



WIND GENERATION OPERATIONS

CHALLENGES AND EXPECTATIONS

OPERATIONS PLANNING STAFF

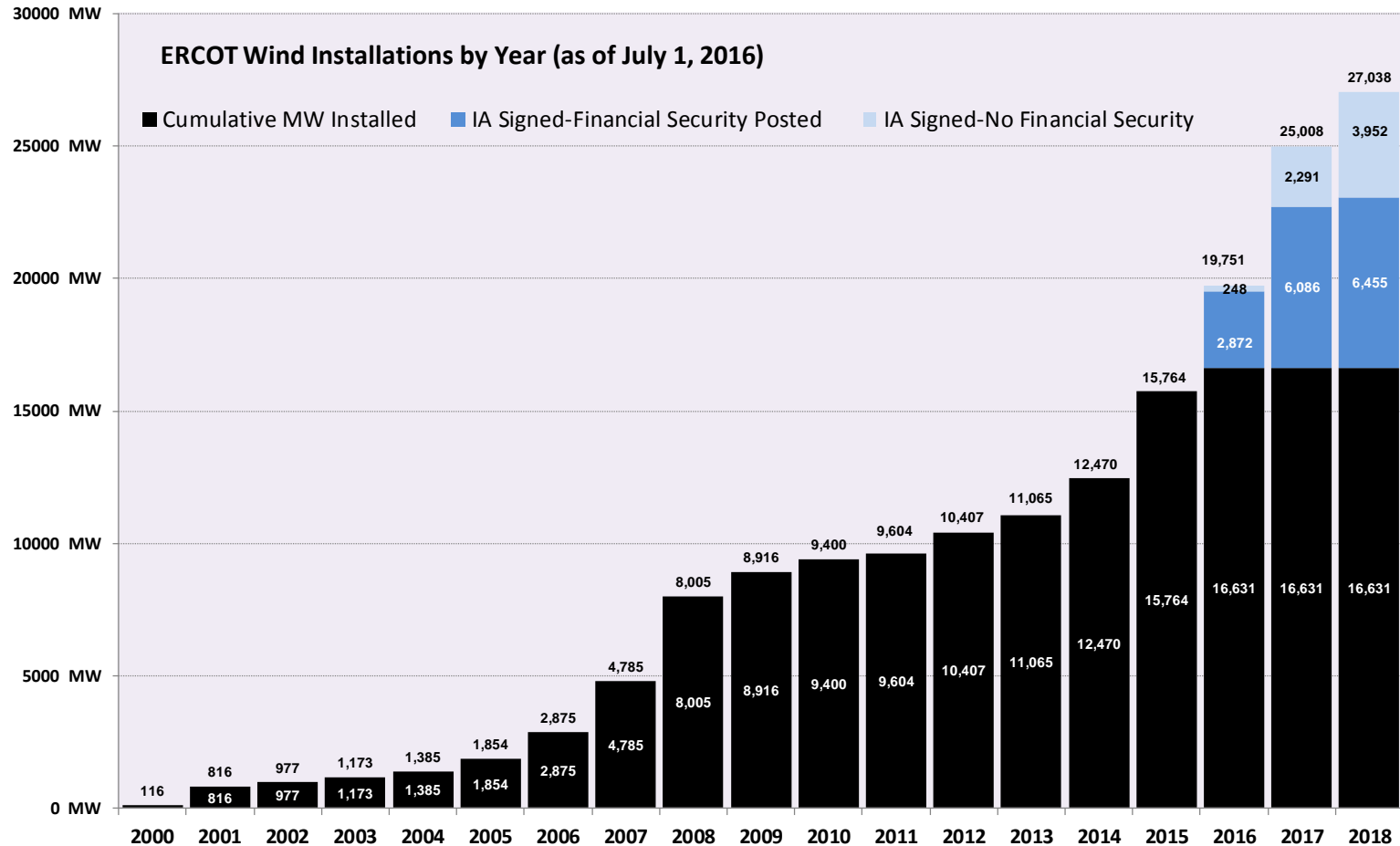
ERCOT

Objectives

- List two challenges in forecasting wind in Texas.
- List three actions a Wind facility experiencing icing issues should take.
- Given an example of telemetry being received from a renewable resource, determine if it is an issue and whether the QSE representing this resource should be contacted to rectify the issue.

Wind Generation and Wind Forecasting in ERCOT

Wind Growth Potential



The data presented here is based upon the latest registration data provided to ERCOT by the resource owners and can change without notice. Any capacity changes will be reflected in current and subsequent years' totals. Scheduling delays will also be reflected in the planned projects as that information is received. This chart reflects planned units in the calendar year of submission rather than installations by peak of year shown.

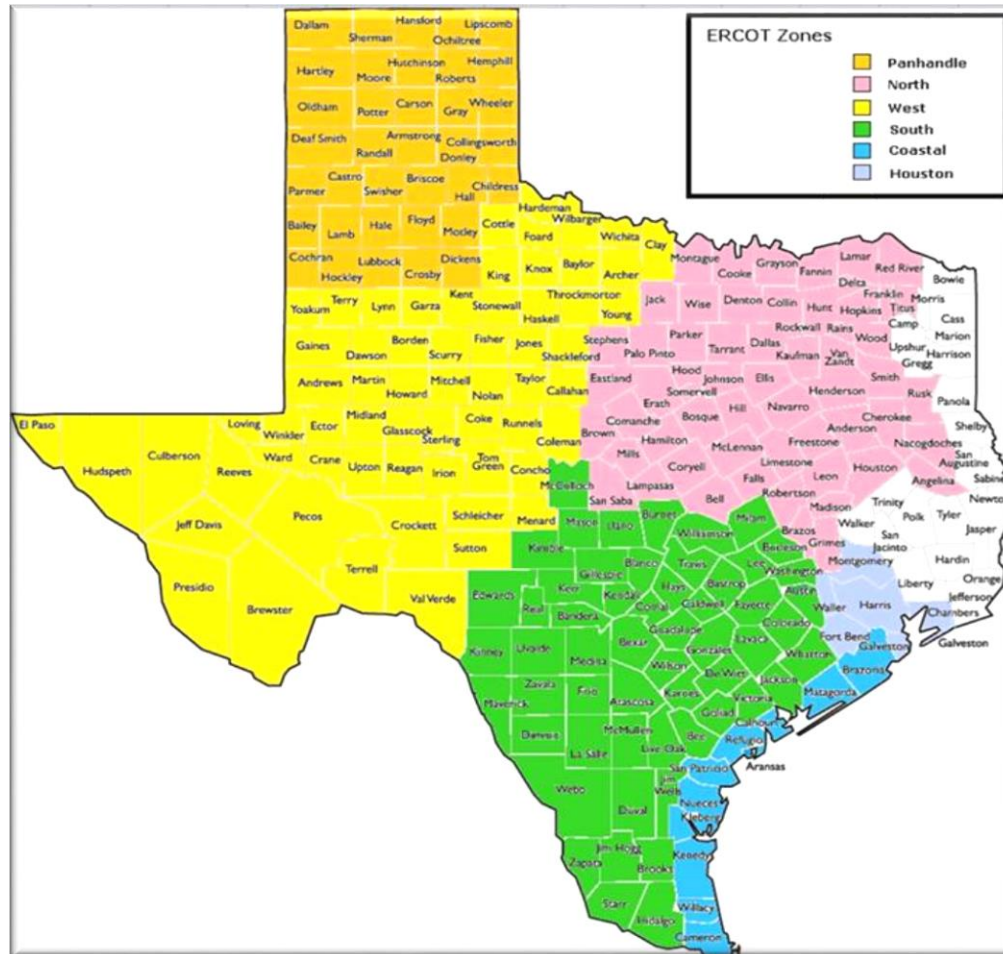
Financial security posted for funding interconnection facilities does not include CREZ's security deposits, which are refunded to the Interconnecting Entity when an IA is signed.

Wind Regions within ERCOT

Panhandle:
3,171 MW

West:
9,572 MW

South:
976 MW



North:
1,116 MW

Coast:
2,041 MW

Wind Records

TIME	LOAD (MW)	WIND GENERATION (MW)	PENETRATION AT RECORD TIME
02/18/2016 21:20	35,528	14,023	39.47%
03/23/2016 01:10	27,245	13,154	48.28%

Wind Generation Forecast

- AWS Truepower computes a Short Term Wind Power Forecast (STWPF) for all Wind-powered Generation Resources (WGR) in ERCOT for a rolling 168 hour timeframe.
- This process uses information from multiple systems, including:
 - RARF (Resource Asset Registration Form) (ex. site geo-location, met tower geo-location)
 - EMS (Energy Management System) (ex. Resource Status, telemetered site specific meteorological data)
 - Outage Scheduler (ex. WGR derate start/stop dates, derate values)
- When submitting COPs, Wind QSEs must use this STWPF for the applicable 168 hours timeframe. (COP HSL must be \leq STWPF.)
 - Note that NPRR 785, upon approval will only require Wind QSEs to update a COP only when wind farm operating conditions dictate COP HSL to be lower STWPF.

*Note that for a WGR going through commissioning process, ERCOT will start providing STWPF to the QSE once WGR receives approval to Generate into the ERCOT Grid (Part II of the Commissioning check list)

WPF Process Inputs

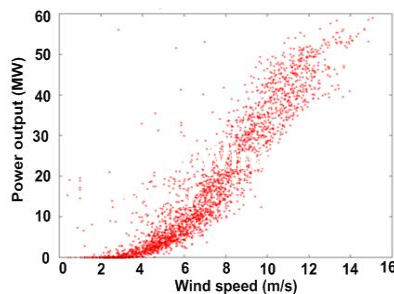
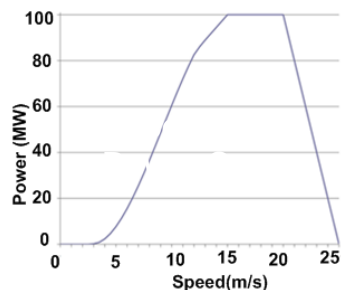
Source	Data
Registration System	<ol style="list-style-type: none"> 1. Resource Name 2. Location of wind farm (latitude and longitude or equivalent for the center point of wind farm) 3. Location of the meteorological tower (latitude and longitude or equivalent) 4. Type (manufacturer/model) and number of turbines 5. Turbine hub height(s) above ground level with associated number of turbines 6. Manufacturer's power curve (capability curve) 7. Resource Commercial Operation Date
Energy Management System (EMS)	<ol style="list-style-type: none"> 1. Most recent Resource (wind farm) status with date/time 2. Most recent MW output of wind farm with date/time 3. Most recent wind speed and direction at hub height from one meteorological tower with date/time 4. Temperature and barometric pressure at 2 m above ground level on the meteorological tower
Telemetry Value (Sent every 5 minutes from EMS)	<ol style="list-style-type: none"> 1. MW Average 2. Wind Speed (mph) 3. Wind Direction (degrees) 4. Temperature (°C) 5. Barometric Pressure (mbar) 6. HSL Average 7. Num of Turbines ON 8. Num of Turbines Off 9. Num of Turbines Unknown 10. Curtailment Flag
Outage Scheduler	<ol style="list-style-type: none"> 1. Turbine Outage/Unit Derate Value (HSL) 2. Turbine Outage/Unit Derate Start 3. Turbine Outage/Unit Derate Stop

NPRR 785

- Synchronizes Short Term Wind Forecast (STWPF) with Current Operating Plan (COP) of Wind Generation Resources (WGRs) and Photovoltaic Generation Resources (PVGRs)
 - ERCOT will automatically prepopulate every WGR and PVGR's COP with most recent forecast for the next 168 hours.
 - QSEs representing WGRs or PVGRs will be required to either submit a COP with the automatically prepopulated forecast **or submit a lower number** (when wind farm operating conditions dictate COP HSL to be lower STWPF).

Challenges in Forecasting Wind

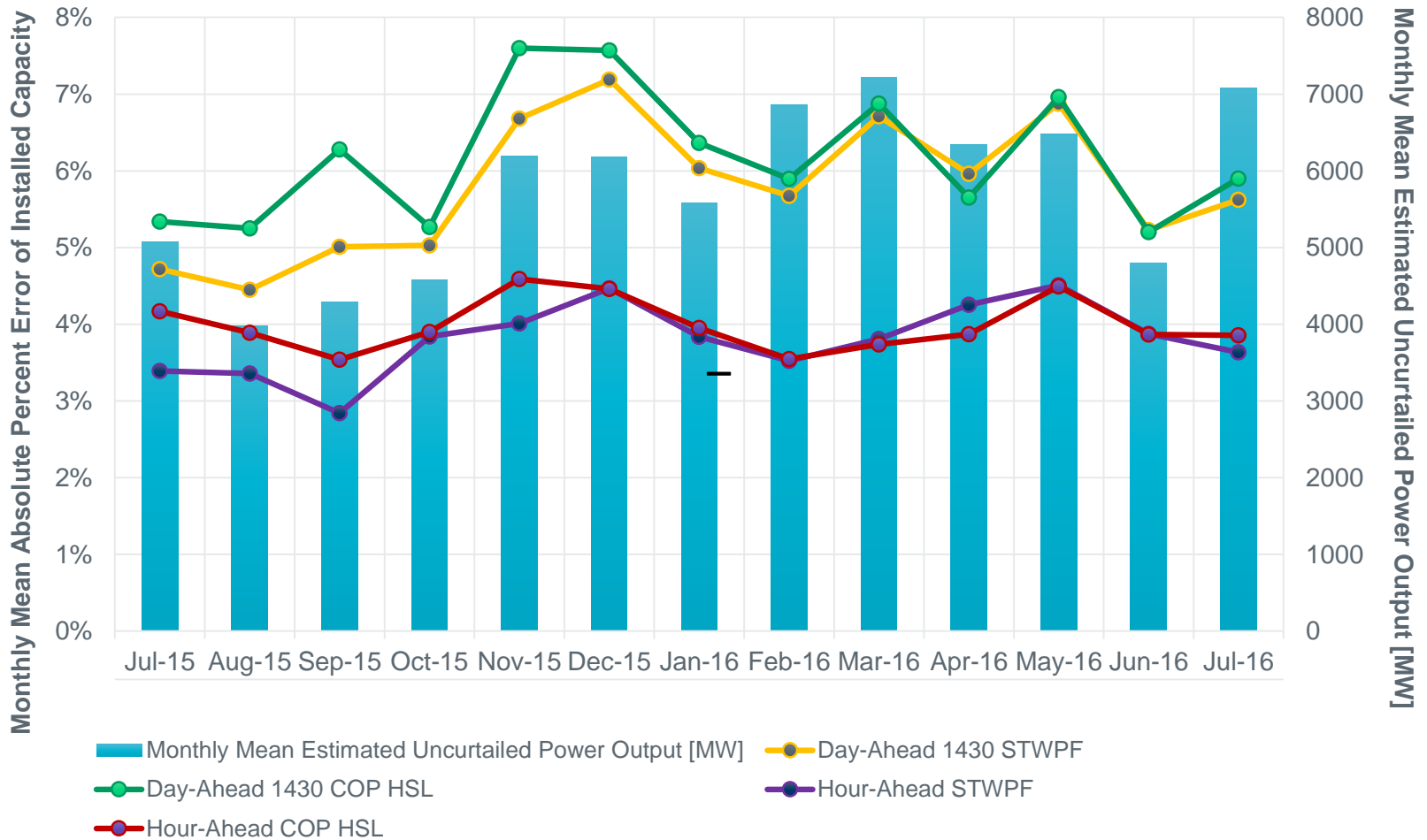
- Relatively concentrated geographic region for wind installation (lack of spatial diversity)
- Texas weather can change rapidly
- Severe changes in wind generation output caused by different types of extreme weather (large wind ramps)
 - Frontal system, trough, or dry line/Thunderstorms/Low-level jets/Weakening pressure gradients/Strengthening pressure gradients
- There is an approximation of hypothetical wind speed-power curve to the real one



*The steep part of the power curve from 4-12 m/s is where power increases strongly with speed.

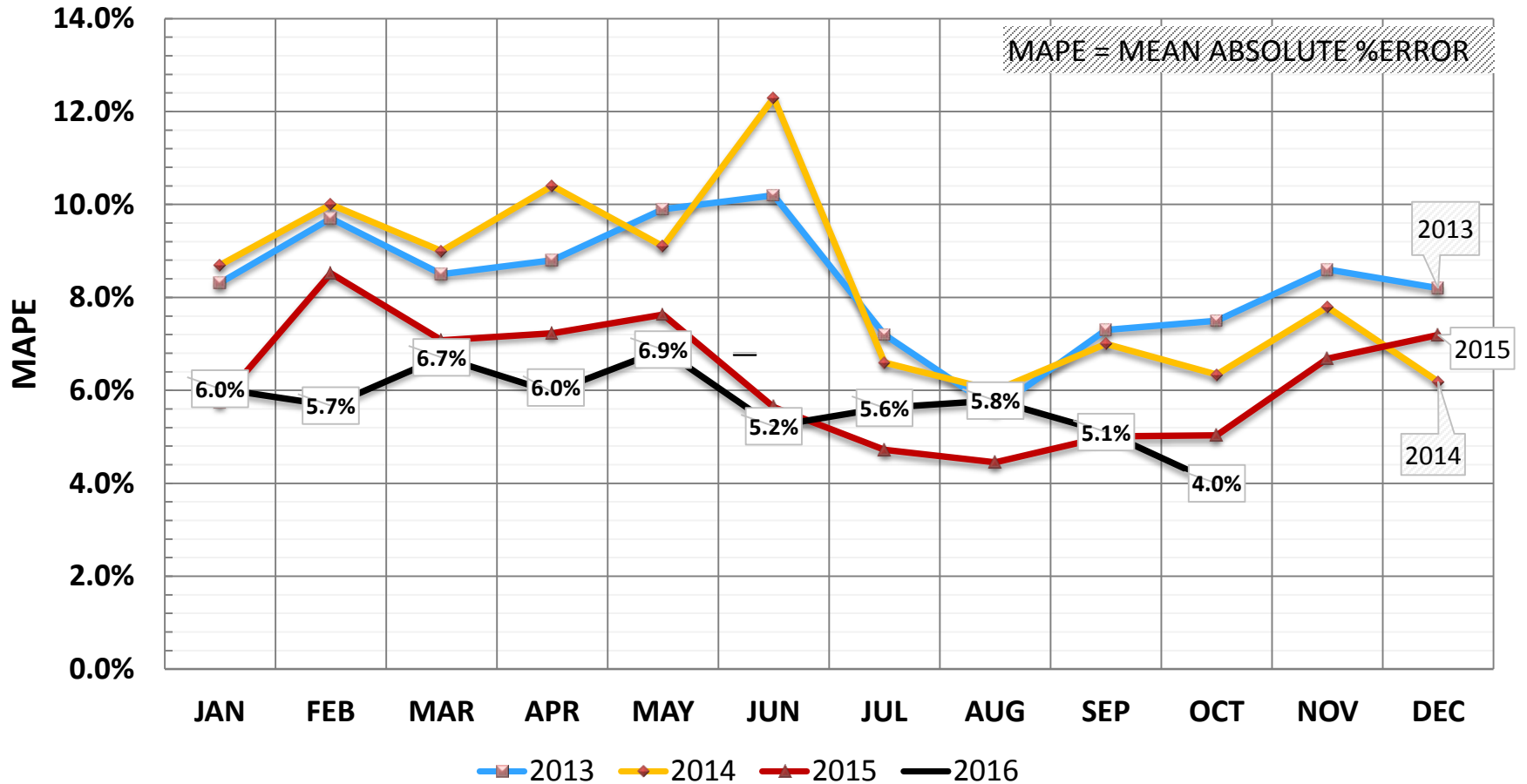
Wind Forecast Errors

WIND POWER FORECAST SYSTEM-WIDE Mean Absolute Percent Error



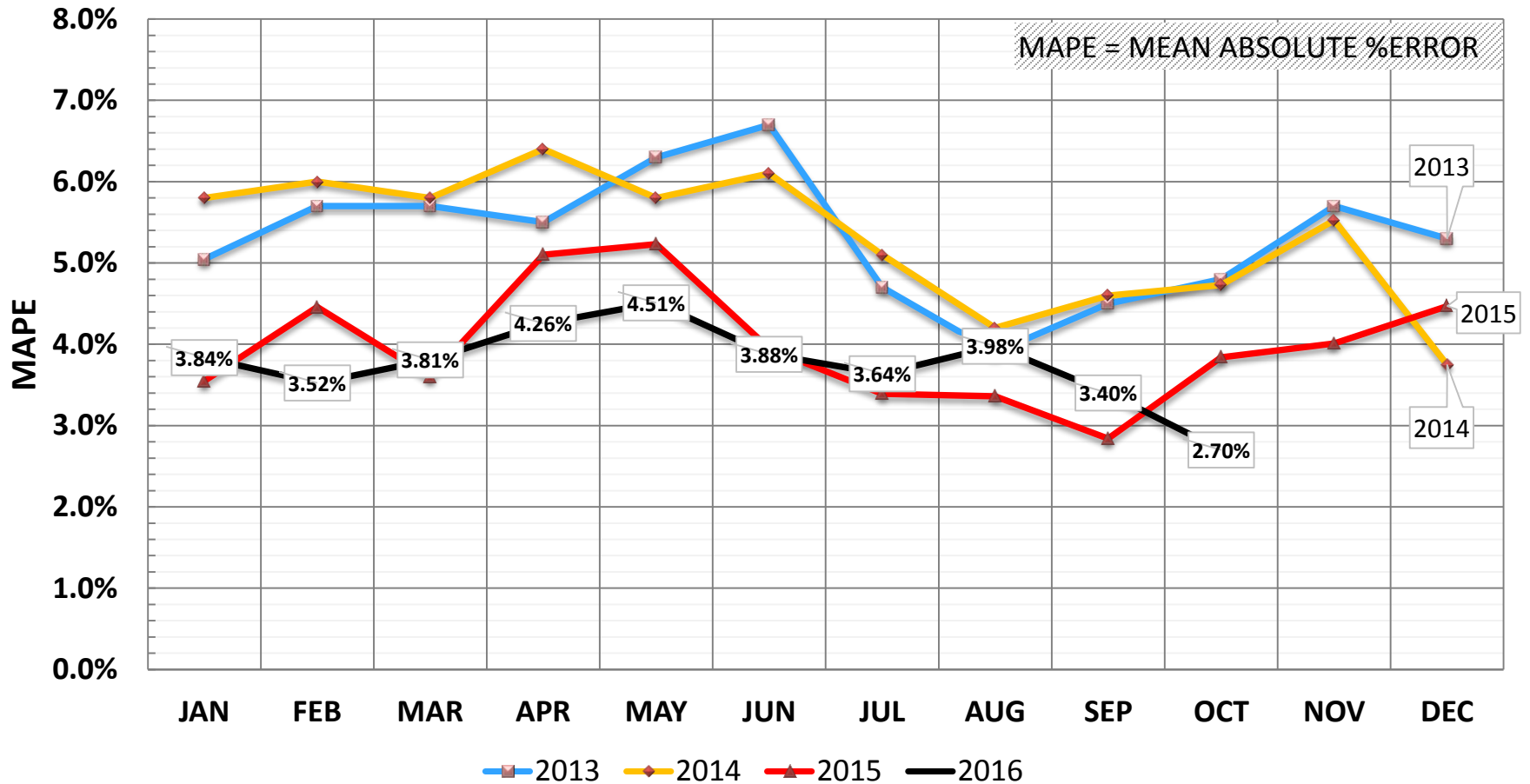
Wind Forecast Errors (Day-Ahead)

DAY AHEAD WIND FORECAST PERFORMANCE



Wind Forecast Errors (Hour-Ahead)

HOUR AHEAD WIND FORECAST PERFORMANCE



Wind Generation Cold Weather Preparation

Icing Impacts



Source: Wind Turbines in Cold Climates: Icing Impacts and Mitigation Systems, <http://www.springer.com/us/book/9783319051901>

Wind Units Failure in Cold Winter

- Frigid Temperatures Exceeds Turbine Limits
 - Wind turbines are typically designed to operate within ambient air temperatures of -15°C/-20°C (5F/-4F)
 - Wind turbines have an automatic shutdown feature to protect components if that range is exceeded.
- Blade Icing
 - Icing on wind turbines affects three different aspects simultaneously
 - the design (aerodynamics, load, control system, and material)
 - the safety (ice throw, unbalanced rotor spinning, over-power, and fatigue)
 - performance (annual energy output, wind measurements, and design life duration)
 - Other impacts
 - wind sensors—rendering ineffective wind-measuring equipment
 - increase noise levels and generally decrease a turbine's cost-effectiveness.

Blade Icing



Safety



Cold Weather Preparation

Inclement Weather Plan

**Preventative Maintenance
Schedule**

Emergency Plan

Communication

Cold Weather Extreme Package

- This ensures that wind turbine operates in temperatures as low as -30C (-22F), and in survival mode without operation, at temperatures as low as -40C (-40F) (**one example**).

	Minimum temperature (standard) operational / survival
Standard weather package	-15°C/-20°C (5F/-4F)
Cold weather package	-30 °C/-40 °C (-22F/-40F)

- ERCOT is aware of at least one vendor that offers an extreme cold weather package. Resource Entities should check with their manufacturer.

Cold Weather Packages

- “Cold Weather Packages” extend temperature ranges by heating components such as the nacelle space, yaw drive and pitch motors, and the gearbox, slip ring, controller and control cabinet, and battery.
- Heating could also prevent another insidious cause of turbine failure.
 - When a turbine is not running, oil that is stationary in radiator passages can quickly cool, and its viscosity can increase.
 - Even if wind turbines are not being used, an important lesson worth learning is that the turbines should be cycled online to provide flow of cooling oil.
 - All cooling equipment for radiators on wind turbines should also be disabled for cold weather events.

Icing Prevention Technologies

- Passive icing prevention methods
 - Rely on the physical properties of the blade surfaces to prevent ice accumulation.
 - An example is application of an anti-adhesive coating on the blade such as teflon.
 - Another approach takes advantage of the heat absorbing capacity of dark colored surfaces and consists in the use of black coated blades.
- Active de-icing methods
 - Consist of thermal, chemical and impulse de-icing
 - In thermal de-icing, electrical elements, similar to the one found on the rear window of a car, can be used to warm and melt the ice accumulation off the blades.
- In a comprehensive wind turbine icing prevention approach, sensors that could detect the build-up of ice on the rotor could be considered.

Wind Operations During Icing Conditions

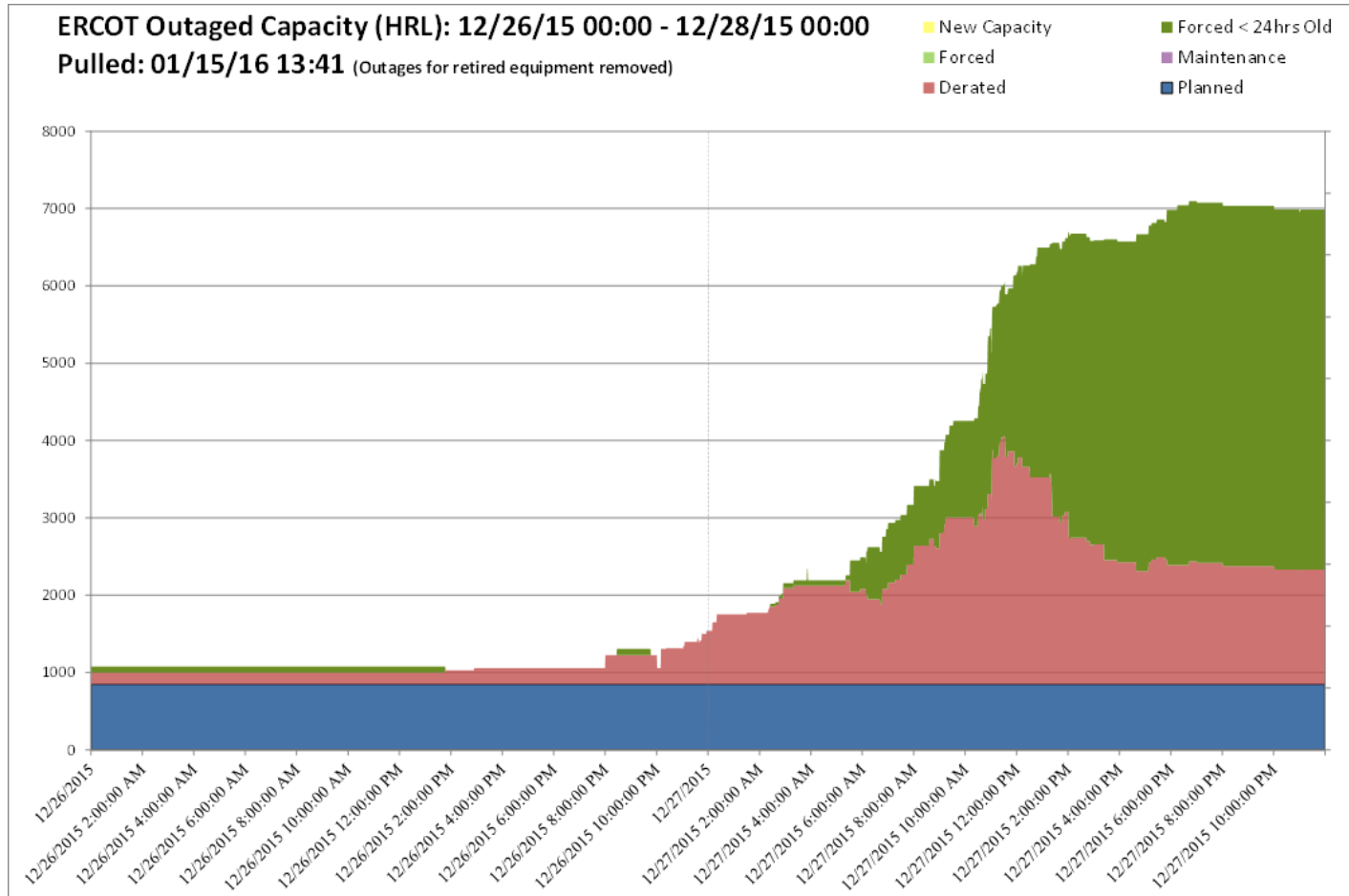
Challenges Created by Icing

- Icing creates a mismatch between the forecast and actual production.
- This creates an error in the forecast which then was provided to WGRs.
- This error may be used in the COP which feeds into RUC.
 - Could lead to ERCOT counting on more wind than WGRs are able to generate.

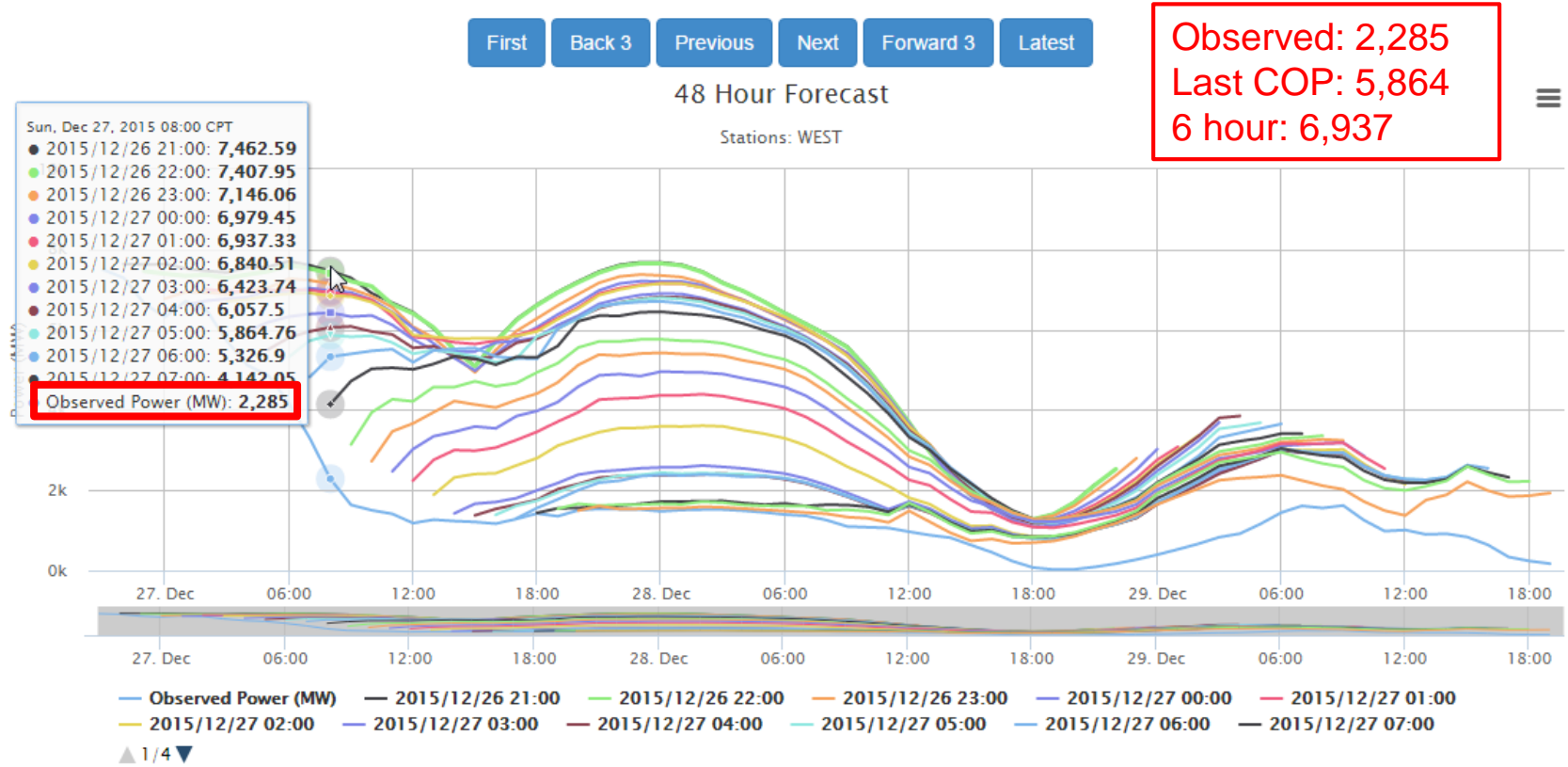
Icing Event Dec 26-27, 2015

- Freezing temperatures on December 26, 2015 in the panhandle region of Texas marked the beginning of icing conditions that lasted throughout the duration of December 27.
- By 3:00 AM on December 27, the wind forecasting error had reached about 1700 MW. Icing was continually reported throughout the day and forecasting error reached nearly 4500 MW by the hour ending HE0800.
- The outage scheduler reported new WGRs related derates and forced outages totaling around 6000 MW by the end of the day.

Wind Outages 12/26 – 12/27



West Wind Forecasts Over Time – HE8



Forecast and Observed Tabular Data ▼

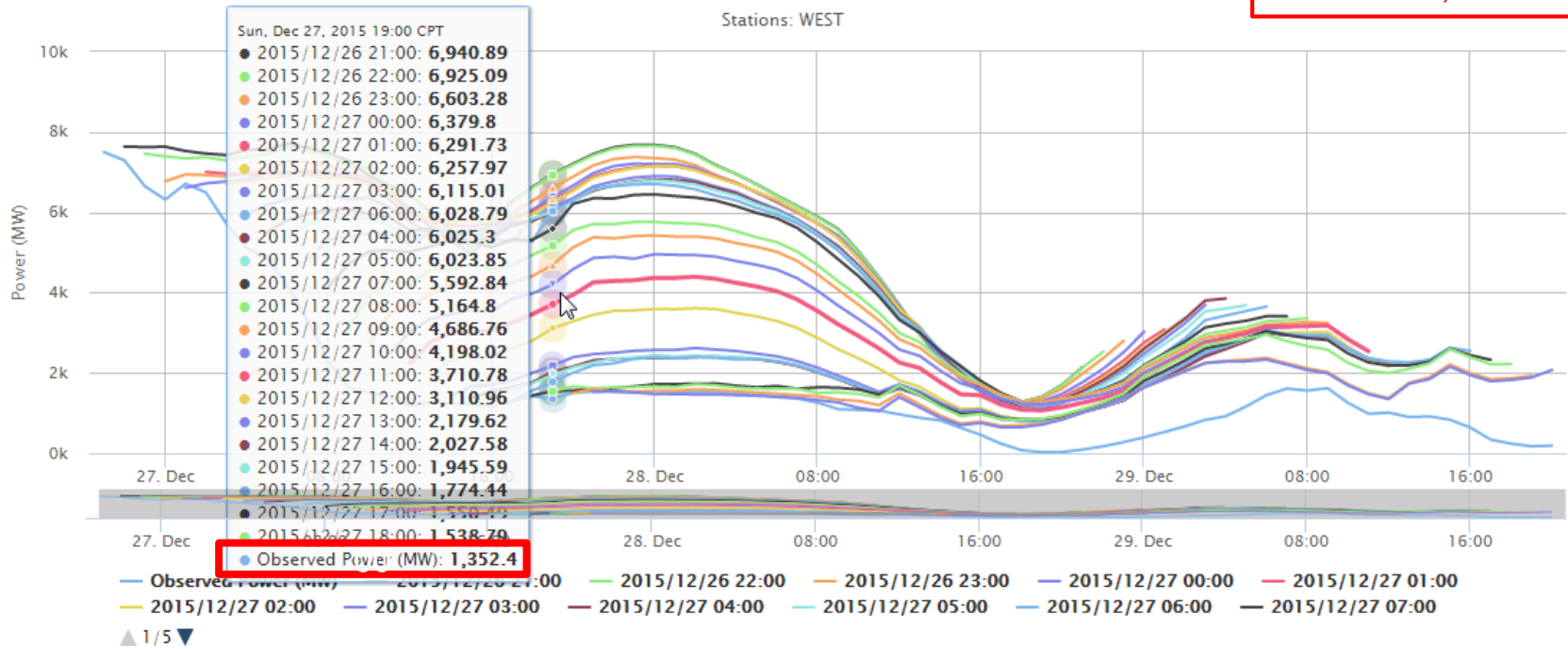
West Wind Forecasts Over Time – HE19

[First](#)
[Back 3](#)
[Previous](#)
[Next](#)
[Forward 3](#)
[Latest](#)

48 Hour Forecast

Stations: WEST

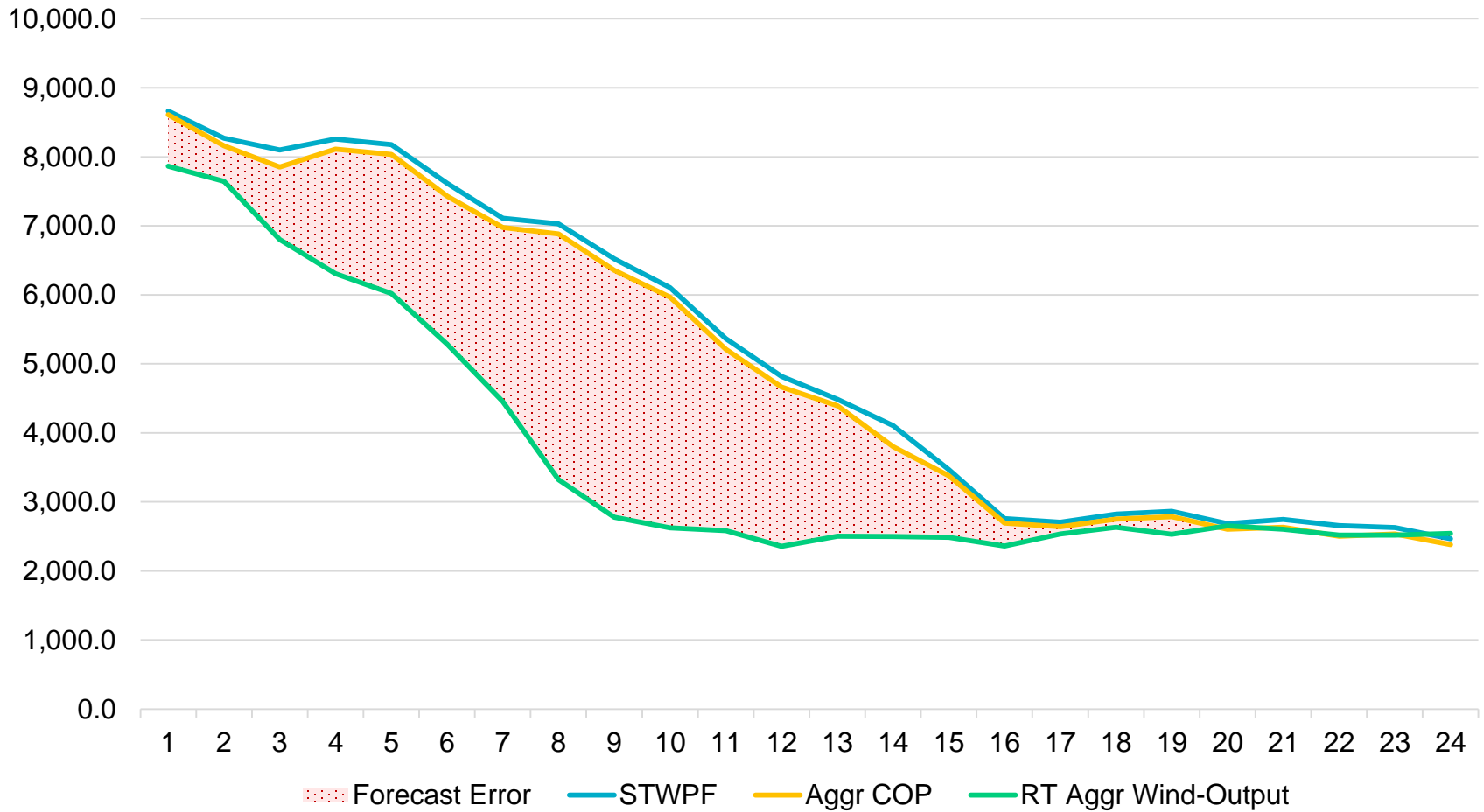
Observed: 1,352
 Last COP: 1,774
 6 hour: 3,110
 12 hour: 5,592



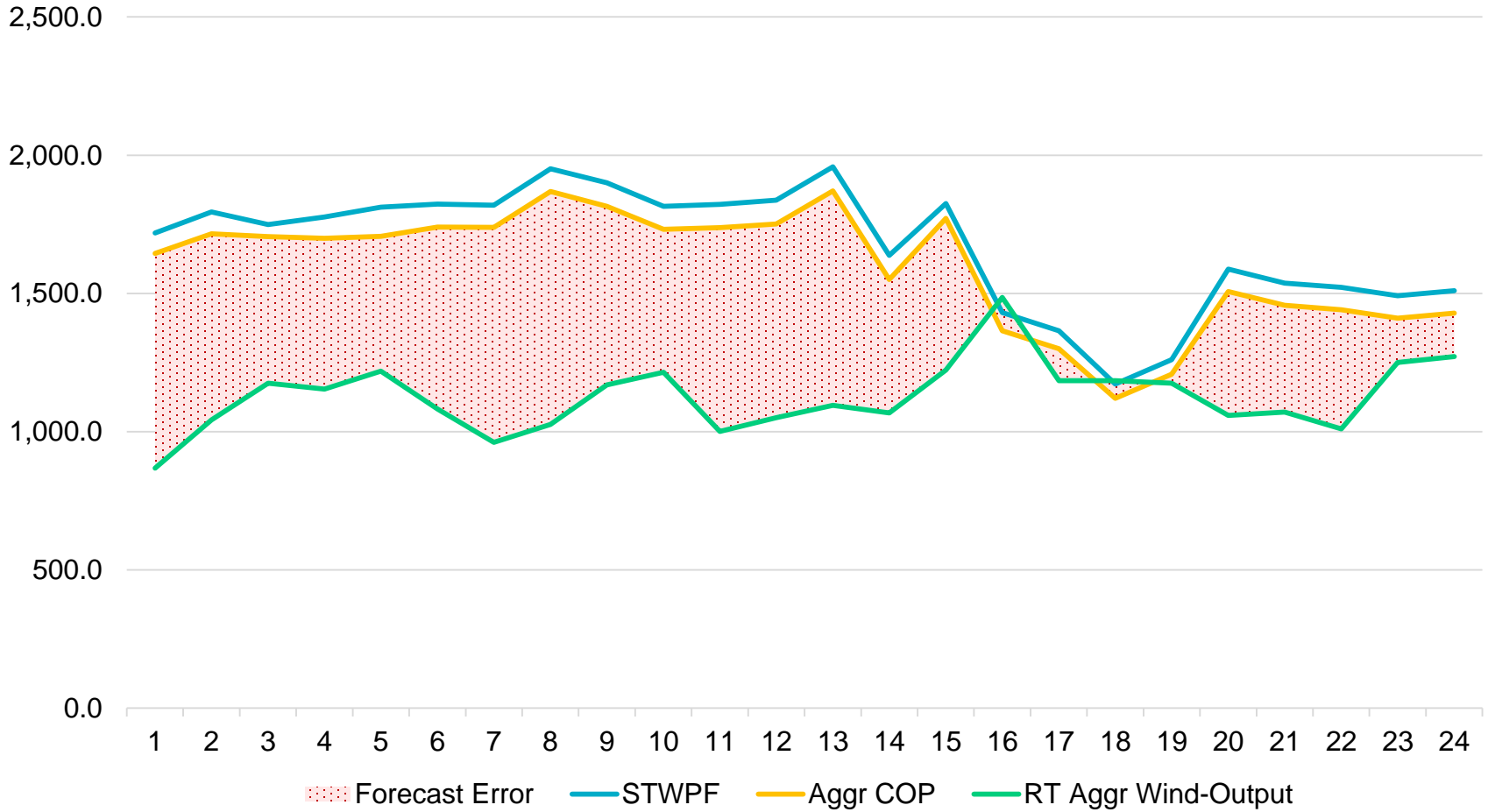
Forecast and Observed Tabular Data



West Wind Hour Ahead Summary

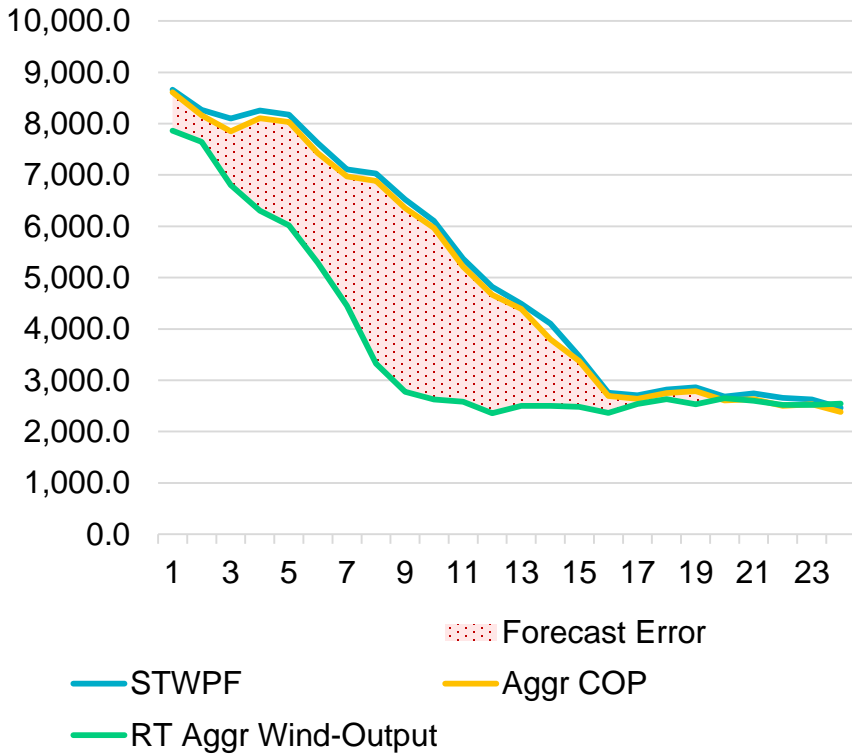


Panhandle Wind Hour Ahead Summary

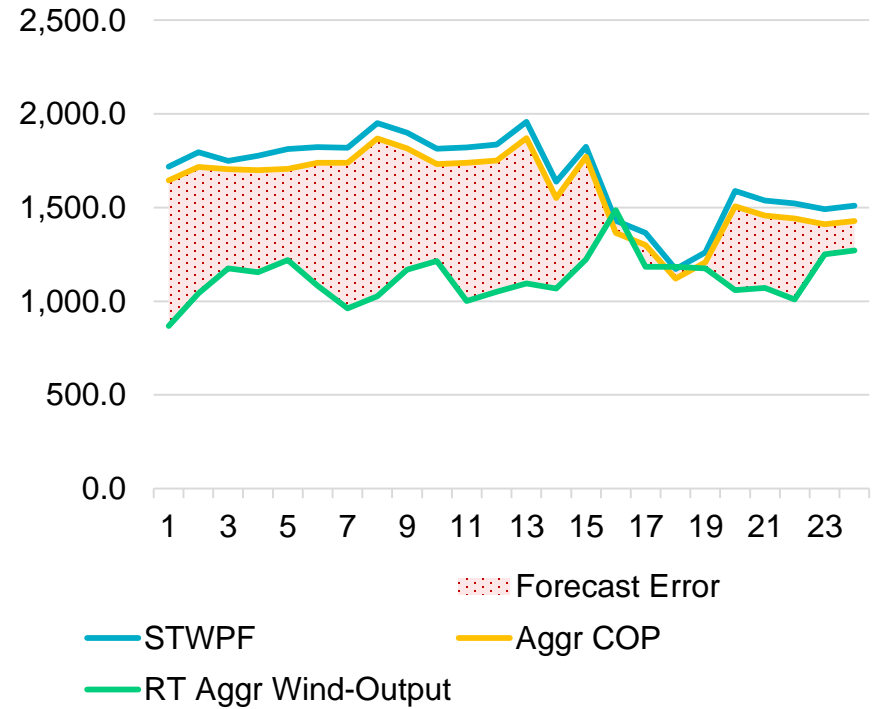


Forecast vs. COP Comparison

West Wind Hour Ahead Summary

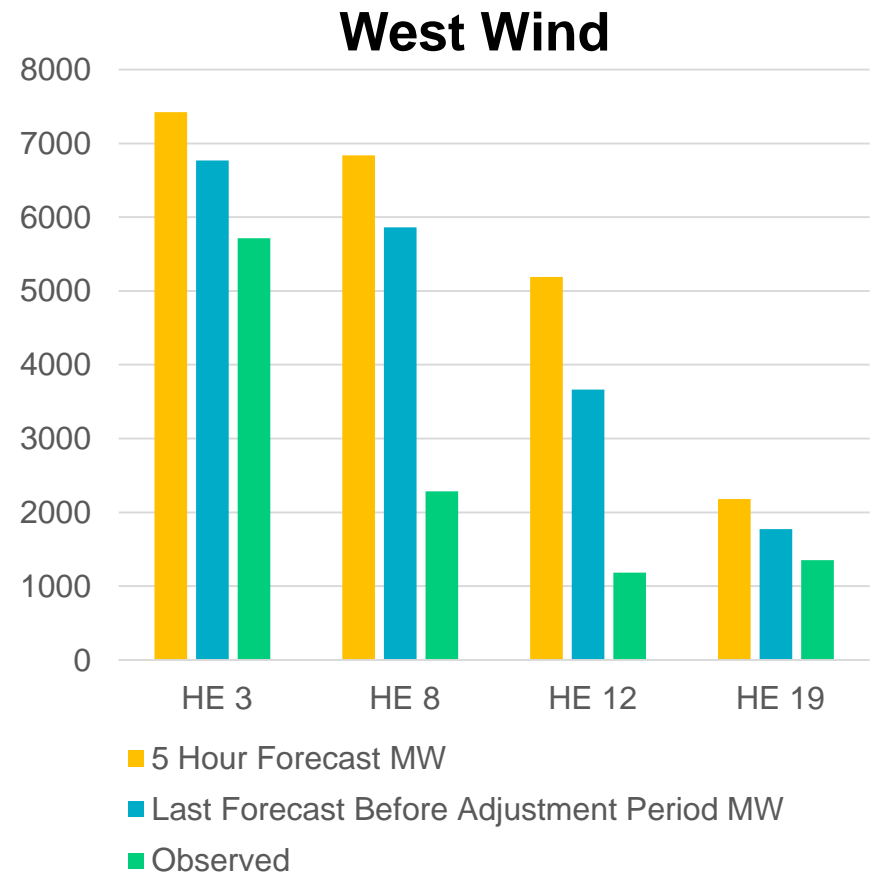
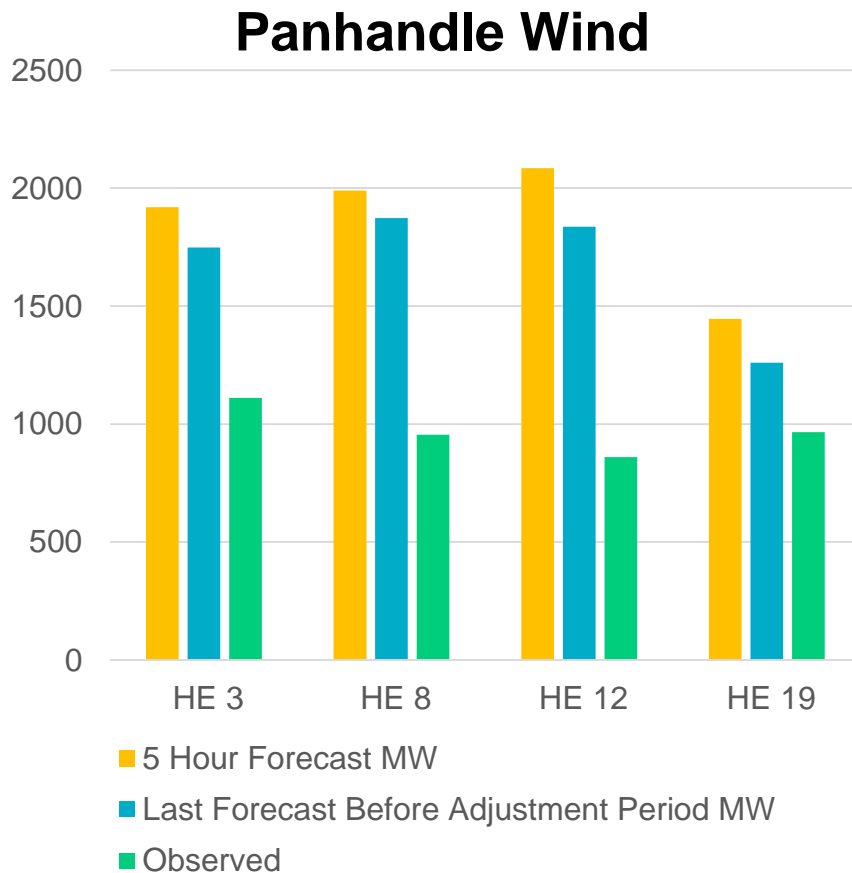


Panhandle Wind Hour Ahead Summary



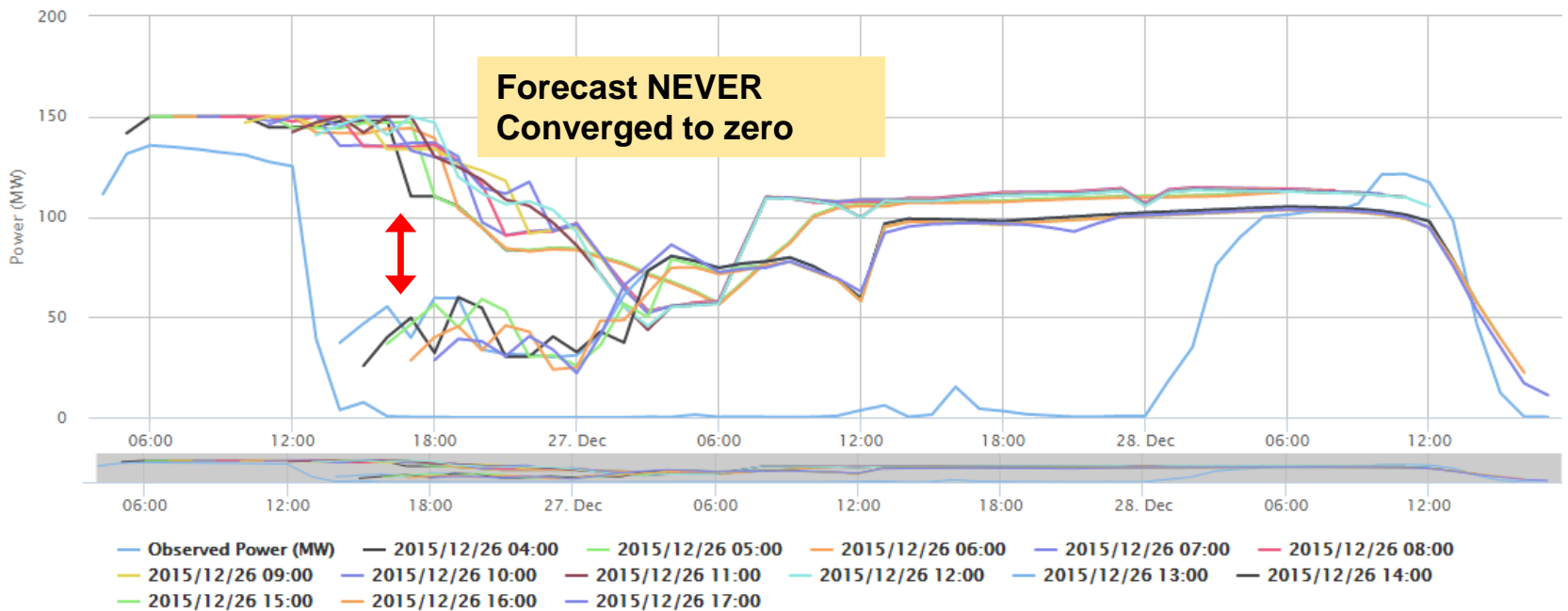
Forecast Performance

Notice the disparity between the last forecast value before the adjustment period and the observed value in HE 8 and 12 versus in HE 19. Delayed outages caused these errors in earlier hours which were then minimized in HE 19. The faster these outages are entered, the faster they are incorporated to the forecast.



Unit's STWF with no Outage Updates

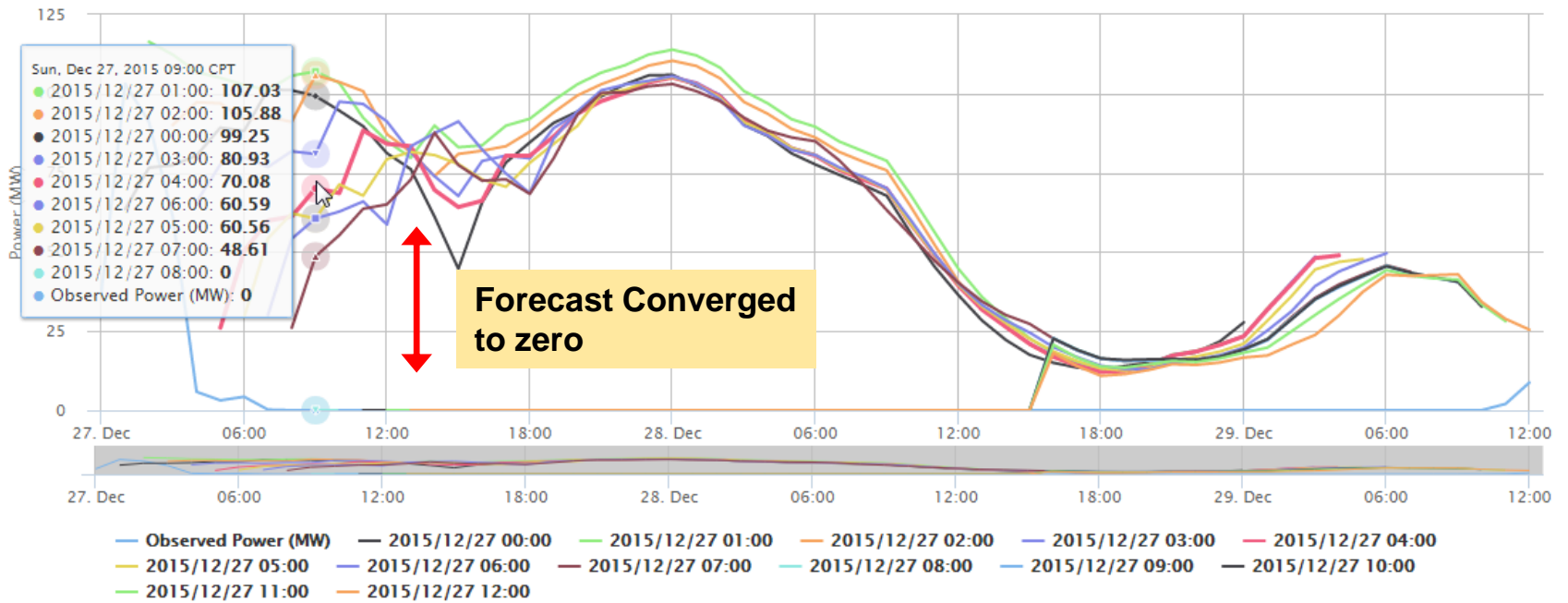
WRONG



Forecast and Observed Tabular Data

Unit's STWF with Outage Updates

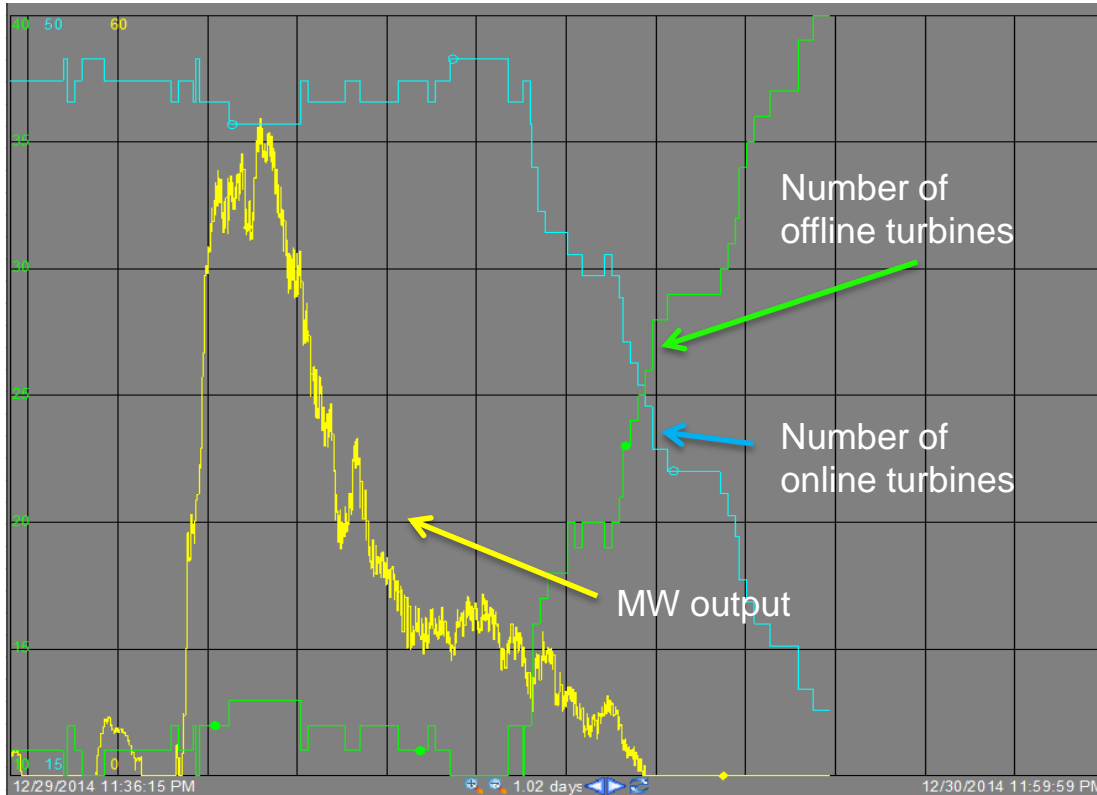
CORRECT



Forecast and Observed Tabular Data

Telemetry During Icing Conditions

WRONG



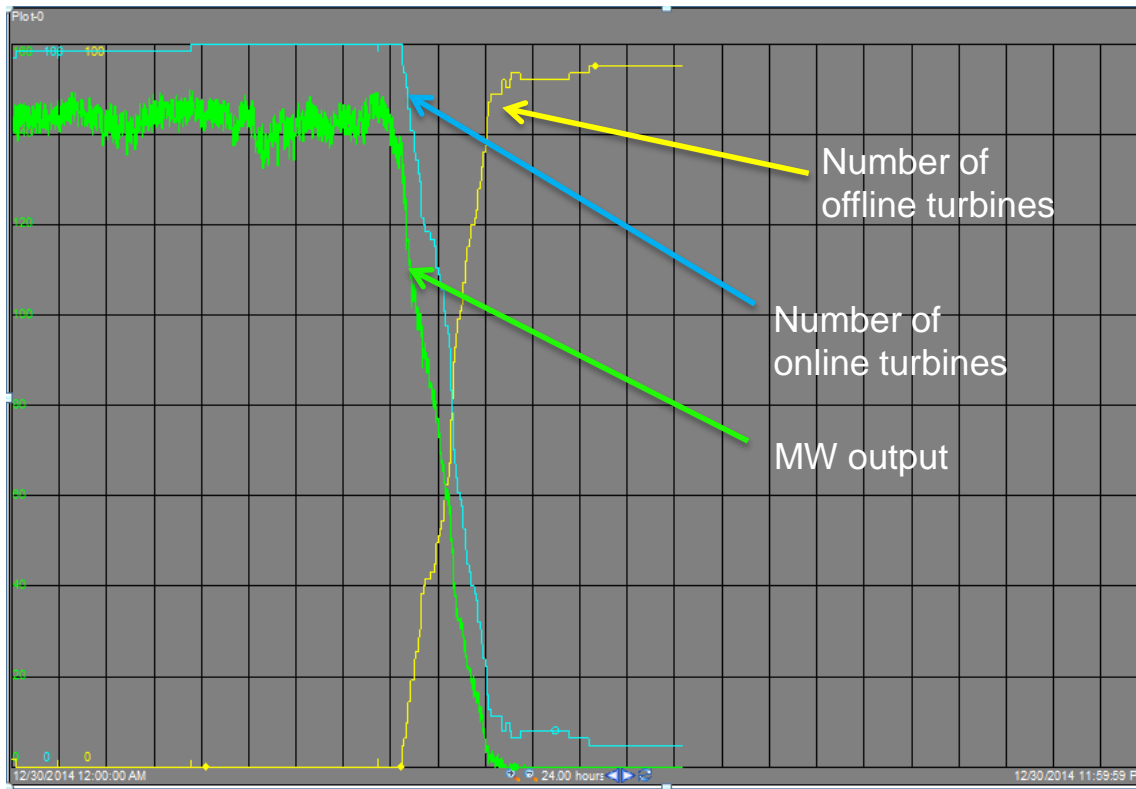
*Remember this is under icing conditions.

While the NTON line does decrease, it does not fall as the unit's MW goes to zero, but is very delayed.

This is too slow.

Telemetry During Icing Conditions

CORRECT



*Remember this is under icing conditions.

The NTON line falls as the unit's MW goes to zero.

This is very good.

Addressing the Wind Turbine Icing

- Use the following when a WGR is experiencing an icing related event,
 - Call the ERCOT Control Room and notify them.
 - Continuously update the telemetry for number of turbines on and off (NTOFF and NTON) as conditions on the ground deteriorate.
 - If the outage/derate is expected to last greater than 2 hours, submit this into ERCOT's Outage Scheduler.
 - In comparison to turbine telemetry, Outage submissions have a greater impact in correcting the forecast.

3.1.4.5 Notice of Forced Outage or Unavoidable Extension of Planned or Maintenance Outage Due to Unforeseen Events

(2) Any Forced Outage that occurs in Real-Time must be entered into the Outage Scheduler if it is to remain an Outage for longer than two hours.

RRGRR-0003

- A survey was conducted in 2015 to gather additional information to gauge the operational limits of the various WGRs in ERCOT.
 - Maximum Operating Temperature (Fahrenheit (°F))
 - Minimum Operating Temperature(Fahrenheit (°F))

 - High Wind Speed Cut-Out (meters per seconds (m/s))
 - High Wind Speed Cut-Out time (minutes)
 - High Wind Speed Cut-Out Reset (meters per seconds (m/s))
 - High Wind Speed Cut-Out Reset Time (minutes)

- This information is now part of the RARF and is fed into the wind forecast received from AWS.

Current and Ongoing Telemetry Concerns

Meteorological Telemetry

Telemetry Name	Data Unit
Wind Speed (MPH)	MPH
Wind Direction (DEG)	Degrees
Temperature (TEMP)	°C
Barometric Pressure (PRES)	mbar
Num. Of Turbines ON (NTON) Num. Of Turbines OFF (NTOF) Num. Of Turbines Unknown (NTUN)	Integer (Count of turbines)

Telemetry Examples (from 9/6/2016)

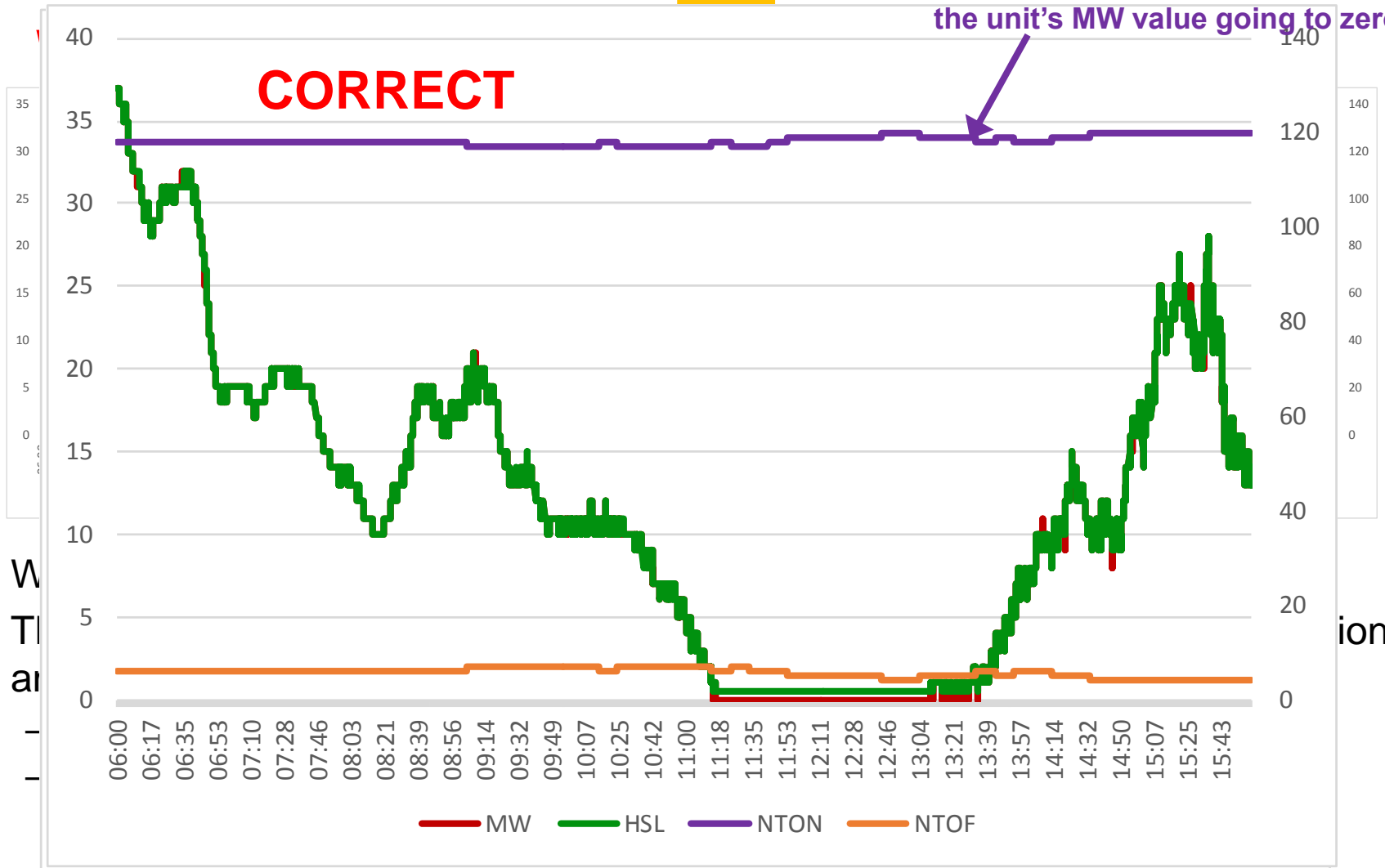
Unit	MW	BP Dev	HSL Dev	Temp	Wind Speed	HSL vs. SCED Basepoint
████████	89	-3	-1	327	↓ 20	
████████	80	5	0	28	↑ 26	
████████	51	-2	-2	23	→ 28	

Unit	MW	BP Dev	HSL Dev	Temp	Wind Speed	HSL vs. SCED Basepoint
████████	116	0	3	0	↓ 0	
████████	117	0	0	0	↓ 0	
████████	77	2	2	21	↗ 12	

Number of Turbines Online (NTON)

The NTON line stays constant despite the unit's MW value going to zero.

CORRECT



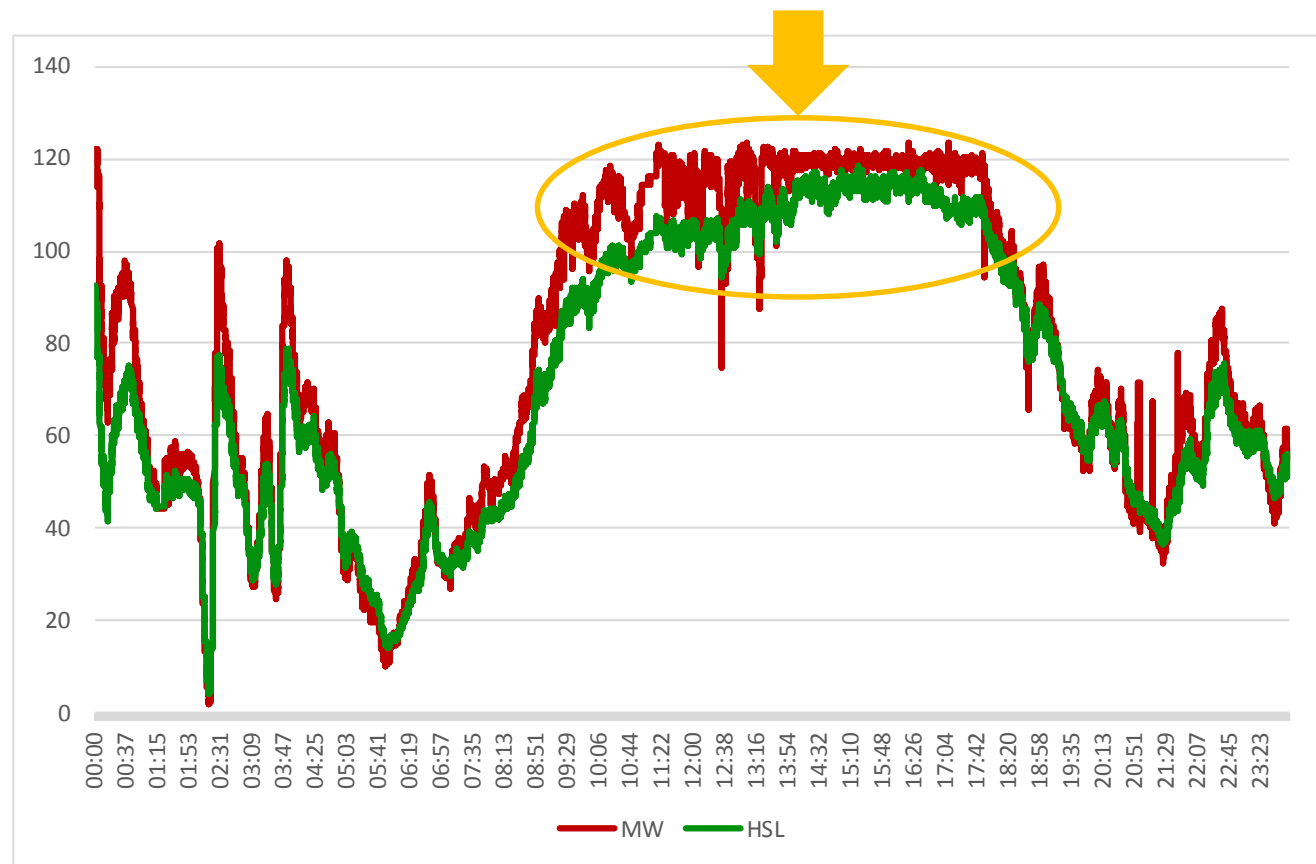
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MW exceeding HSL telemetry

- MW telemetry **must never** exceed the HSL.
- When a WGR is UNCURTAILED its MW and HSL values should be exactly the same.

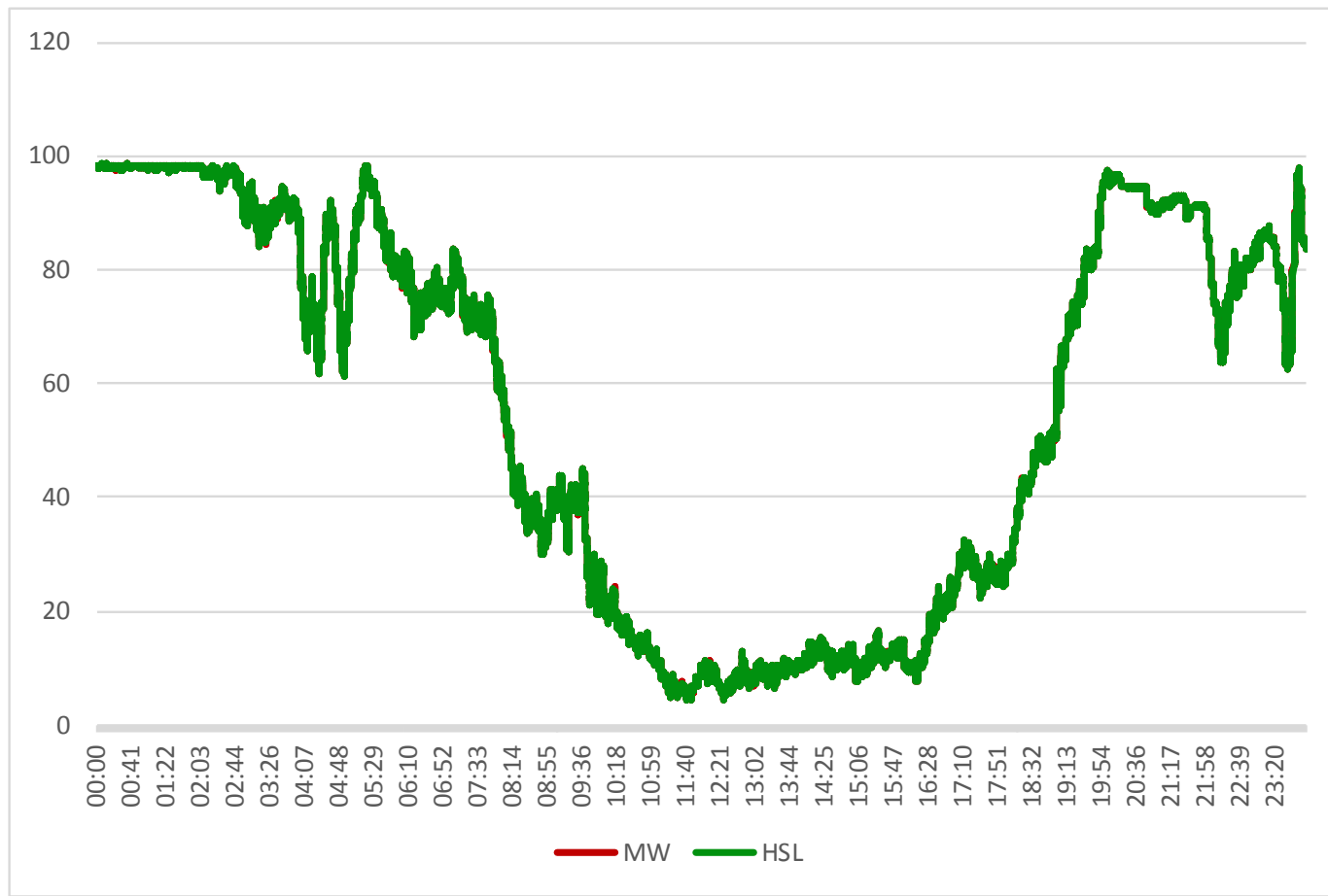
WRONG



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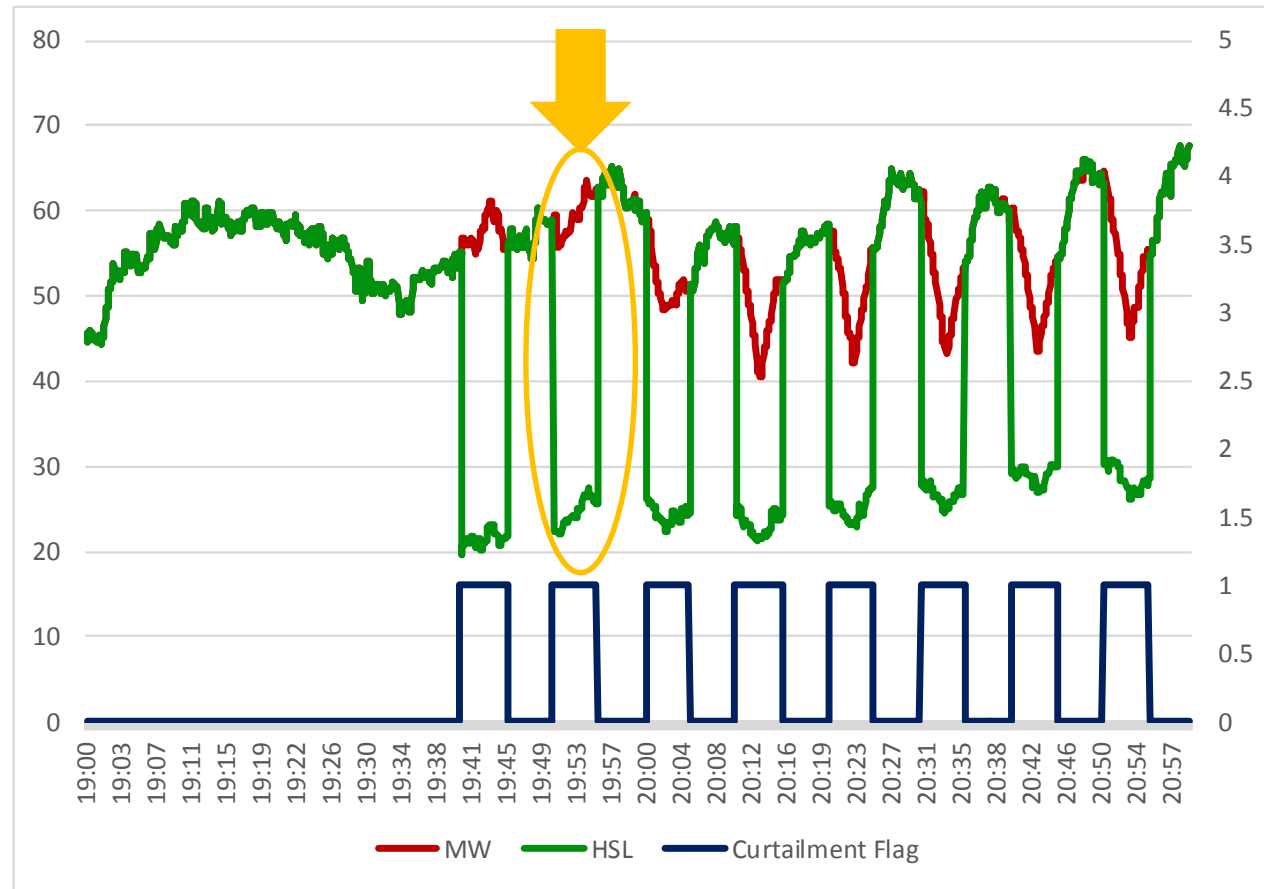
CORRECT



WGR Under Curtailment

- ERCOT nodal protocols and Business Practices dictate that when under curtailment a WGR's HSL **must** represent actual power generation potential.
- HSL **should never** lower dramatically under curtailment scenarios.

WRONG

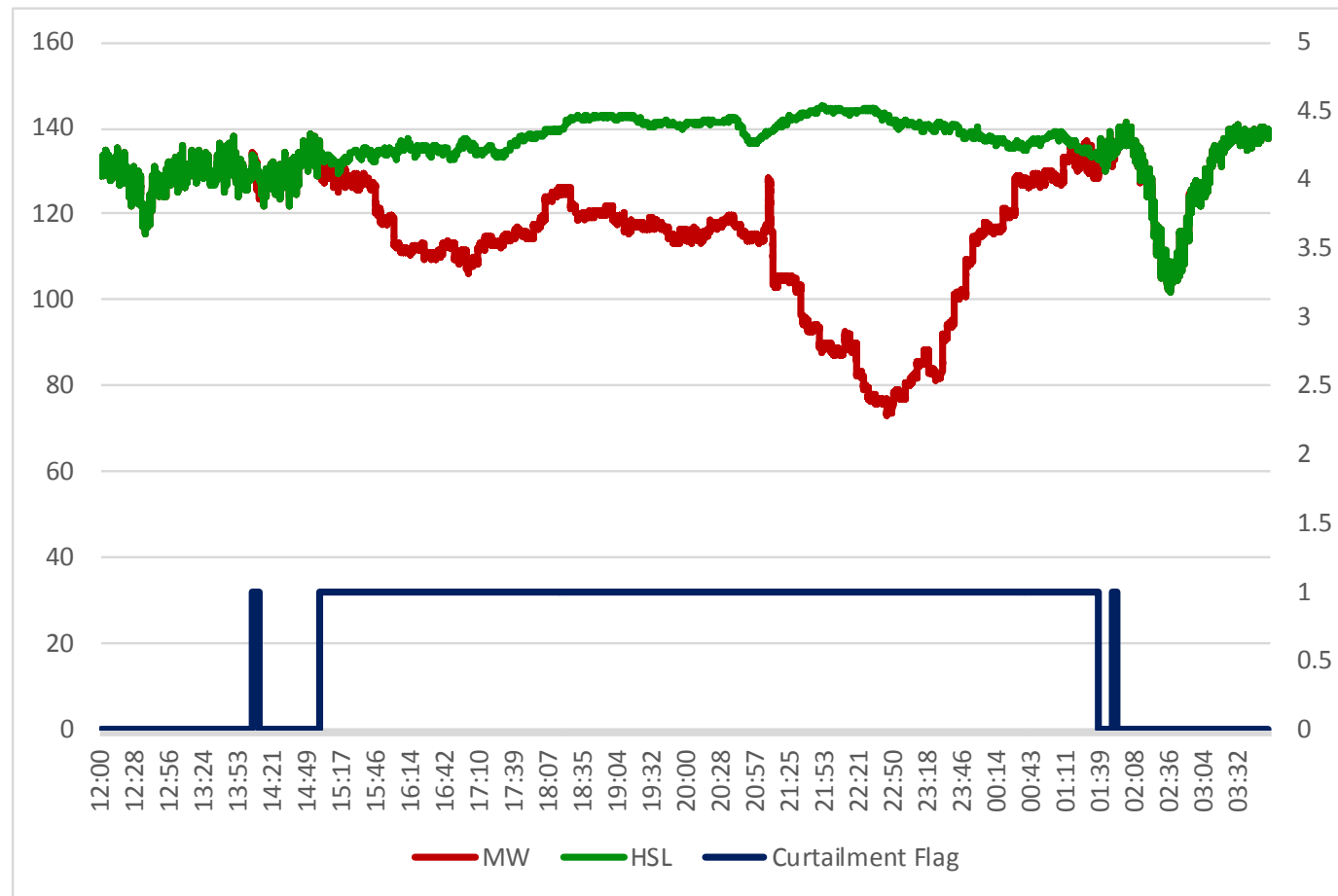


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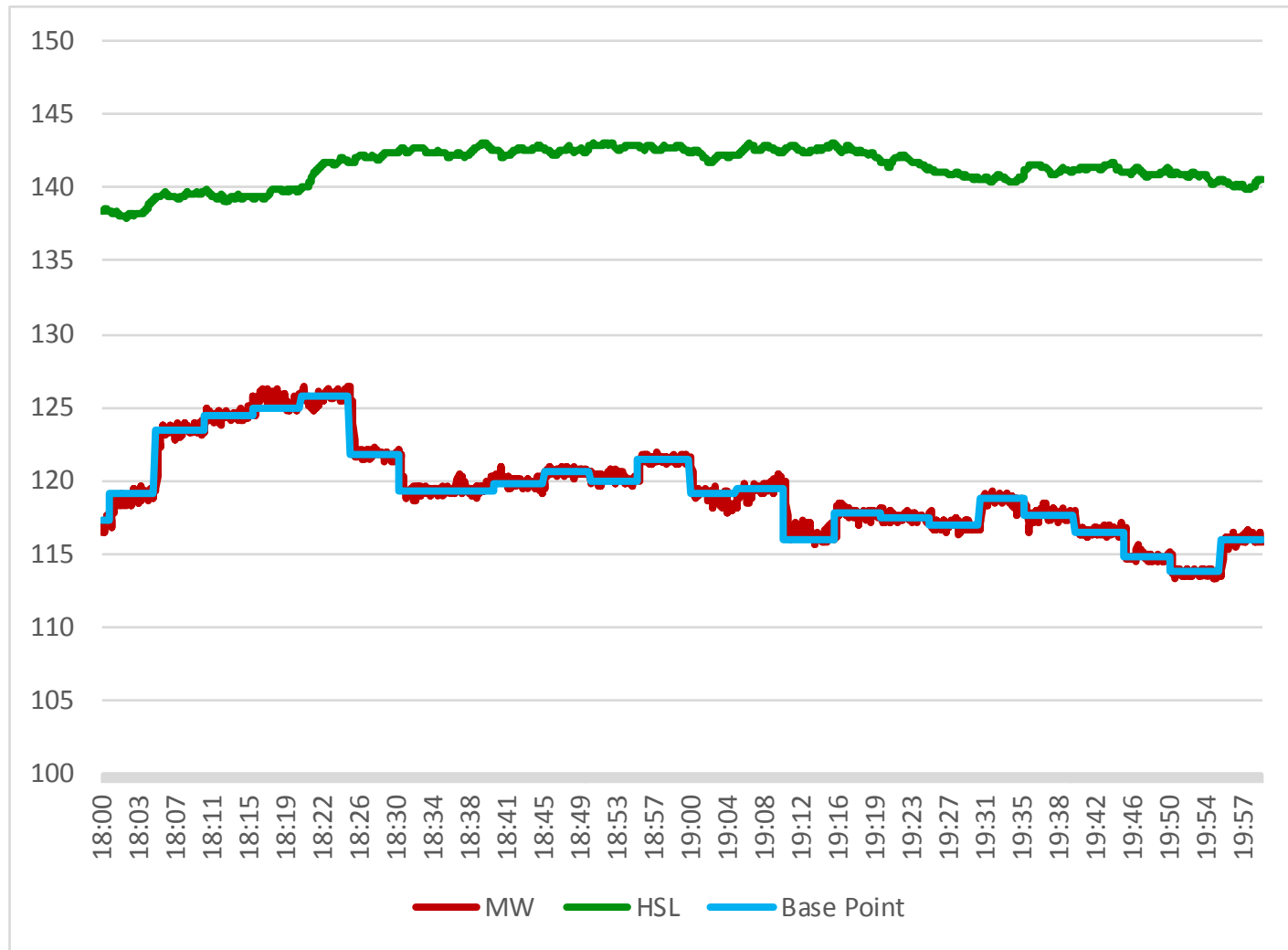
CORRECT



WGR Under Curtailment

- WGRs **must** follow ERCOT Base Point when under curtailment

CORRECT



Questions?