Uncertainty and Forecasts

Applications and Value of Uncertainty Forecasts

PRESENTED TO

UVIG Forecasting Workshop
Tutorial Session

PREPARED AND PRESENTED BY

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THE Brattle GROUP

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Agenda

1. History of Net Load Ramps.

2. Going Forward

3. Appendix

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1. History of Net Load Ramps.

- Predictable (long-term trend)
- Unpredictable (forecast deviation)
- Net Loads Ramping magnitude has been increasing constantly

2. Going Forward

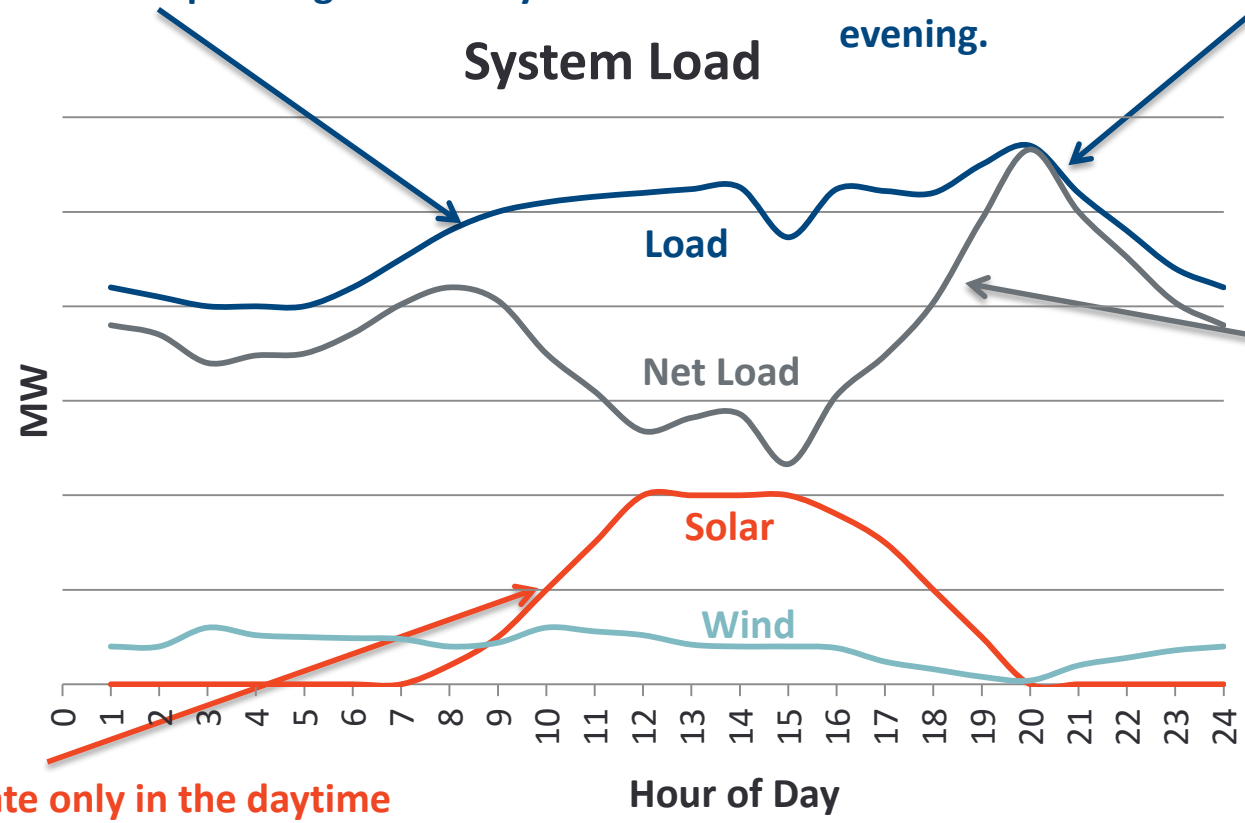
3. Appendix

History of Net Load Ramps:

Increasing Renewables Penetration

Traditionally, system loads ramp up in the morning hours as people wake up and industrial entities start operating for the day.

System loads ramp up again in the evening as people return from work and settle in for the evening.



When solar units produce a significant amount of generation, they cause significant net load ramping in the evenings.

Solar units operate only in the daytime ramping down before evening peak.

History of Net Load Ramps:

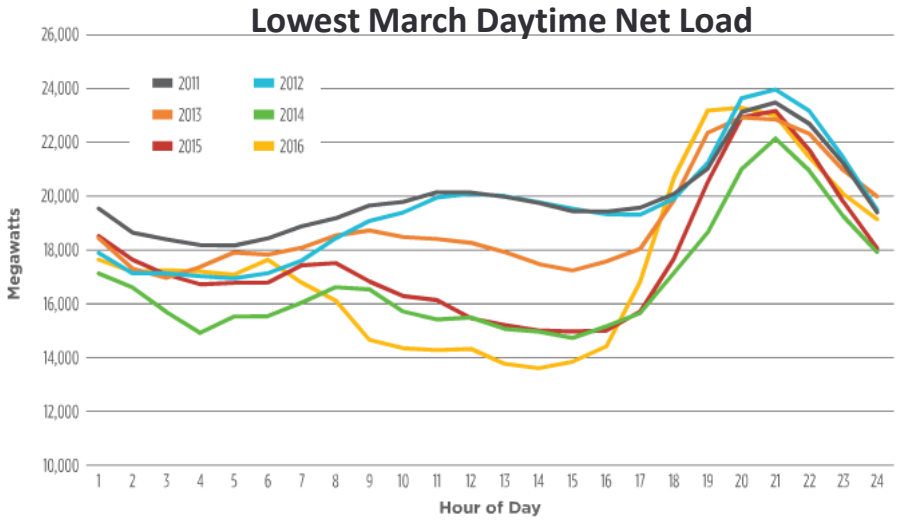
The CAISO Duck

CAISO started worrying about net ramping events in 2013 and published their duck graph.

- In 2013 with 8 GW of wind and 4 GW of solar they experienced an evening ramp of about 5 GW
- They expected that this would increase to 8.5 GW by 2016 and 12 GW by 2020[1]
- However, by 2016 CAISO had over 10.5 GW of solar installations and experienced spring net ramping of close to 10 GW, exceeding expectations

The belly of the duck has also had a big impact on average LMPs in CAISO, reducing the average peak hour LMP by around $5/MWh (adjusted for natural gas price differences) for every 1 GW reduction in net load.

Source: [1] "Demand Response and Energy Efficiency Roadmap: Maximizing Preferred Resources," CAISO, December 2013



Source: "The ScottMadden Energy Industry Update," Scott Madden. Volume 16 – Issue 2
http://scottmadden.com/reports/V16_I2/files/35.html

	Minimum Net Load		Average RT LMP Hours 7 - 18 ($/MWh)	
	Predicted March 31	Actual March	March 31	March
Year	(GW)	(GW)	($/MWh)	($/MWh)
2012	20.5	16.8	$ 19.41	$ 18.22
2013	18.8	16.9	$ 13.14	$ 20.05
2014	16.8	14.7	$ 11.58	$ 15.27
2015	15.8	14.3	$ 7.35	$ 15.99
2016	15.0	13.8	$ 1.36	$ 17.13

Source: CAISO, Scott Madden, Velocity Suite – ABB Inc., Brattle Analysis

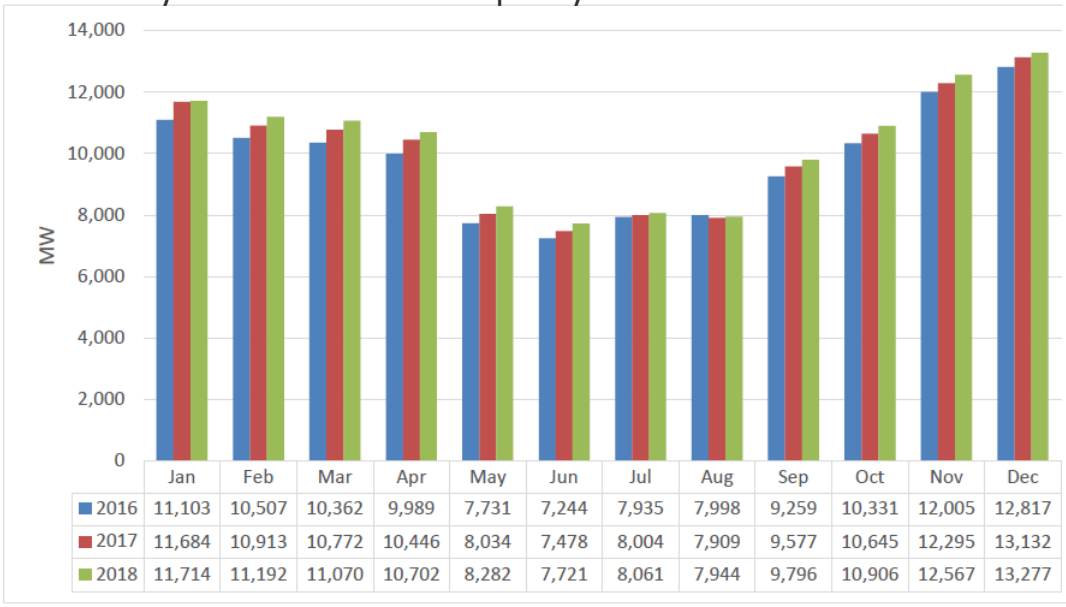
History of Net Load Ramping:

Long Term Forecasting

CAISO is forecasting the net ramps shown in the duck curves and conducting their long term resource planning to ensure that it has enough flexible capacity to help with the evening net load ramp.

- The "2018 Final Flexible Capacity Needs Assessment" defines flexible capacity need (by month) as the maximum expected 3 hour ramp plus 3.5% of the forecast peak load.
  - In 2018 they are planning for a maximum flexible capacity need of 15.7 GW.
- In 2016 they only required 12.8 GW, and expected that in 2018 they would need 13.2 GW.

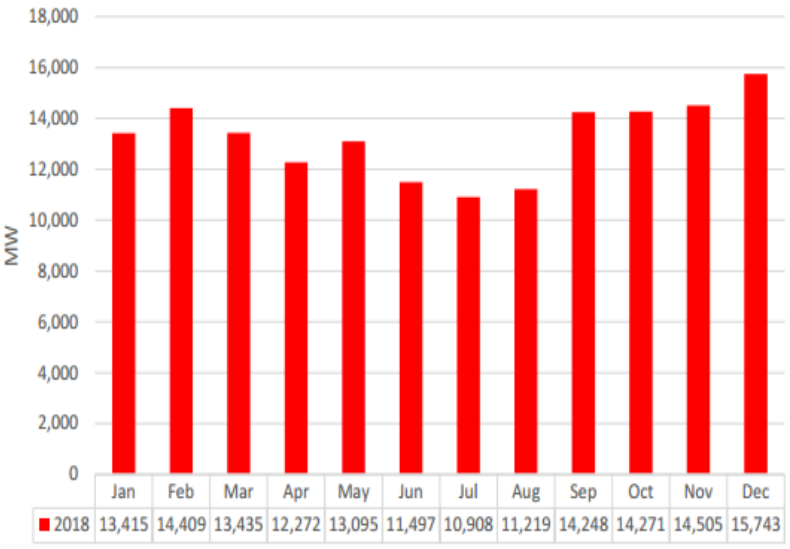
ISO system-wide flexible capacity needs for 2016 – 2018



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	11,103	10,507	10,362	9,989	7,731	7,244	7,935	7,998	9,259	10,331	12,005	12,817
2017	11,684	10,913	10,772	10,446	8,034	7,478	8,004	7,909	9,577	10,645	12,295	13,132
2018	11,714	11,192	11,070	10,702	8,282	7,721	8,061	7,944	9,796	10,906	12,567	13,277

Source: "Final Flexible Capacity Needs Assessment for 2016", CAISO, May 2015

Forecasted Flexible Capacity Need for 2018



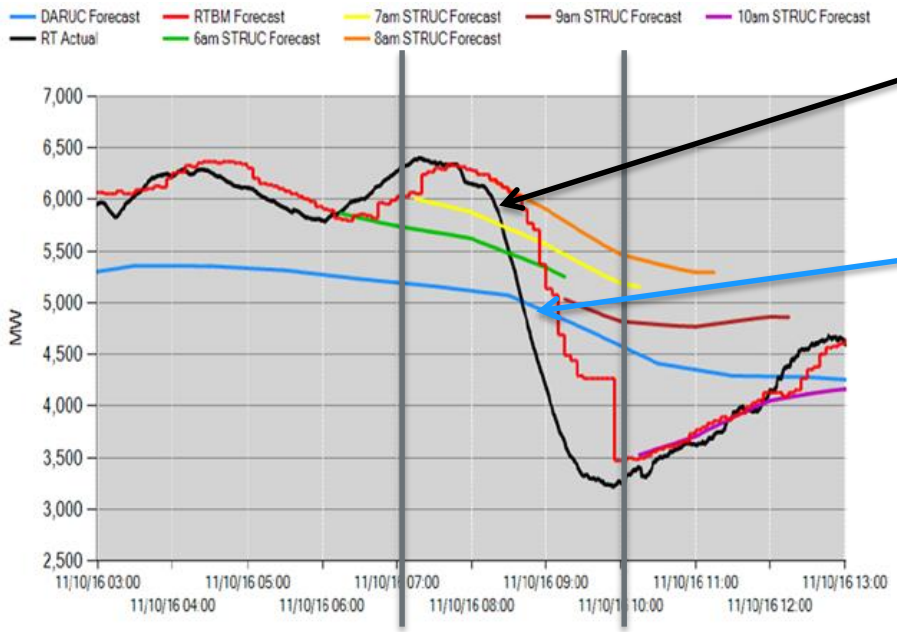
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	13,415	14,409	13,435	12,272	13,095	11,497	10,908	11,219	14,248	14,271	14,505	15,743

Source: "Final Flexible Capacity Needs Assessment for 2018", CAISO, April 2017

History of the Net Load Ramps:

SPP Wind Ramping

In SPP, high wind penetration causes large net load ramp events at unexpected times.

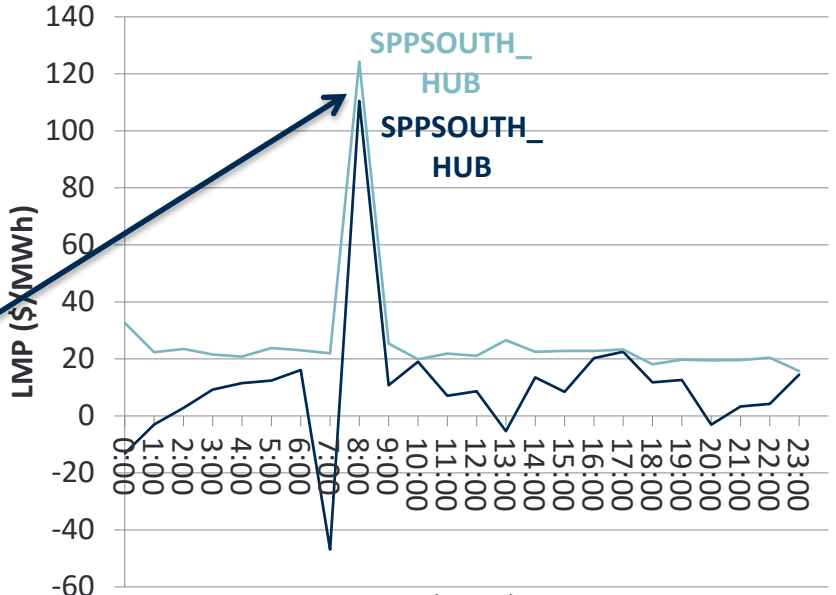


Source: "Strategic Planning Committee Meeting Materials", SPP, 2016, https://www.spp.org/documents/45117/spc%20materials%2020161201%20pgd.pdf

On November 10, 2016 wind generation dropped by over 3 GW in a 3 hour period.

The DA wind forecast only predicted a 750 MW drop.

The 11/10 ramp event caused large price spikes in the RT Market



Source: SNL Energy, Brattle Analysis

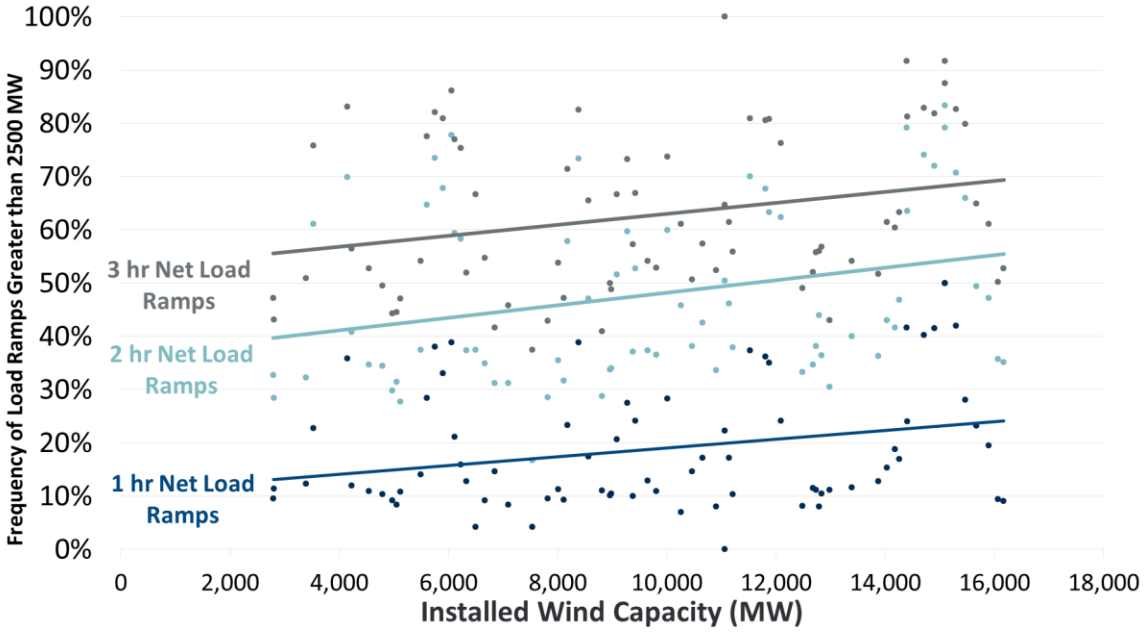
History of the Net Load Ramps:

ERCOT Net Load Ramping Frequency

As more renewables are installed on systems, net load volatility will increase

- We can see this trend with ERCOT's wind penetration. As more wind is added to the system, the frequency with which large net load changes occur increases

Frequency of Large Net Load Ramps vs. Installed Wind



Source: ERCOT wind database.
Notes: In this analysis net load is defined as total system load less wind generation, and other renewable sources are ignored

Agenda

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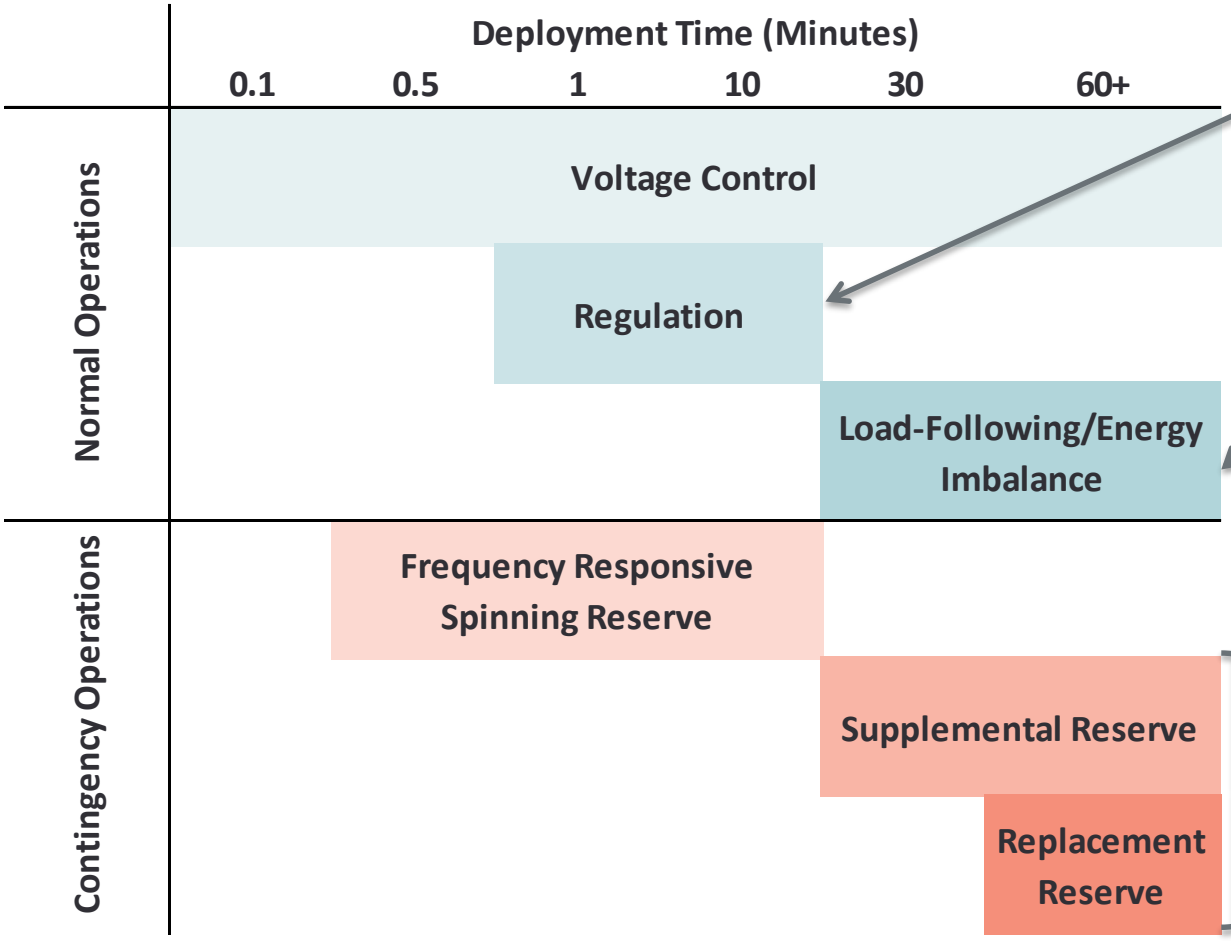
2. Going Forward

3. Appendix

Going Forward:

Determining Operating Reserve Requirements



Traditionally: percentage of load

Update: Include factor for total nameplate variable resource capacity.

Traditionally: does not exist

Update: Create new product to cover operational ramps

Traditionally: largest contingency

Update: Evaluate installed variable capacity as possible contingency.

Source: "SPP WITF Wind Integration Study" 2010

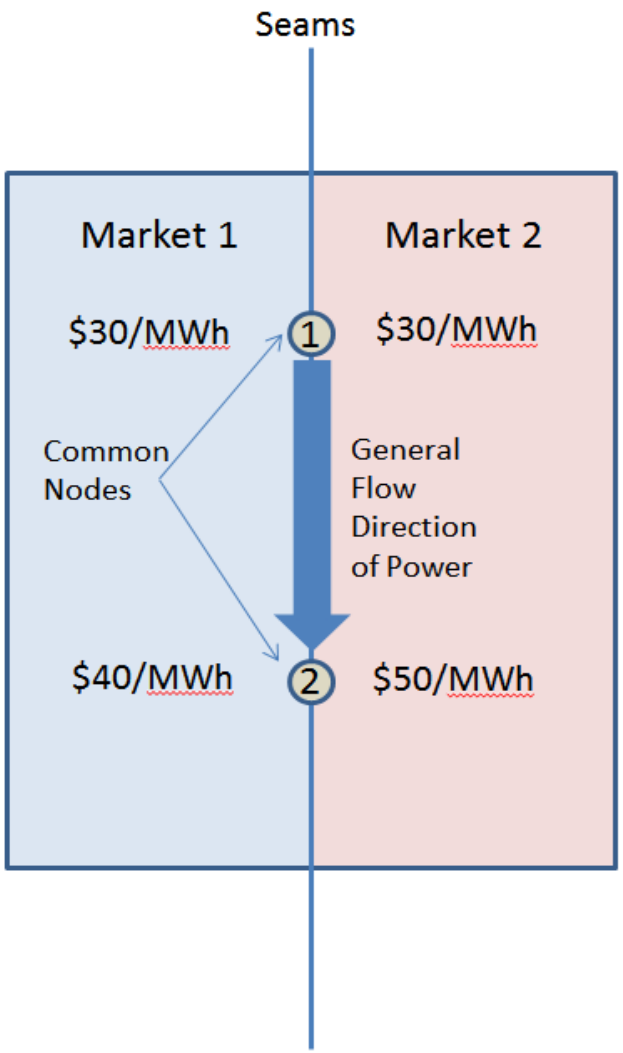
Going Forward:

Next Steps?

- System Operators are changing regulation requirements, developing/ implementing ramping products, and changing the rules for variable resource qualification for reserves.
  - These changes are built upon the current "hourly dispatch" market structures.
  - Can dispatch be optimized for a longer period?
    - CAISO: Daytime LMPs (<$5) vs Evening Regulation (≈$15).
    - Would there be savings if renewables were "pre-curtailed?"
    - Closer to commitment logic or look-ahead logic.
    - Potential to reduce load following needs.
- Regional expansion of the geographical footprint is also an option but has natural limits.
  - Can Inter-RTO RT Energy Transactions be enhanced?
    - One concept is to have an Energy Imbalance market between two (or more) RTOs at the seams. This market occurs "near" real-time (e.g., hour ahead, 30 mins ahead, or 15 mins ahead).

Going Forward:

Direct Inter-RTO RT Energy Transactions Concept



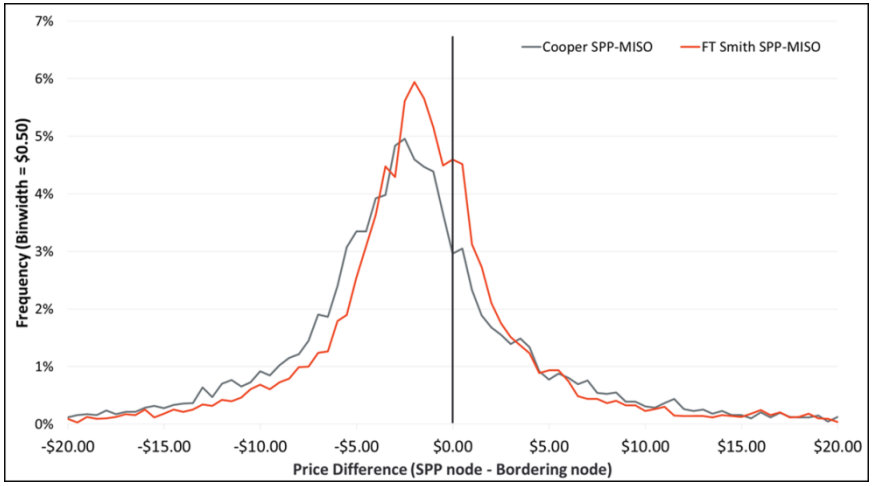
Energy Imbalance market between two (or more) RTOs at the seams. This market occurs "near" real-time (e.g., hour ahead, 30 mins ahead, or 15 mins ahead).

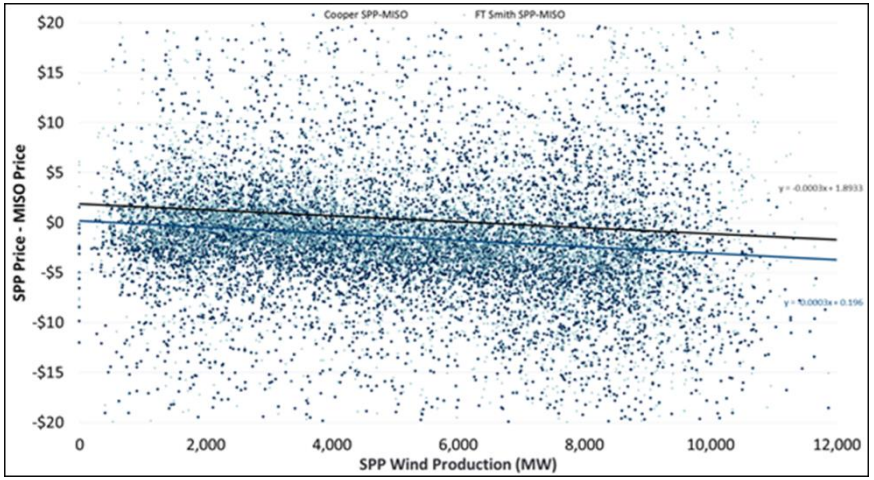
Illustrative Example

- Nodes 1 and 2 are common nodes (or nearly common nodes) at the border of two markets (Market 1 and Market 2).
- Assume a new collaboration model where the two Markets can trade across the border directly (near real-time) rather than exclusively depending on third-party traders or marketers.
  - Node 1: No transactions.
  - Node 2: Market 2 will purchase from Market 1, increasing sales from Market 1 (effectively increasing load for Market 1).

Going Forward:

Direct Inter-RTO RT Energy Transactions Potential





2016 historical LMPs at two SPP/MISO border nodes (Cooper and Ft Smith) indicates that in about 2/3 of the hours SPP prices are lower than MISO prices.

Price difference increases with wind production in SPP.

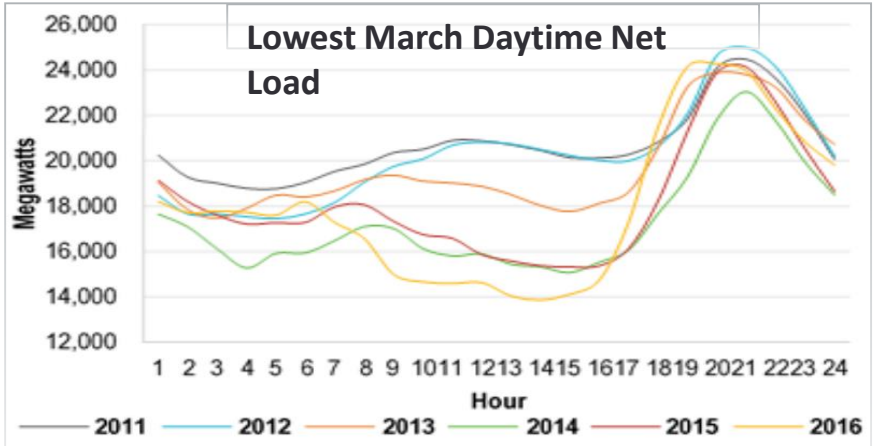
Direct inter-RTO transactions would help to deal with extreme events, similar to the sudden wind drop event that occurred in November 2016.

A preliminary estimate of the efficiency benefits of inter-RTO energy transactions between SPP and MISO is $50 – $70 million/year (under 2016 condition).

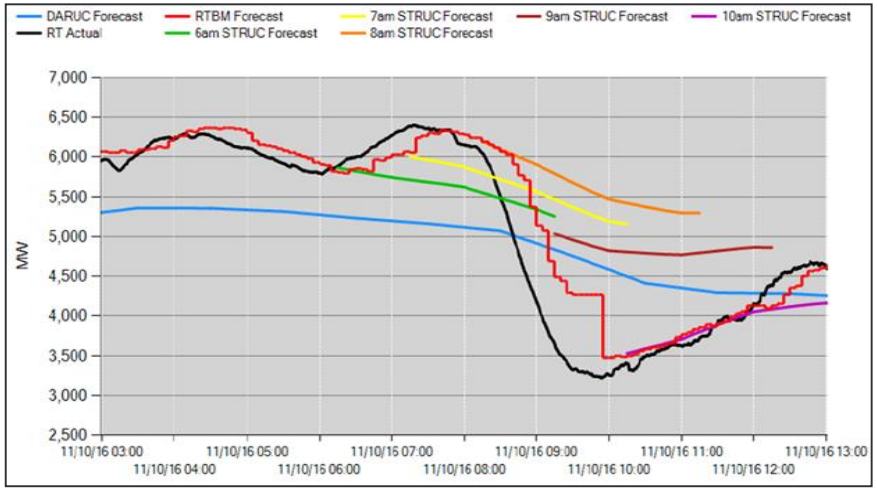
1000 MW transaction with average price difference of $7.5/MWh indicates $65 million per year.

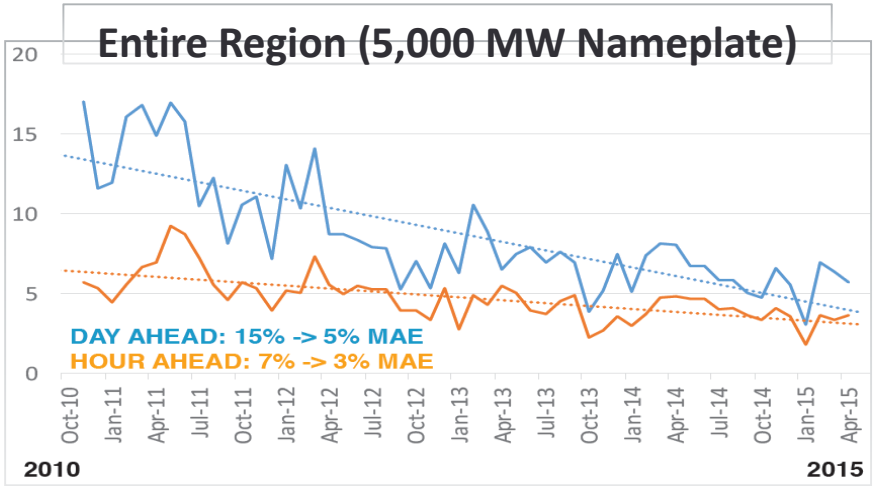
Going Forward:

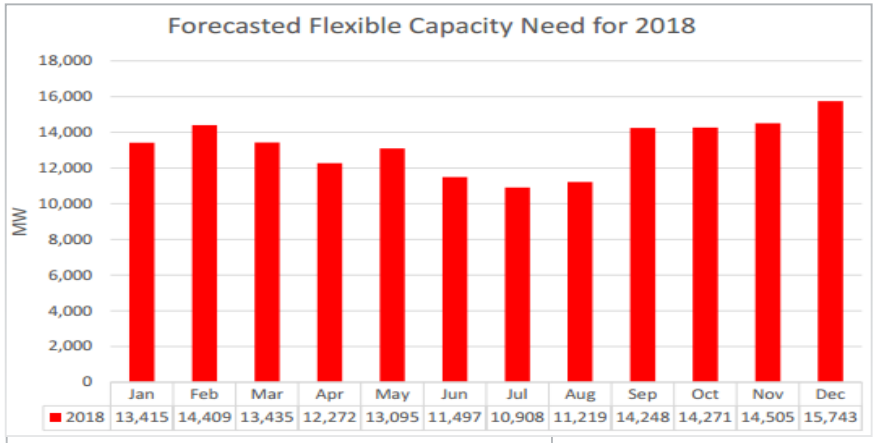
Discussion



Source: Scott Madden 2016







Source: CAISO 2017

Appendix

Operational Forecasting

SPP Operating Reserves

CAISO Regulation Requirements

CAISO Flexibility Operating Reserve

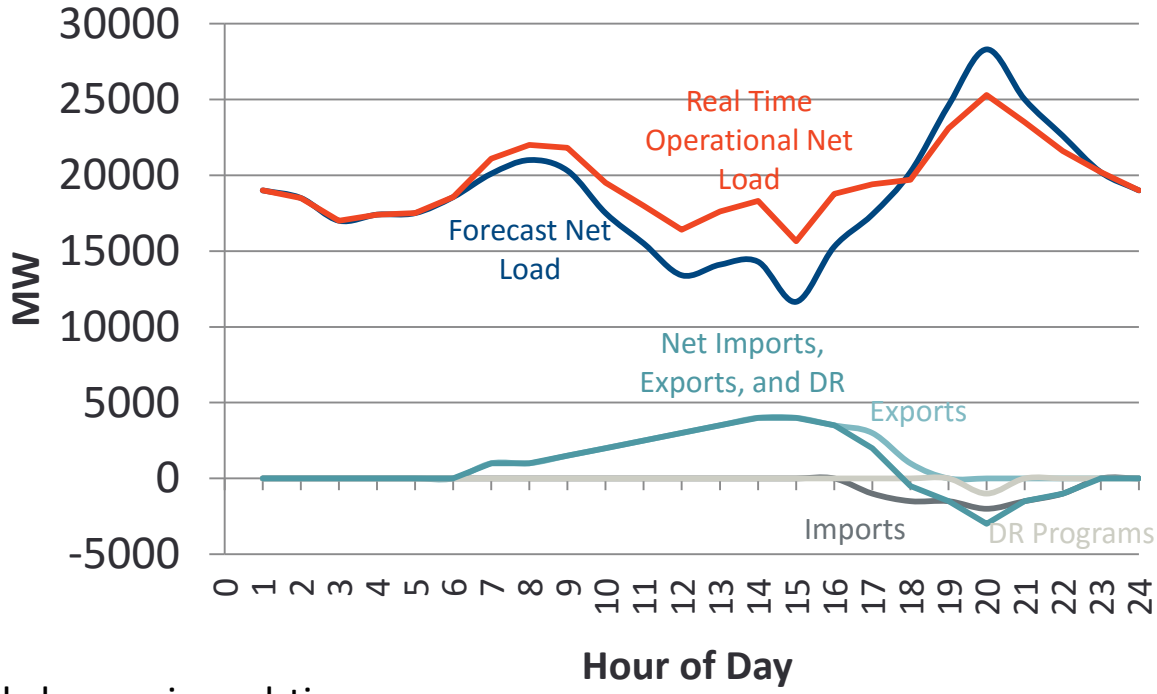
Forecast Improvements

Appendix:

Operational Forecasting

Despite planning fleet flexible for net ramping, system operators still need to address forecast variations in operations. In operations, forecast certainty can make a huge difference to the options available and the capacity required.

- When at ramp event is known at the time of unit commitment.
  - Operators can minimize ramping needs through import and export scheduling and DR programs.
  - They can then account for remain ramping needs through optimal commitment of thermal generation and battery resources.



- If the net ramping event is only known in real-time:
  - Options are reduced to relying on peaking units, renewable curtailments, and deployment of operating reserves.
  - The full ramp must be met by these fewer resources.

Appendix:

SPP Operating Reserves

SPP has already made changes to their regulation requirements and is working on implementing a ramping product and changing the rules for variable resource qualification for reserves.

- Regulation Up and Down requirements are determined based on:
  - Load Magnitude
  - Load Variability
  - Variable Resource Magnitude (typically 11-12% of total requirement)
  - Variable Resource Variability (typically 3-4% of total requirement)
- Changes in process:
  - Ramp Product
    - Appropriately compensates fast-ramping generators to hold back in the energy market and be available for net load ramps
    - Used to address price volatility and scarcity.
  - Variable Resources in Upward Reserves
    - Currently only allowed to bid for downwards reserves

Sources: "Strategic Planning Committee Meeting Materials", SPP, 2016, https://www.spp.org/documents/45117/spc%20materials%2020161201%20pgd.pdf
"Export Pricing Task Force Meeting Materials", SPP, 2016, https://www.spp.org/documents/46250/eptf%20minutes%2020161130.pdf

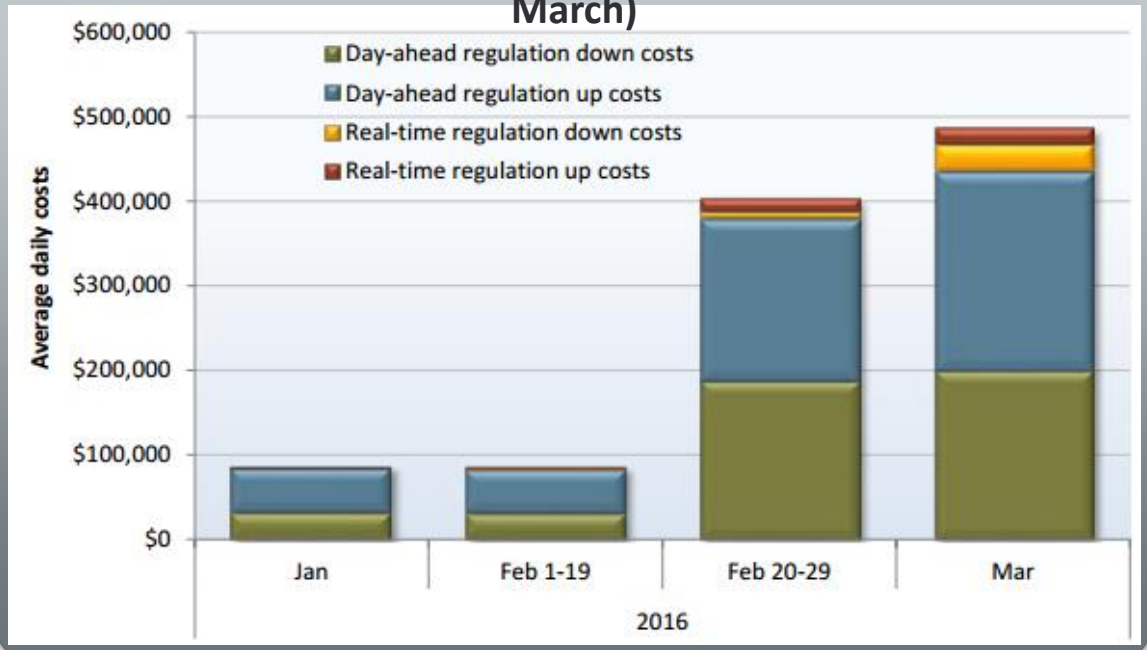
Appendix:

CAISO Regulation Requirements

In February 2016 CAISO doubled their regulation reserve procurement.

- Previously the requirement was 300 – 400 MW, requirements now are 600-800 MW depending on renewables forecasts.
- Regulation prices roughly tripled in this period, from $5/MWh to $15/MWh
- Total regulation payments increased significantly, from less than $100,000 to over $400,000 per day

Average daily regulation procurement costs (January – March)



Source: "Q1 2016 Report on Market Issues and Performance," CAISO, http://www.caiso.com/Documents/2016FirstQuarterReportMarketIssuesandPerformance.pdf

Appendix:

CAISO Flexibility Operating Reserve

In November 2016 CAISO approved a flexible ramping product to help with net load ramping due to variable resource integration

- The product is an enhancement of the flexible ramping constraint that CAISO first implemented in 2011
- The new product ensures that flexible resources are set aside and compensated to cover net load ramping and uncertainty in the net load forecasts.
  - Covers upward and downward ramping in CAISO RT markets
- The product was designed so that CAISO operators do not have to regularly call regulation reserves to cover the net load ramping events.

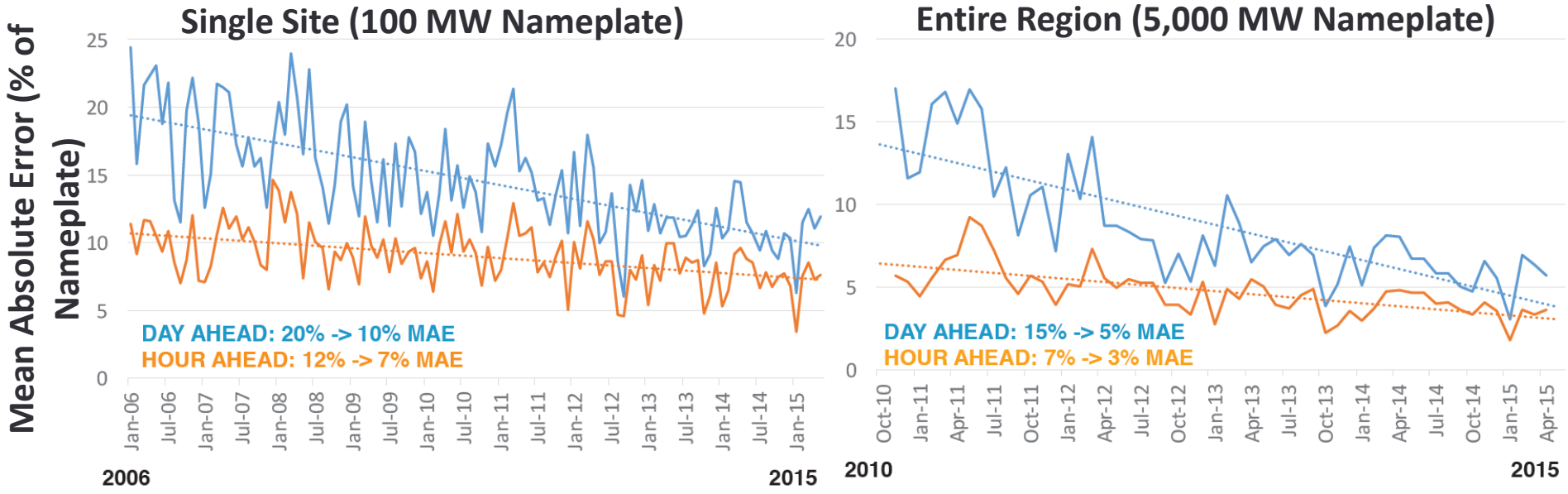
Source: "FERC Approves New Flexible Ramping Product for CAISO," Troutman Sanders, October 2016
"FERC approves CAISO ramping product, rejecting calls to make it biddable," UtilityDive, September 2016

Appendix:

Forecast Improvements

Due to the specific nature of weather forecasts, net load forecast uncertainty can be reduced by increasing the size of the system.

- Increasing the system size across time zones can help smooth the base load peaks.
- Additionally, renewables in different areas will not all experience the same forecast deviations (except for large events like the upcoming eclipse).



Source: "Determining the Value of More Accurate Wind Power Forecasting in Global Electricity Markets" Vaisala, EWEA 2015 Wind Forecasting Workshop, October 2015, http://www.ewea.org/events/workshops/wp-content/uploads/2015/10/EWEA-Wind-Power-Forecasting-2015-Workshop-01-02-Pascal-Storck-Vaisala.pdf

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