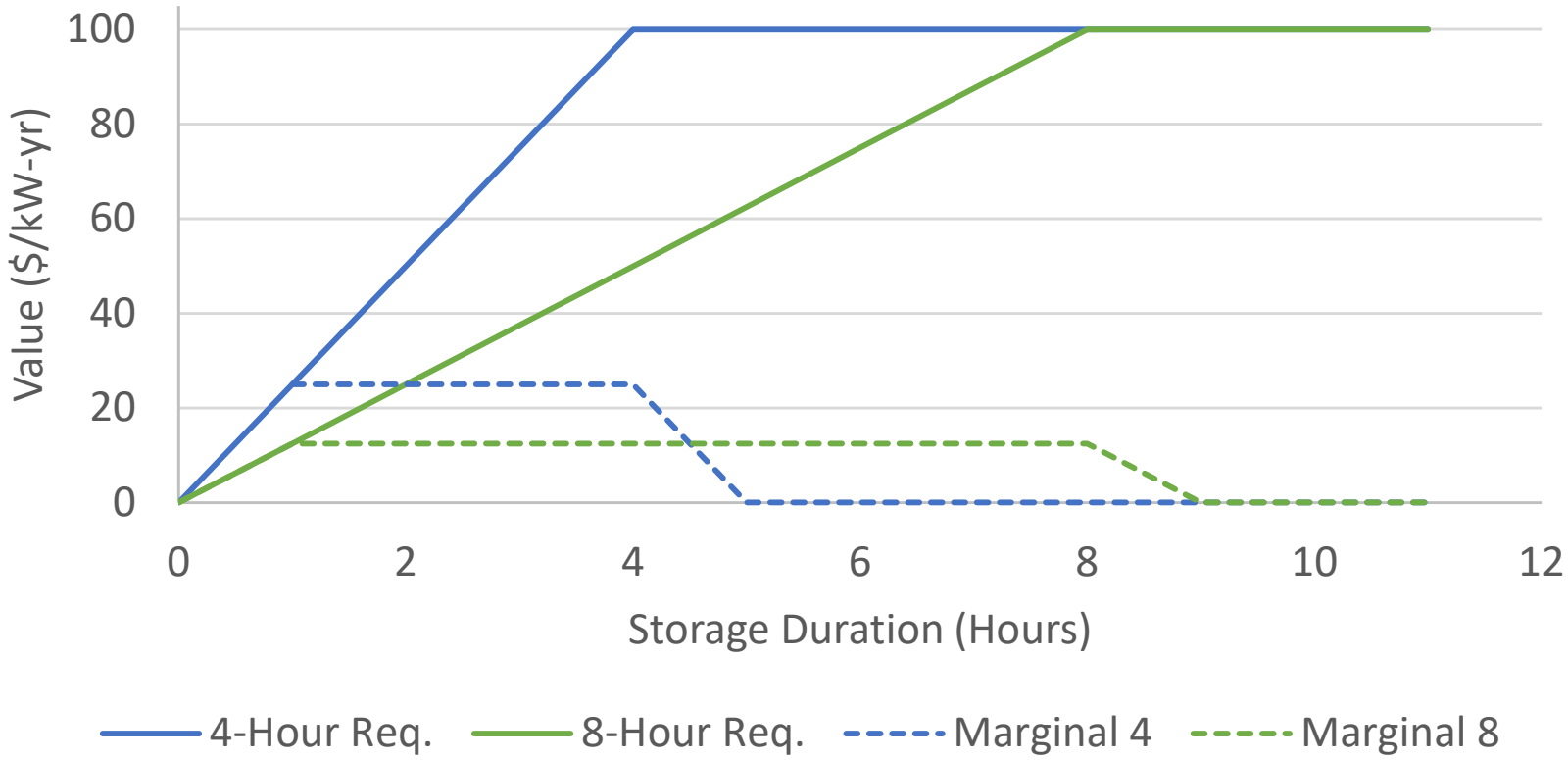




Decline in Winter Capacity Value – ERCOT Example



Change in Value Proposition Under a Longer (But Still Linear) Duration Requirement



Important to recognize that longer duration capacity requirements do not increase the value of longer duration storage – it decreases the value of shorter duration storage

Additional Services that Favor Longer Duration

- New operating reserve products? (No)
- Resilience
  - Significant overlap with capacity credit
- Transmission
  - Only partially additive to other services
- All the normal regulatory and market barriers on these services…

Conclusions – Beyond Four Hours?

- Most of the monetizable benefits of storage can be achieved with durations of 4 hours in summer peaking systems
- Transition to durations beyond 4 hours will be driven by changes in valuation based on several factors:
  - A shift to longer winter peaks and changes in capacity credit/resource adequacy rules
  - Potential monetization of transmission and resilience-based services

Thank you

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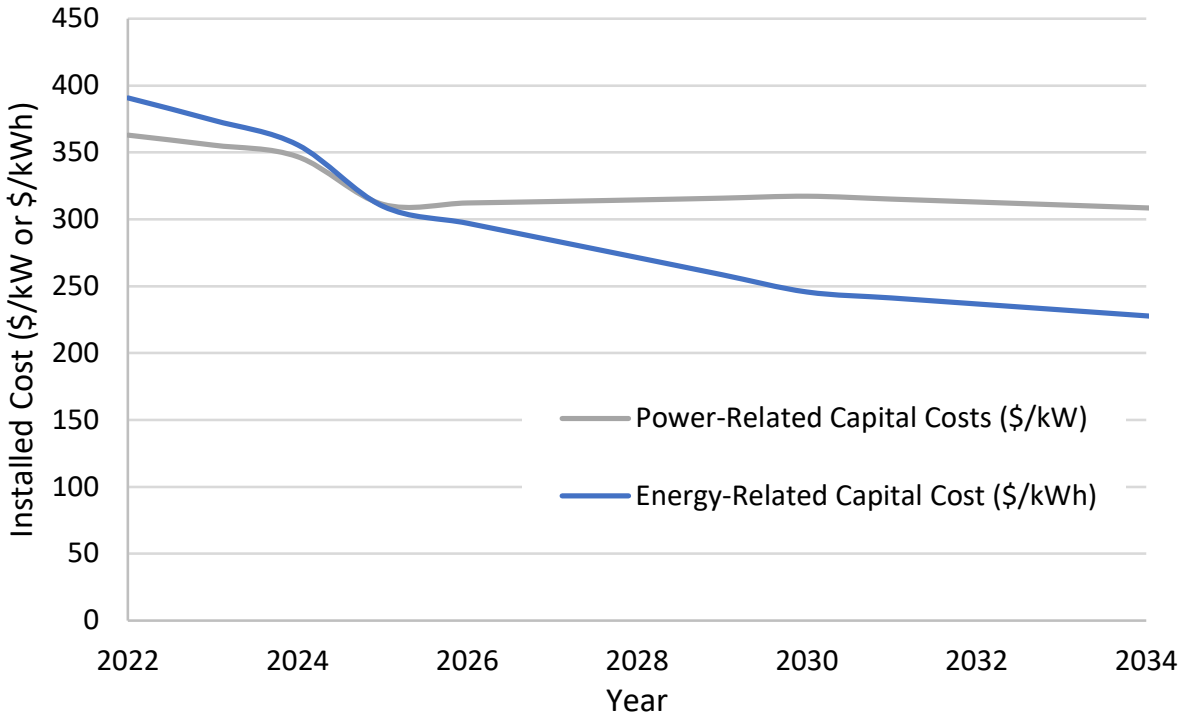
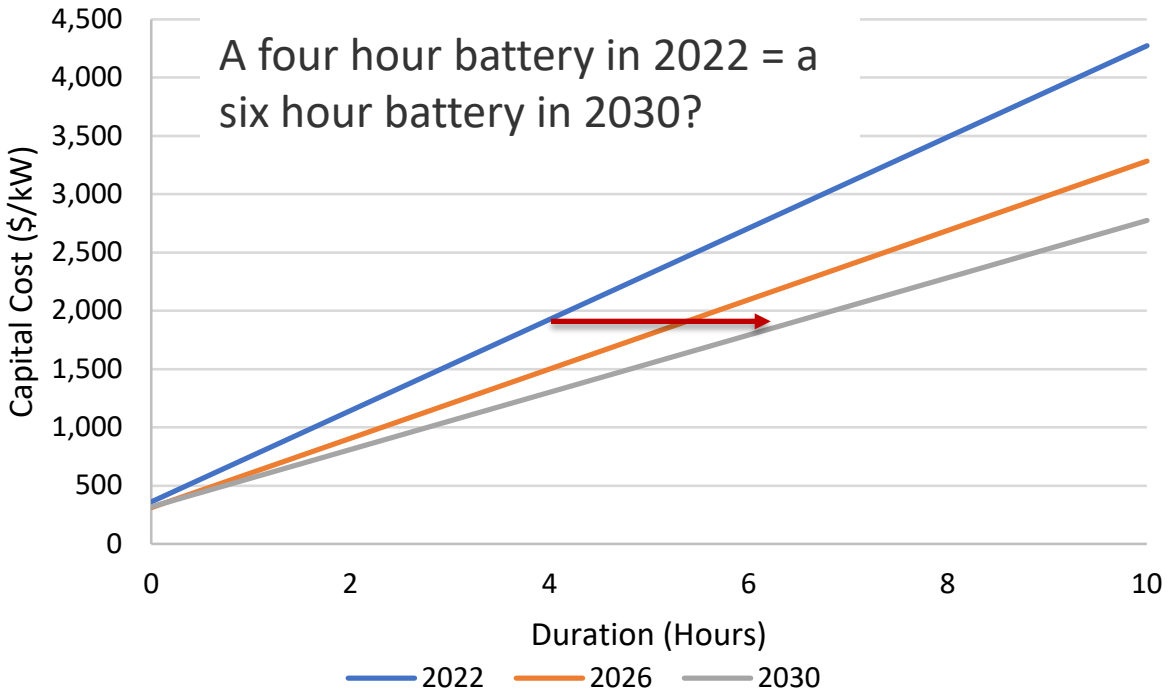
Beyond Li-Ion? Declining costs and potential longer duration

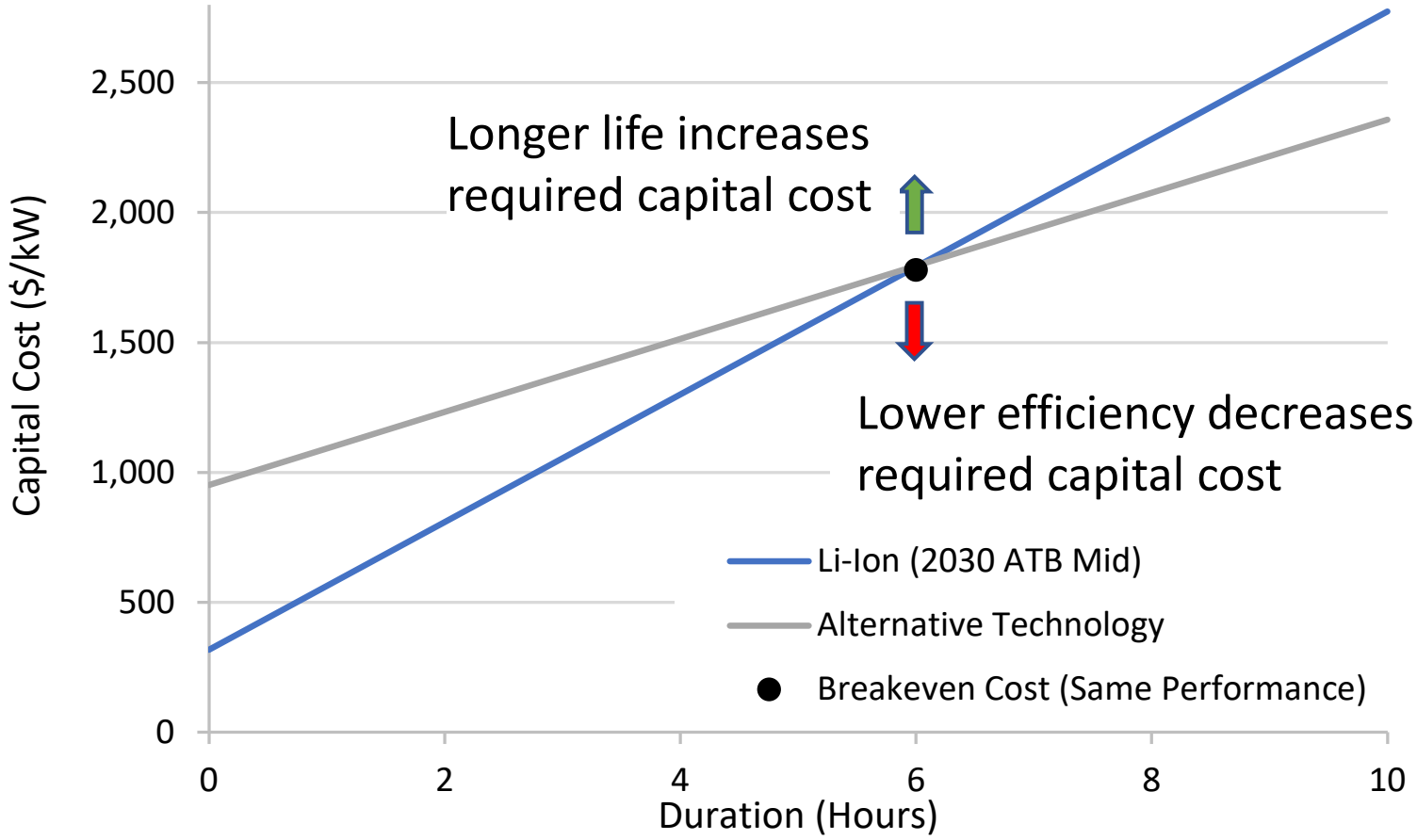


ATB mid-case estimates for Li-Ion



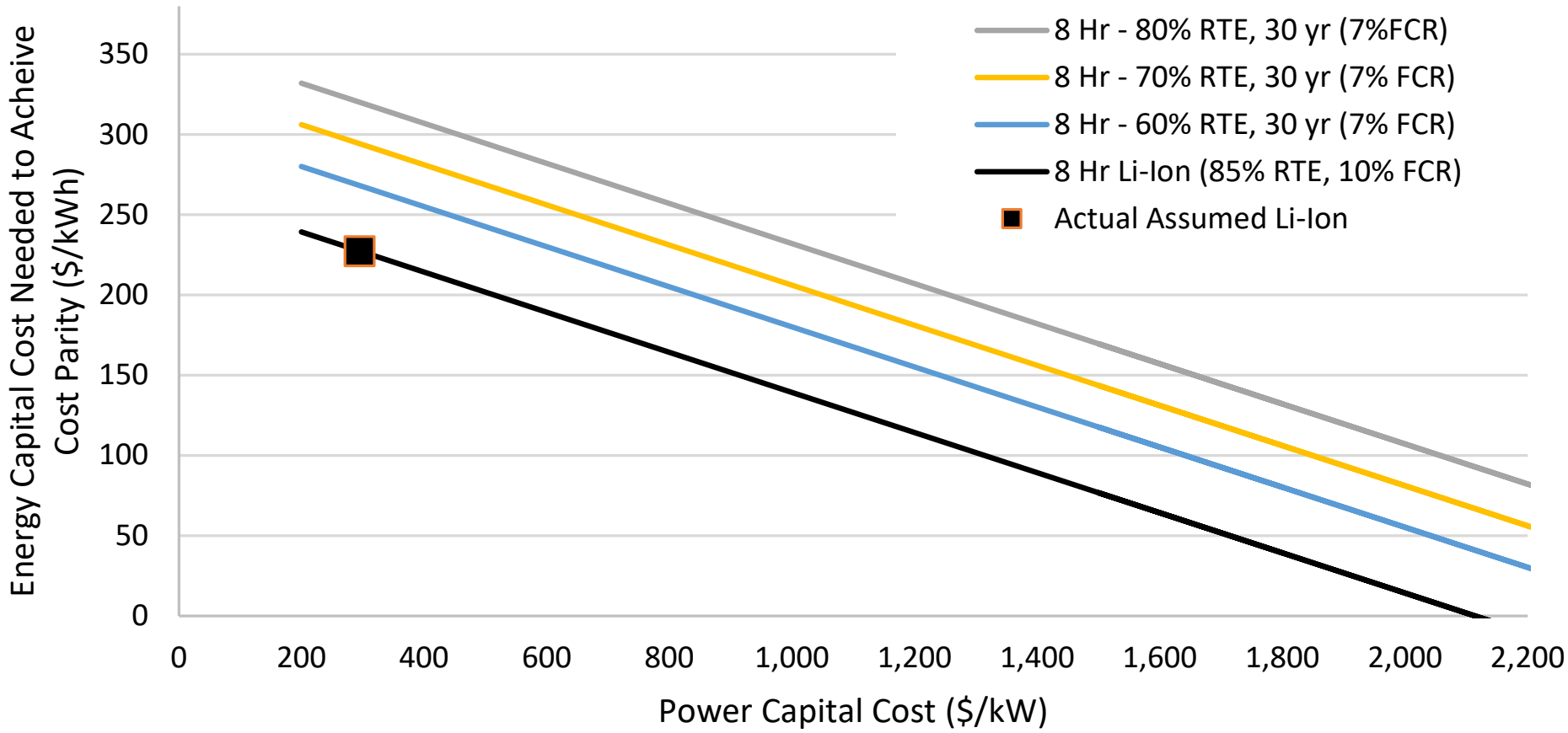
Conceptual Breakeven Drivers

1) Energy capital cost
2) Power capital cost
3) Efficiency
4) Life



Many longer-duration storage technologies are based on higher power-related costs, but lower energy related costs, creating a crossover point at a certain duration

Breakeven Conditions for 8-Hour Devices in 2030



Conclusions – Beyond Li-Ion?

- There is a large surface space of power- and energy-related costs combinations that could beat Li-Ion, especially considering the potential for longer life, which tends to offset the lower RTE (up to a point)