Operational Challenges and Potential Opportunities Transitioning to a Low Carbon Grid

ESIG Fall Session 9, System Planning Considerations for High VRE Penetration

October 27, 2020

Clyde Loutan

Principal, Renewable Energy Integration, CAISO

California is aggressively pursuing a low carbon future

- Aggressive renewable energy goals

33% by 2020 → **60% by 2030** → **100% zero-carbon by 2045**

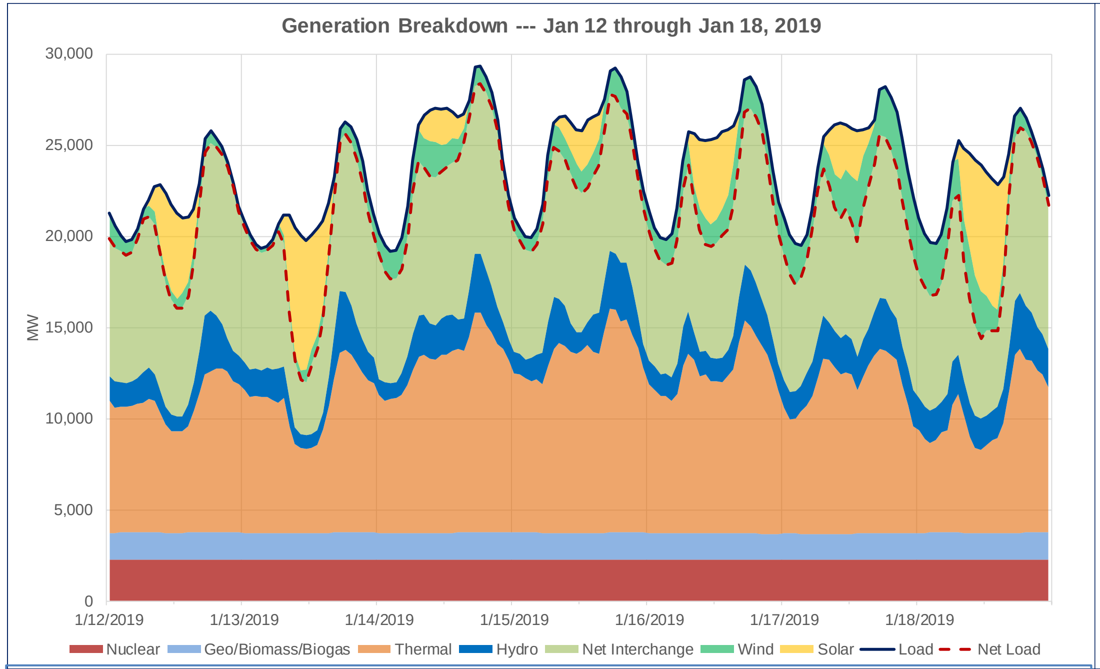
- Deep greenhouse gas (GHG) reduction goals

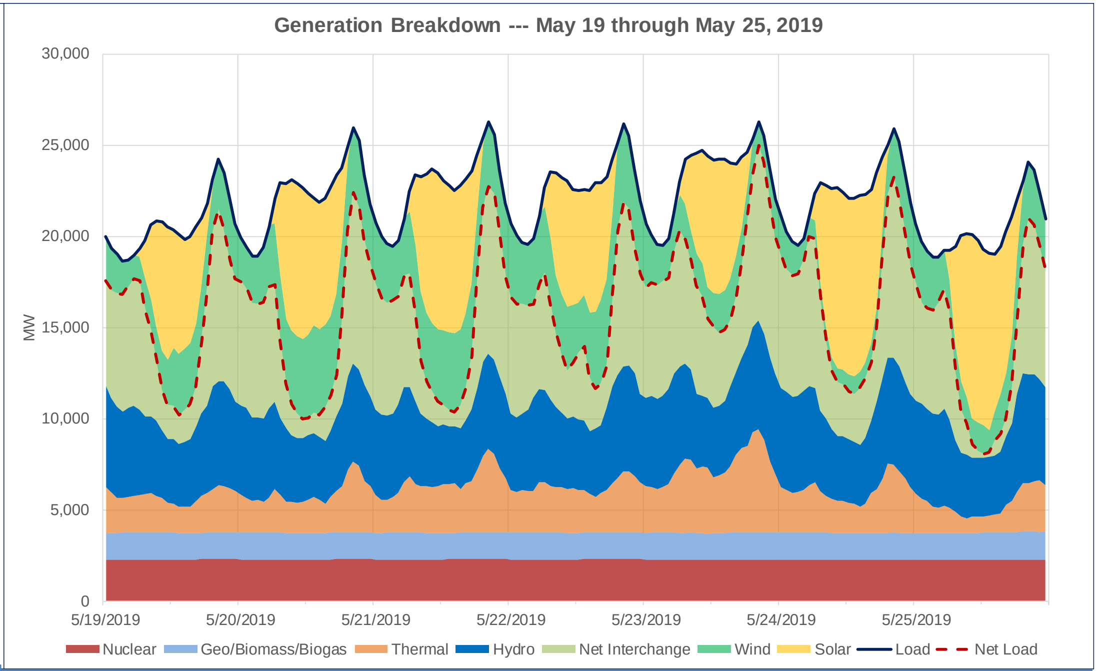
2020 Target
Reduce GHG emissions to 1990 levels
→
2030 Target
40% below 1990 levels
→
2050 Target
80% below 1990 levels

- Robust electric vehicles goal: 1.5 million by 2025
  - 250,000 Charging Stations
- 12,000 MW of distributed generation by 2020
- 2 GW of battery storage by 2021

→ **Decarbonization is creating opportunities to develop a high renewables and high DER energy service industry**

Challenges under different operating conditions





Cloudy Days

- Weather: Cloudy/slight rain
- Maximum net import was 9,820 MW
- Max hourly solar production was 1,970 MW
- Maximum simultaneous wind/solar was about 3,800 MW and occurred during HE11
- Maximum thermal generation was about 12,000 MW

During Hydro Spill Conditions

- Rely on gas fleet for most ancillary services
- Typically operate gas fleet at low operating levels to minimize over supply
- Committed gas fleet cannot provide adequate primary frequency response obligation
- Need renewable resources to provide essential grid services

What are some of the biggest operational challenges?

- Integrating renewables is making significant impact on how we meet mid-day demand
- Management of increased oversupply requires economic bids from all resources, including renewables
- Increasing evening ramp requires flexible capacity to balance supply and demand
- Need additional solutions such as storage, TOU rates, regional collaboration, and using all resources flexibly could help manage increasing oversupply and ramping needs
- Need to maintain sufficient production capacity during periods of low renewable production due to multiple days of cloud cover and low winds
- The volume and speed at which solar resources ramp up is faster than demand is increasing and needs to be managed
- Renewable resources need to follow dispatch instructions similar to other resources

Operational challenges on the grid associated with large scale DERs and loads

- Lack of visibility of distribution system
- Uncontrollable nature of DER output
- PV inverters in large amounts can affect the frequency response and voltage profile of the system
- Forecast assumptions of “net load” seen by operators
- Variability of “combined heat and power” production due to load, natural gas prices, real-time energy prices etc.
- Predicting price responsive loads behavior to real-time prices
- Demand response variability and forecast uncertainty
- Uncertainty/assumptions associated with commercial, Industrial and residential storage

What is the ISO doing?

- Sharing awareness of the how demand is balanced during different conditions
- Assessing ability of the resource fleet and import to meet demand in all periods
- In near-term to mid-term, ensure sufficient gas resources are maintained to meet demand when renewable production ceases
- In long-term, support alternatives to gas resource or overbuilding renewables to meet high demand periods
- Support Time-of-Use rates to incentivize demand to respond to system conditions
- Incentivize renewable resource to provide controllability and essential reliability resources traditional provided by conventional resources

What levers must we pull to create a more favorable load shape and operationally sustainable grid?

Shifting

Storage – increase the effective participation by energy storage resources.

Demand response – enable adjustments in consumer demand, both up and down, when warranted by grid conditions.

Time-of-use rates – implement time-of-use rates that match consumption with efficient use of clean energy supplies.

Renewable portfolio diversity – explore procurement strategies to achieve a more diverse renewable portfolio.

Shaping

Western EIM expansion – expand the western Energy Imbalance Market.

Regional coordination – offers more diversified set of clean energy resources through a cost effective and reliable regional market.

Electric vehicles – incorporate electric vehicle charging systems that are responsive to changing grid conditions.

Flexible resources – invest in fast-responding resources that can follow sudden increases and decreases in demand.

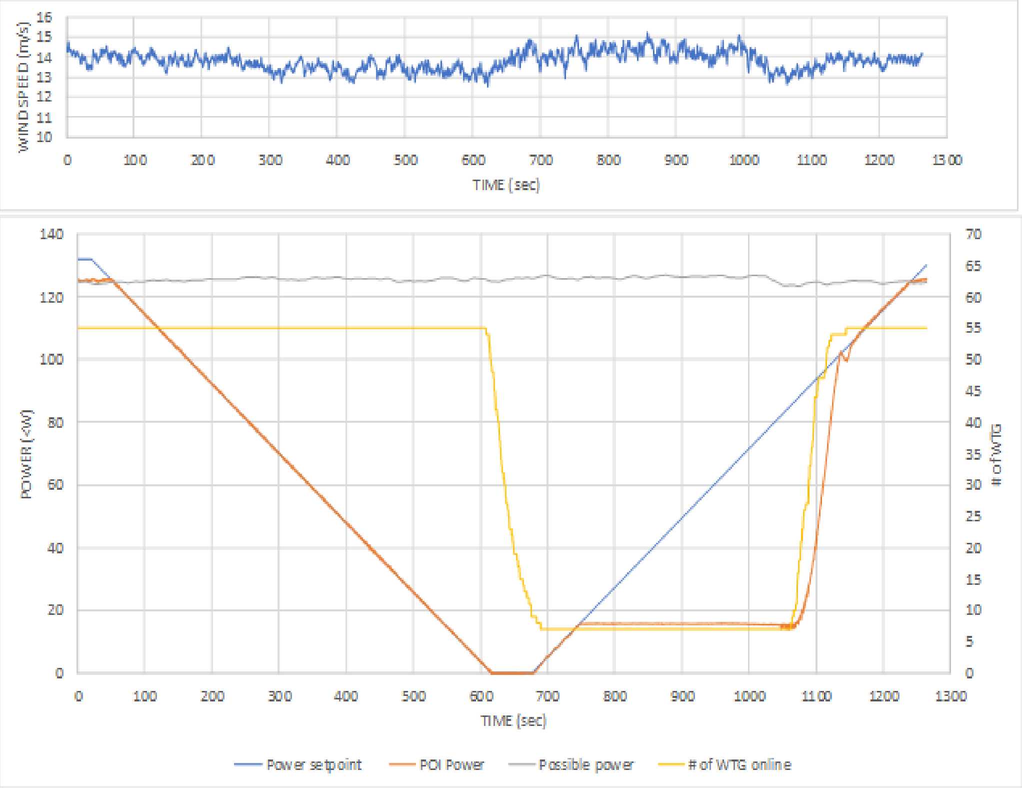
Wind, solar and storage resources can provide essential reliability services and in some cases faster and better than conventional resources

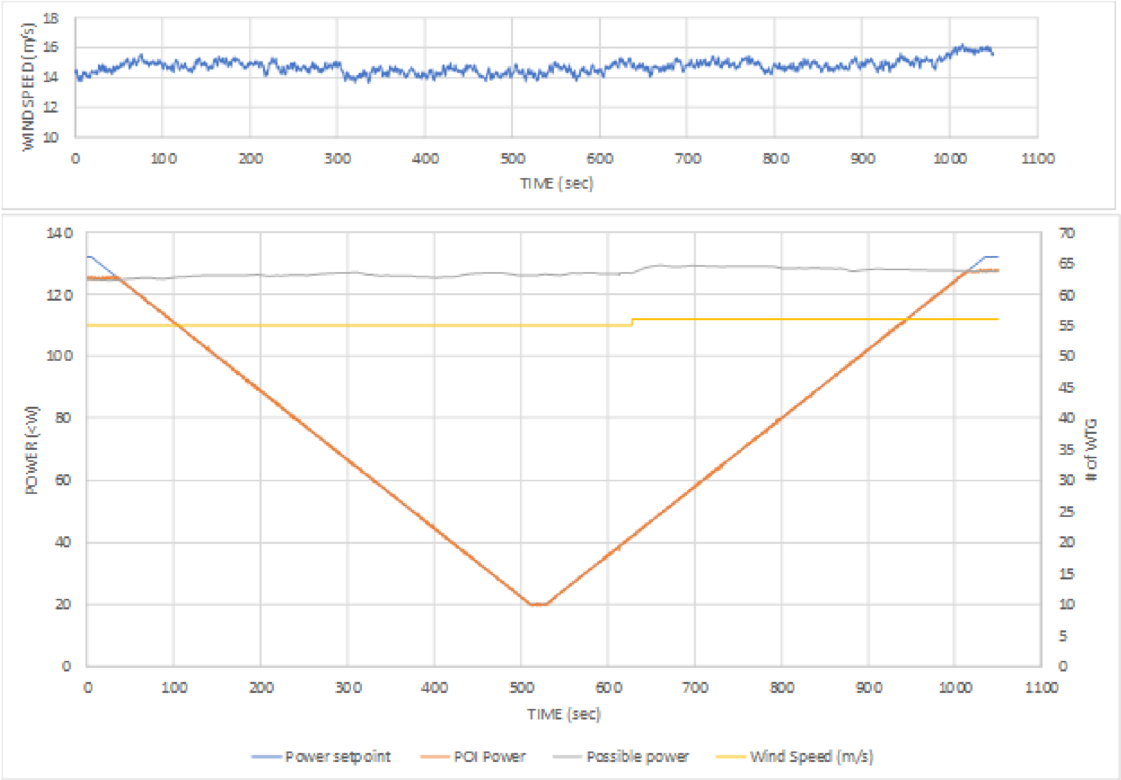
The rest of this presentation focuses on wind resources providing essential grid services

- Wind resources with smart inverters and a plant level controller can be a critical factor in integrating additional renewables to the grid
- Wind plants can follow dispatch instructions
- Wind resources with the right operating characteristics can help:
  - Support California's aggressive carbon reduction goals
  - Support international efforts to decarbonize the grid

Note: The Avangrid Renewables Tule Wind Farm demonstration wasa joint effort by the CAISO, NREL, General Electric and Avangrid Renewables

The 131.1 MW Tule WPP following upward and downward dispatch instructions from the CAISO at a constant ramp rate

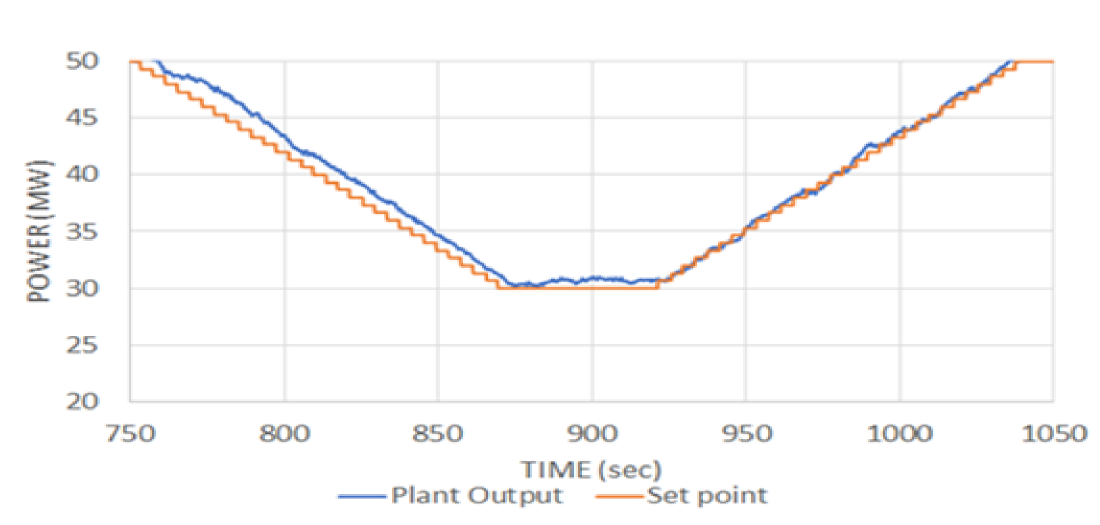


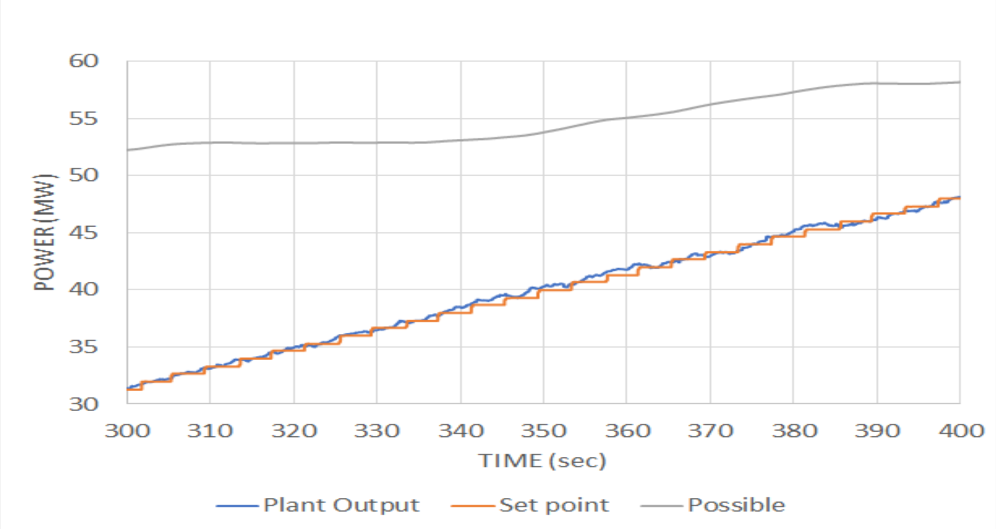


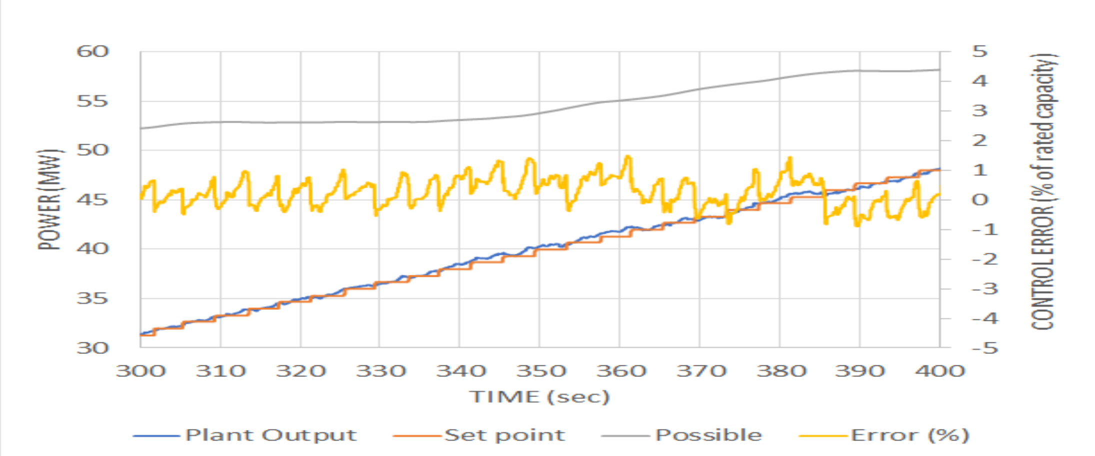
During the recovery process the plant controller was operating in a mode with an end goal to achieve the peak power production only at the end of the production restoration interval

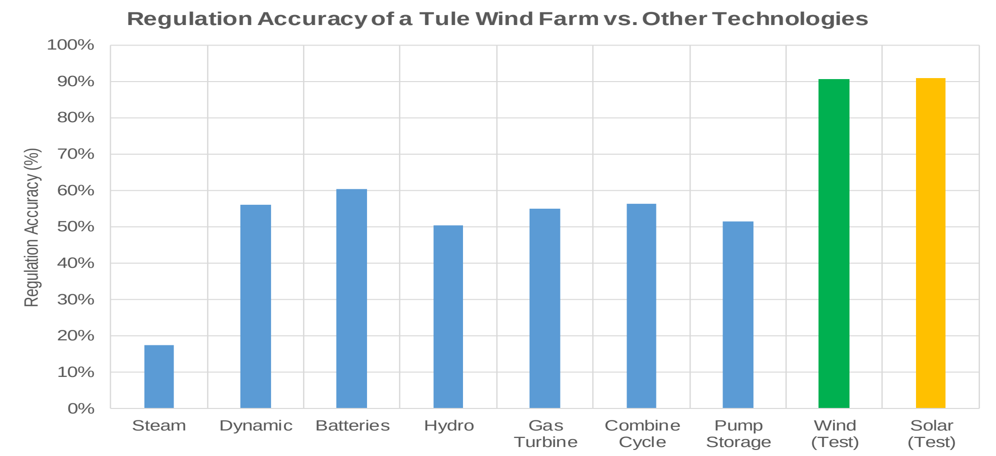
During the downward and upward ramps the plant demonstrated its ability to accurately follow the active power set points

The 131.1 MW Tule WPP following 4-second AGC signals from the CAISO with a control error within ± 2% of the plant capacity



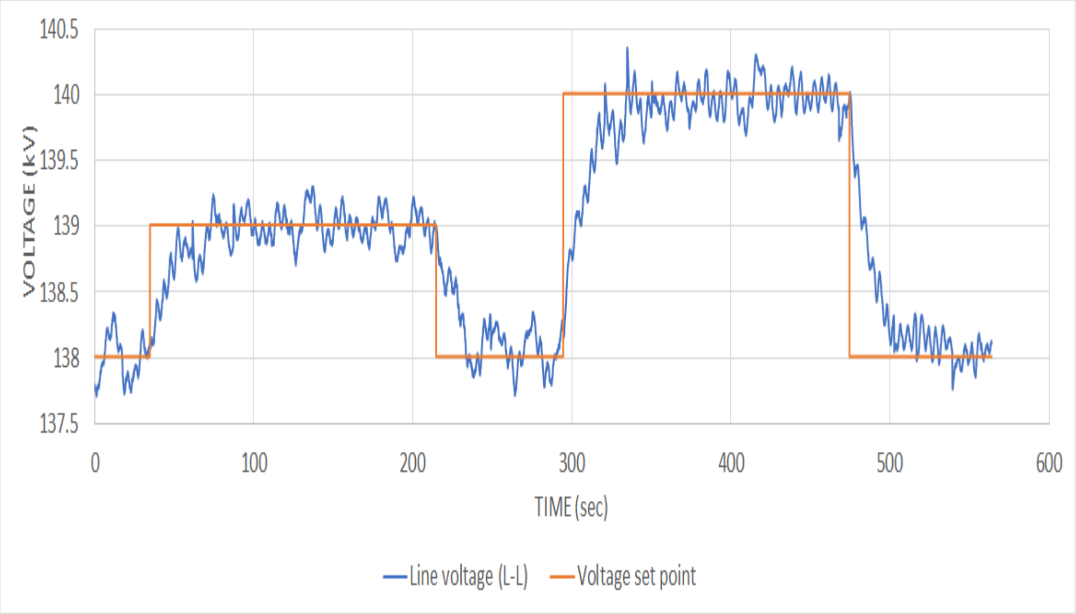




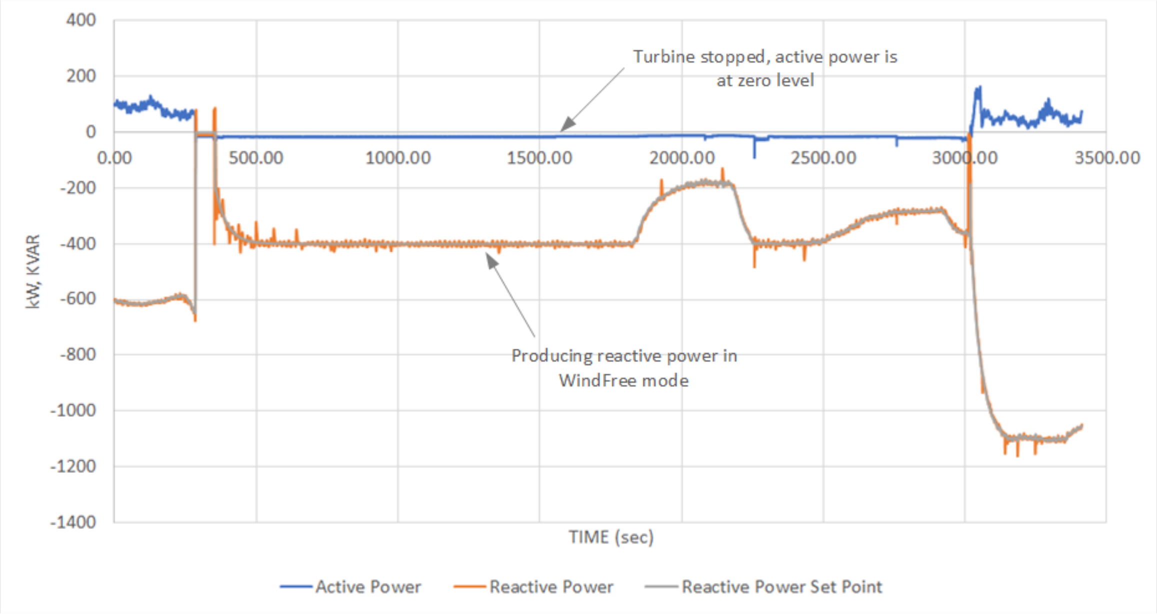


The 131.1 MW Tule WPP providing voltage control when the plant output was varied between zero and full output

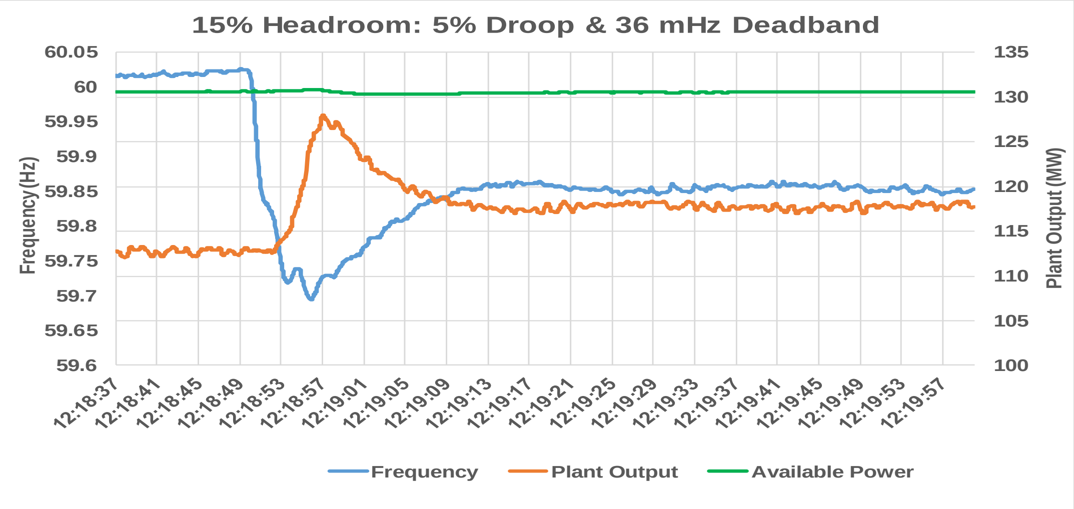
Wind plant following different voltage set-points at the high side of step-up transformer

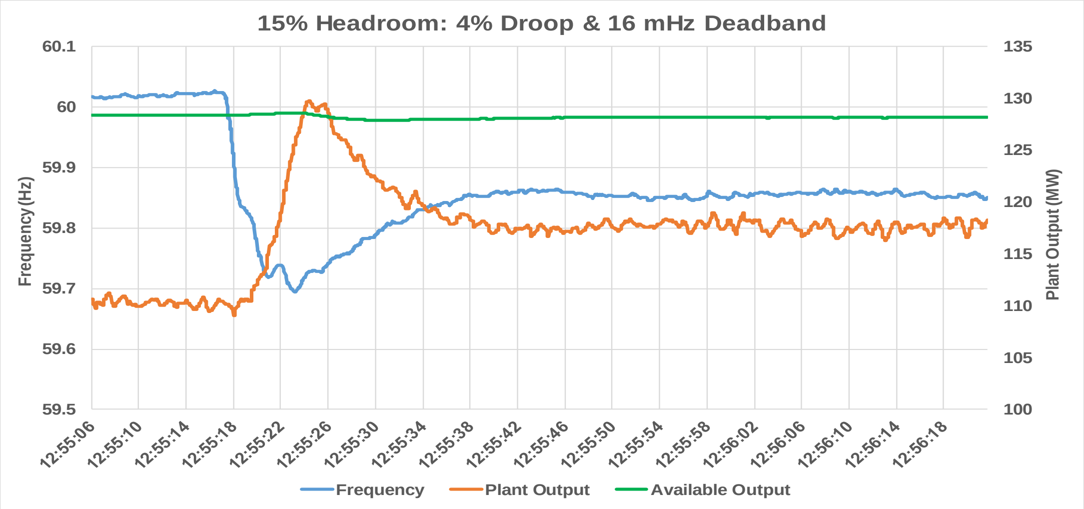


Reactive power control in WindFREE mode at zero MW output



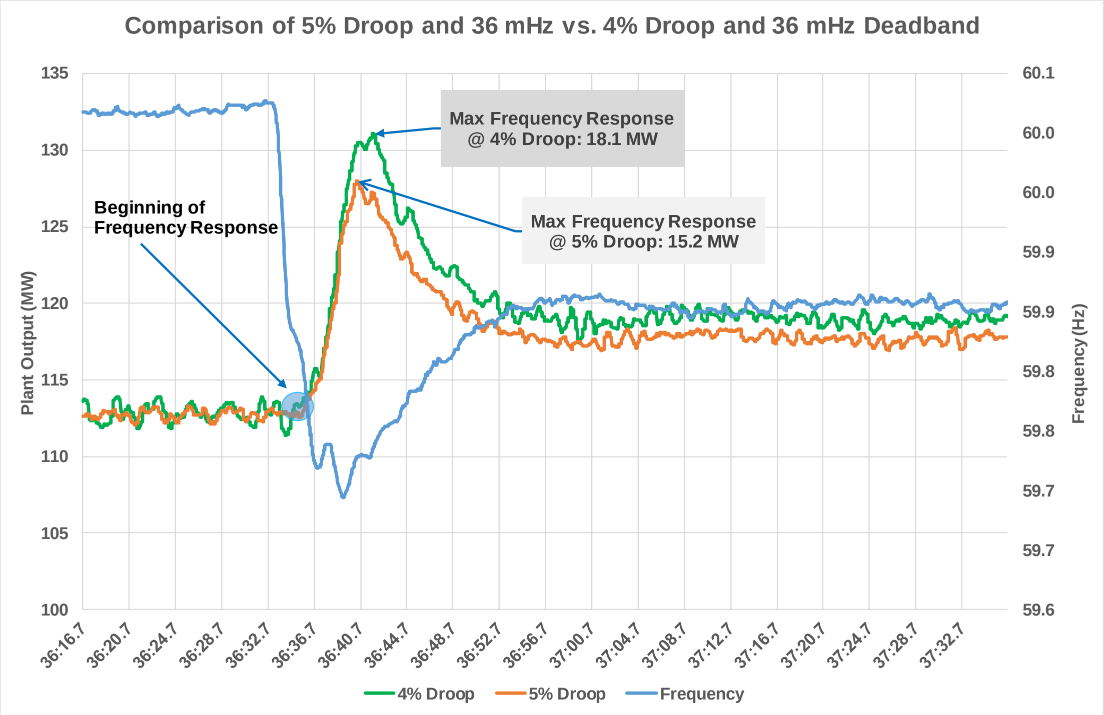
The 131.1 MW Tule WPP providing frequency response for a low frequency event

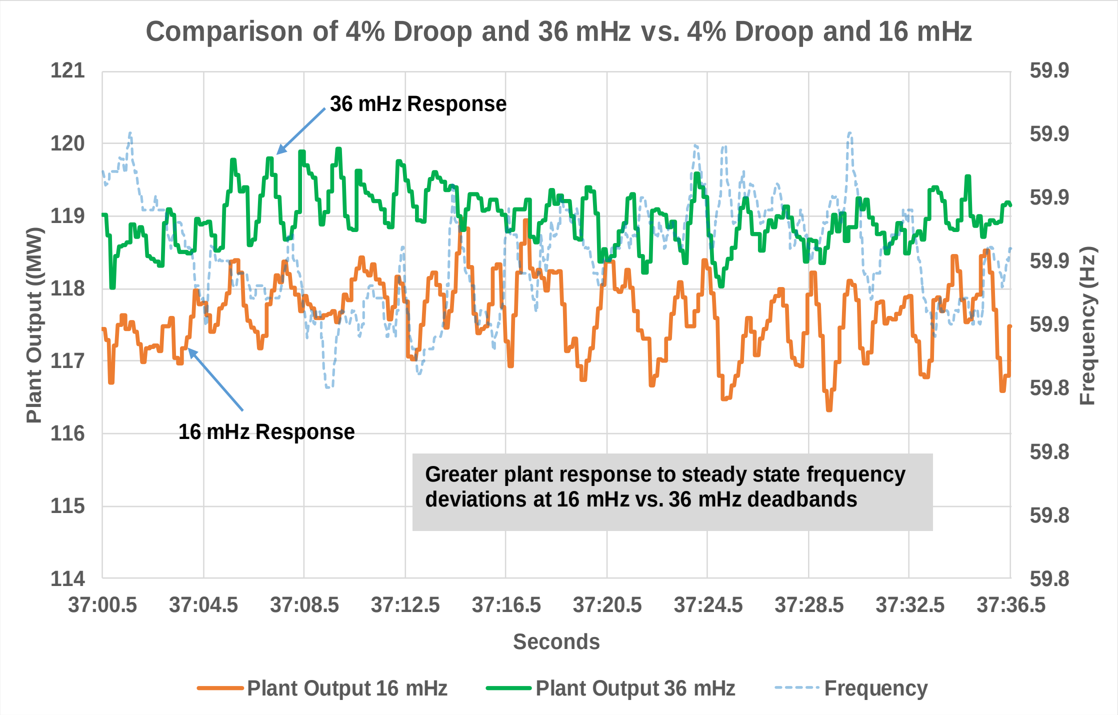




- CAISO’s analysis of actual frequency response following actual frequency events shows that on days with high renewable generation production and low loads, maintaining adequate resources with enough headroom to meet the primary frequency response obligation is a challenge
- While not implemented at the Tule WPP, it should be noted that GE does provide software solutions to support higher speed responses to frequency events when required by grid operators

The 131.1 MW Tule WPP providing frequency response in both the transient and steady-state timeframes





Frequency response at 5% and 4% droop settings and 36 mHz bandwidth for the same low frequency event

Steady state frequency response at 36 mHz and 16 mHz deadbands for the same frequency deviations

Summary

- Improvements in smart inverter technology and advanced plant controls allow inverter-based resources to provide essential reliability services during various mode of operation
- Variable energy resources with the right operating characteristics are necessary to decarbonize the grid
- WPPs capability to provide a full suite of grid-friendly controls already exist. It is mainly a matter of activating these controls and/or implementing communications upgrades to fully enable them
- Fast response by wind inverters make it possible to develop other advanced controls, such as STATCOM functionality, power oscillation damping controls, subsynchronous control oscillation damping and mitigation and other features
- Fine-tuning the power plant controller to achieve rapid and precise response might be necessary
- Many utility-scale WPPs are already capable of receiving curtailment signals from grid operators; each plant is different, but it is expected that the transition to AGC operation mode will be relatively simple with modifications made only to a PPC and interface software.

References

Helpful Links

Avangrid Renewables Tule Wind Farm – Demonstration and Capabiliy to Provide essential Grid Services
http://www.caiso.com/Documents/WindPowerPlantTestResults.pdf

Using Renewables to Operate a Low-Carbon Grid – Demonstration of Advanced Reliability Services from a Utility=scale solar PV Plant
https://www.caiso.com/Documents/UsingRenewablesToOperateLow-CarbonGrid.pdf

Demonstration of Essential reliability Services by a 300-MW Solar PV Power Plant
https://www.nrel.gov/docs/fy17osti/67799.pdf

Integration of Renewable Resources, November 2007
https://www.caiso.com/Documents/Integration-RenewableResourcesReport.pdf

Thank You