Forecast Error the New Norm

How to mitigate risk with high levels of renewable penetration?

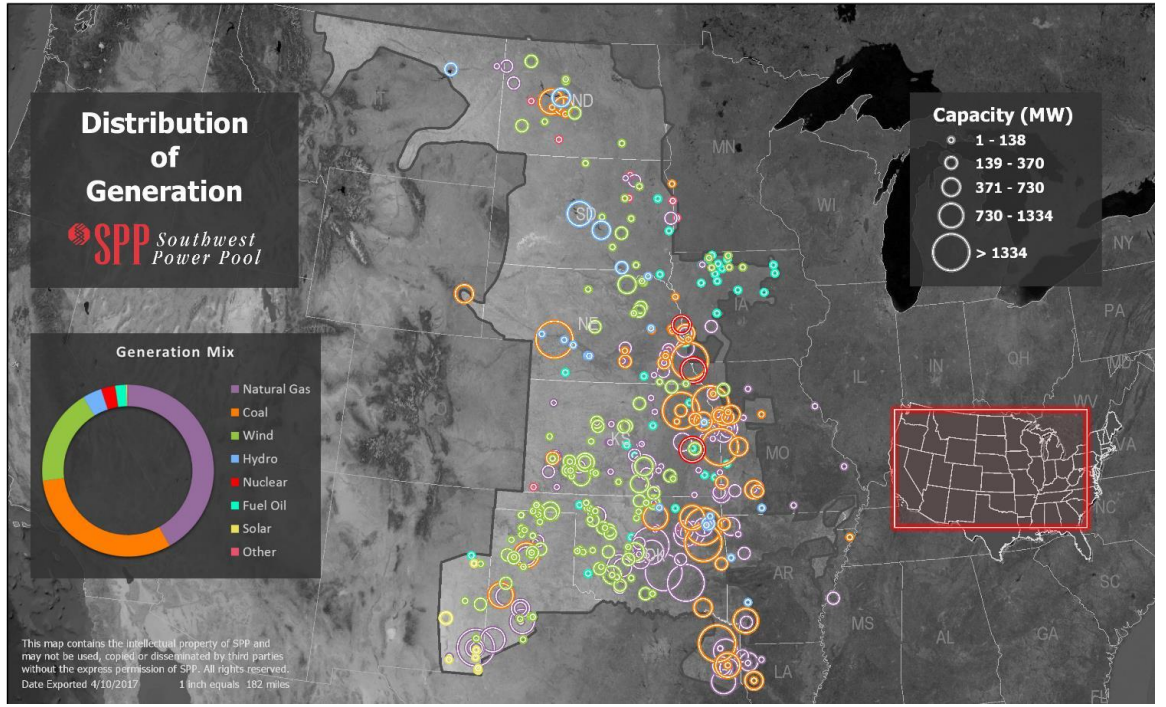
Gunnar Shaffer

SPP Operations Engineer

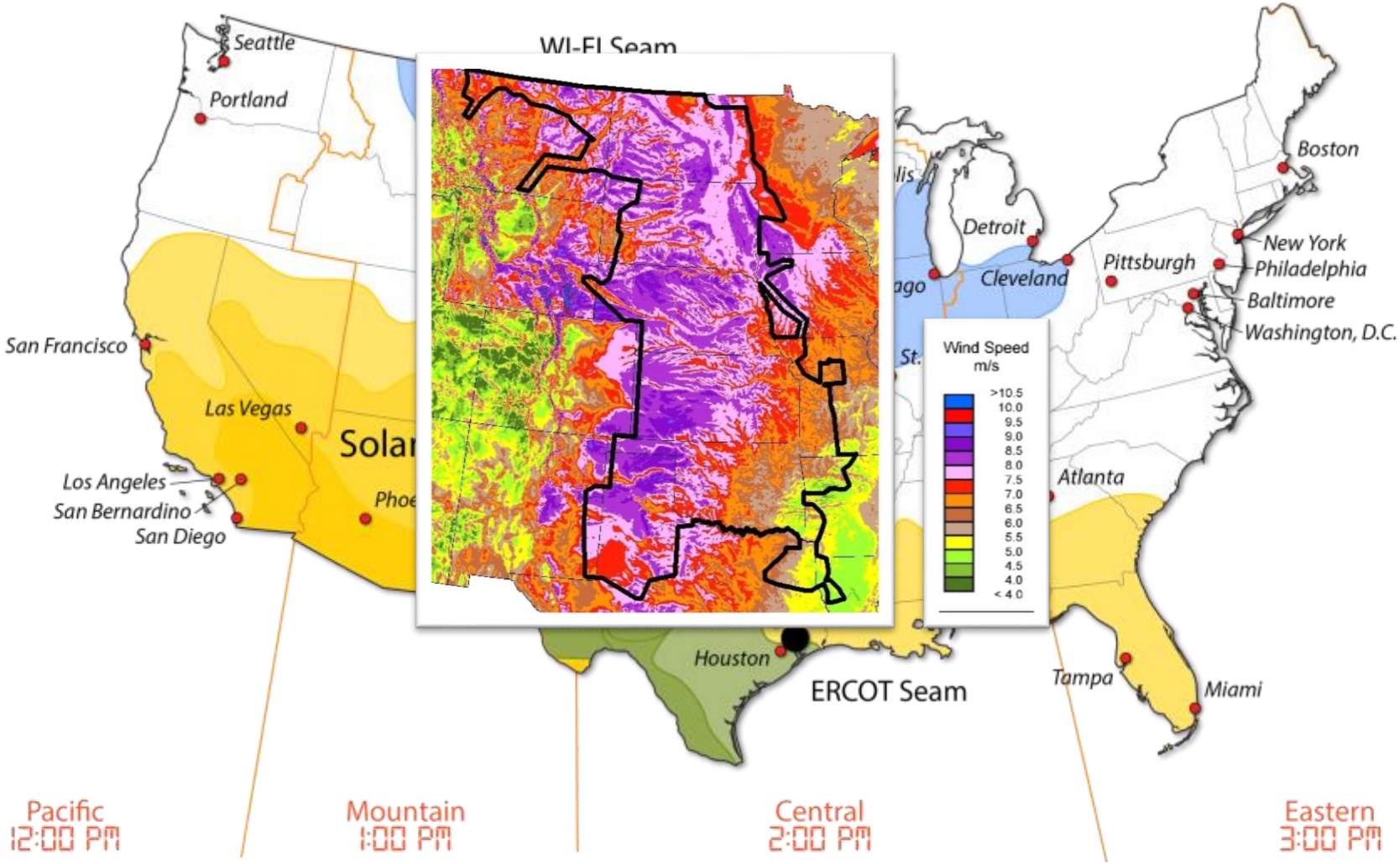
6/5/2019

SPP Wind, Solar & Energy Storage

- **Wind**
  - Installed: 21,578 MW — 5/1/2019
  - Wind Turbines: 11,000 — 5/1/2019
  - Wind Peak: 16,524MW — 05/17/2019
  - GI Queue: 61GW — 4/1/2019
  - Wind Penetration % of Load: 67.3% — 4/27/2019
  - In 2018, 70 days above >50% Pen.
- **Solar**
  - SPP Market: 215MW — 6/1/2019
  - GI Queue: 28GW — 6/1/2019
- **Energy Storage**
  - Installed: 10MW/20MWh — 6/1/2019
  - GI Queue: 5,300MW — 6/1/2019
- **Total Renewable Energy Penetration**
  - 71.4% — 4/27/2019



SPP's Unique Opportunity



The challenge will only Grow!

Rising Challenges in SPP Operations

- 70%+ High Wind Penetration
- +7GW DA Wind Forecast Error
- +15GW Wind Swings
- Flowgate Overloading and Curtailments
- Increased Uncertainty
- FERC Order 841 Design

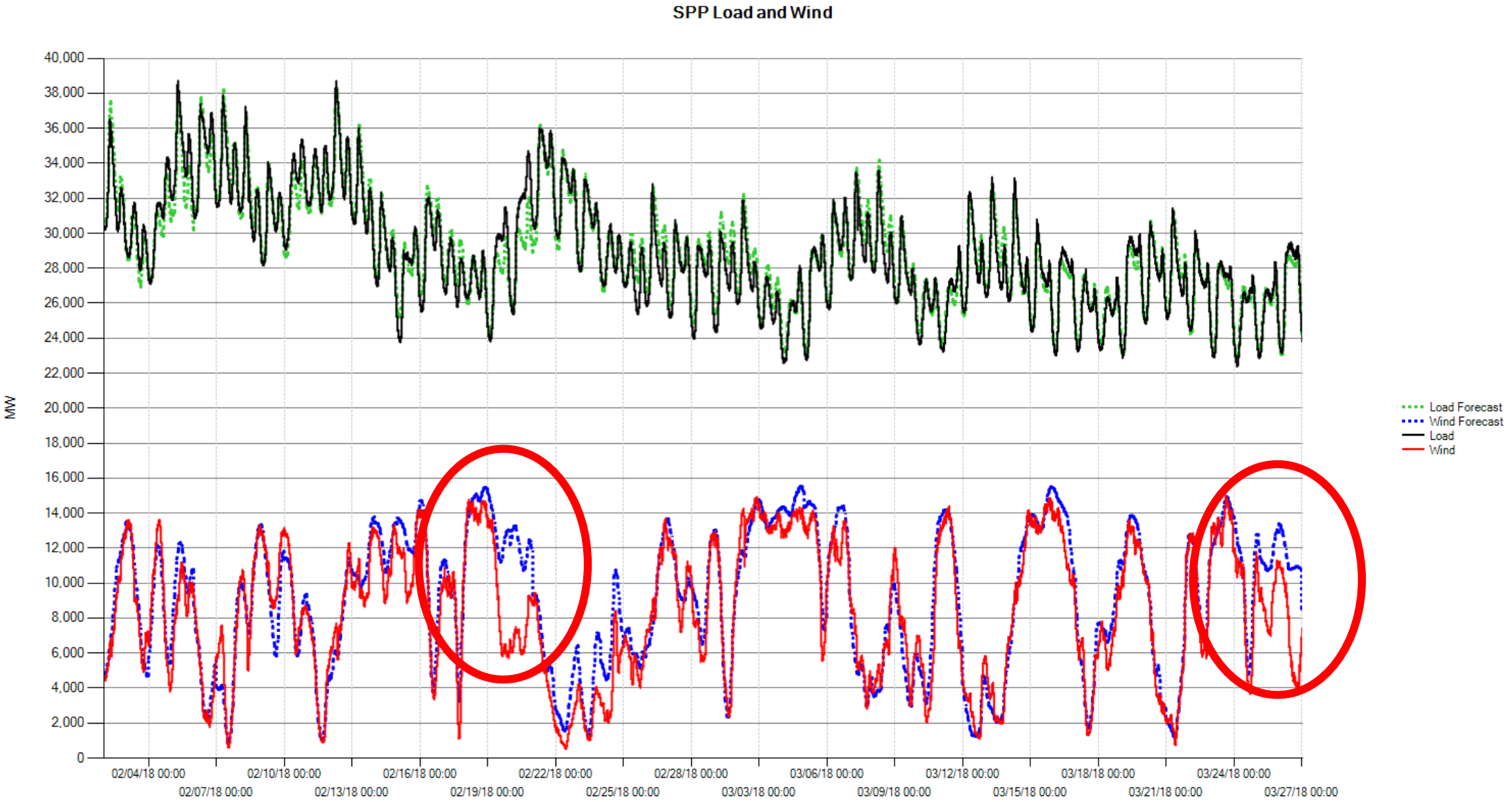
SPP Capacity Example

- SPP Total Installed Capacity ~ 90 GW

How could you possibly be tight?

- Wind capacity ~ 21 GW
- Cool spring day with low wind conditions example:
  - Obligation (Load, Exports, OR): **33 GW**
  - Headroom: 1 GW
  - **Outages: 30 GW**
  - Low wind: 2 GW
  - Remaining capacity: **7 GW**

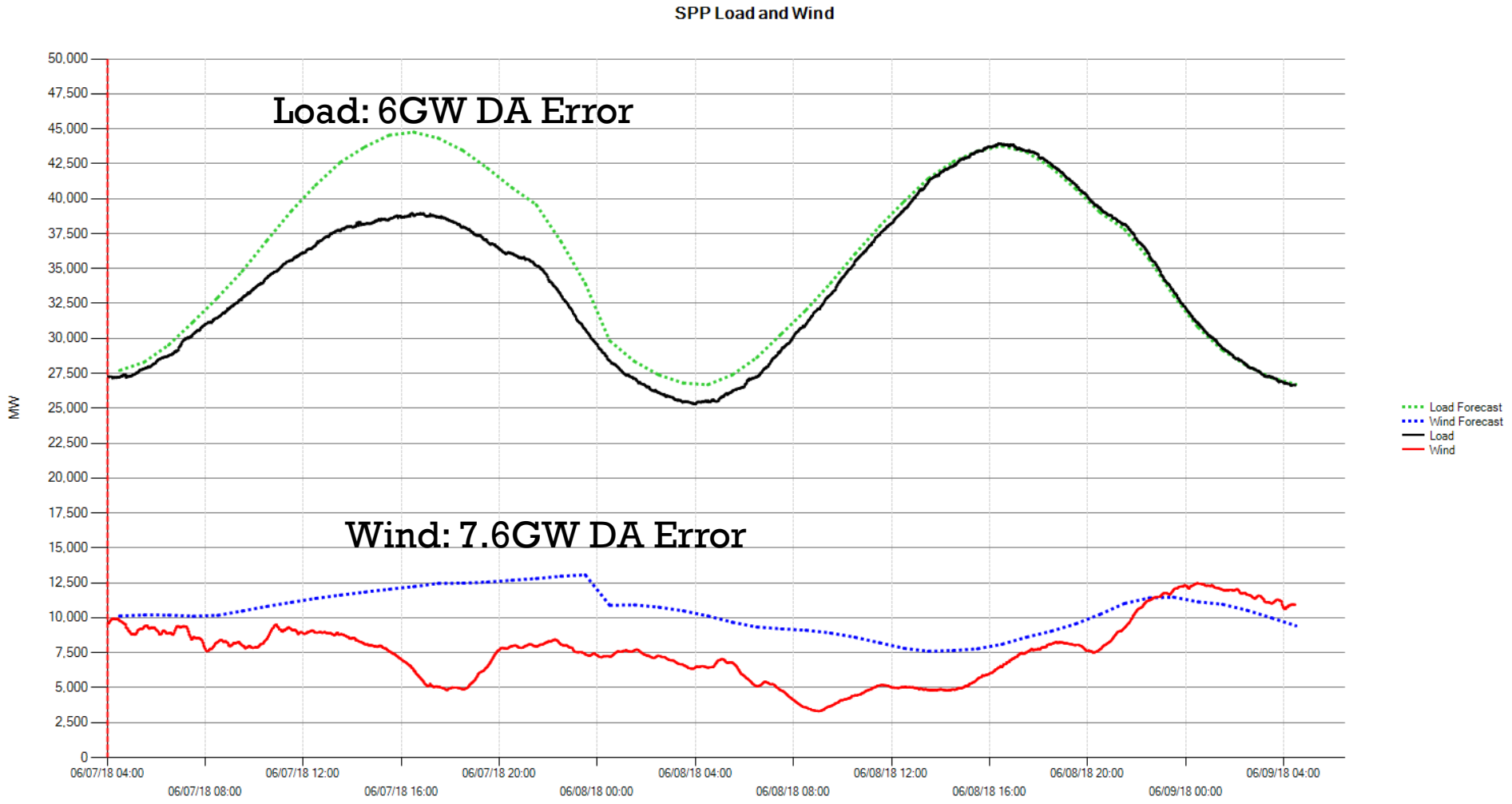
SPP can experience large errors in the DA Wind Forecast



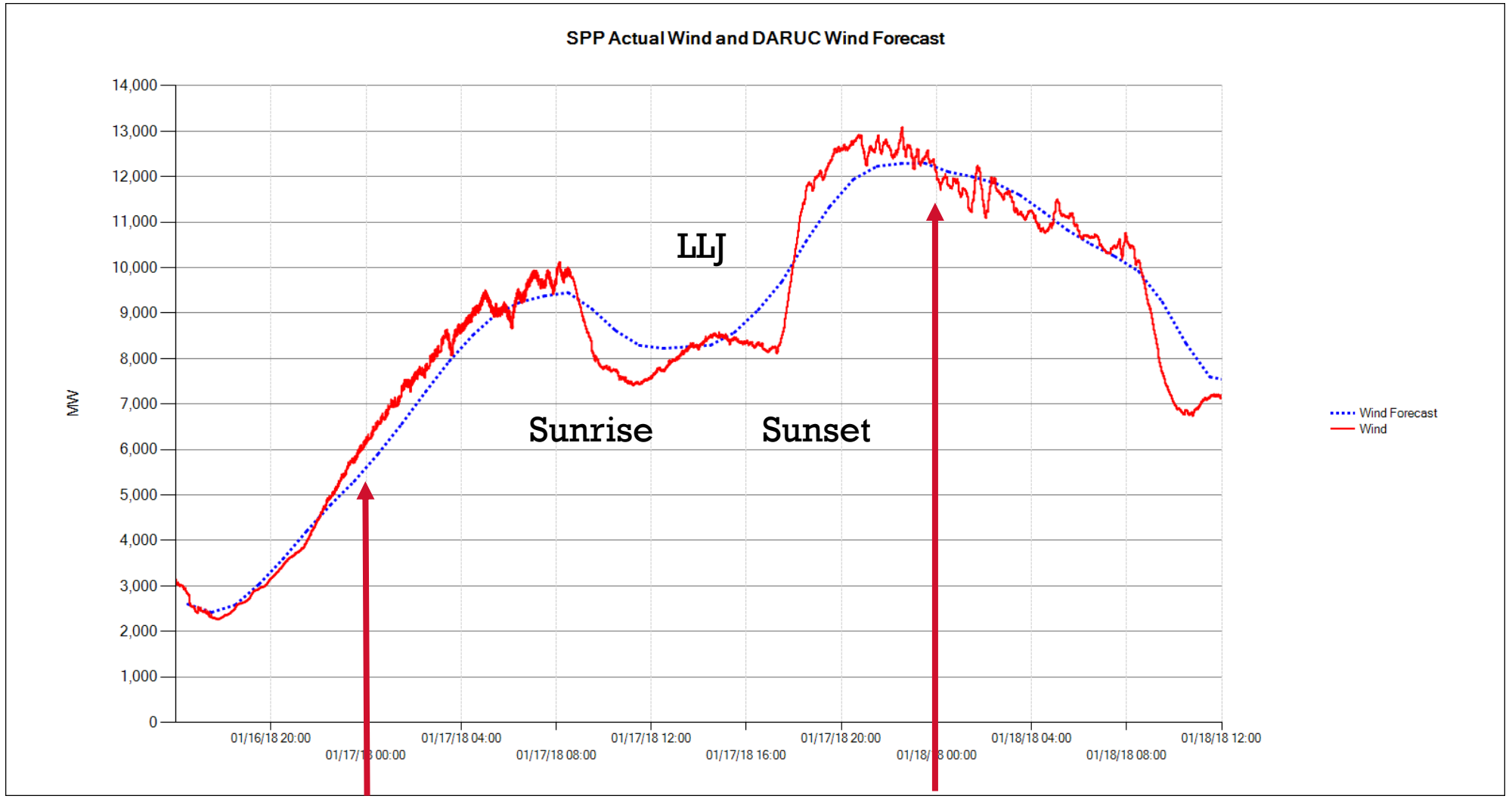
Feb 4th → Mar 27

Weather Forecast Error Impacting **Load and Wind**

- 6/7-8/2018



Sunrise/Sunset Wind Ramp Error



SPP's Wind Forecast Approach

- 2 Wind/Solar Forecast Vendors
- Individual Wind Farm Forecast
- Primary inputs
  - Current generation
  - Total Capability
  - Turbine Availability
  - Actual Weather
  - Historical Weather
- Deterministic Forecast
- Probabilistic Forecast
- 85/15% Confidence Bands
- Icing forecast
- Combined Best Forecast
  - Discussion and Analysis to add another Forecasting Vendor in 2019

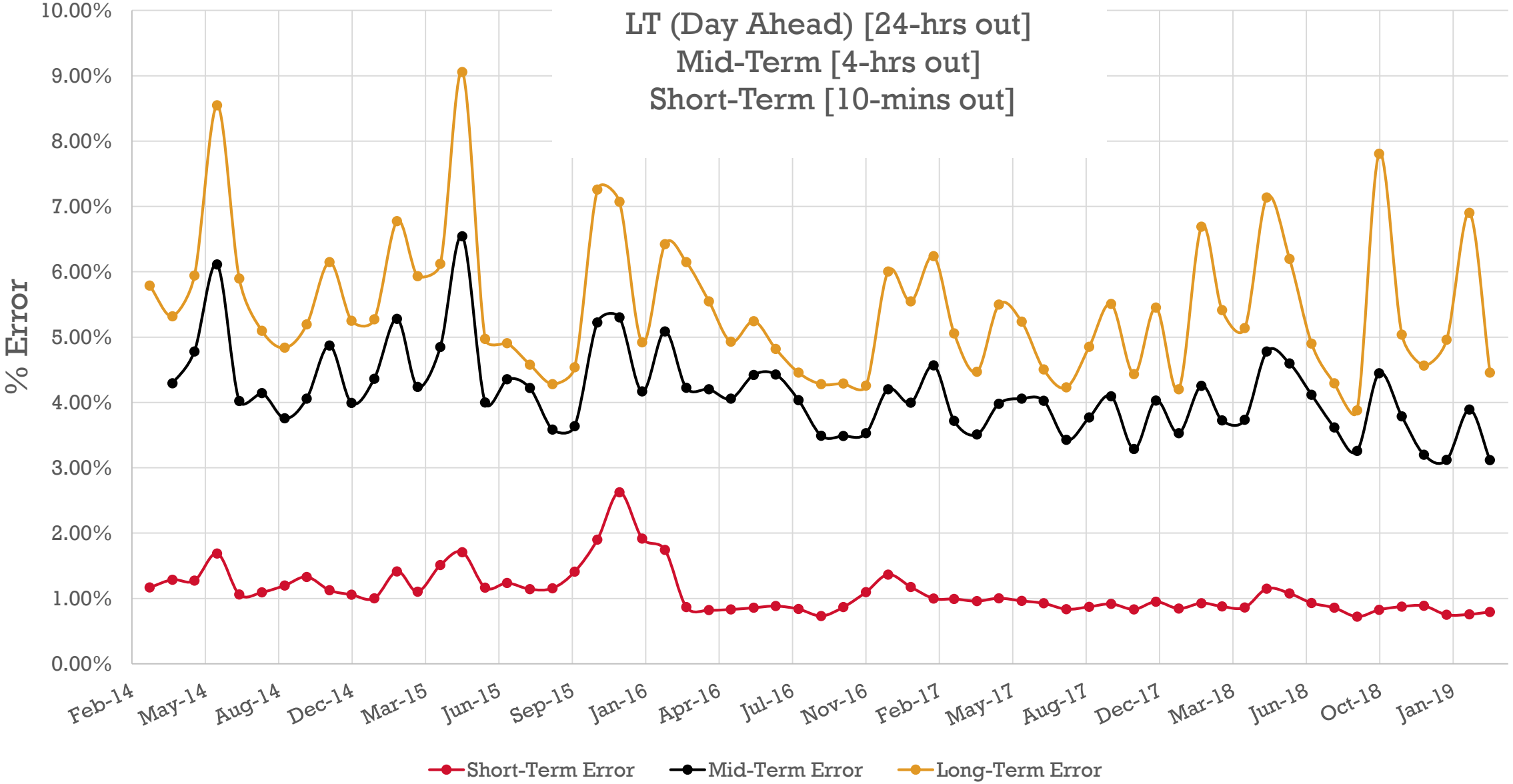
SPP Wind and Solar Forecast Horizons

- Short Term: 0 → 4 hours, with 5 minute intervals, updates every 5 min
- Mid Term: 0 → 72 hours, with 1 hour intervals, updates every 1hr
- Long Term: 48 → 168 hours, with 1 hour intervals, updates 8 x day

- +Icing Forecast
- +Alert Emails for Forecast Uncertainty
- +Advanced Portal

Wind Forecast MAPE Error

LT (Day Ahead) [24-hrs out]
Mid-Term [4-hrs out]
Short-Term [10-mins out]

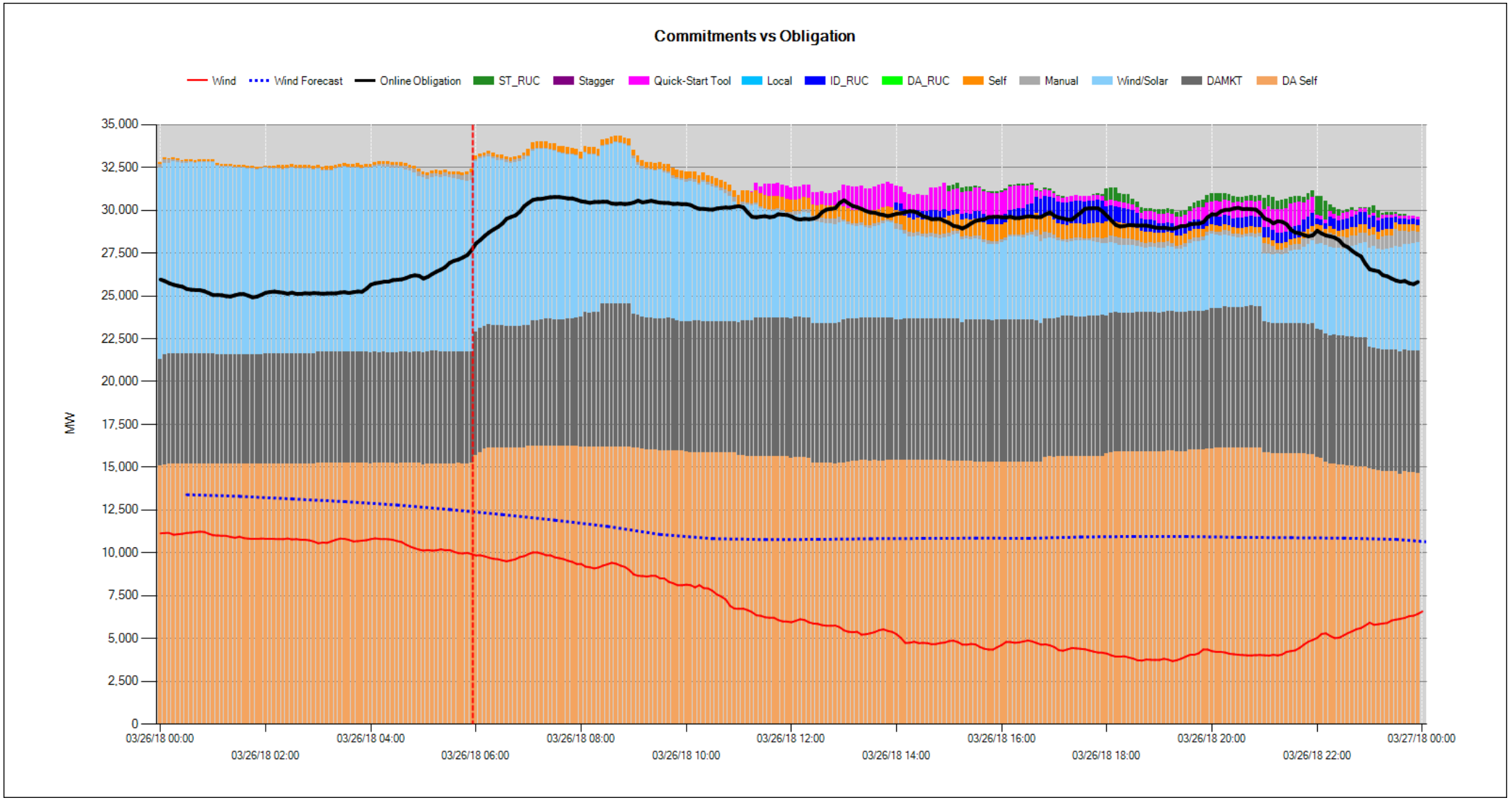


URT
Uncertainty Response Team

URT

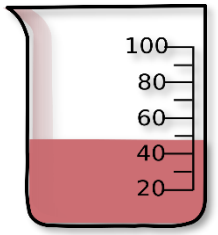
- When: July 4th 2018
- Who: 5 Ops Engineers
- What:
  - Daily Analysis looking Day Ahead
  - Study Extreme Weather
  - Alert Operators
  - Run IDRUC Studies
  - Suggest long lead unit commitments or extensions

The Beginning of URT…

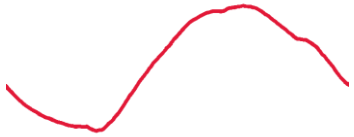


Risk due to unexpected changes in:

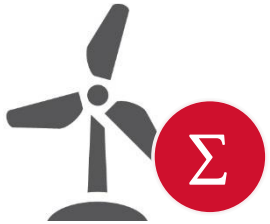
Capacity



Peak Demand



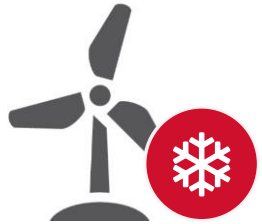
Total Wind



Wind Penetration

Wind Drop

Wind Icing



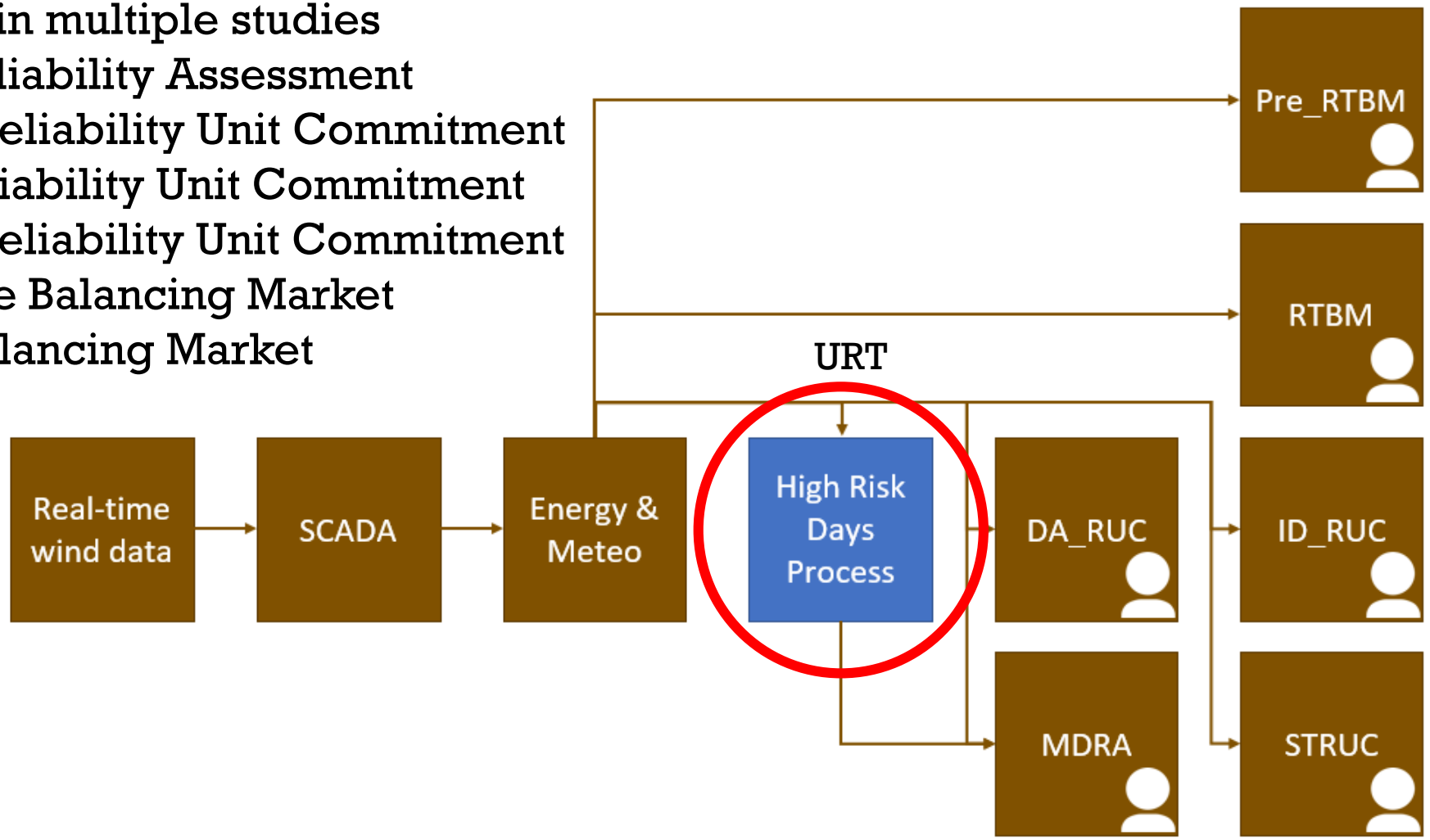
EHV Outages

Weather

Wind Forecast Process

Forecasts are used in multiple studies

- Multi-Day Reliability Assessment
- Day-Ahead Reliability Unit Commitment
- Intra-Day Reliability Unit Commitment
- Short-Term Reliability Unit Commitment
- Pre Real-Time Balancing Market
- Real-Time Balancing Market



Contributor	Tue, May-07-2019	Wed, May-08-2019	Thu, May-09-2019	Fri, May-10-2019	Sat, May-11-2019
10 MIN CAP	995	722	896	804	974
1 HOUR CAP	2941	2629	2229	1959	3417
HIGH LOAD	31757	30495	28396	27637	25908
LOW LOAD	23095	23162	22799	22724	21999
TRAD. CAP	20075	18378	21655	24822	22333
HIGH WIND	11562	14276	14987	5691	5360
LOW WIND	6723	8850	6054	3488	3052
WIND PEN	47.32	56.09	65.72	25.02	23.21
WIND DROP	2253	808	1117	473	253
EST. WIND LOSS (ICE)	168	201	N/A	N/A	N/A
345kV OUTAGES	24	29	26	26	24
230kV OUTAGES	35	38	35	35	29

Uncertainty Risk:

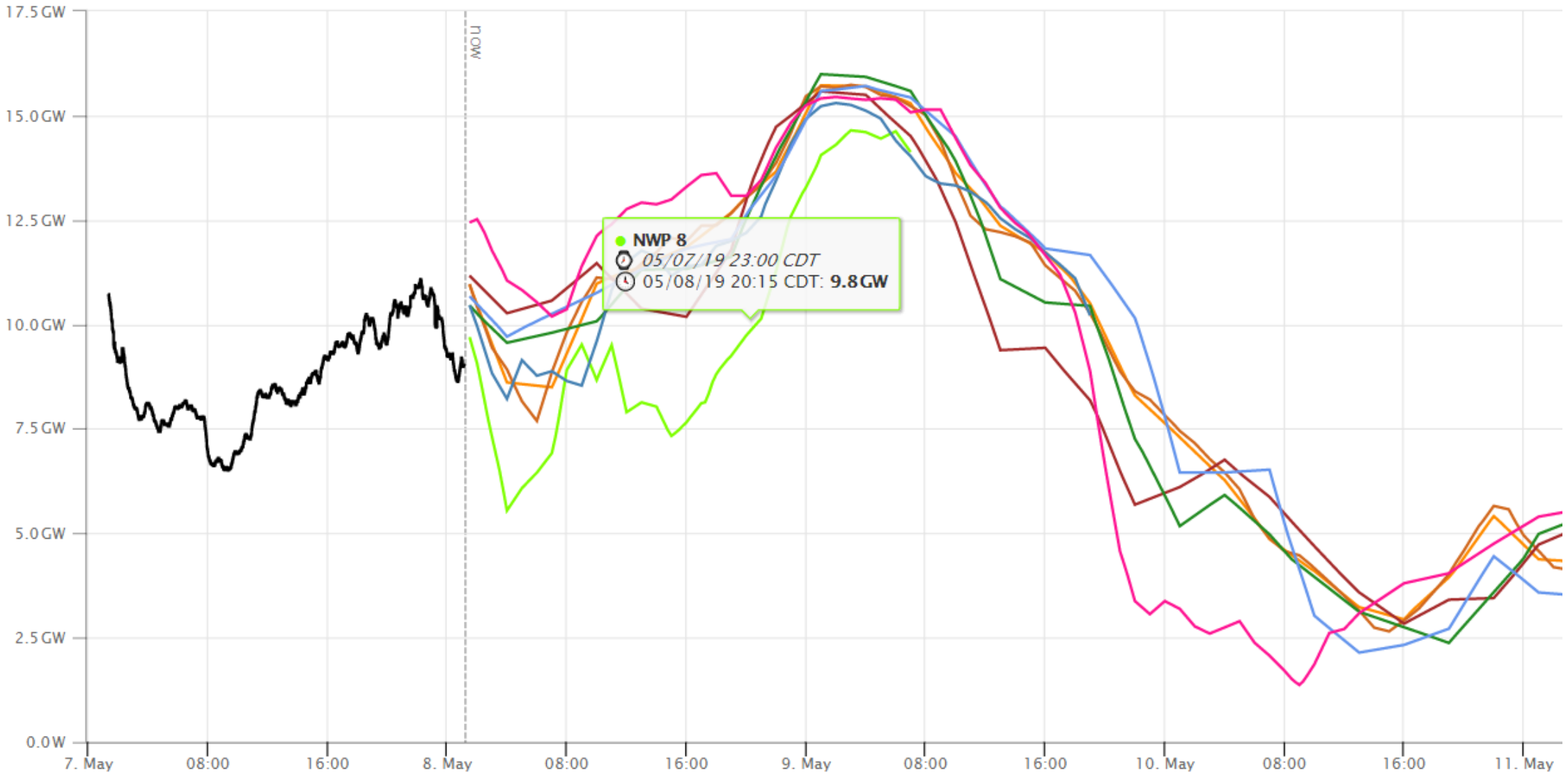
Horizon	Tue, May-07-2019	Wed, May-08-2019	Thu, May-09-2019	Fri, May-10-2019	Sat, May-11-2019
One Hour	Low	Moderate	Low	Moderate	Low
Four Hour	High	Low	Low	Moderate	Low
Eight Hour	High	Low	Low	Low	Low

What triggers an URT study?

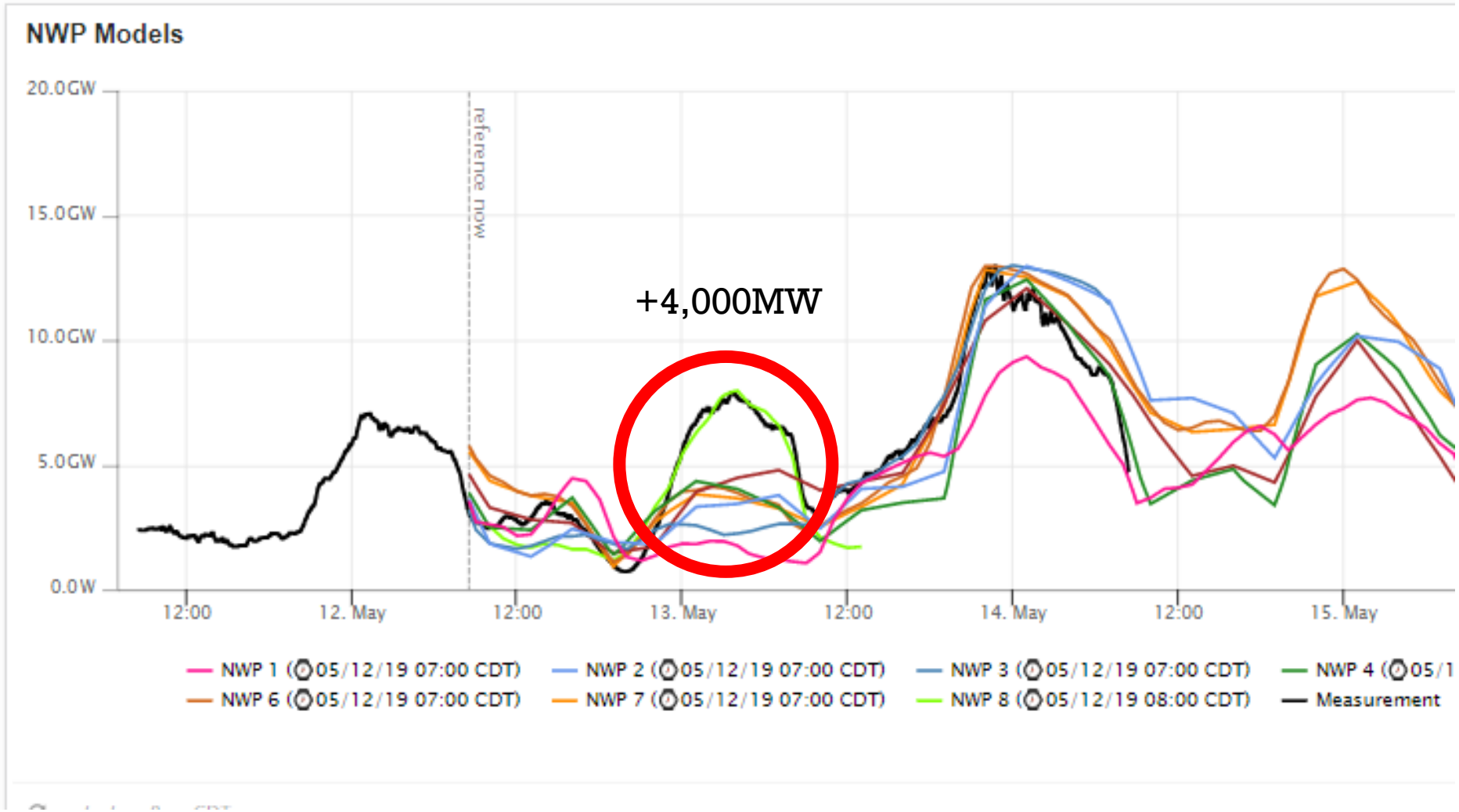
Uncertainty Capacity Margin(4HR):

Value	Tue, May-07-2019	Wed, May-08-2019	Thu, May-09-2019	Fri, May-10-2019	Sat, May-11-2019
URT Cap. Margin	963	1809	3884	1293	3344
Rampable HR	0	219	3761	989	0
Capacity	5448	6625	3884	3416	6857
Wind Error	2213	3025	1939	1292	1504
Load Error	1045	913	732	732	913
Resource Error	1228	1097	1089	1089	1097
Market Interval	05/07/2019 14:00	05/08/2019 09:00	05/09/2019 21:00	05/10/2019 12:00	05/11/2019 12:00

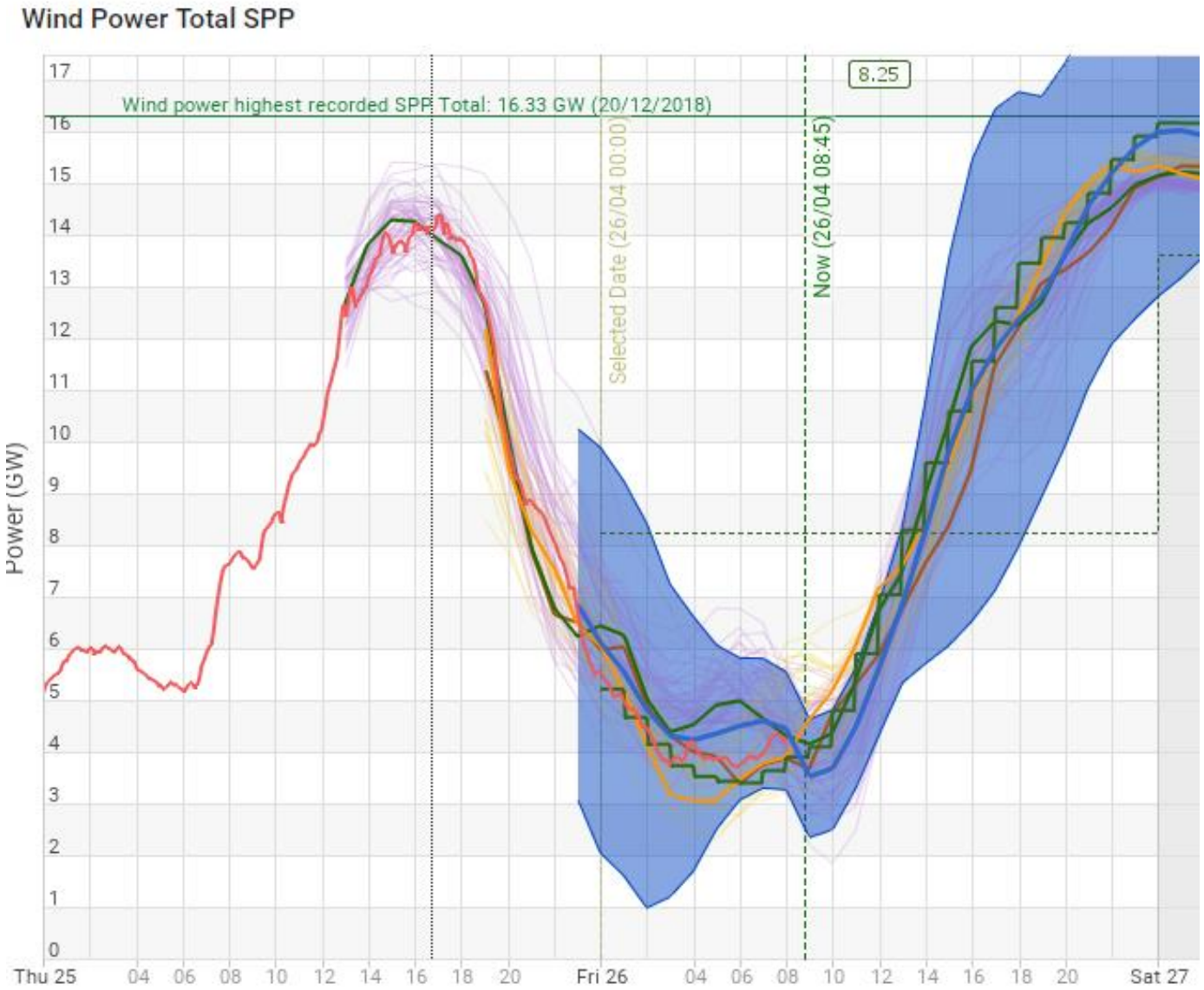
NWP Models


17.5 GW
15.0 GW
12.5 GW
10.0 GW
7.5 GW
5.0 GW
2.5 GW
0.0 W
NOW
NWP 8
05/07/19 23:00 CDT
05/08/19 20:15 CDT: 9.8 GW
7. May
08:00
16:00
8. May
08:00
16:00
9. May
08:00
16:00
10. May
08:00
16:00
11. May

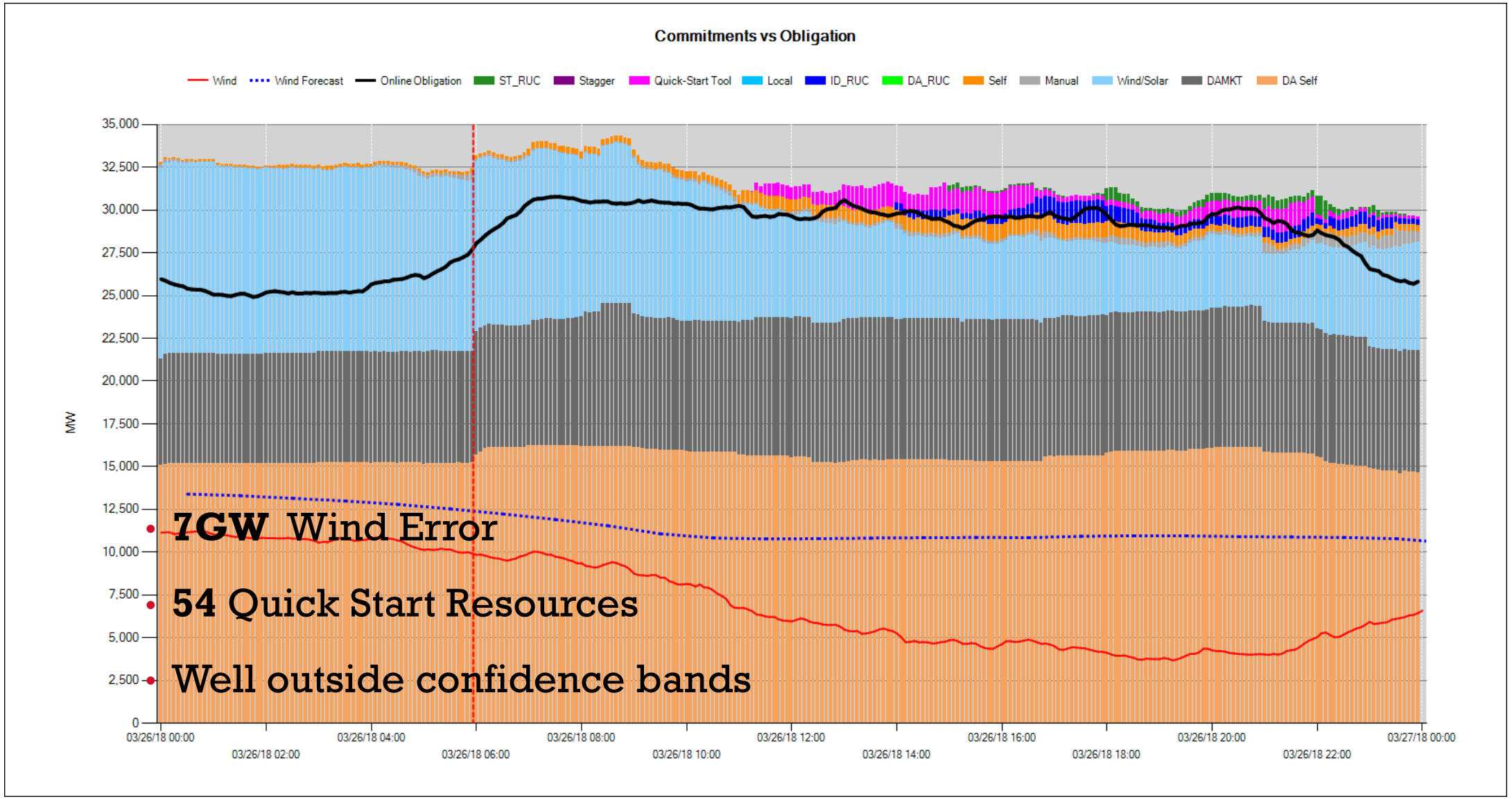
Shout out to:
NOAA HRRR -- Energy & Meteo!



Don‘t trust in one weather model only!
Benefit of combination



Unit Commitments vs Obligation with Wind Forecast Error

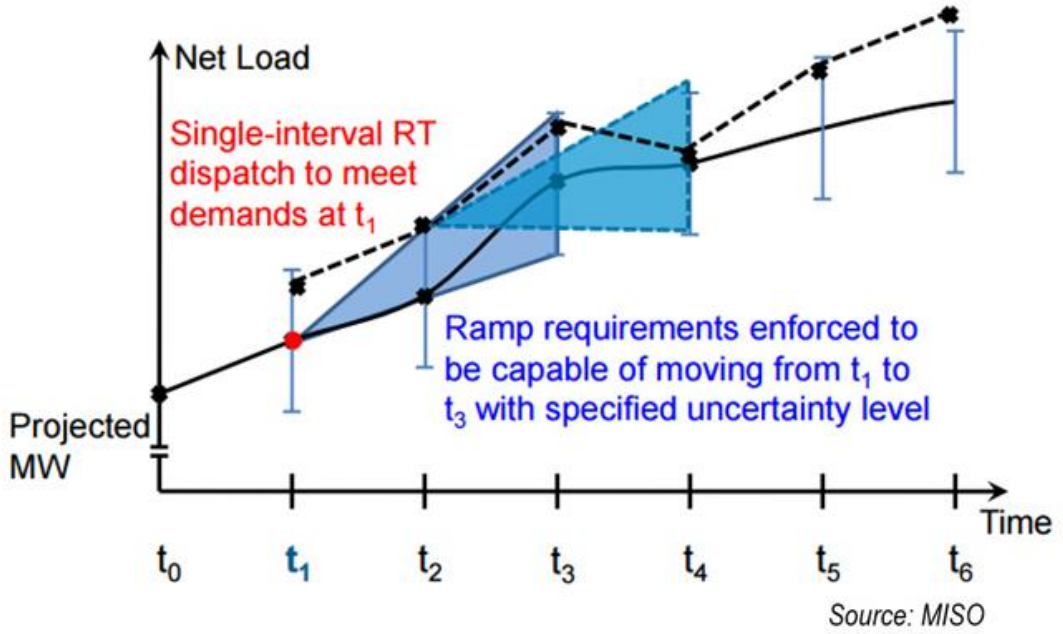


LOOKING AHEAD:
Wind Forecast Improvements 2019

- Evaluation of 2nd Vendor
- **Combined Best Forecast**
  - Economics: Increased accuracy → Leads to better economic commitments
  - Reliability: Increased accuracy → Better situational awareness and reliability
- Bottom up and Top down Forecasting Approach
- Probabilistic Forecasting
- Ensemble Forecasts

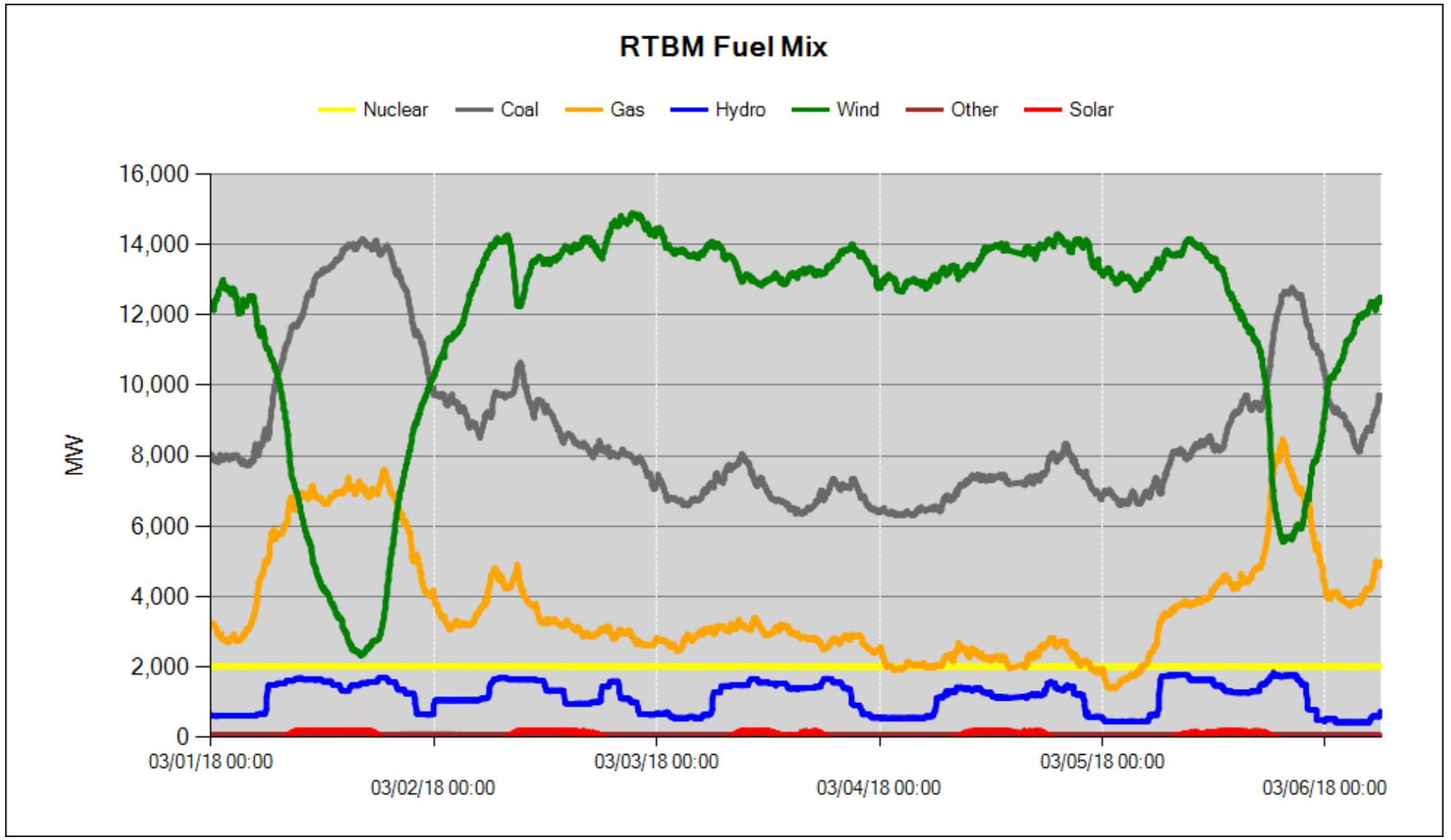
Ramp Capability Product

- GE has worked with MISO to implement their version of a ramp capability product
- The requirement amount is determined by historical net load error
- Better probabilistic forecasts could inform us of the appropriate amount to procure instead simply relying on past events
- Understanding the value of this ramp is incredibly important and hard to determine. Too much will add to the cost burden while too little will reduce reliability
- Explicitly pricing operational ramp needs in the market will help provide transparent incentives to participants



Source: MISO

Variability + Reliability Requires Fuel Diversity



Question?

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