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LOLP Proxy QC Methodology Proposal

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Motivation

- **The Idea:**
  Weight hourly load impacts by LOLP

- **The Challenge:**
  Actual grid conditions diverge from planning conditions, but actual intervals do not produce LOLP values

- **The Solution:**
  Define a proxy variable for LOLP from hourly data reflecting actual grid conditions and needs

LOLP Proxy Proposal

Define LOLP Proxy

- Probability of E event as function of System Marginal Energy Cost

Daily Capacity Measurement

- Top 3 consecutive LOLP proxy hours in each day
- Resource capability/availability weighted by LOLP proxy

Linear Regression of Daily Capacity as function of temperature & key factors

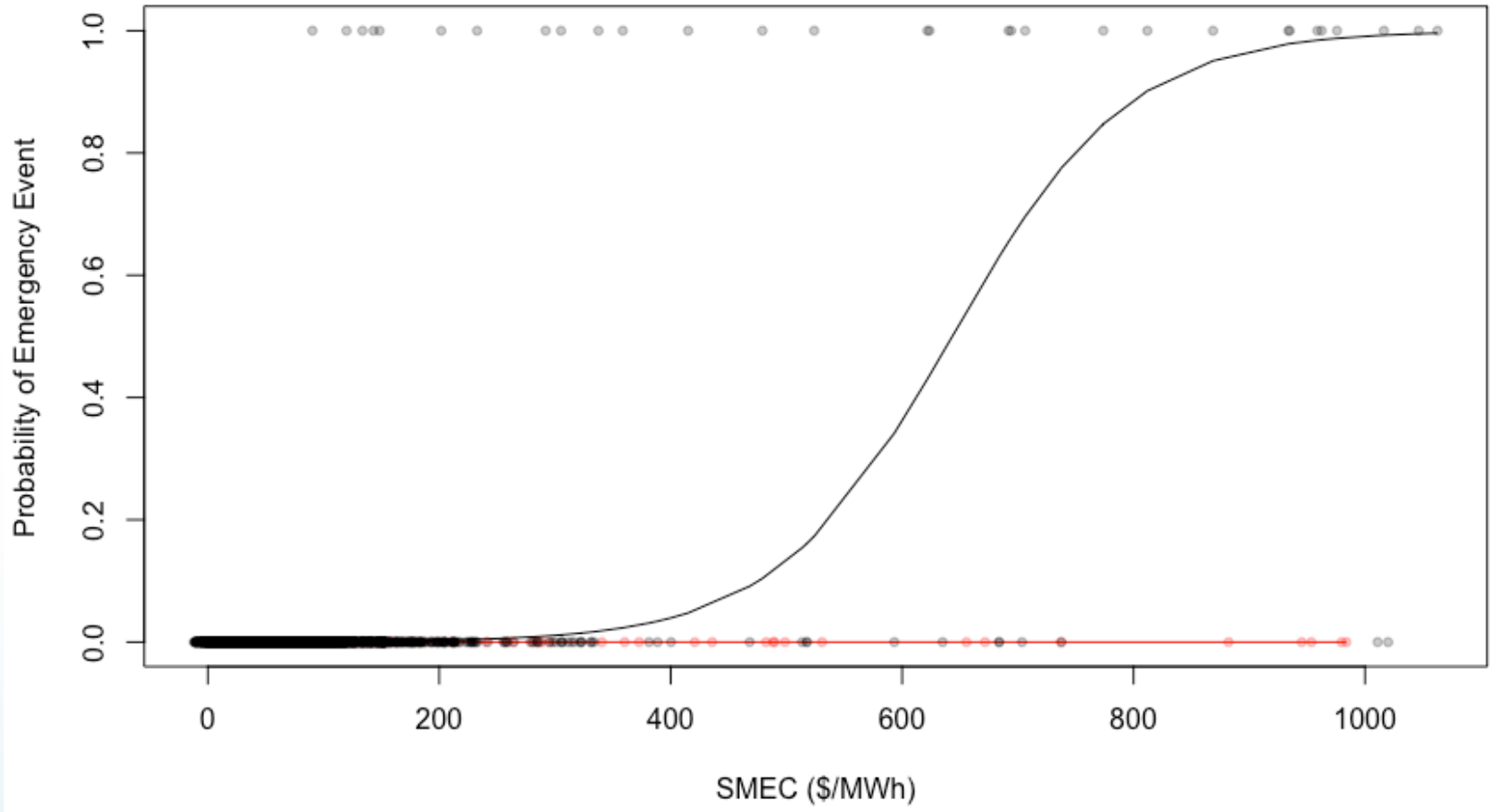
- Limiting change points

Apply Planning Temperature Assumptions

- 1-in-2 peak temperature (or 1-in-n?)

Price and Grid Emergencies

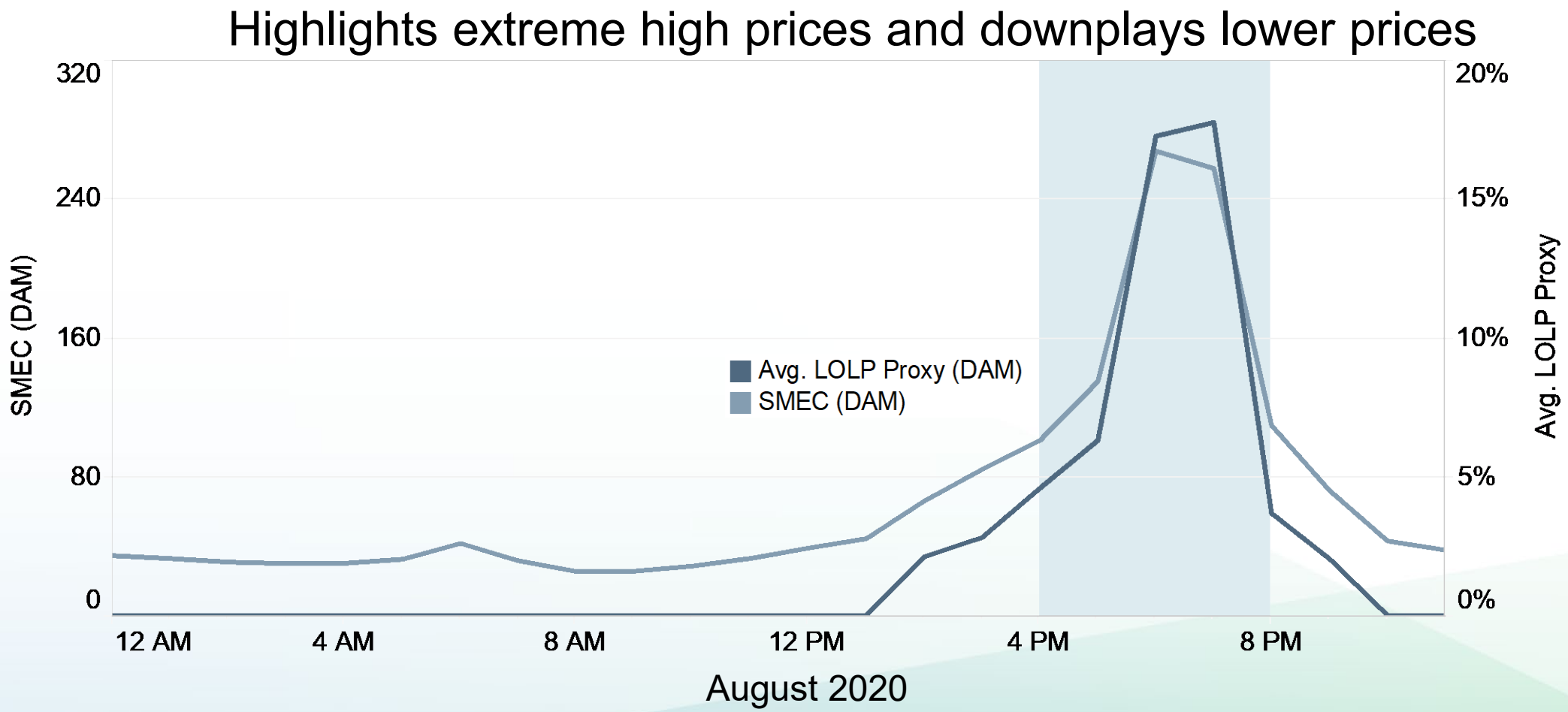
Day-ahead System Marginal Energy Cost → Probability of Emergency Event



LOLP Proxy: P = 1/(1 + exp(8.44561 – 0.01313*[SMEC] + 20.685*[Feb13–18]))

Note: Feb 13–18 2021 hours (red) flagged and controlled for in regression

Weight Captures High LOLP Hours



System Marginal Energy Cost

Why SMEC?

1. Reliability pricing is integrated into CAISO market by design (Soft energy bid cap)
2. SMEC reflects both predictable and random variation in grid needs

Why Not Net Load?

1. Net load takes supply limitations of only wind and solar into account
   a. Ramping constraints
   b. Derates of thermal generation under high temperatures
   c. Hydro limitations from drought
2. Reliability implications of net load sensitive to supply stack
   a. Marginal price generally bounded ~$0–$1,000/MWh

Price as Reliability Signal

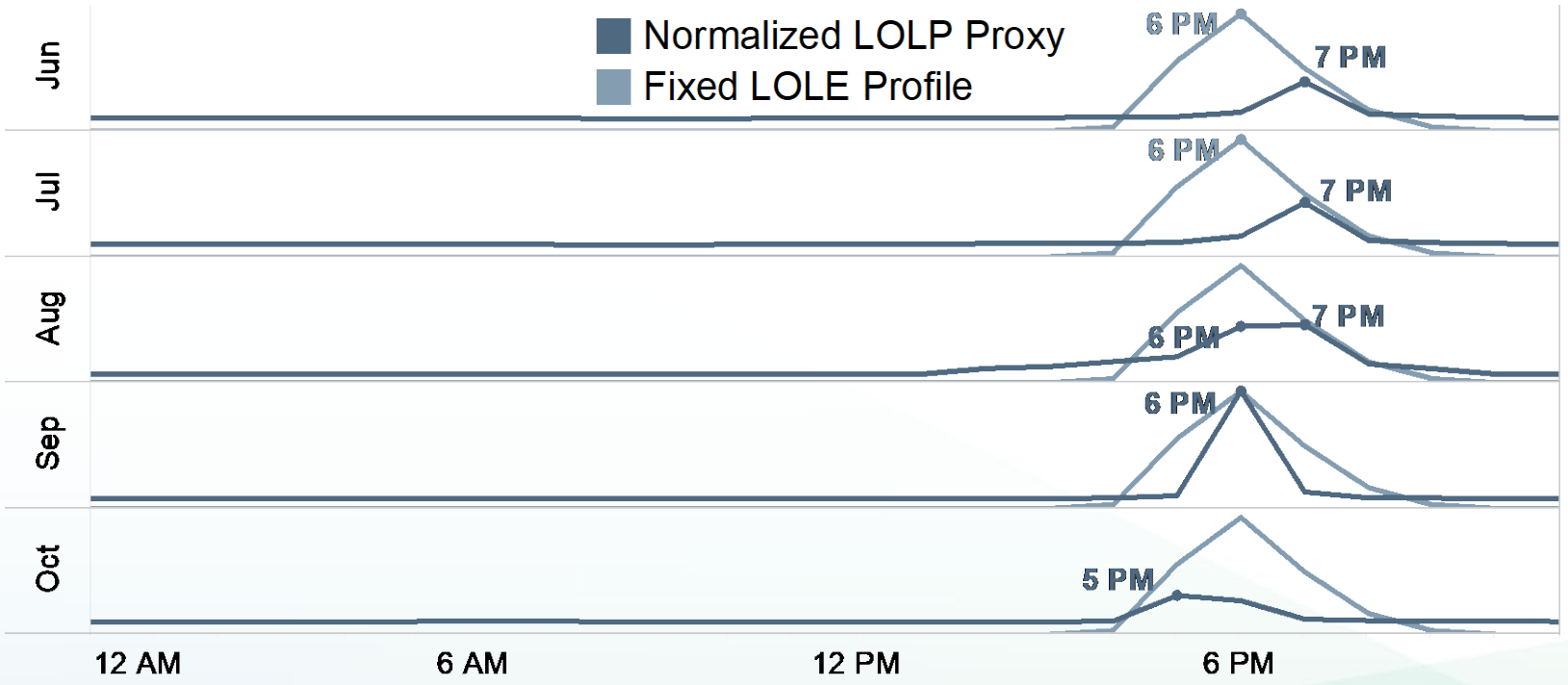
"The CAISO currently bases prices on the $1000/MWh bid cap when there is an insufficiency of bids to meet the power balance constraint."

"$1,000/MWh is far in excess of what the highest reasonable cost-justified offer could be from a resource in the CAISO generation fleet."

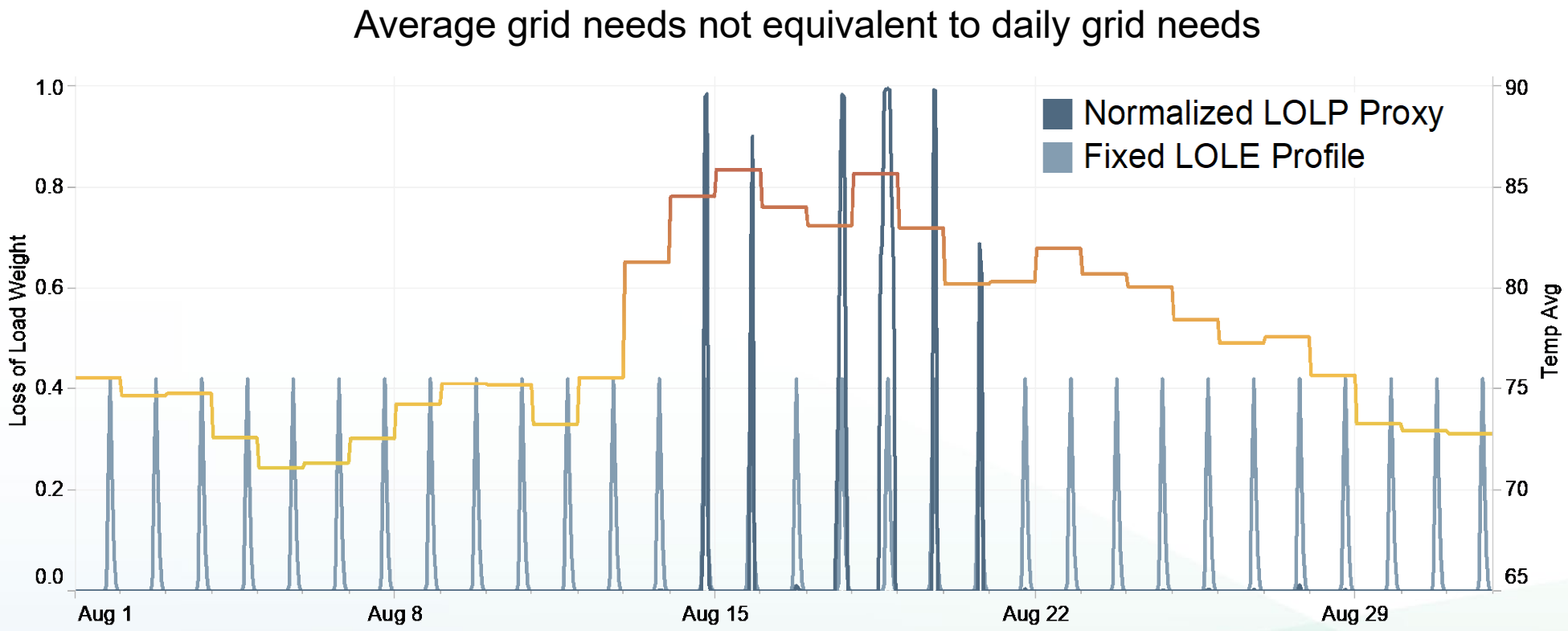
CAISO Comments to FERC, Docket No. RM16-5-000

Predictable Patterns: Magnitude and Timing

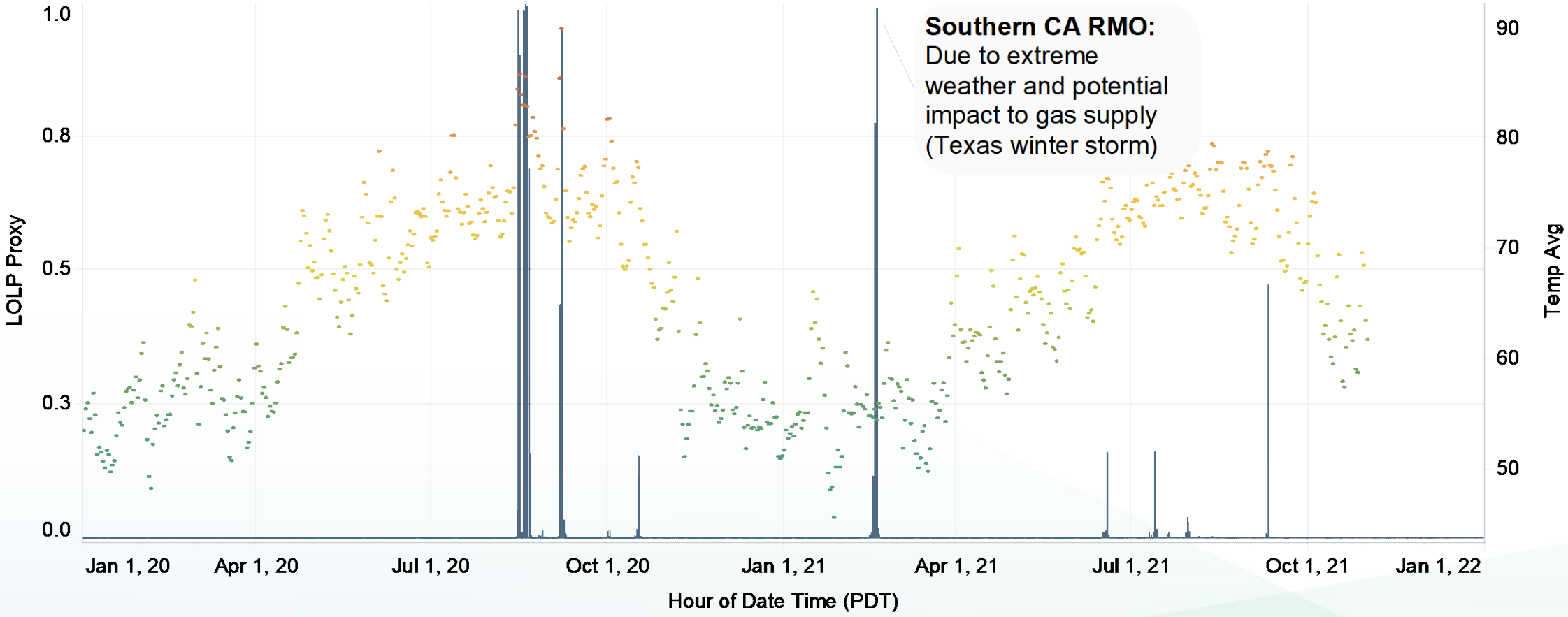
Grid needs shift earlier in the evening with decreasing day length



Variability in LOLP (1)



Variability in LOLP (2)



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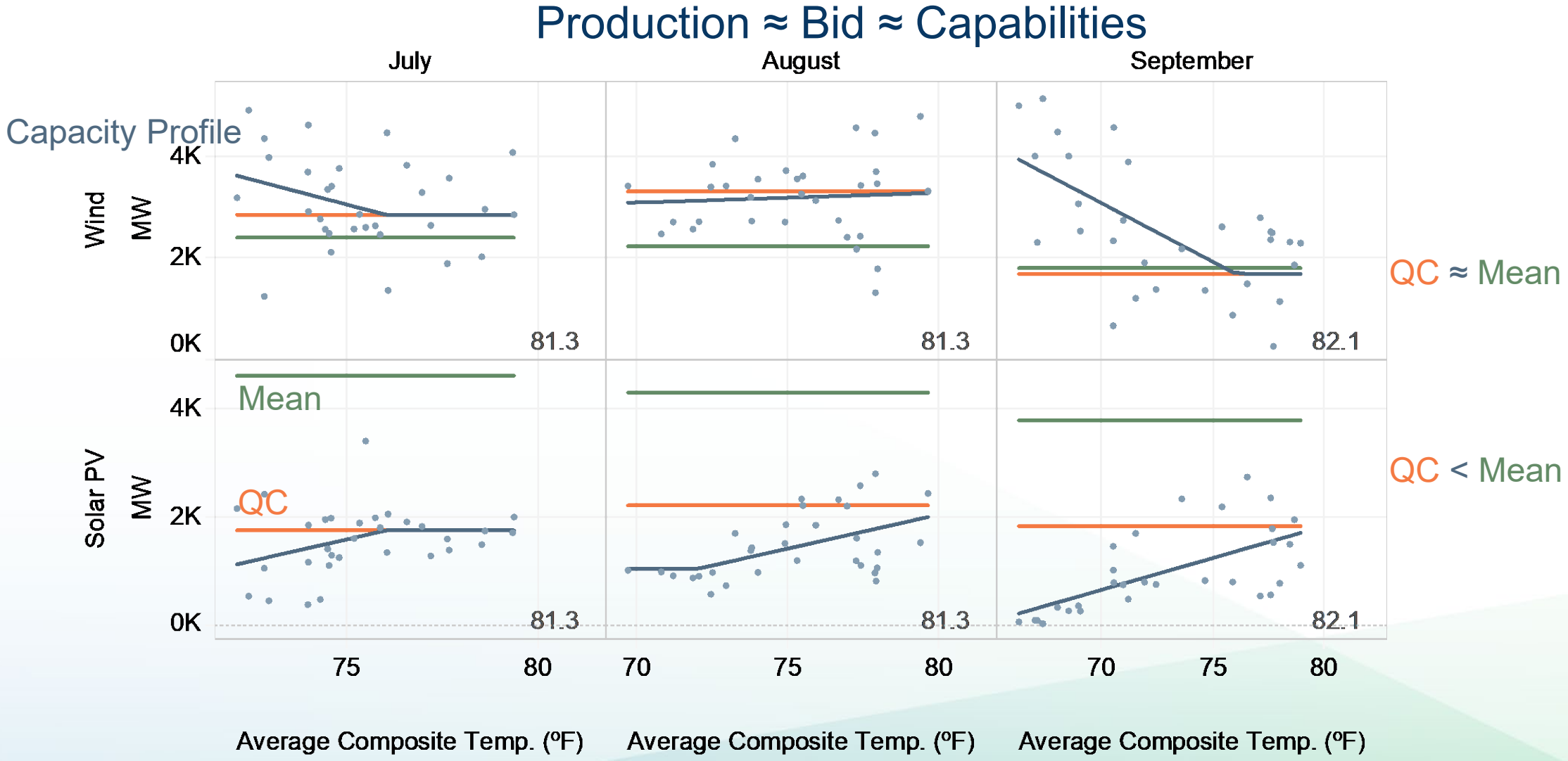
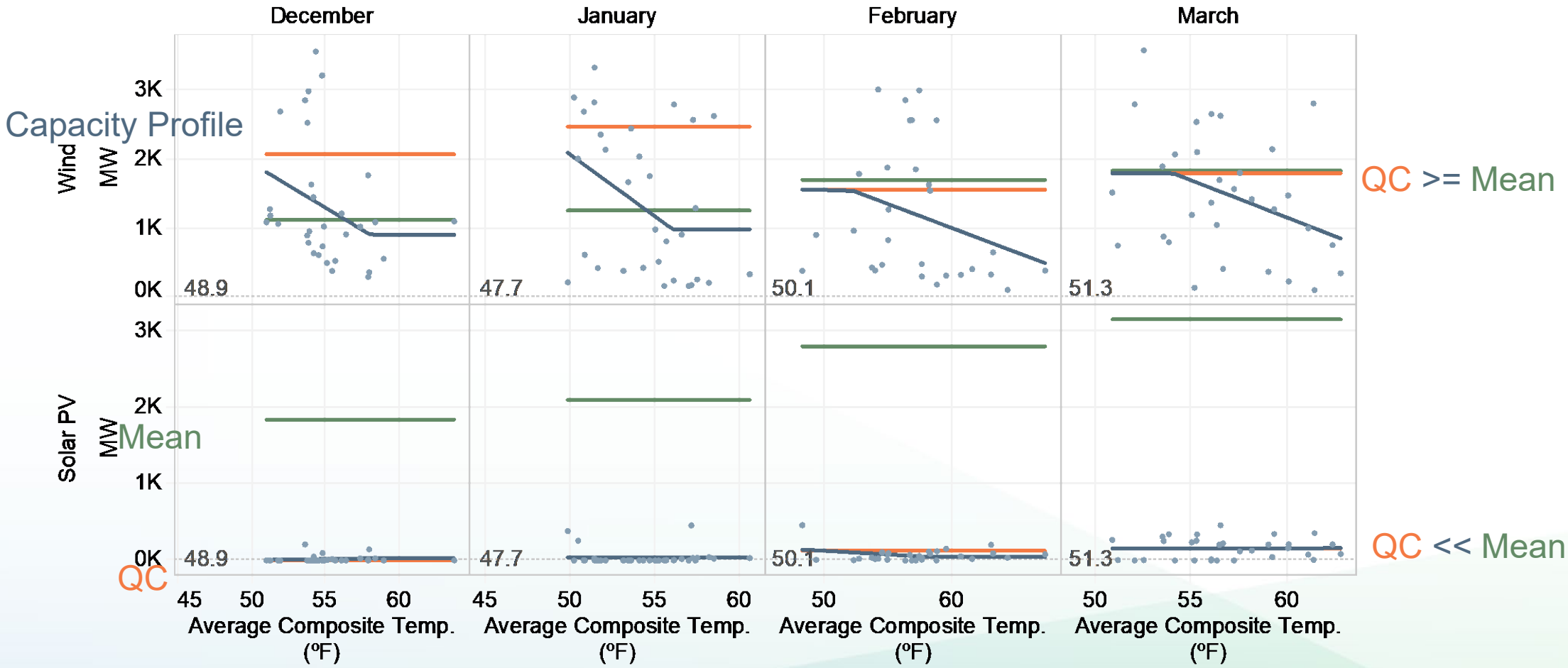
Example: Solar + Wind



Example: Solar + Wind (Winter)

Production ≈ Bid ≈ Capabilities



Daily Capacity Measurement Alternatives

Change number of hours per day

- Increase from 3 (as proposed) to 4 (status quo)

Use AAH

- Apply weights to 4 consecutive hours within AAH

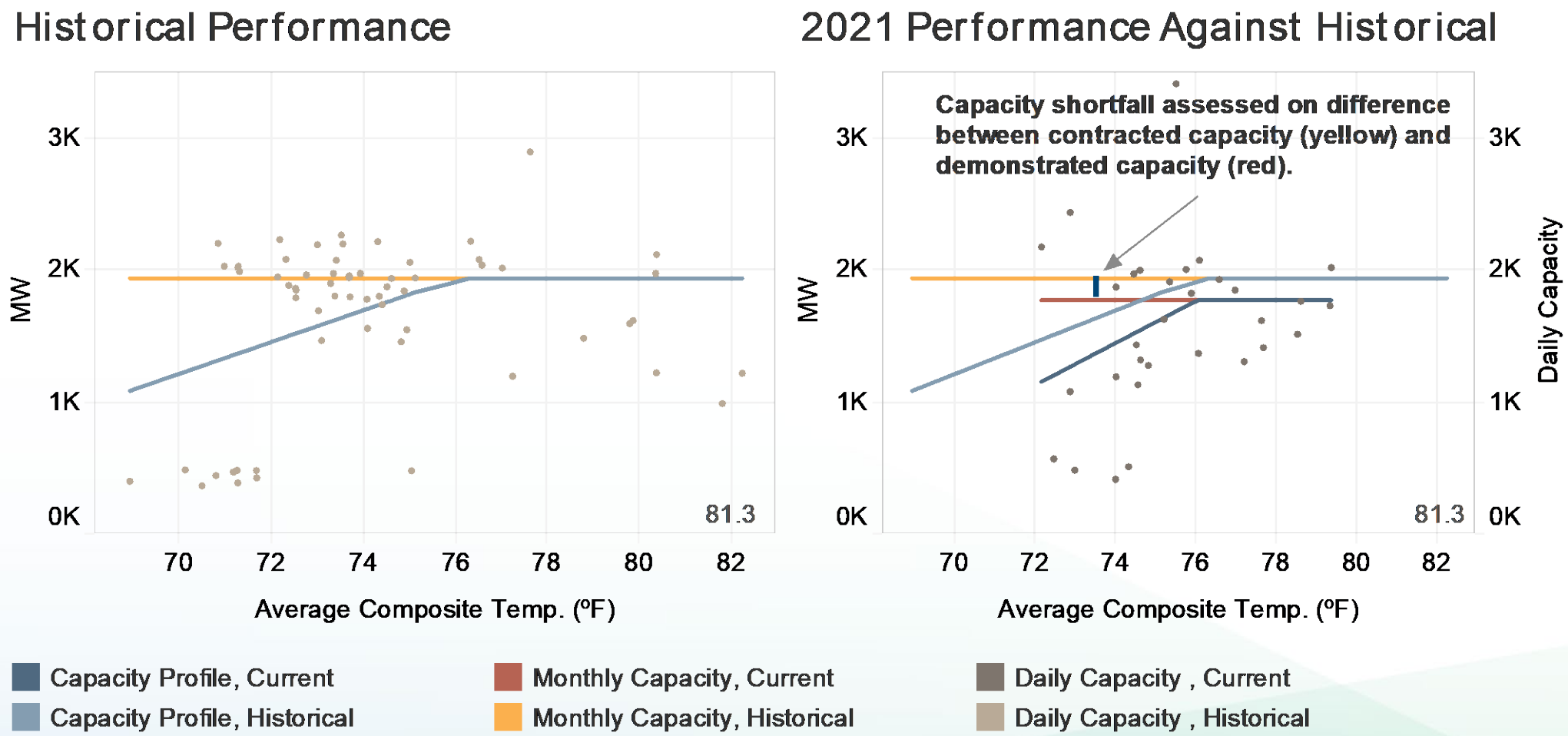
Include all hours over cutoff

- 98% of hours <0.02
- Some months would often have no weighted hours

Include top quantile of hours

- 1% of hours ~7 hours per month
- n% of hours ~7n hours per month

Ex Post/Ex Ante Process

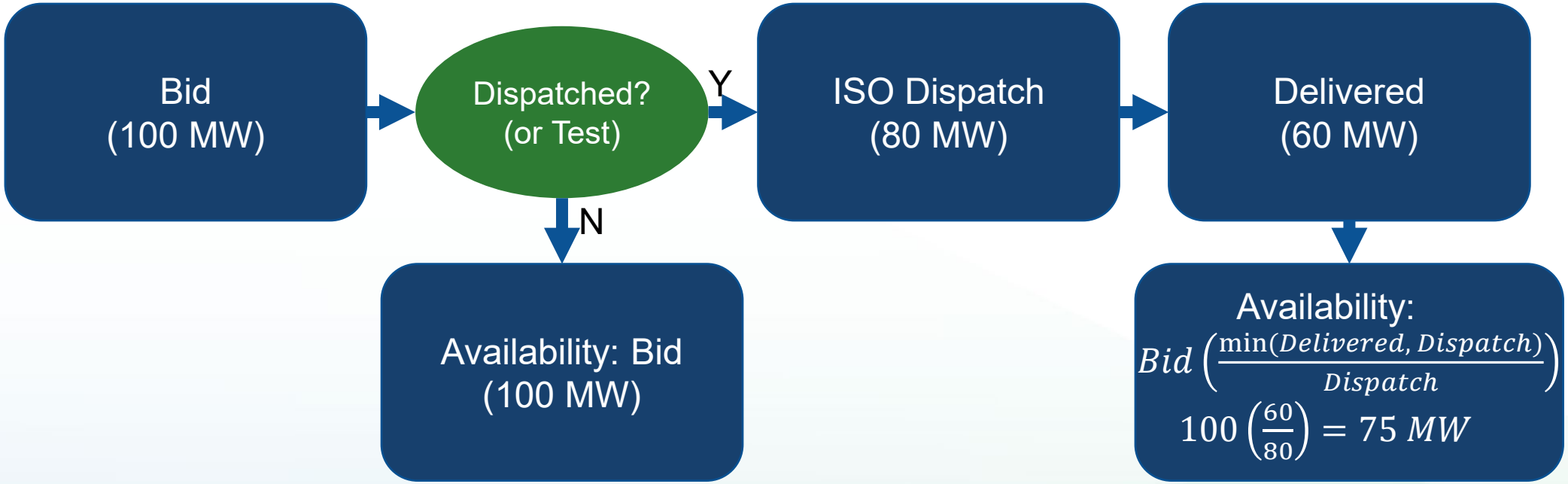


*Adjust for enrollment/resource characteristics in between steps.

Supporting Policy Details

- **Analytical** or **Incentive-based:** Flexibility to apply to either approach
- **Weather-sensitive Baseline:** Comparison group w/ data access
- **Hourly Capability:** Combination of bids, dispatches (or tests), and delivery
- **Capacity Shortfall Penalty:**
  - Equivalent to double the capacity shortfall
  - Mitigate risk with aggregation and tradable capacity obligations

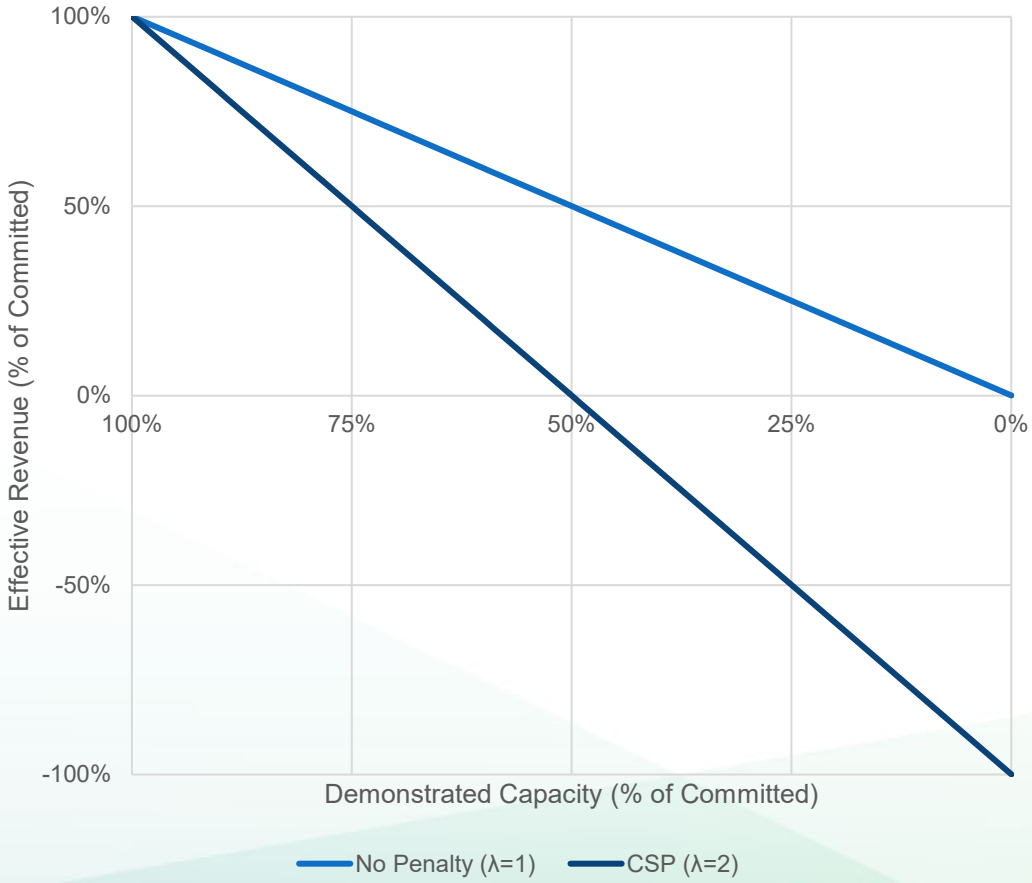
Hourly Capability



Capacity Shortfall Penalty (CSP)

Demonstrated capacity below contract faces penalty:

- No bonus for exceeded capacity commitment
- Parameter λ defines severity of penalty
  - λ = 0 implies DRP compensated for committed capacity regardless of performance
  - λ = 1 implies DRP compensated for demonstrated capacity
  - λ > 1 implies true penalty

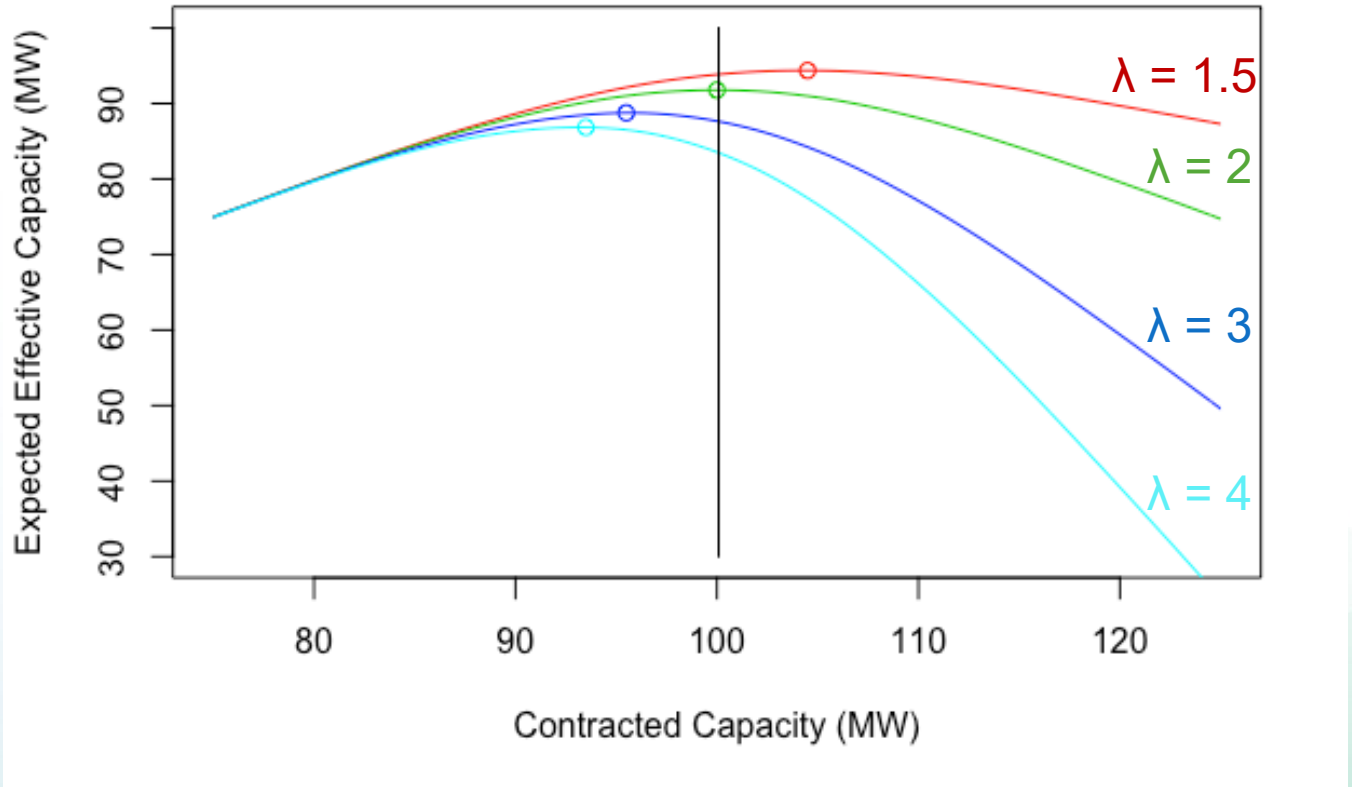


CSP Effective Capacity Example

- Effective Capacity: Capacity equivalent for a resource meeting capacity obligations
- Resource awarded 100 MW
- Resource demonstrates 90 MW
  - 10 MW Capacity Shortfall
- Effective Capacity:
    - λ = 0: 100-0*10 = 100 MW
    - λ = 1: 100-1*10 = 90 MW
    - **λ = 2: 100-2*10 = 80 MW**

Optimal Penalty Parameter

- Simulated capacity awards and average outcomes for resource with average 100 MW and S.D. 10 MW
- λ = 2 incentivizes DRP to commit to average/median expected performance



Risk Management: Aggregation

- Significant risk when disaggregated resources are penalized for underperformance and not rewarded for overperformance
- Solution: Allow aggregation of multiple resources with different underlying characteristics, on different sub-LAPs, etc.

Parent Resource ID	Total Demonstrated Capacity	Non-aggregated Shortfall	Aggregated Shortfall
1	104.7	6.1	0.0
2	102.4	7.0	0.0
3	101.1	7.8	0.0
4	100.8	7.5	0.0
5	99.4	9.1	0.5
6	98.9	7.8	1.0
7	98.5	9.6	1.4
8	98.0	9.0	1.9
9	97.9	9.8	2.0
10	97.2	9.5	2.7

Risk Mgmt Extension: Residual Capacity Market

- RCM: Allow DRPs with demonstrated capacity above contracted capacity to sell that "residual capacity" to DRPs with shortfall
- Similar to buying energy in the spot market when resources do not meet bid
  - Avoids λ penalty multiplier
- Retains DRP incentives to claim capacity they expect to meet

Total Demonstrated Capacity	Shortfall with DRP Aggregation Only	Shortfall with RCM
999.2	9.9	0.71

Outstanding Issues

- From Day-ahead Market to Hour-ahead and Real-time
  - Same price function?
- Consecutive top SMEC hours? Top hour +/- 1?
- Local vs. system reliability
  - Apply sub-LAP LMP for local reliability
- Temperature planning assumptions: 1-in-n?

Questions?

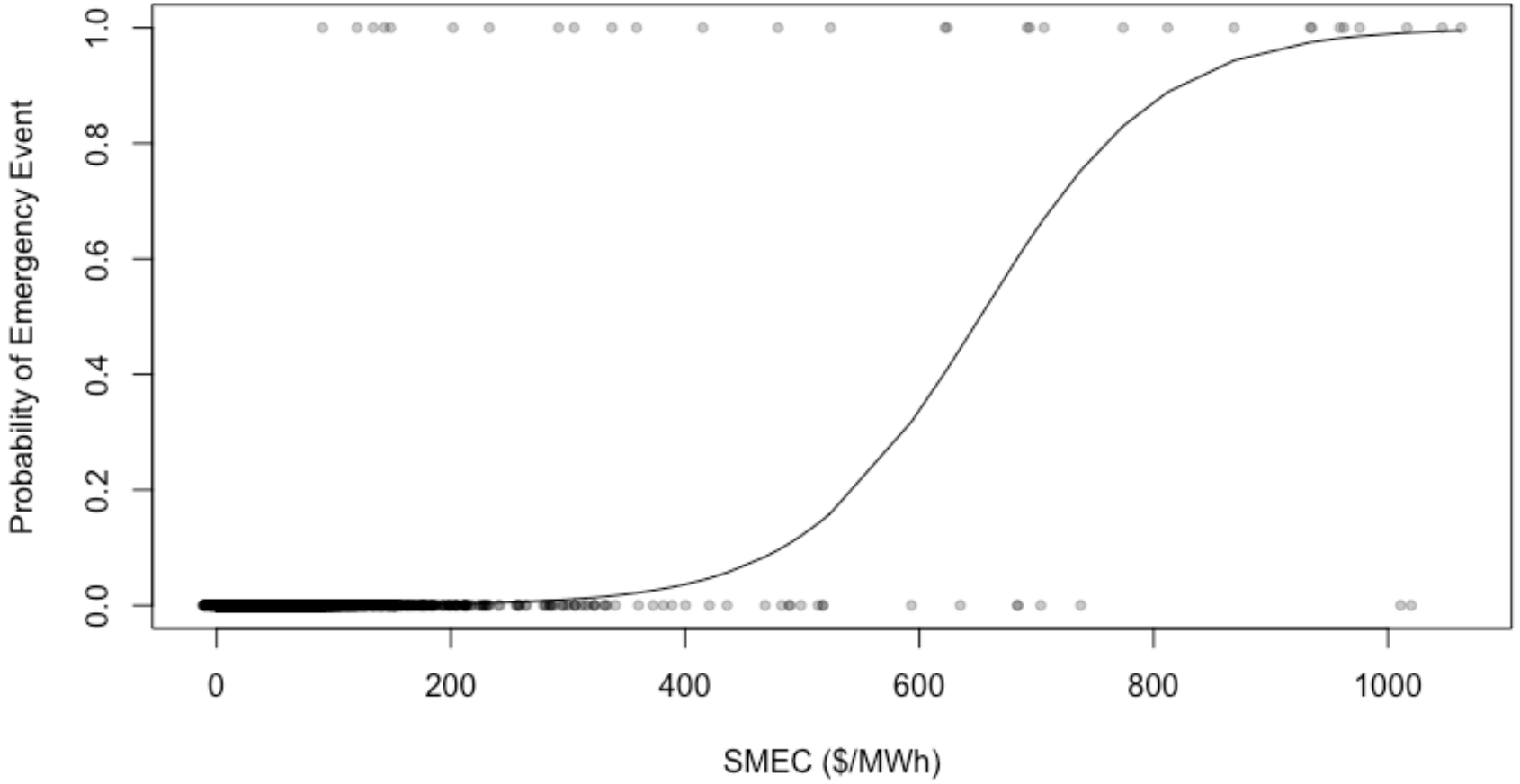
Comparison to ELCC

Month	Wind		Solar	
	ELCC	LOLP Proxy	ELCC	LOLP Proxy
June	33%	37%	31%	14%
July	23%	39%	39%	12%
August	21%	47%	27%	16%
September	15%	24%	14%	13%
October	8%	1%	2%	8%
November	12%	9%	2%	2%

Compare to 7.8% marginal ELCC (E+ and Astrape)

Price and Grid Emergencies

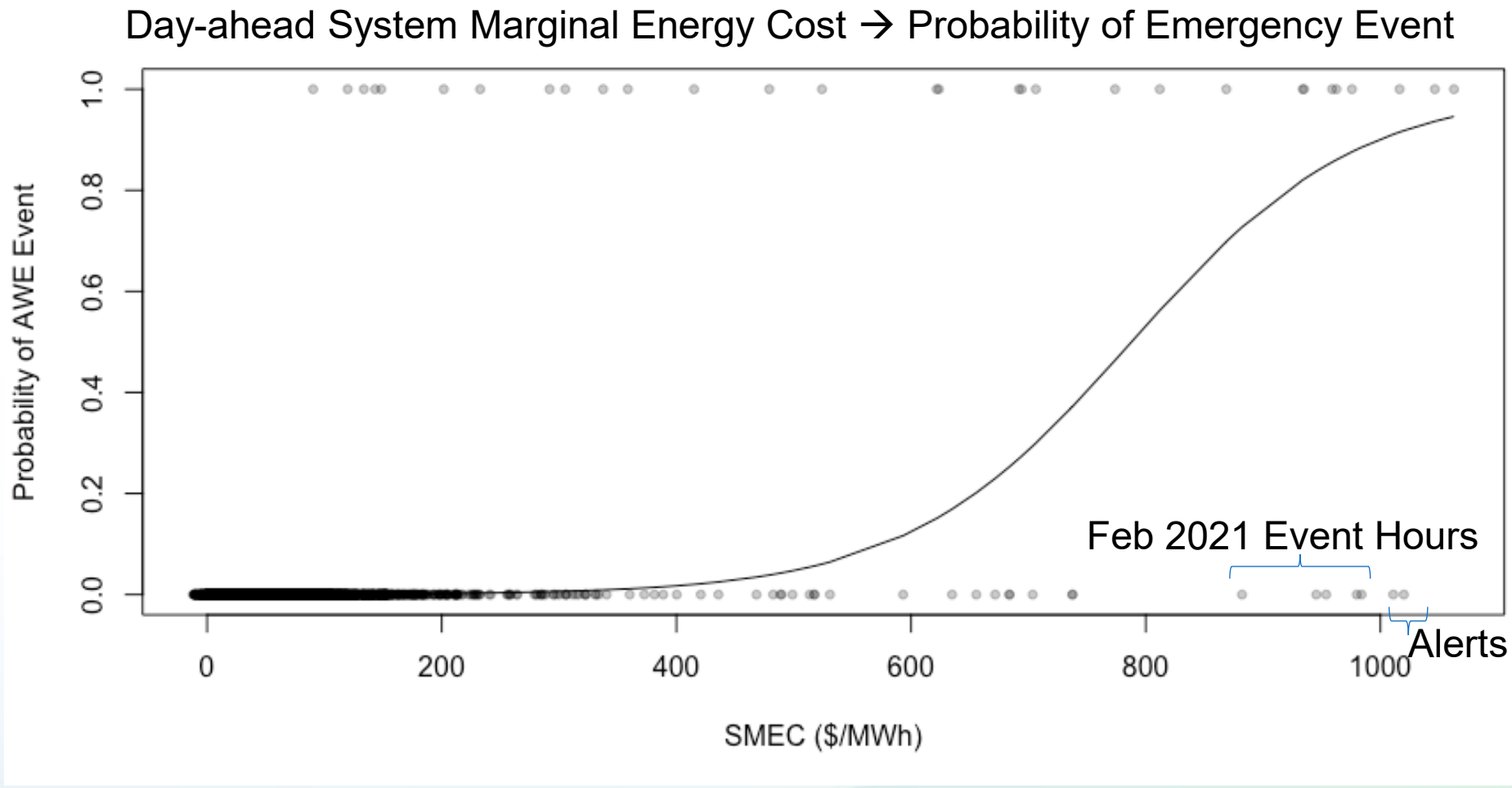
Day-ahead System Marginal Energy Cost → Probability of Emergency Event



LOLP Proxy: P = 1/(1 + exp(8.471 – 0.013*SMEC))

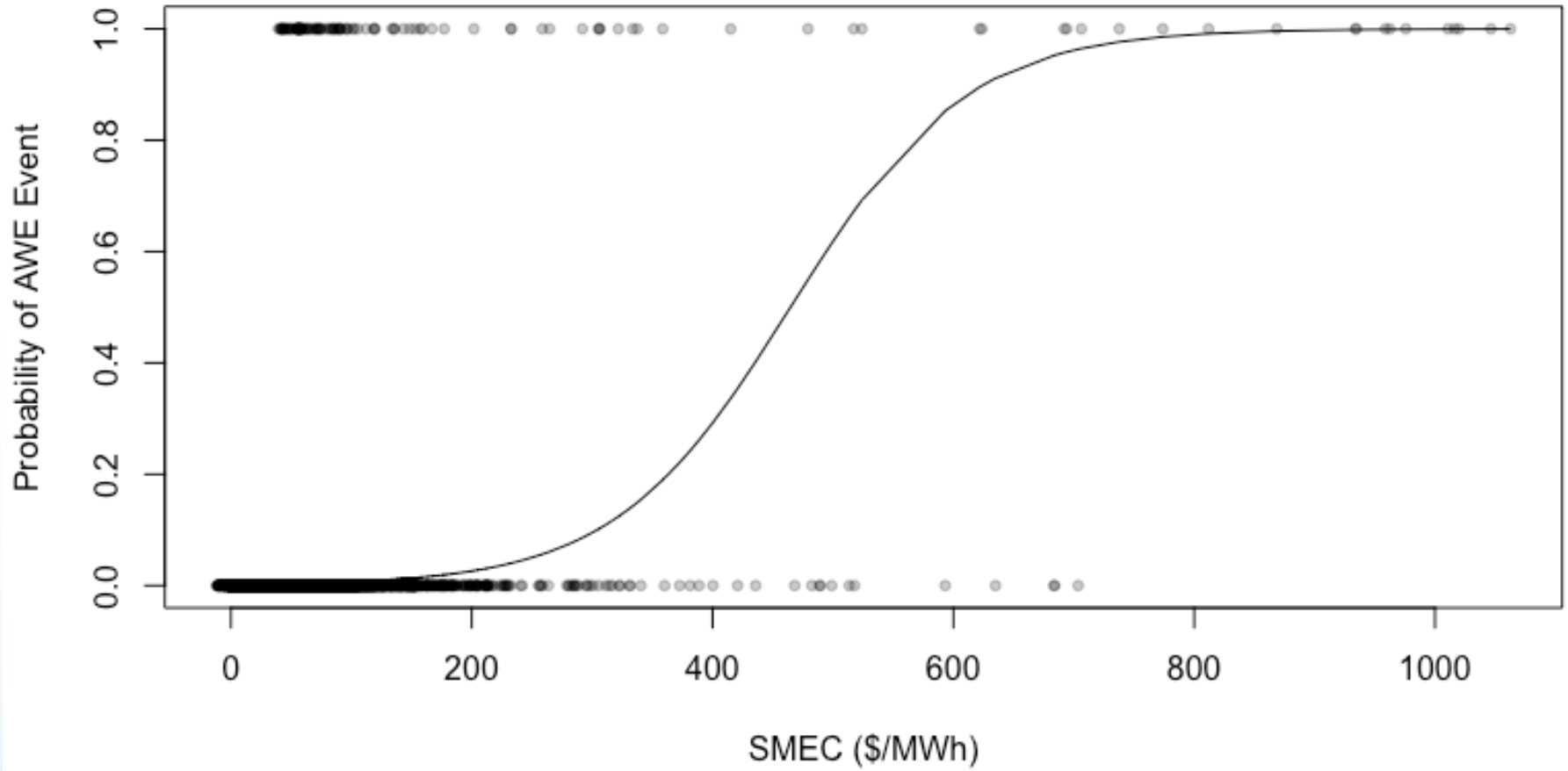
Note: Feb 2021 hours with SMEC > 500 removed.

Price and Grid Emergencies



Price and AWE Events

Day-ahead System Marginal Energy Cost → Probability of AWE Event

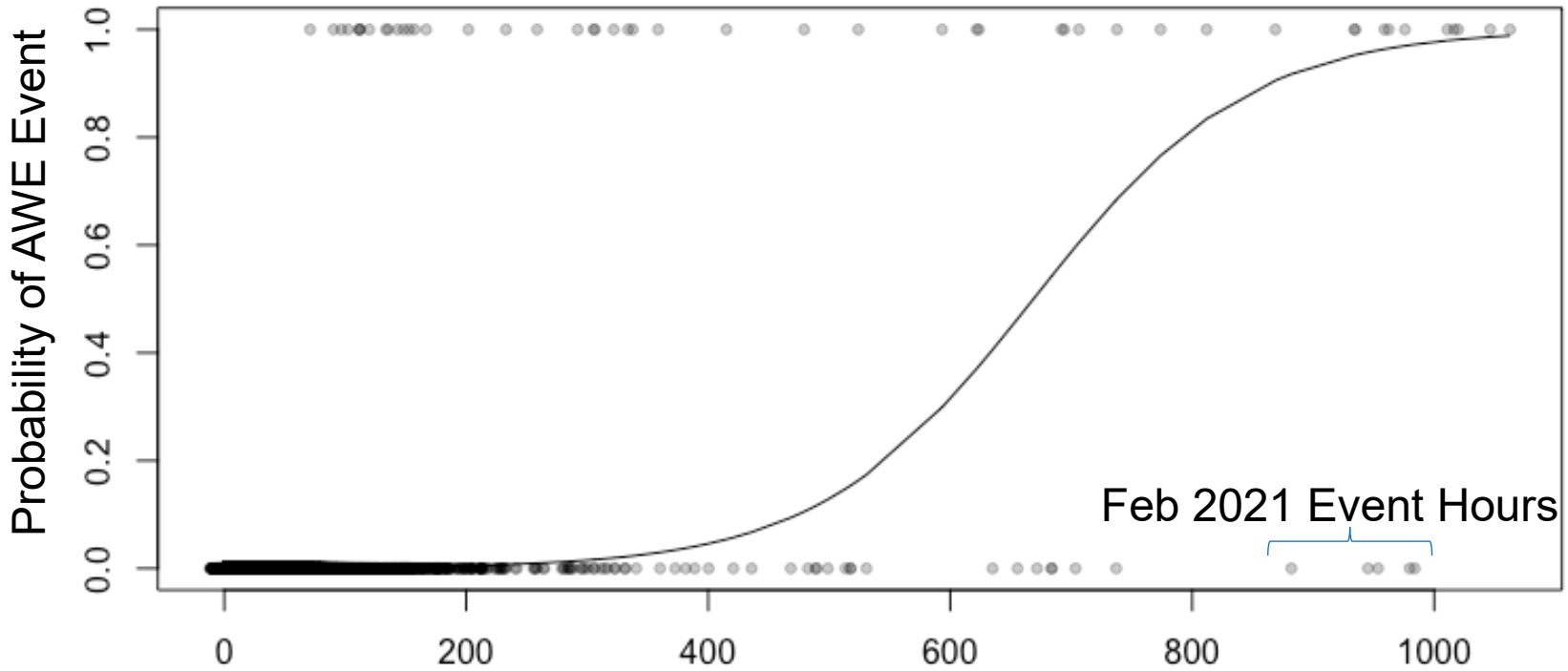


LOLP Proxy: P = 1/(1 + exp(6.357 - 0.0137*SMEC))

Note: Feb 2021 hours with SMEC > 500 removed.

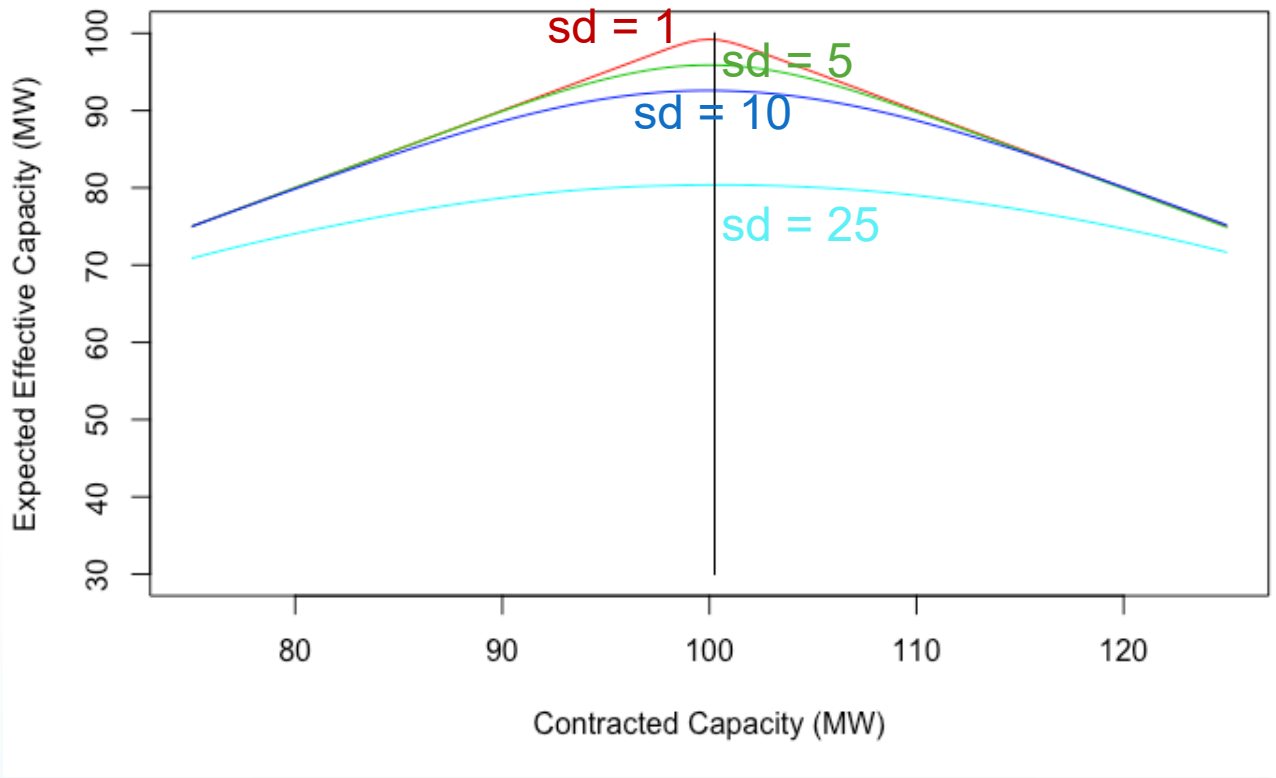
Price and AWE Events

Day-ahead System Marginal Energy Cost → Probability of AWE Event



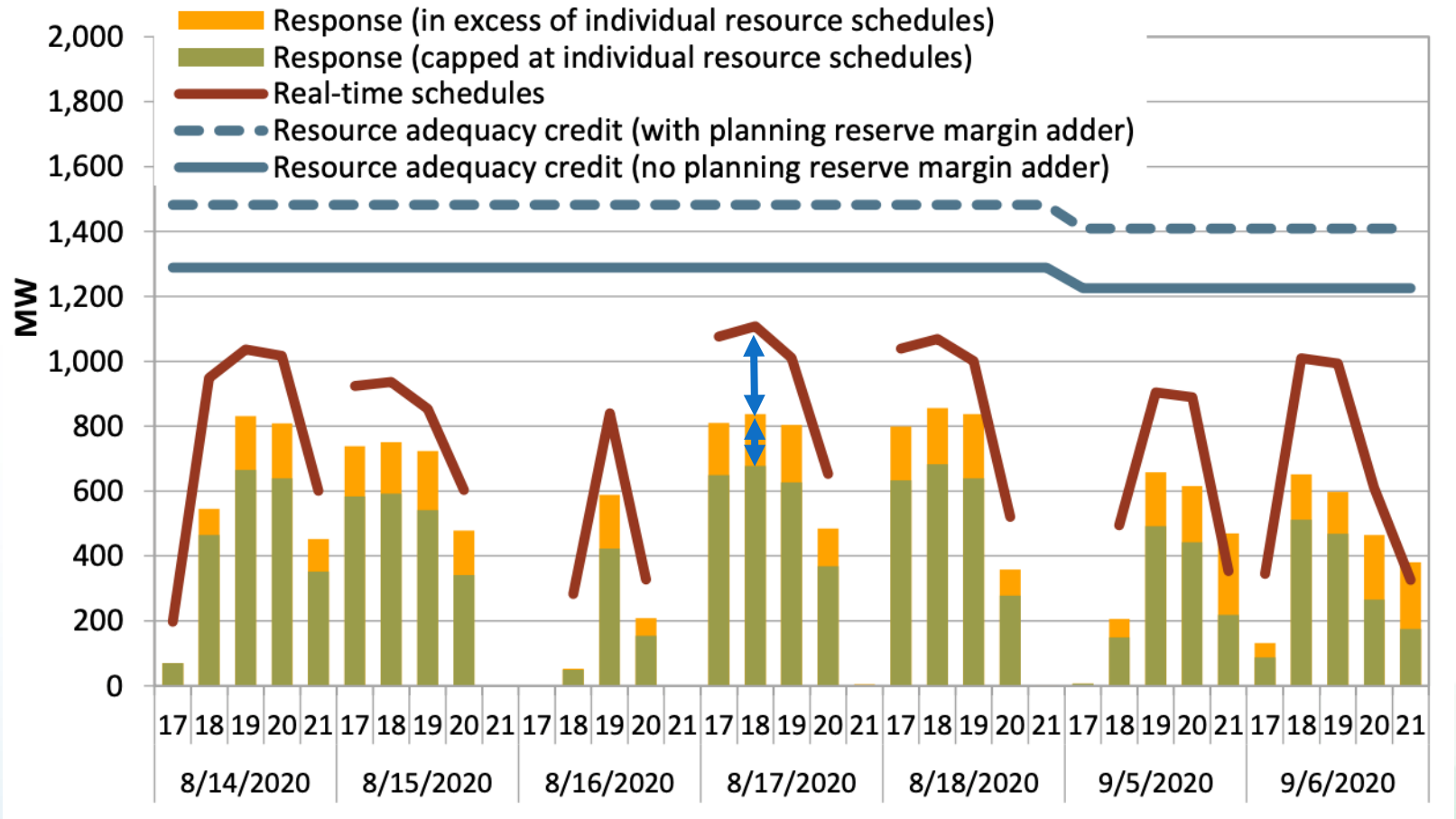
LOLP Proxy: P = 1/(1 + exp(6.121 - 0.00990*SMEC))

CSP and Standard Dev.



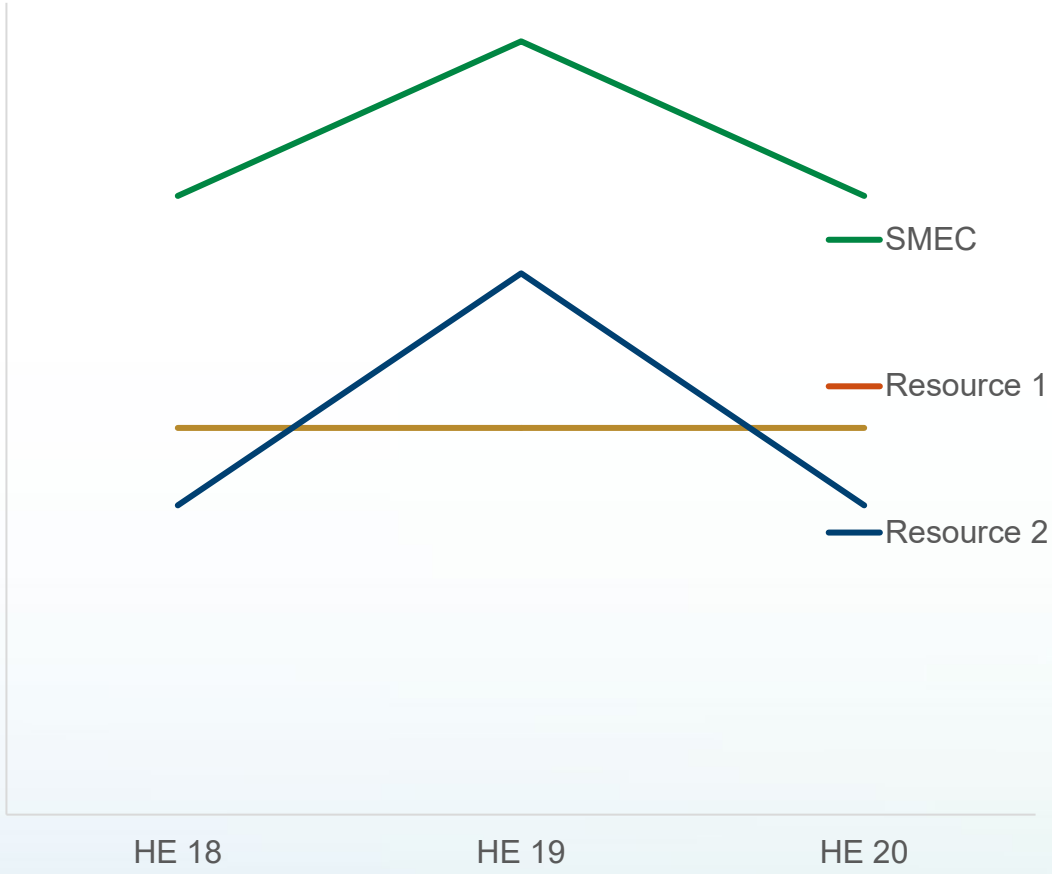
CSP Risk for Small Resources

Hold DRPs accountable for total capacity shortfall, not individual resource shortfall



Source: CAISO Department of Market Monitoring

Intraday Weighting



Conjecture: Resource 2 has greater contribution to reliability than Resource 1

- Same *average* load impact over top 3 hours
- Weighting does not change hourly impact of flat resource

Planning Temperatures

- Increase temperature planning assumptions from 1-in-2 to 1-in-4
- Use CAISO's temperature forecast by sub-LAP for alignment with operations