CC Power Board Meeting – General Manager Update

3/17/21

Overview

- Administrative Update
- Long Duration Storage Project Update
- Items for Future Board Meetings

Administrative Upate

- Filings made with Secretary of States' Office
- Draft Conflict of Interest Code in review with FPPC
  - Once finalized, will be posted for 45-day public comment period
  - Calendared for Board meeting for discussion and possible approval
- Bank account established
- Initial cash calls have been made to the participants
- Contracts executed based upon Board approval
  - Gridwell – LDS negotiations support
  - Keyes & Fox – LDS negotiations support
  - SVCE – website support
  - Maher Accountancy – accounting services

QUESTIONS

LDS Project Update

- *ad hoc* Project Oversight Committee (POC)
  - Held initial kickoff meeting 3/5/21
  - Focus
    - Narrowing project list for further evaluation – late March
    - Finalize short list recommendations – mid-April
    - Work with Negotiating Team on negotiation principles
  - Longer-term – advise negotiating team on issues and recommendations

QUESTIONS

Items for Future Board Meetings

- April Board Meeting (4/21/21)
  - Approval of New Members (Clean Power SF, Valley Clean Energy)
    - Requires new members to file certified copy of resolution by its governing body
      - Agreeing to the provisions of the JPA Agreement
      - Requests to become a member
    - Board approval by at least 2/3 vote (6 members)
  - Budget Adjustment to Reflect New Members
  - Recommendations on CC Power Policies
  - Ratification of LDS Project Process and Delegations
  - Update on LDS Project
- May Board Meeting (5/19/21)
  - Recommendation on General Counsel selection
  - Conflict of Interest Code Approval
  - LDS Project budget adjustment and allocation based upon short list participation
- June Board Meeting (Not yet scheduled – 6/16/21)
  - Recommendation on General Manager selection
  - LDS Project Update

Ascend Analytics

Better models. Better decisions.

Battery Storage Overview - CC Power Board Meeting

Brent Nelson, Manager of Forecasting and Market Analysis

3/17/2021

Ascend Analytics

- Founded in 2002 with 50 employees in Boulder, Oakland and Bozeman
- Seven integrated software products for operations, portfolio analytics, and planning
- Consulting and custom analytical solutions

Proven and Broadly Adopted

Differentiated Value for Enhanced Decision Analysis

PowerSimm OPS
OPERATIONAL STRATEGY

- Optimal short-term dispatch
- Determine operating strategies from position and financial exposure
- Track realized customer revenue and costs to settled day ahead and real time price
- Optimize financial exposure between day ahead and real time prices

PowerSimm Portfolio Manager
PORTFOLIO MANAGEMENT

- Portfolio management
- Generation asset management
- Hydro and renewable asset modeling
- Retail management & pricing
- Energy purchases and sales
- CFaR, GMaR, EaR

PowerSimm Planner
VALUATION & PLANNING

- Asset valuation
- Resource Planning
- Capacity Expansion Planning
- Reliability Analysis
- Renewable Integration
- Long-term Price Forecasting

Smart Bidder
STORAGE OPTIMIZATION

- Optimal offers to ISO
- Continuous adjust ISO offers
- Forecast probabilities of price spikes
- Renewables plus storage

BatterySimm Valuation
STORAGE VALUATION

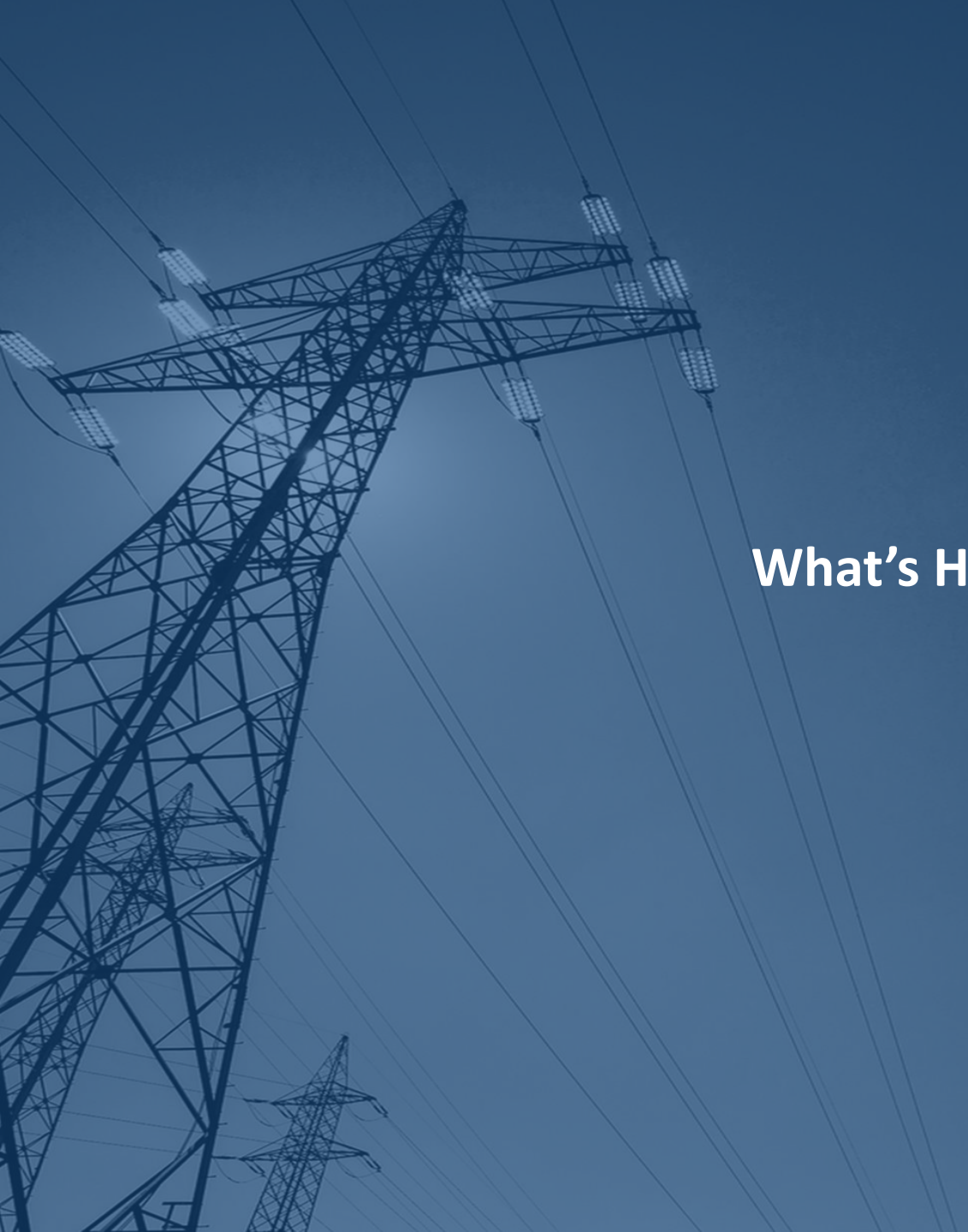
- Optimal siting and sizing
- Captures realistic revenues given imperfect foresight
- Battery cycle analysis

Ascend Market Intelligence

- Power, ancillary, and capacity price forecasts, including subhourly and geographic evolution
- Market reports and analysis
- Hourly and subhourly nodal and hub price simulations

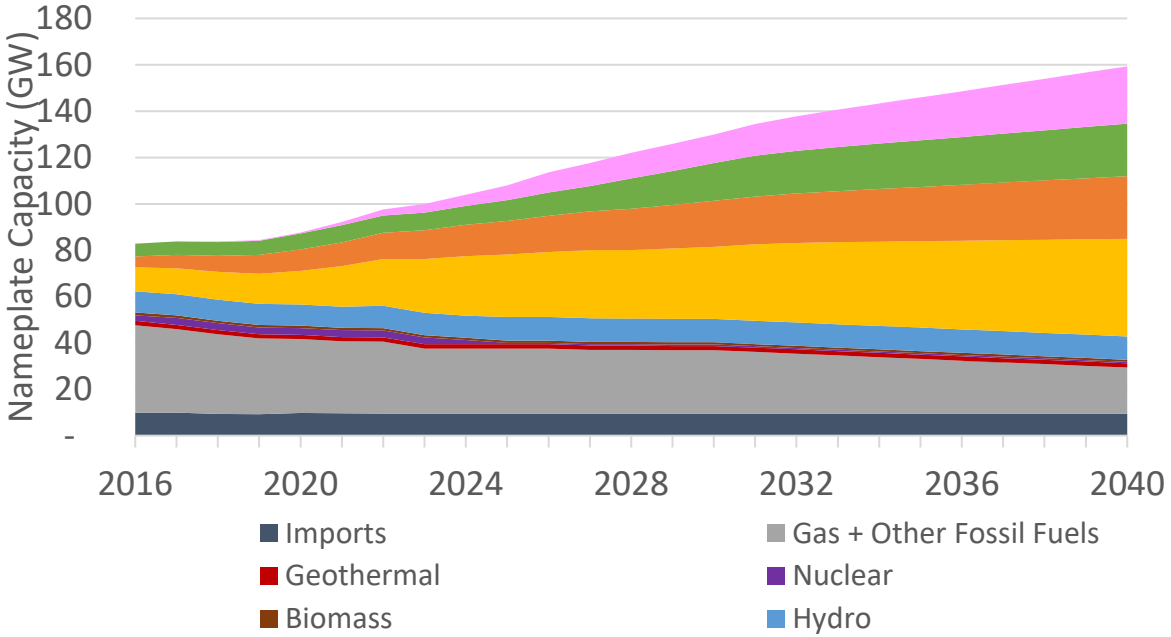
Key Takeaways

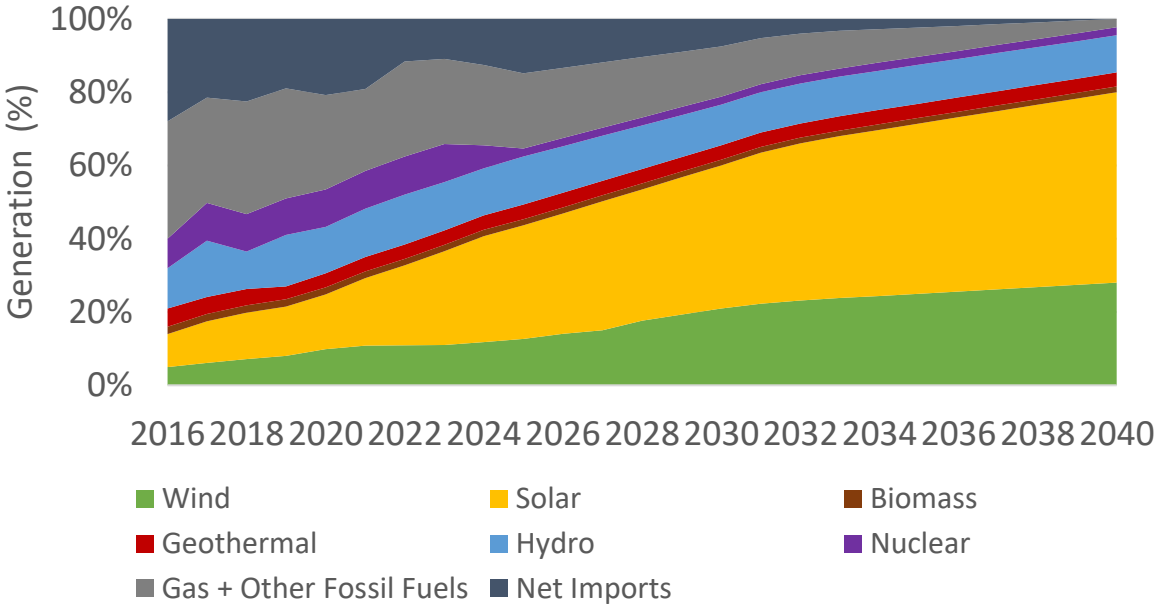
- CAISO is experiencing an influx of renewable energy, creating supply volatility and an opportunity for storage
- The renewable supply in California is solar-heavy, creating a need for long-duration storage for sundown clean energy and clean capacity
- The power sector is at an inflection point, making history (and the present) poor predictors for the future
- Forecasts must explicitly model volatility to properly value storage
- Forecasts should adhere to long-run equilibrium in a competitive market (while also considering barriers to entry)



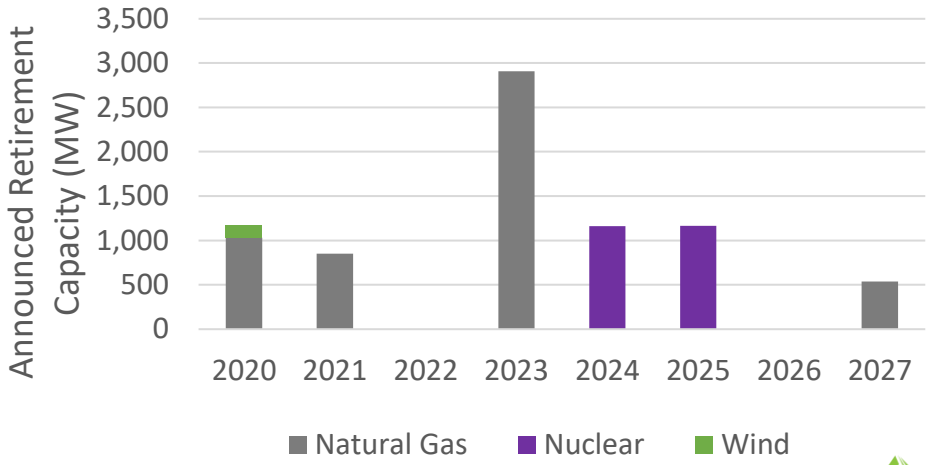
What’s Happening in CAISO?

CAISO is gaining large quantities of intermittent resources while losing baseload and flexible capacity



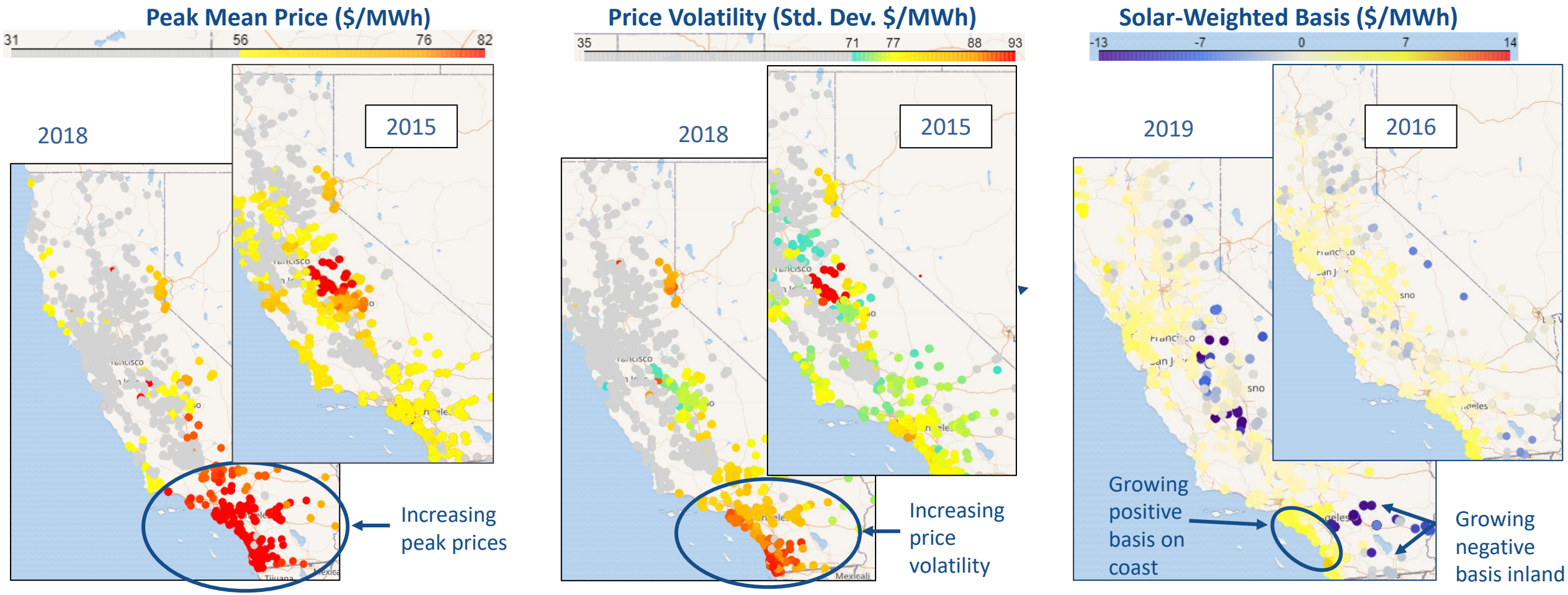


- Capacity equal to ~20% of peak load may be retiring over the next 10 years
  - ~8 GW of announced retirements (lower right)
  - ~6 GW of potential economic and legislative retirements
- Low prices for renewables combined with demand from customers and corporations could result in even higher renewable penetration than required by policy
- **Storage deployments are heavily outpaced by the continued addition of intermittent resources and thermal retirements**



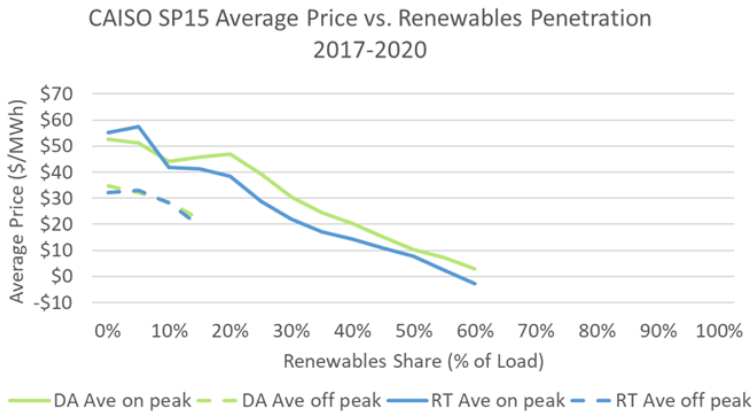
- CAISO Interconnection Queue from: http://www.caiso.com/planning/Pages/GeneratorInterconnection/Default.aspx
- Retirements from: https://www.eia.gov/electricity/data/eia860m/

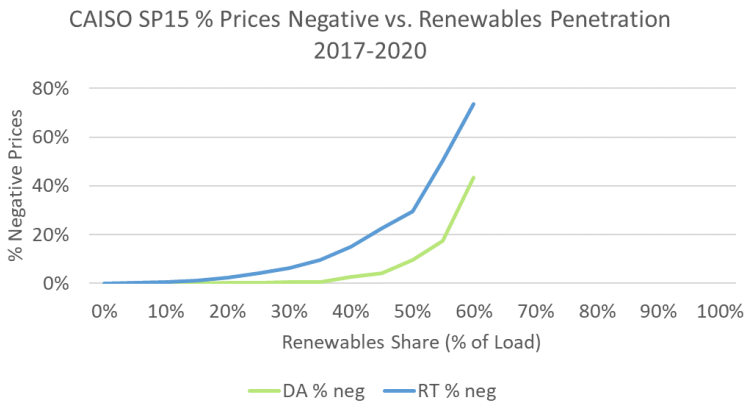
Geographic Shift in Generation

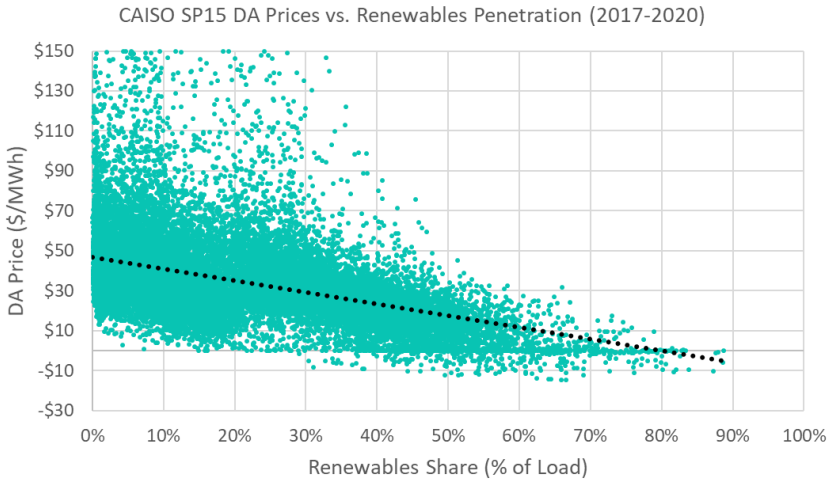


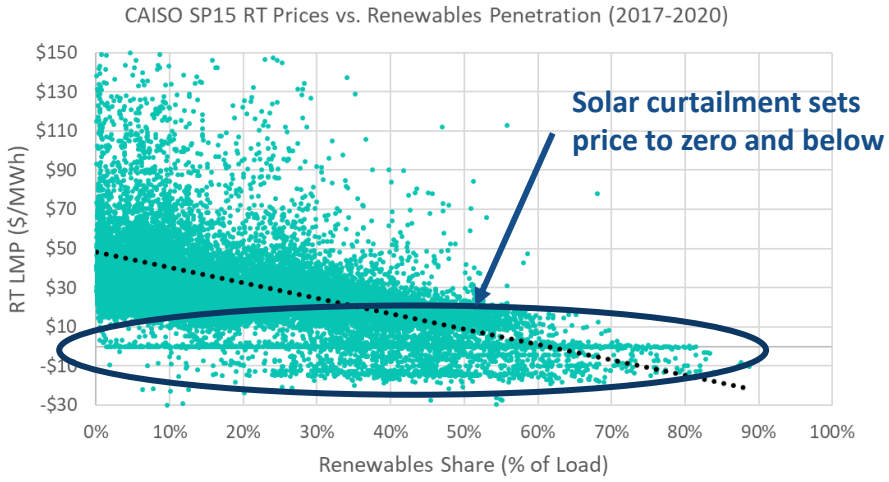
- **Retirement of coastal thermal plants pushes generation inland to the desert, creating peak period congestion and volatility along the southern coast**
- **High concentration of solar generation in desert regions results in increasing negative basis to load centers and declining value of solar generation**

Price Depression as Renewable Penetrations Rise







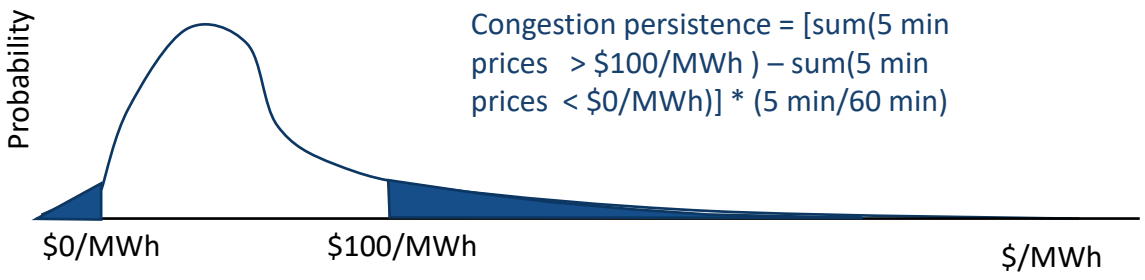


- Price depression at high renewables penetration appears in both real-time and day-ahead markets, on-peak and off-peak
- Negative prices and renewable curtailment grow as renewables shares climb above ~25%, then rapidly accelerate at penetrations above 50%
- *But it's not just the average that is affected by renewables…*

Volatility Increases with Renewable Penetration

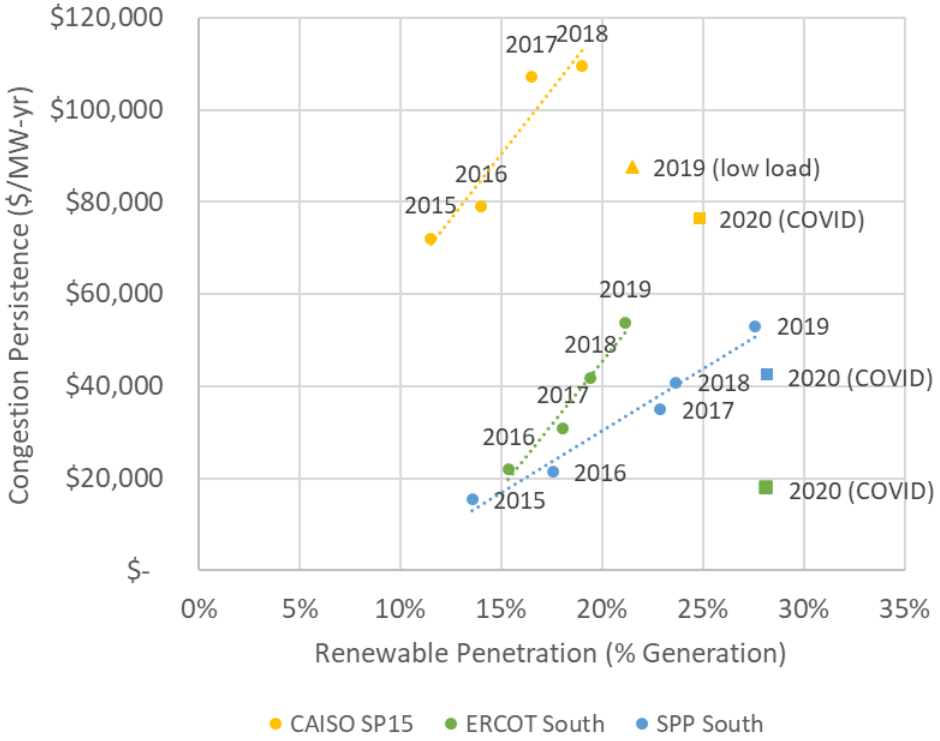
Congestion persistence is Ascend's metric for describing the prevalence of extreme prices

- It measures the area under the tails of the price distribution as shown in the graph below
- It is the strongest driver of energy arbitrage opportunities and can be interpreted as the upper bound for revenue of a BESS system with no energy constraint
- Energy storage will derive more value from price swings in the real-time market than the day-ahead market



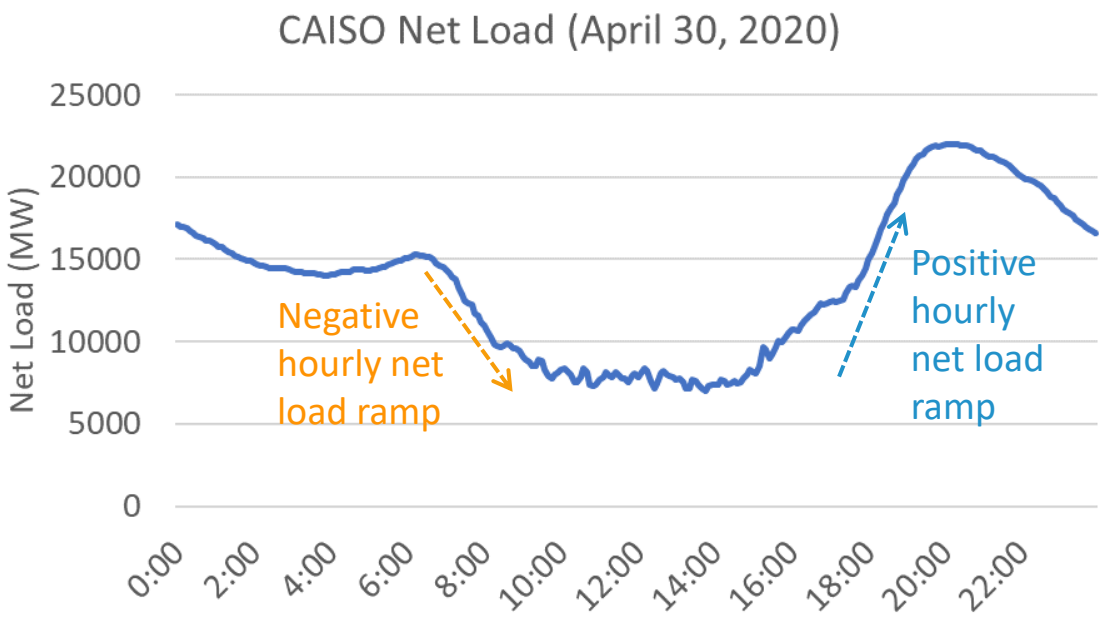
Congestion Persistence has a strong linear trend with renewable penetration across multiple ISOs

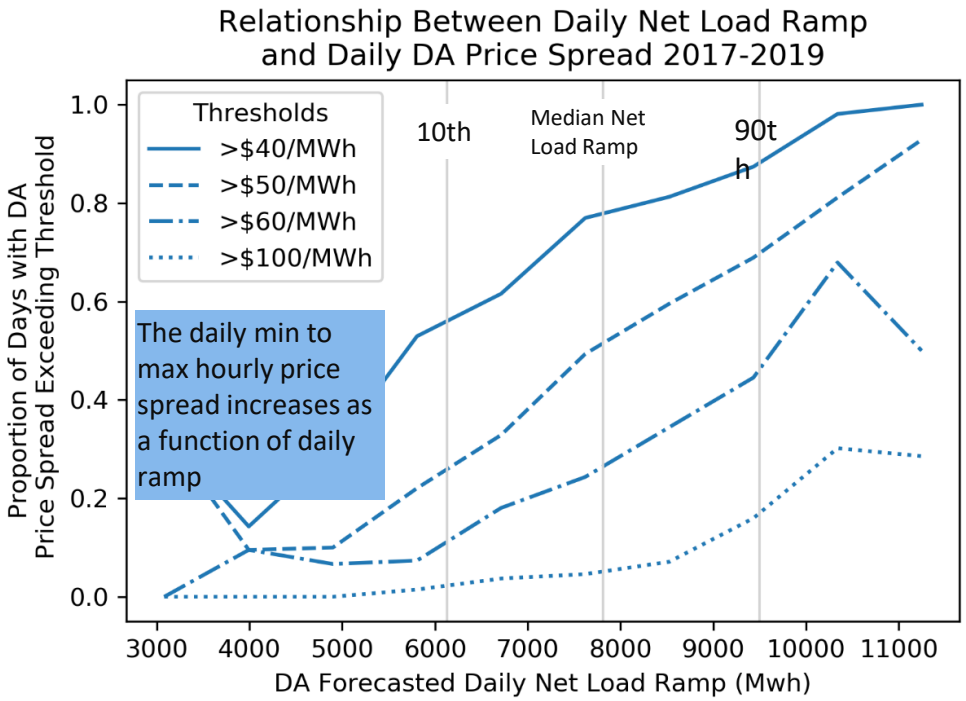
- Across ISOs we see a correlation between congestion persistence and renewable penetration



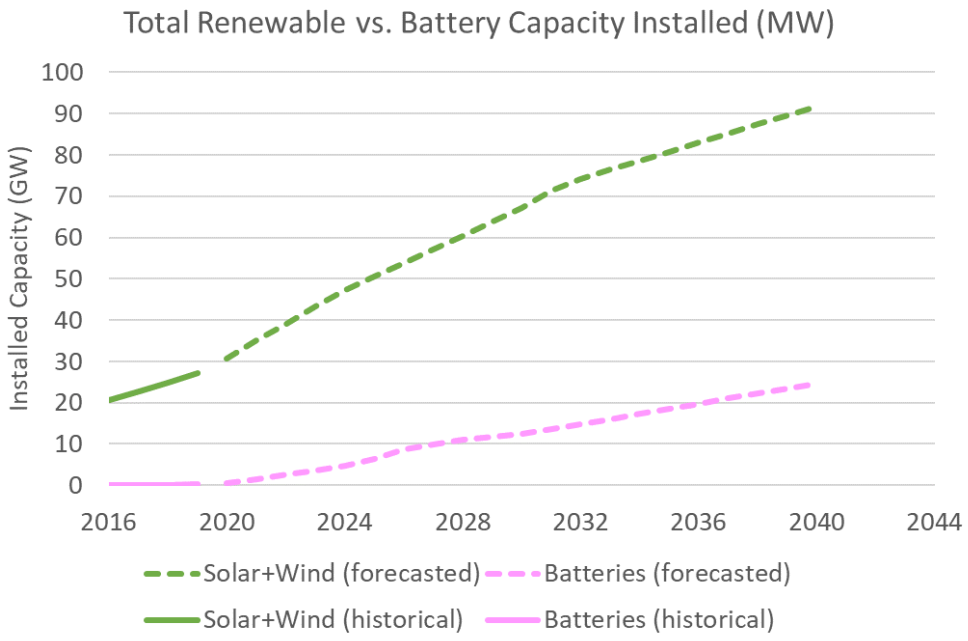
Drivers of Price Volatility

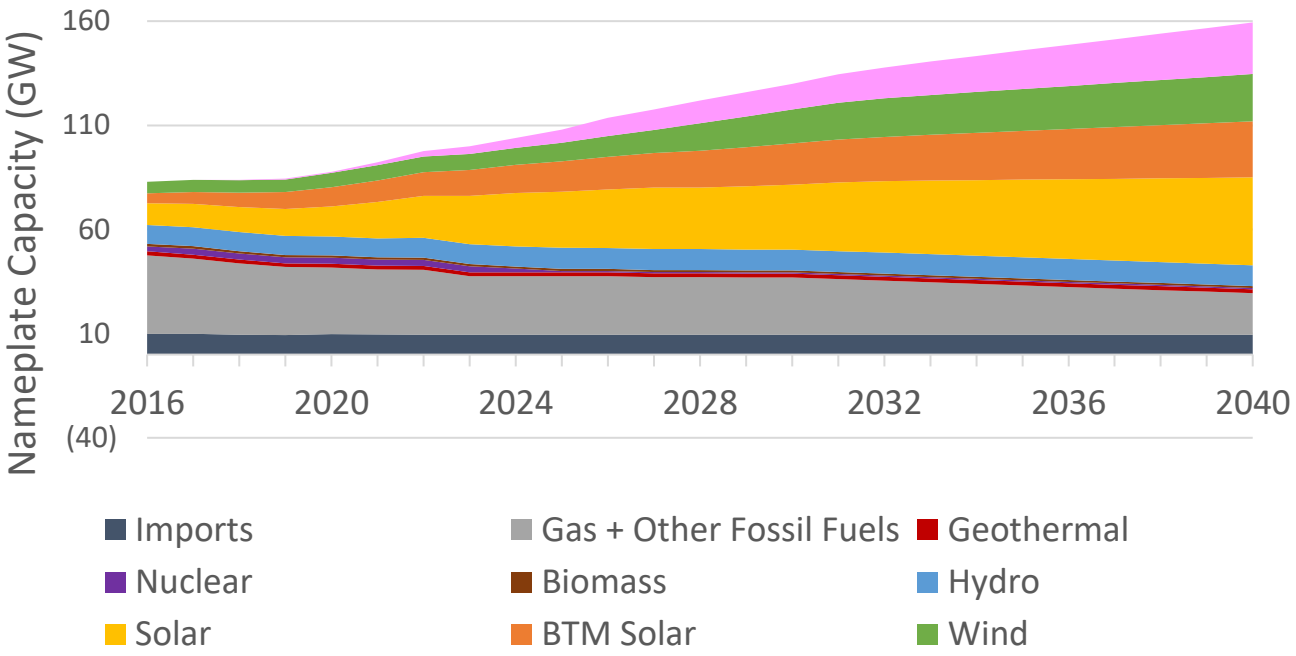
Cause	Definition	Expected Impact (Frequency and Impact)
Congestion	Regional imbalance between supply and demand	Location specific. Generally frequent & moderate
Scarcity	When supply is tight relative to load	Infrequent & large
Forecast Error	Difference between day-ahead and real-time net load (load – renewables)	Continuous & small. Storage will largely address forecast error.
Net Load Ramp	The hourly net load ramps drive price differences	Frequent & large. Storage can partly mitigate.





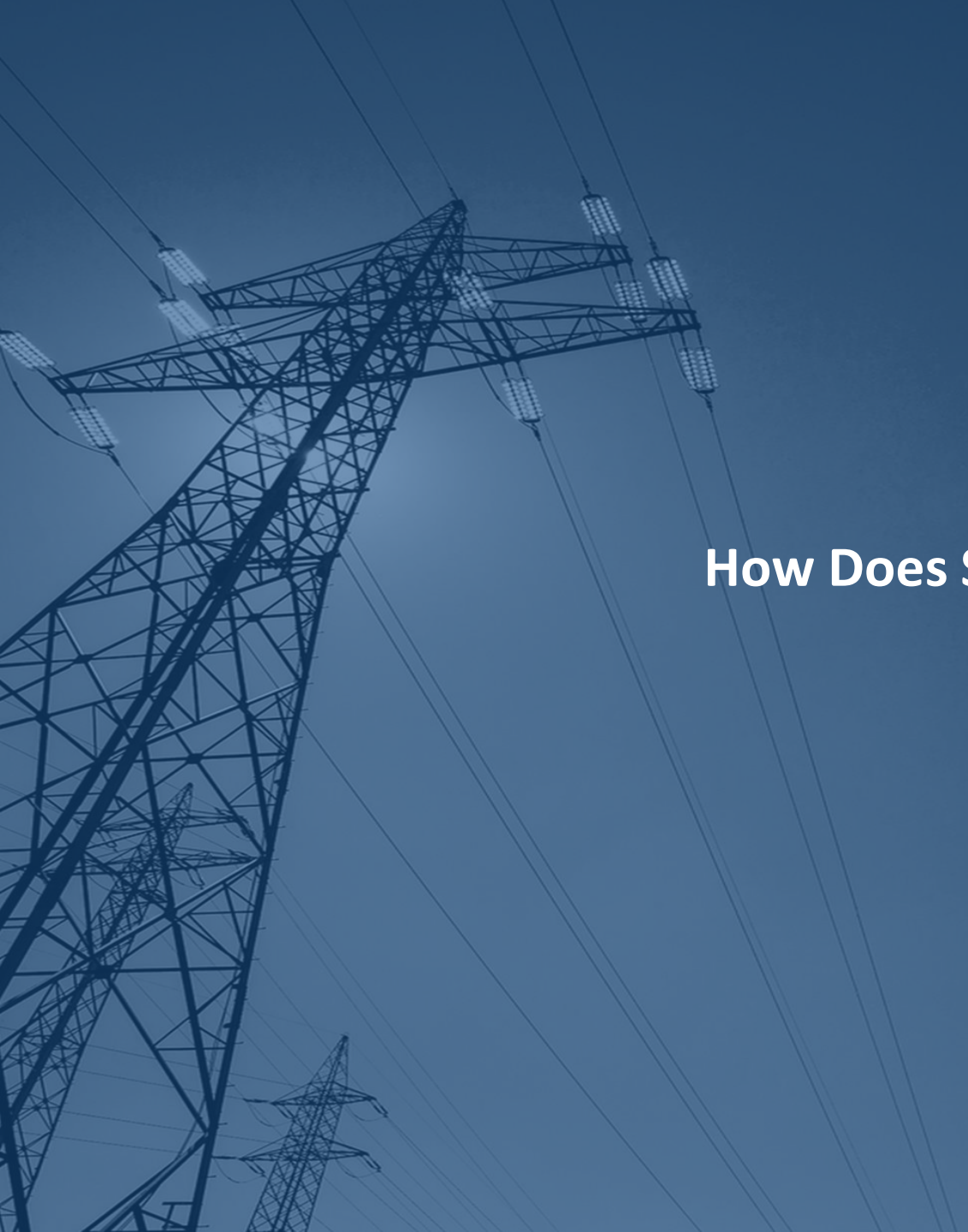
Energy Volatility Will Continue: Thermal Out, Renewables & Batteries In





- CAISO has 14 GW of wind, 48 GW of solar, and 58 GW of batteries currently in its interconnection queue
- In addition to roughly 7 GW of announced thermal retirements there are 6 GW of potential economic and legislative retirements over the next 10 years, causing a loss of 7-13 GW across the ~50 GW peak market
- **New storage must offset not only both existing and new renewables, but also thermal generation retirements.**
  - Volatility is already high with the current thermal fleet. Thermal retirements will push market volatility even higher and drive a continued need for flexible storage.

Source: Internal Ascend forecasts
- CAISO Interconnection Queue from: http://www.caiso.com/planning/Pages/GeneratorInterconnection/Default.aspx
- Retirements from: https://www.eia.gov/electricity/data/eia860m/



How Does Storage Create Value?

Revenue Opportunities: Real-Time Energy Price Spikes

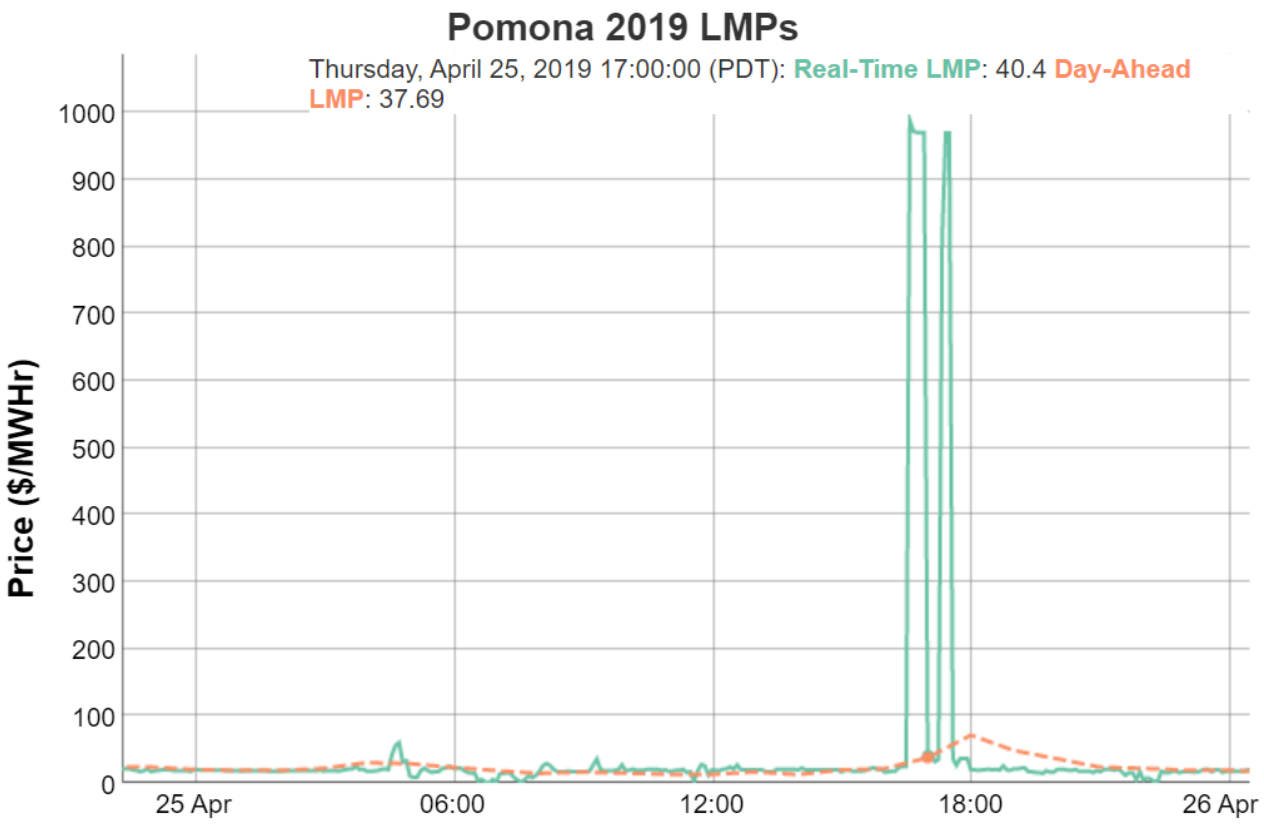
Q. How does storage make money with energy optimization?

A. Physically operate to the volatile 5 min market by charging low or negative and sell high. When prices are relatively flat, sell ancillary services.

Q. How does volatility in price drive value for storage?

A. The greater the up-down movement in prices, the greater the revenues from real-time energy optimization.

Greater volatility provides sustained opportunity in areas with long development lead times and significant growth in renewables.



Importance of price spikes:

- Occur ~1.5% of time
- Represent 22% of average price and 30% of retail costs because of demand coincidence

Opportunity of chasing spikes:

- Provide ancillaries
- Energy Prices: Day-ahead (hourly) and Real-time (5/15-minute)

RT 5 min energy prices spike (positive and negative) for 5 to 20 minutes.
DA prices are less volatile.
Increasing intermittent renewables are driving up RT and DA volatility

Definition:
LMP = locational marginal price or Pnode price

Value Stacking of Storage for Day-ahead (DA) + Real-time (RT) Markets

- Ancillary Services
  - Regulation DA
  - 10-min Spin or response reserve service

Q. How does value stacking reduce risk and increase revenue?

A. By dispatching storage across multiple commodities (energy and ancillaries), storage realizes greater revenue and earns insurance premium for DA vs RT price spreads.

- Energy
  - Real-time
  - Day-ahead
  - DA and RT

- Combination of Energy and Ancillaries
  - RT
  - DA and RT

Market CAISO

Market Product

Product	DA Use	RT Use
Energy	☐	☐
Regulation Down	☑	☐
Regulation Up	☑	☐
Spin	☑	☐
Non Spin	☐	☐

Day-Ahead market timestep 60 minutes

Real-Time market timestep 5 minutes

Market CAISO

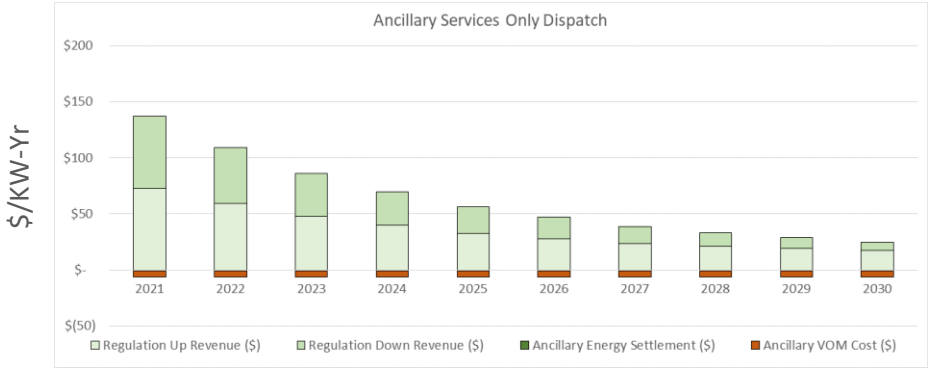
Market Product

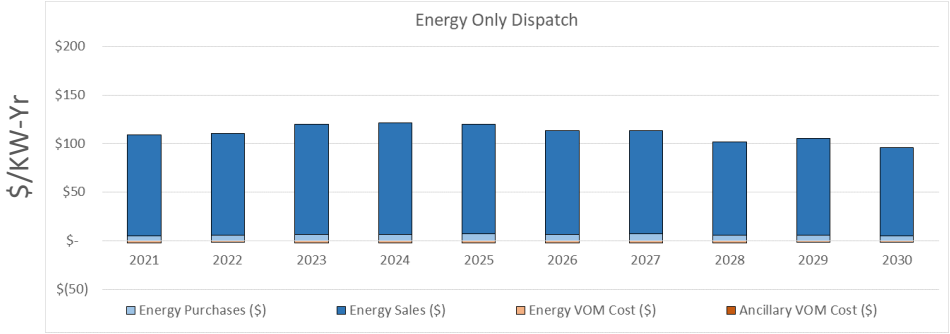
Product	DA Use	RT Use
Energy	☐	☑
Regulation Down	☐	☐
Regulation Up	☐	☐
Spin	☐	☐
Non Spin	☐	☐

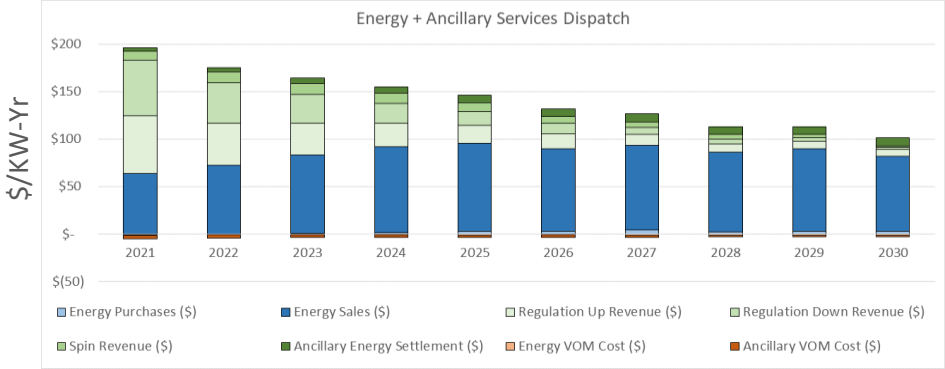
Market CAISO

Market Product

Product	DA Use	RT Use
Energy	☐	☑
Regulation Down	☑	☐
Regulation Up	☑	☐
Spin	☑	☑
Non Spin	☐	☐



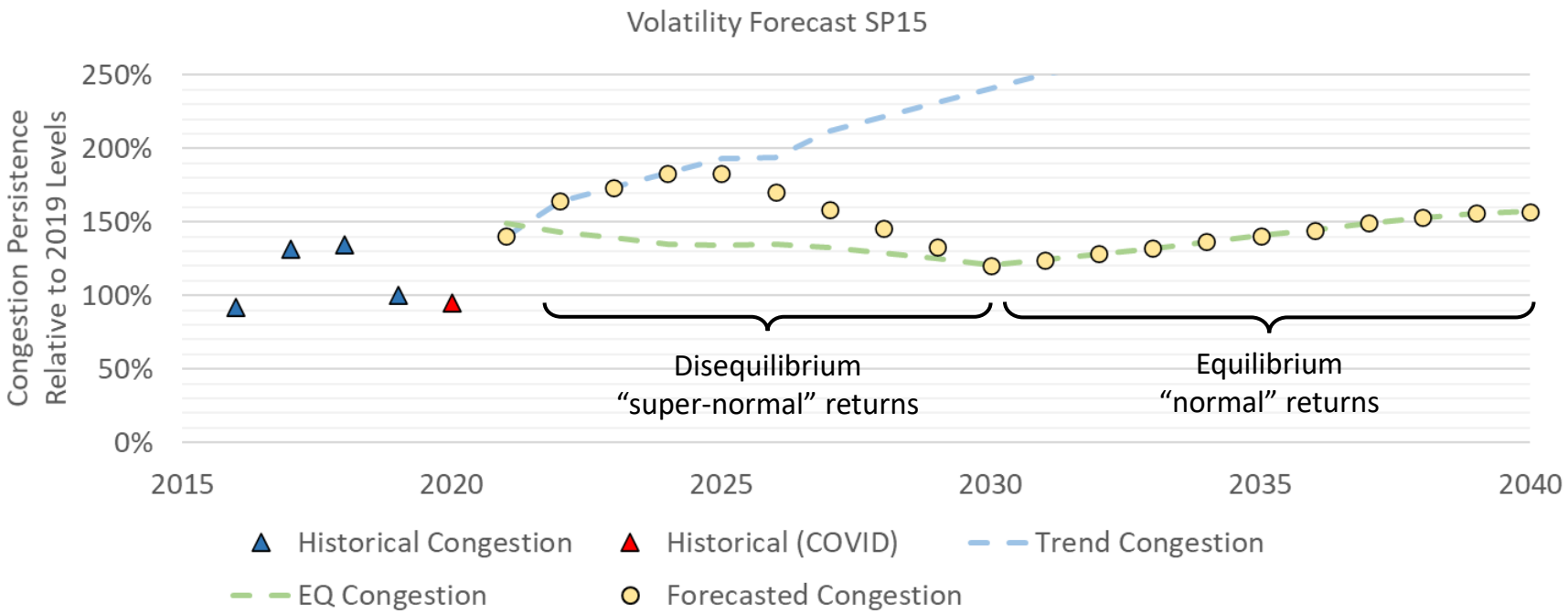




Projected SP-15 Volatility

Q. How does market timing create value? Won't storage deployment reduce volatility?

A. The rapid structural change of power markets is creating opportunity for early entrants to earn "super-normal" returns for projects in locations with high price volatility.



Forecast of volatility:

- In the near-term (years 1-4), volatility drives super-normal returns while the system is in disequilibrium and the volatility follows its empirical relationship with renewable penetration.
- In the medium-term (years 5-10), volatility is still sufficient to drive super-normal returns, but it tapers off to its long-run equilibrium* as more batteries enter the system and mitigate future growth in price spikes.
- In the long-term (years 10+), volatility is just sufficient to support entry of new BESS units at normal returns,* with volatility rising as ELCC and RA value declines

*Assumes a revenue requirement of 10% on projected capital costs and 10-year payback for 2h storage

Source: Historical data from CAISO OASIS; Internal Ascend forecasts

Storage progression path

Q. What is the progression in relative economics to thermal gen for batteries?

A. Begin with short-duration and high frequency movements for ancillary services (<1-hr) to long-duration firm capacity (> 4-hr). Today storage is 35% more expensive than conventional new gas capacity, but its flexibility can make it more economic in markets with high renewable penetration rates.

Storage Progression Path	Duration/	Timing as Economic	Definition
Ancillary Services	1 hr	2016-present	• Regulation of 1 min movements up or down in power to keep the system balanced. • 10 Min spin in case of a large generator outage
Renewable integration and peak shaving	2 hr	2018-present	• Capturing market price spikes and serving energy during evening ramps
Firm capacity	4 - 6 hr	2018-present	• Providing energy over multiple hours during peak demand conditions.
Green “sun-down” energy	6 - 8 hr	2028	• Shifting energy from sunshine hours to sundown hours.

Clean Sundown Energy

Q. How can long-duration storage provide value for clean energy for CCA's and their corporate customers (e.g., FB, Alphabet, Amazon, Microsoft,…)?

A. i) Furnish clean capacity, ii) Hedge against ancillaries, and iii) Provide clean sun-down energy

Month-Hour Abs Short Volume [MWh]

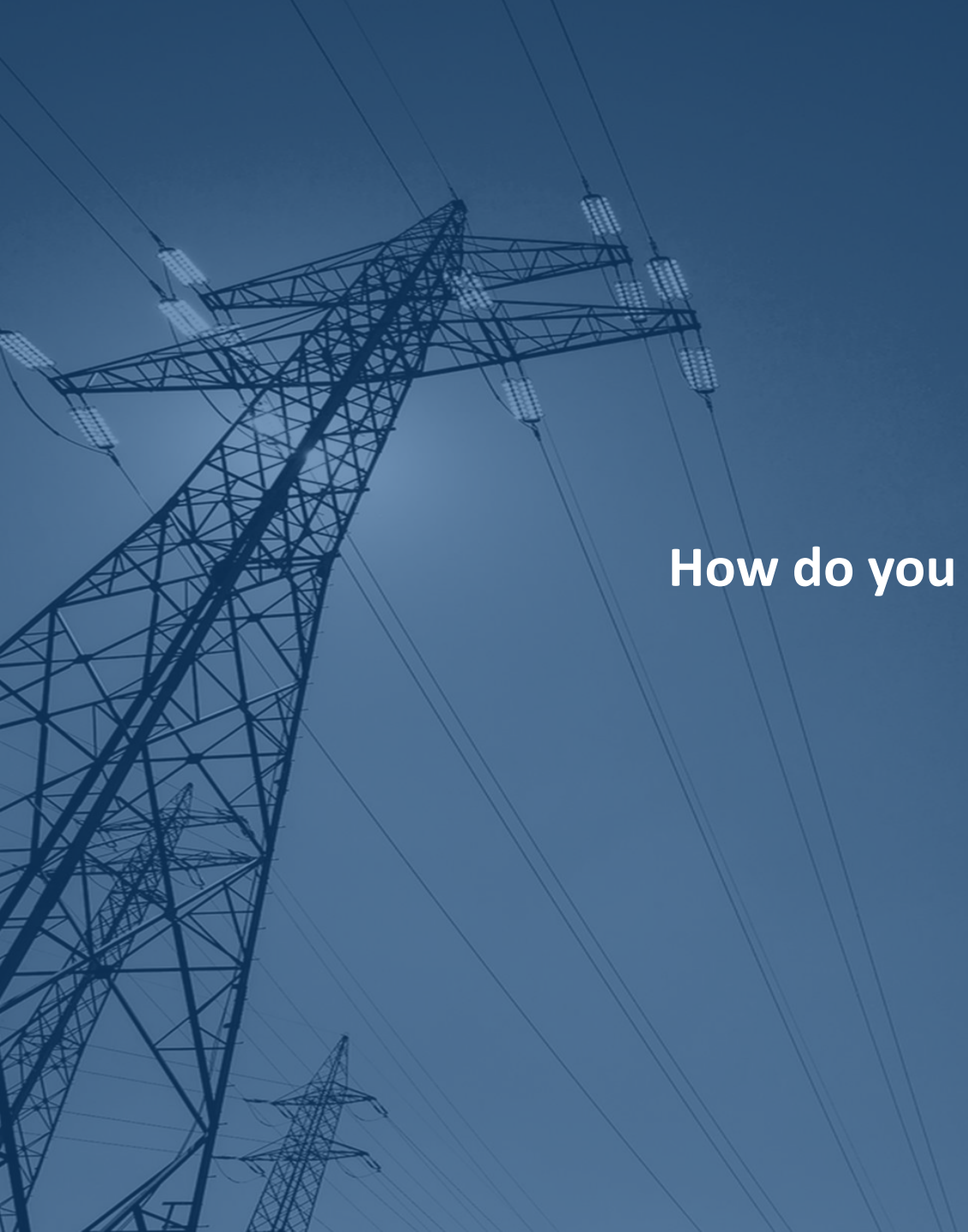
	HE01	HE02	HE03	HE04	HE05	HE06	HE07	HE08	HE09	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24
Jan	180	170	160	160	180	180	210	190	90	10	-	-	-	-	-	20	150	250	270	270	260	240	200	190
Feb	150	140	140	140	140	130	160	80	-	-	-	-	-	-	-	-	-	140	190	180	180	170	150	130
Mar	160	150	140	140	140	150	130	40	-	-	-	-	-	-	-	-	-	50	160	180	190	190	170	150
Apr	70	60	60	50	60	70	10	-	-	-	-	-	-	-	-	-	-	-	60	100	120	110	90	80
May	80	60	70	70	70	10	-	-	-	-	-	-	-	-	-	-	-	-	20	70	100	110	100	70
Jun	150	140	130	130	130	50	-	-	-	-	-	-	-	-	-	-	-	10	100	170	190	200	180	150
Jul	280	260	260	260	230	180	120	90	50	50	50	60	70	40	60	90	120	200	290	340	330	330	300	270
Aug	230	220	220	220	210	220	150	80	40	20	10	-	-	-	-	10	60	160	260	270	270	270	240	230
Sep	230	230	230	220	210	230	160	70	20	10	-	-	-	-	10	50	120	250	300	310	310	280	240	210
Oct	210	200	190	160	150	160	140	60	-	-	-	-	-	-	-	20	140	250	270	290	290	250	230	220
Nov	200	200	200	200	180	180	210	110	60	50	30	20	10	20	40	110	230	300	300	300	290	260	240	210
Dec	180	170	170	180	180	180	210	190	120	70	50	30	20	30	50	110	220	300	310	310	300	270	230	220

Max 12x24 $/MWh	$90	Min 12x24 $/MWh	$50	Min Short MW	10	Min Short Rel. $/MWh	($10)	Min HE 18-20 $/MWh	$55

Hourly Willingness-to-Pay to Satisfy Short Position

	HE01	HE02	HE03	HE04	HE05	HE06	HE07	HE08	HE09	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24
Jan	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 55.6	$ 50.3	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ -	$ 50.0	$ 50.0	$ 66.2	$ 71.5	$ 71.5	$ 68.8	$ 63.5	$ 55.0	$ 55.0
Feb	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0
Mar	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0
Apr	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0
May	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0
Jun	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0	$ 55.0
Jul	$ 74.1	$ 68.8	$ 68.8	$ 68.8	$ 60.9	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 55.0	$ 76.8	$ 90.0	$ 87.4	$ 87.4	$ 79.4	$ 71.5
Aug	$ 60.9	$ 58.2	$ 58.2	$ 58.2	$ 55.6	$ 58.2	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ 50.0	$ 50.0	$ 55.0	$ 68.8	$ 71.5	$ 71.5	$ 71.5	$ 63.5	$ 60.9
Sep	$ 60.9	$ 60.9	$ 60.9	$ 58.2	$ 55.6	$ 60.9	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ 50.0	$ 50.0	$ 50.0	$ 66.2	$ 79.4	$ 82.1	$ 82.1	$ 74.1	$ 63.5	$ 55.6
Oct	$ 55.6	$ 52.9	$ 50.3	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 50.0	$ 50.0	$ 66.2	$ 71.5	$ 76.8	$ 76.8	$ 66.2	$ 60.9	$ 58.2
Nov	$ 52.9	$ 52.9	$ 52.9	$ 52.9	$ 50.0	$ 50.0	$ 55.6	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 60.9	$ 79.4	$ 79.4	$ 79.4	$ 76.8	$ 68.8	$ 63.5	$ 55.6
Dec	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 55.6	$ 50.3	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 50.0	$ 58.2	$ 79.4	$ 82.1	$ 82.1	$ 79.4	$ 71.5	$ 60.9	$ 58.2
Average	**$ 54.5**	**$ 53.7**	$ 53.4	$ 53.2	$ 51.8	$ 51.6	$ 43.1	$ 37.5	$ 25.0	$ 25.0	$ 16.7	$ 12.5	$ 12.5	$ 12.5	$ 16.7	$ 29.2	$ 30.8	$ 52.7	**$ 67.0**	**$ 69.0**	**$ 68.1**	**$ 64.8**	**$ 60.1**	**$ 57.5**
Rank	**7**	**8**	9	10	12	13	14	15	18	18	20	22	22	22	20	17	16	11	**3**	**1**	**2**	**4**	**5**	**6**

Total Shape Value	$ 60.8
Average HE 19-22	$ 67.3
Average HE 01-02, 19-24	$ 61.9



How do you forecast storage value?

Ascend Analytics Fundamental Forecasting Framework

Ascend Analytics
Better models. Better decisions.

Policy and Macro Assumptions

- Climate & RPS Policy
- Load Growth
- Market Forwards
- Electrification
- Technology Costs

Can be adjusted based on scenario assumptions

Buildout

- Supply Stack
- Interconnection Queue
- Transmission

Price Formation

- Load
- Ramps
- Power Flows
- Renewable Generation
- Curtailment
- Marginal Unit
- Weather

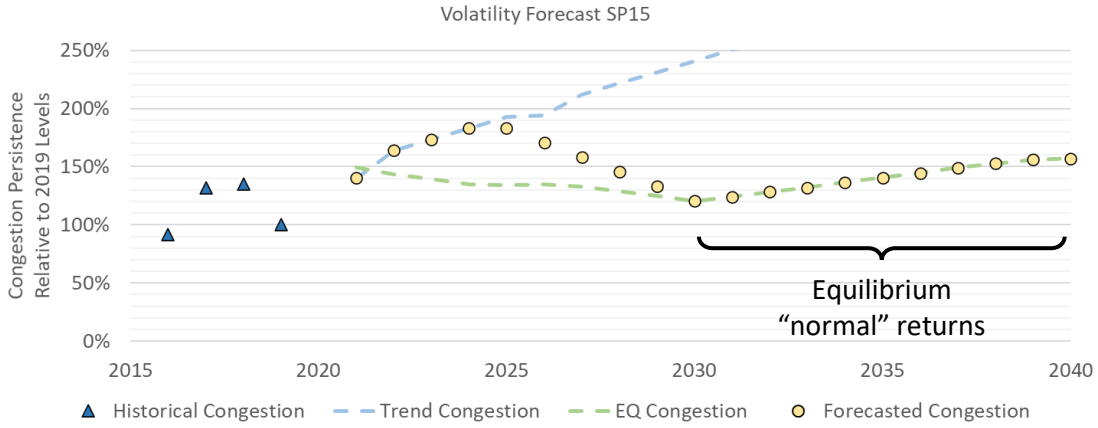
Outputs

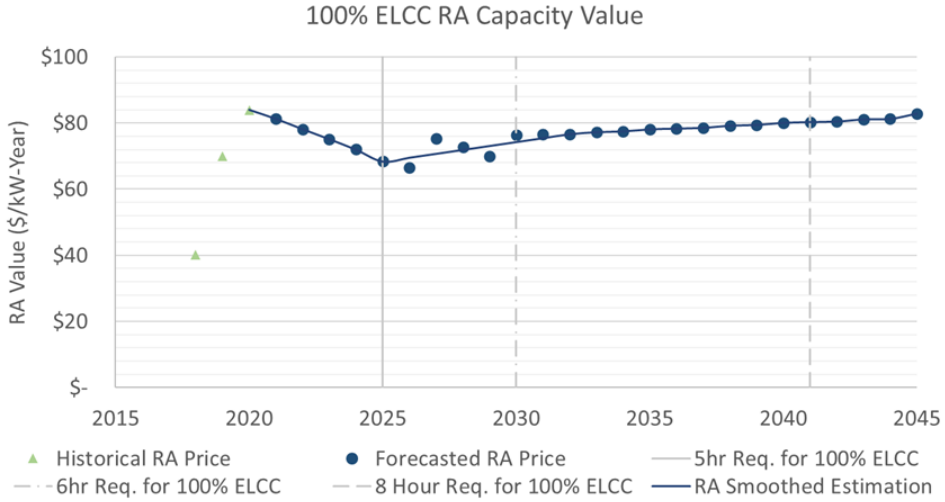
- Long-run on/off-peak forwards
- Volatility
- Price Shapes
- RT Price Spikes
- Capacity Prices
- Ancillary Prices

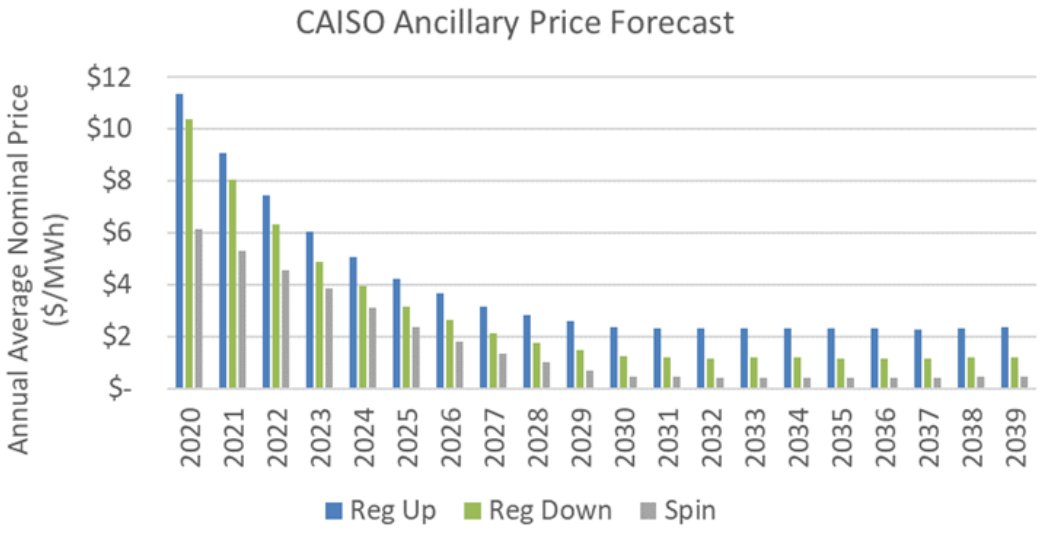
Fundamental Anchors

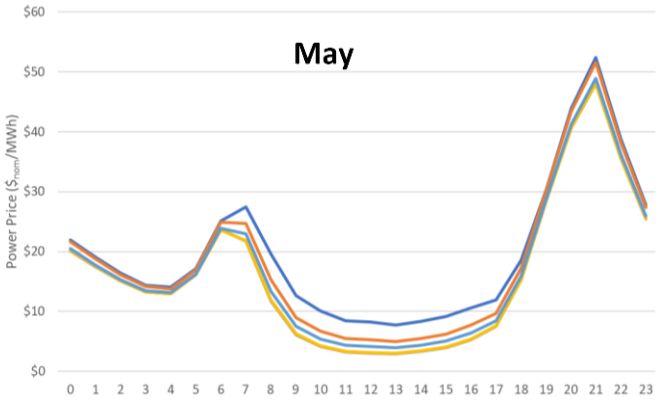
- Alignment with Markets
- Long-run equilibrium
- Barriers to Entry
- Stakeholder Demand
- Meaningful Uncertainty

Long-Term Forecasts that Honor Long-Run Equilibrium









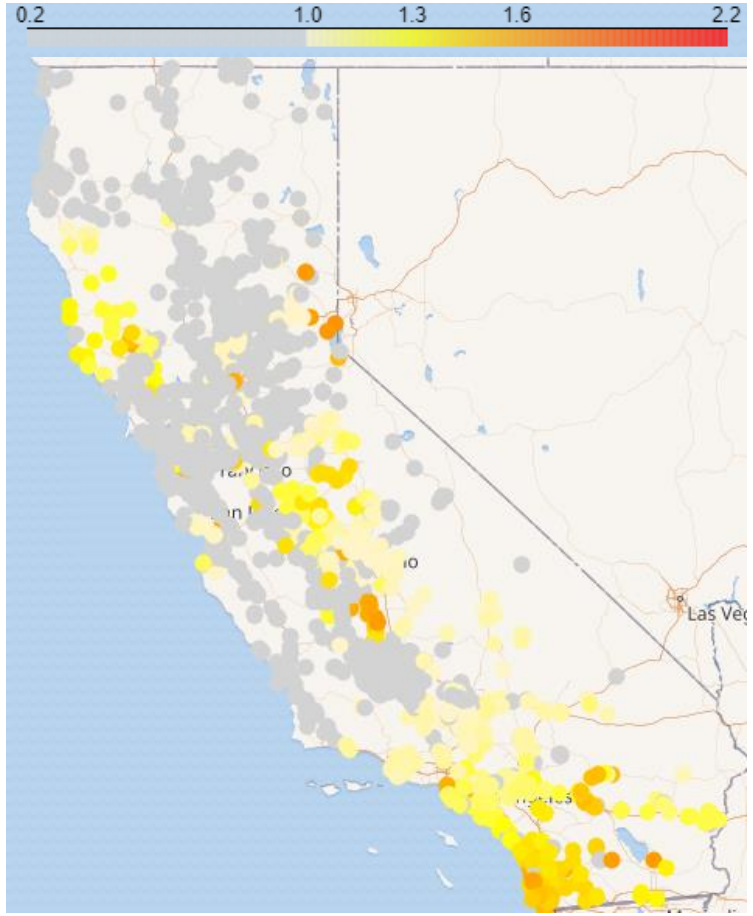
What will happen as storage deployment increases?

- Equilibrium volatility
- Equilibrium ancillary revenues
- Declining storage ELCC
- Equilibrium shapes

Accounting for Geographic Variability in the Long-Run

Step 1: Recognize that not all locations are created equally

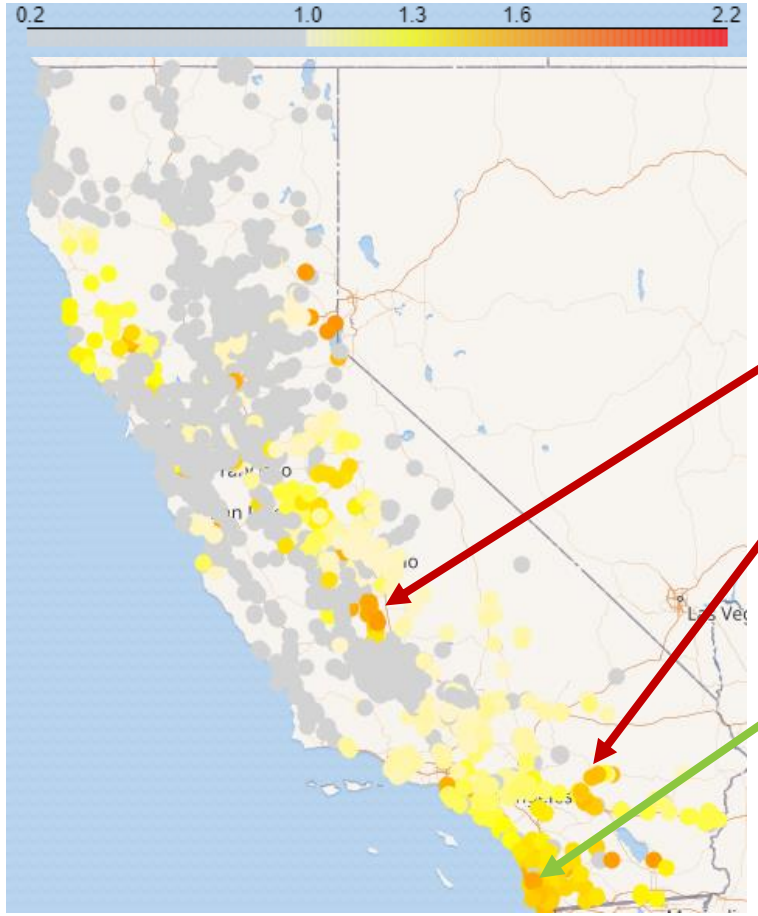
Congestion persistence (volatility) indicates high renewable penetration, and/or limited supply options



Accounting for Geographic Variability in the Long-Run

Step 1: Recognize that not all locations are created equally

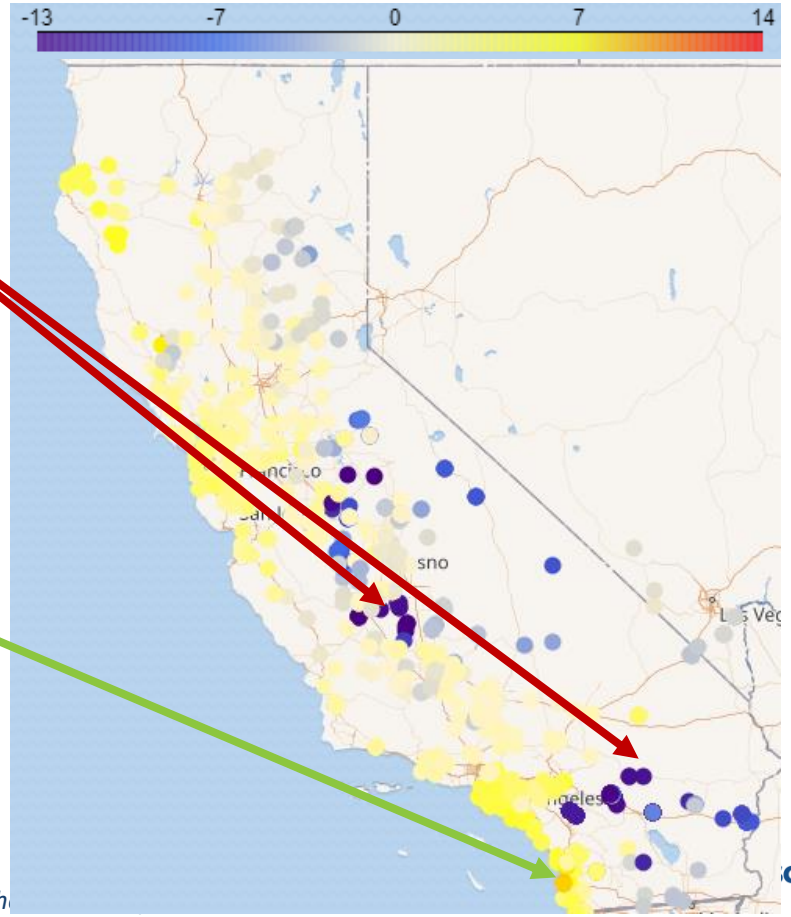
Congestion persistence (volatility) indicates high renewable penetration, and/or limited supply options



Step 2: Recognize history may not predict future (but it might)

Solar-Weighted Basis indicates imbalance between supply & demand

Negative basis indicative of open space, low population density => ease of adding storage & transmission



Easy-to-mitigate volatility

Hard-to-mitigate volatility

Forecasting - Key Takeaways

- The power sector is at an inflection point, making history (and the present) poor predictors for the future
- A base forecast should align to the best expectation of future conditions (rather than continuation of the status quo)
- Forecasts (and forecasters) should have an answer for how structural changes to the market are being accounted for
- Forecasts should adhere to long-run equilibrium in a competitive market
- Ascend's forecasts do these things

Ascend Analytics
Better models. Better decisions.

Contact Information

Brent Nelson PhD, Manager of Forecasting and Market Analysis
bnelson@ascendanalytics.com

Gary Dorris PhD, CEO
gdorris@ascendanalytics.com

David Millar, Director of Resource Planning Consulting
dmillar@ascendanalytics.com

Headquarters:

1877 Broadway St
Suite 706
Boulder, CO 80302
303.415.1400