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Developing Hydrologically Accurate Power Flow and Dynamic Planning Cases for Atypical Weather Events

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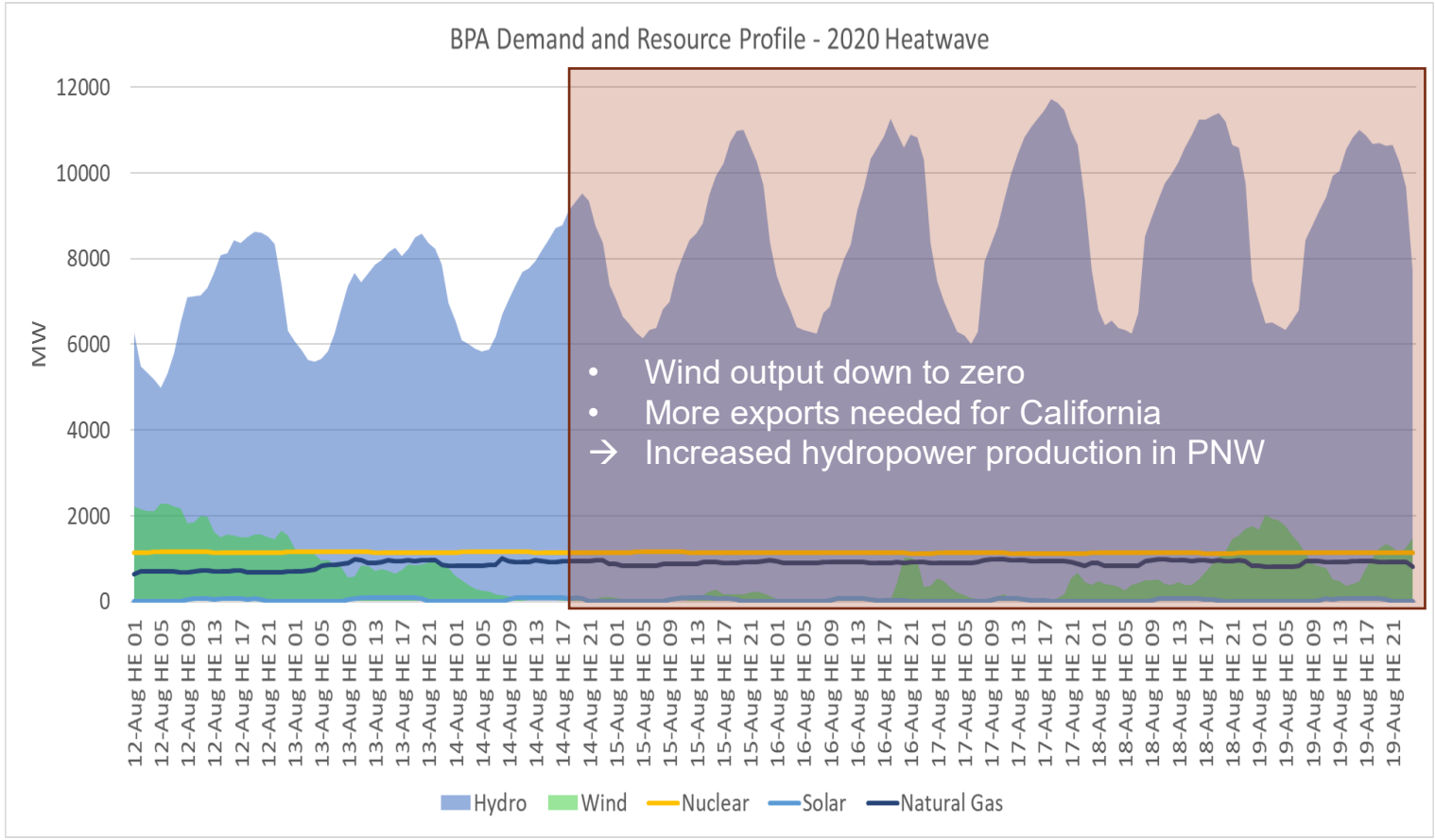
Evolving conditions and stress events are changing reliability and resilience needs

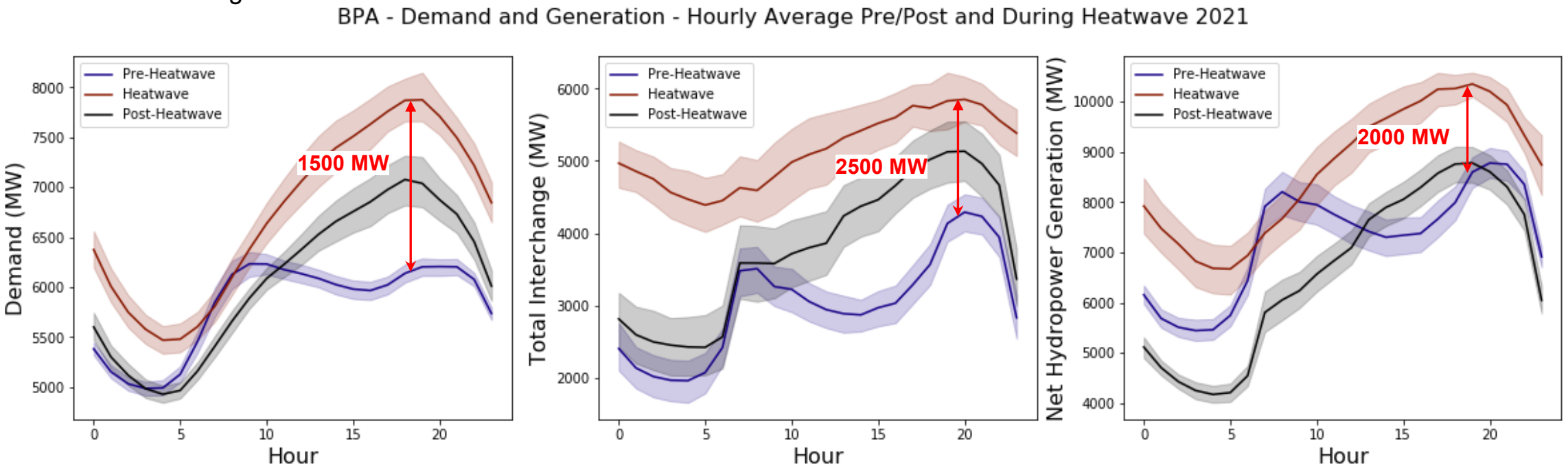
- Increased incidences of extreme weather events
  - Heat waves, cold waves
- Increasing common mode failure events
  - Weather impacts resources, infrastructure, and loads simultaneously
- A different set of resource attributes is required to deal with these events



Historical Data Analyses from EIA data: BPA Metrics – Pre/Post and During Heatwave

Pre-heatwave: May
Heatwave: 22 June – 6 July
Post-heatwave: August

Analytics Summary



- BPA peak demand increased significantly during the heatwave period (June 22 – July 6)
- Hydro generation responded well in following the load and supplying the peak demand during the heatwave period
- Total exports increased significantly during the heatwave period to support the demand of neighboring BAs (PACW, PGE, SCL, PSE)
- No significant contribution from other resource types

These studies are needed to assess the role of hydropower in a rapidly evolving power grid

We have the framework to look at various grid resilience scenarios

- Different future grid scenarios
- Combinations of extreme events
- Changes in future generation mix
- Ramping down / replacement of generation assets

Weather Driven Resource Modeling
- Outcome: Wind, Solar, and Load Profiles
- Outcome: Generator and Line Ratings
- Outcome: Monthly and Weekly Water Budgets

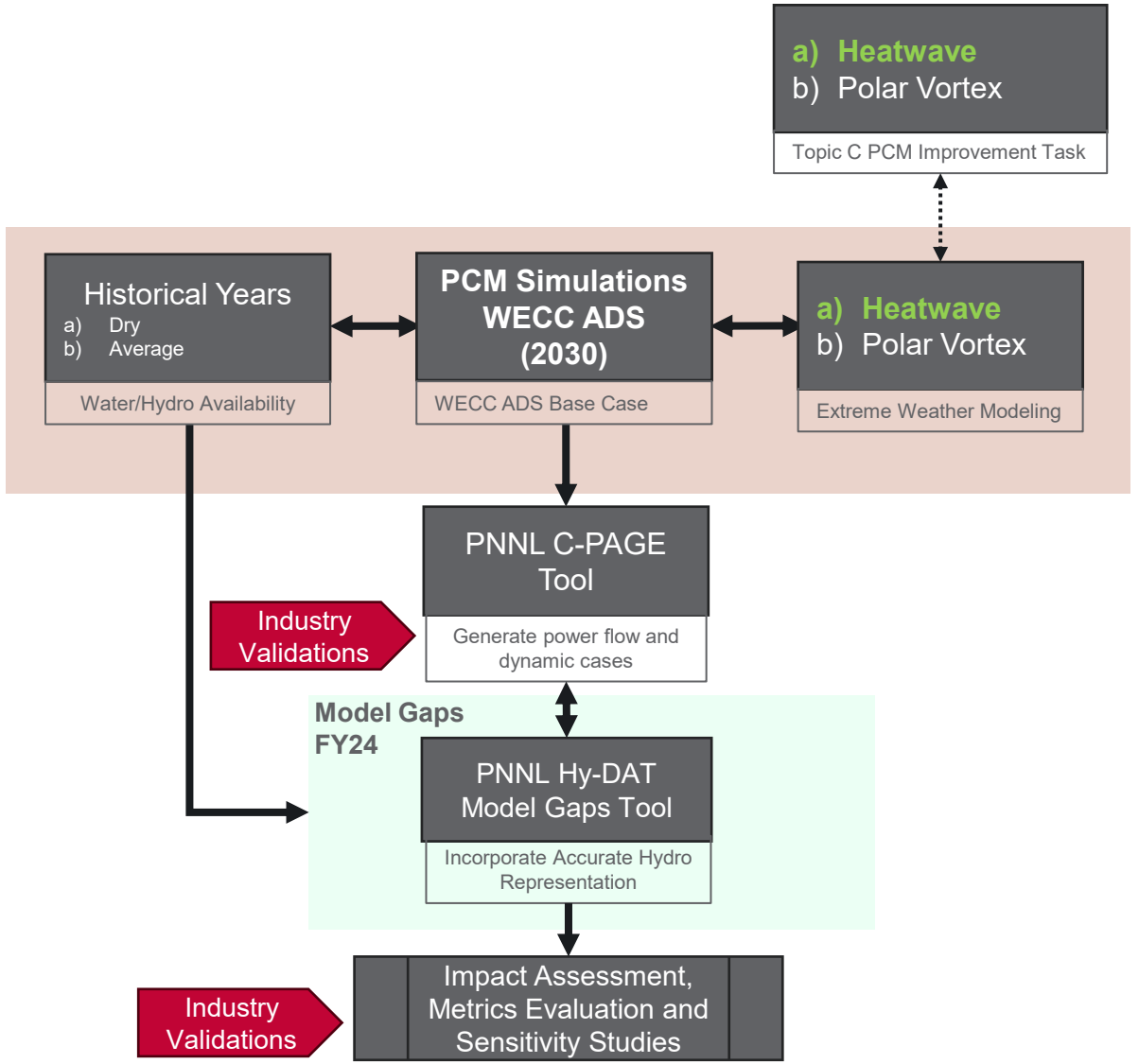
Resource Adequacy Modeling
- Input: Resource Availability/Reliability and Demand
- Process: Simplified Simulation with Stochastic Events
- Outcome: Probabilistic Risk Metrics and Stress Conditions

Production Cost Modeling
- Input: Current and Future Grid Models
- Process: Hourly Simulations During Stress Conditions
- Outcomes: LMPs, Unserved Energy, Dispatch.

PNNL's C-PAGE Tool
- Process: Automated Creation of Operations Scenarios
- Outcome: Power Flow Models for Contingency Analysis

Contingency Analysis
- Input: Contingencies – Generation Outages
- Outcome: Voltage and Flow Violations
- Outcome: Quantification of Hydropower Role

Overall Process for Developing Accurate Planning Cases During Extreme Stress Conditions



PCM Scenarios to be modeled

Modified WECC ADS (2030) PCM (FY25)

- Base Case (A) + Average water year (2009)
- Base Case (B) + Drought water year (2001 + 2010)
- Stress Scenario Heatwave (2015 + 2018) + Average water year (2009)
- Stress Scenario Heatwave (2015 + 2018) + Drought water year (2001/2010)

WECC ADS (2030) PCM (FY26)

- Stress Scenario Coldsnap (E) + Average water year
- Stress Scenario Coldsnap (F) + Drought water year

Some Results from earlier modeling exercise: Scenarios – Compounding Set of Extreme Events

Scenario	Event 1	Event 2	WECC ADS Case	Load	Wind	Solar	Hydro	Thermal Derate
1a	Heatwave 1 23 Jun – 30 Jun	Transmission forced outage - Path 65 & 66 outage due to wildfire	2030 WECC ADS	2030 WECC using 2021 weather profile	NREL 2021 (forecast)	NREL 2021 (forecast)	PNNL 2021* (688 plants weekly)	20% - thermal units that use freshwater withdrawals
1b	Heatwave 1 23 Jun – 30 Jun	Heatwave 2 23 Aug – 30 Aug	2030 WECC ADS	2030 WECC using 2021 weather profile	NREL 2021 (forecast)	NREL 2021 (forecast)	PNNL 2021 (688 plants weekly) HWB*	20% - thermal units that use freshwater withdrawals
2b	Drought + Heatwave 1 23 Jun – 30 Jun		2030 WECC ADS	2030 WECC using 2021 weather profile	NREL 2021 (forecast)	NREL 2021 (forecast)	PNNL 2001 (688 plants weekly) HWB*	20% - thermal units that use freshwater withdrawals

Weather impacts not just system load but also water availability and generation from different sources

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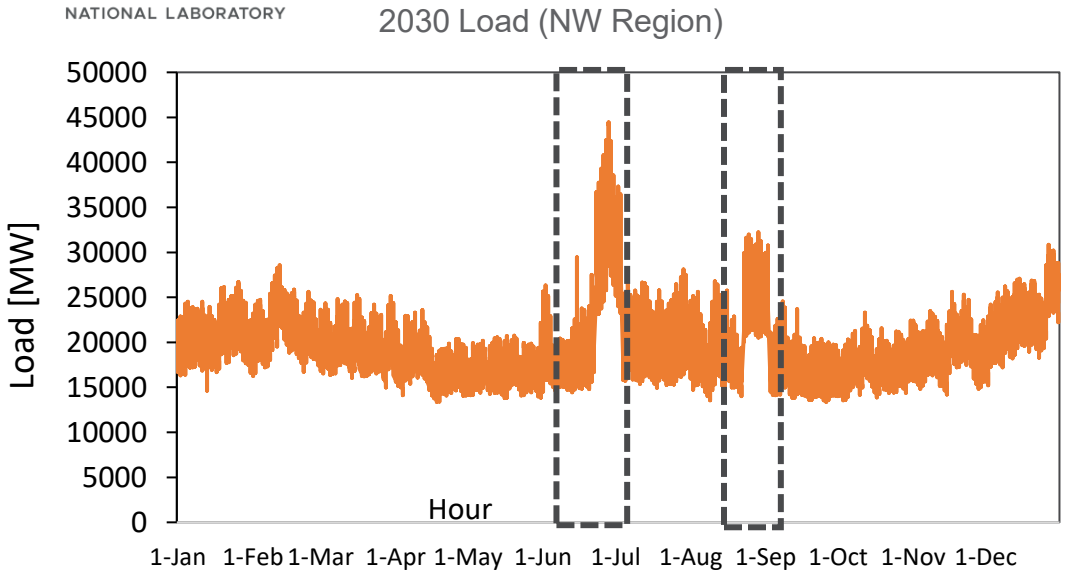
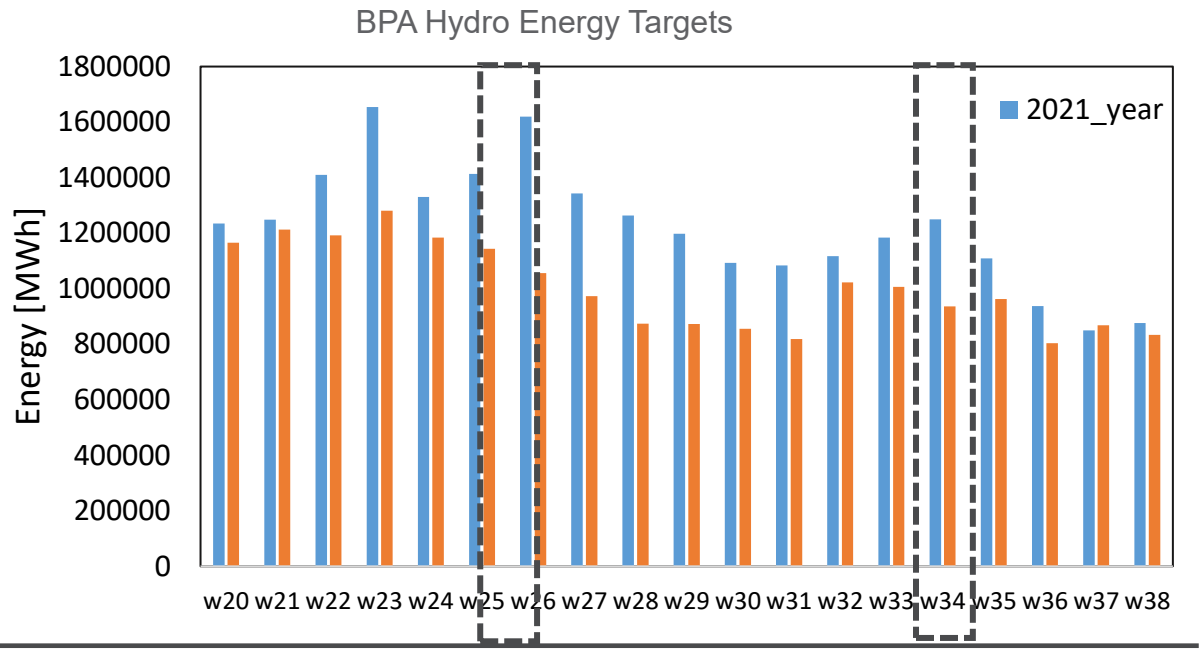
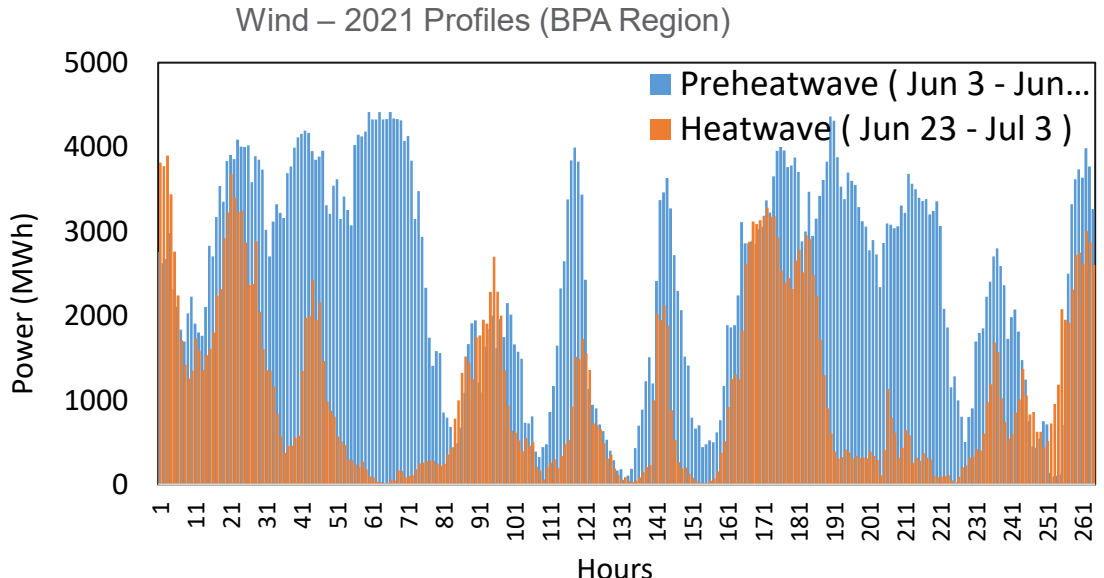
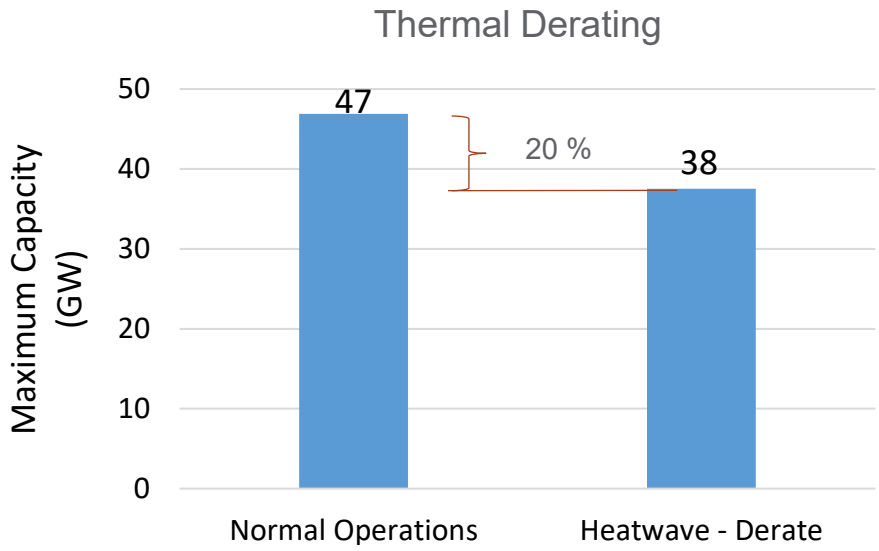


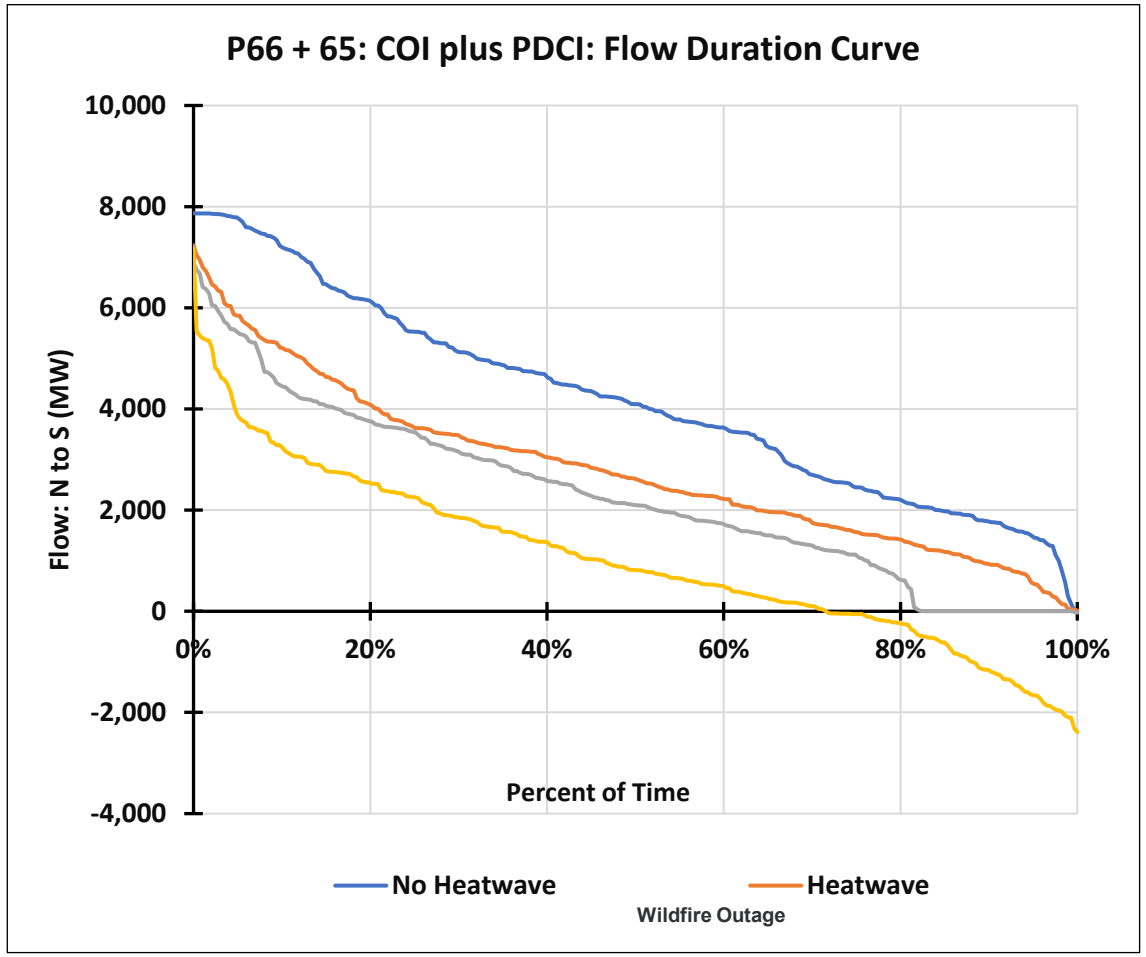


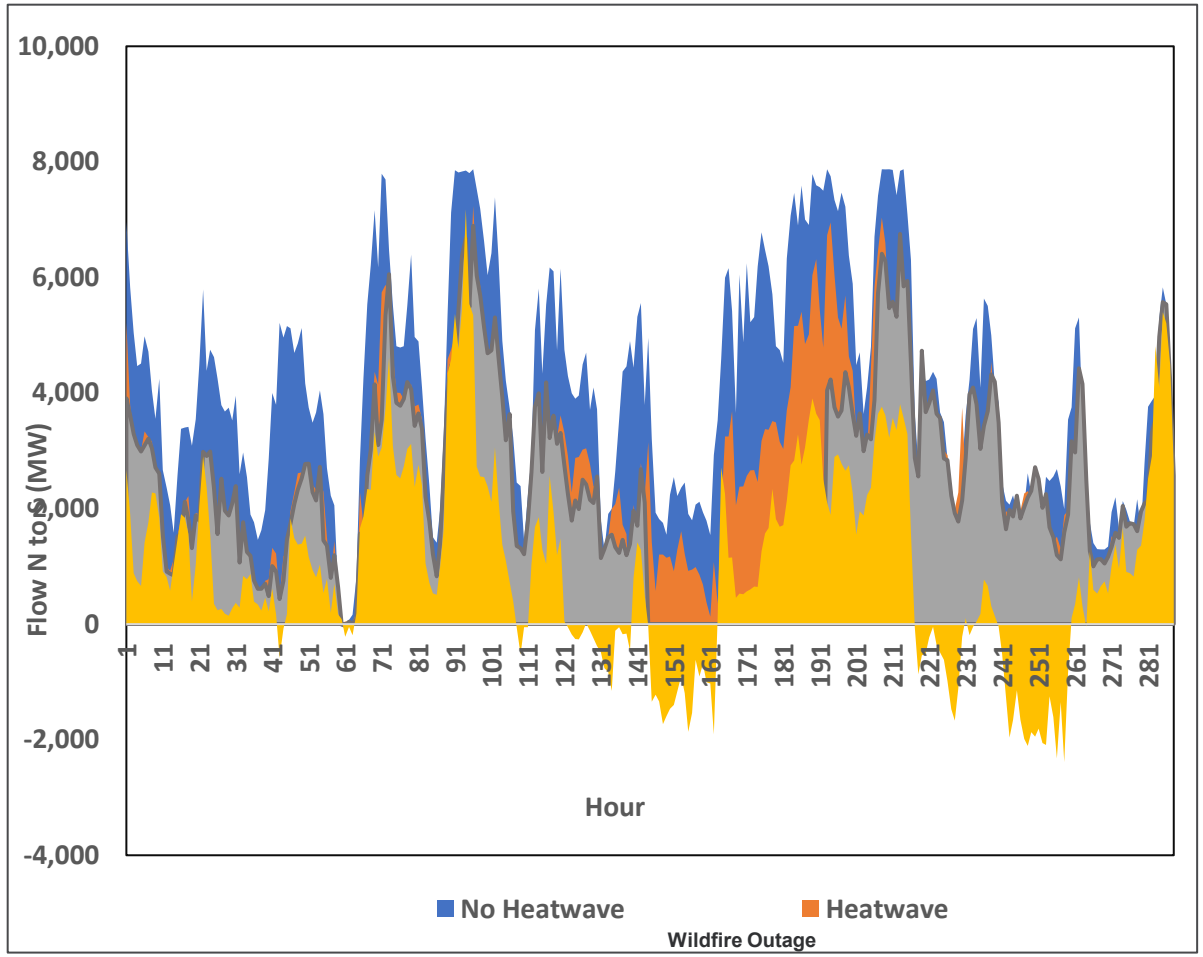




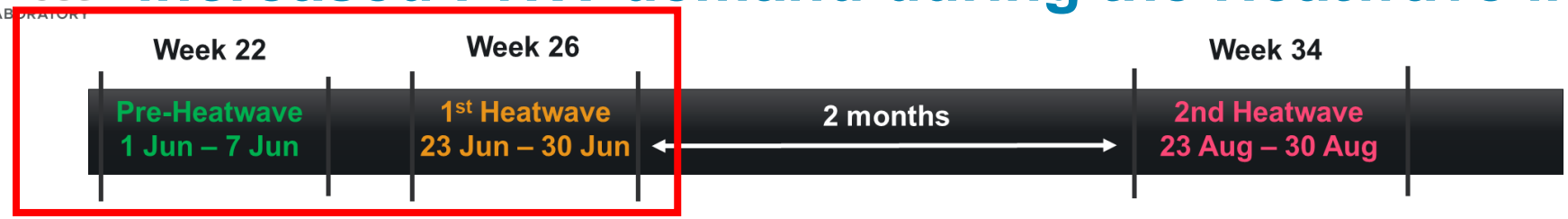
Path 65 and 66 Flows during Stress Grid Conditions

- WECC **2030** ADS: 2nd Heatwave (**23 Aug. – 30 Aug.**)

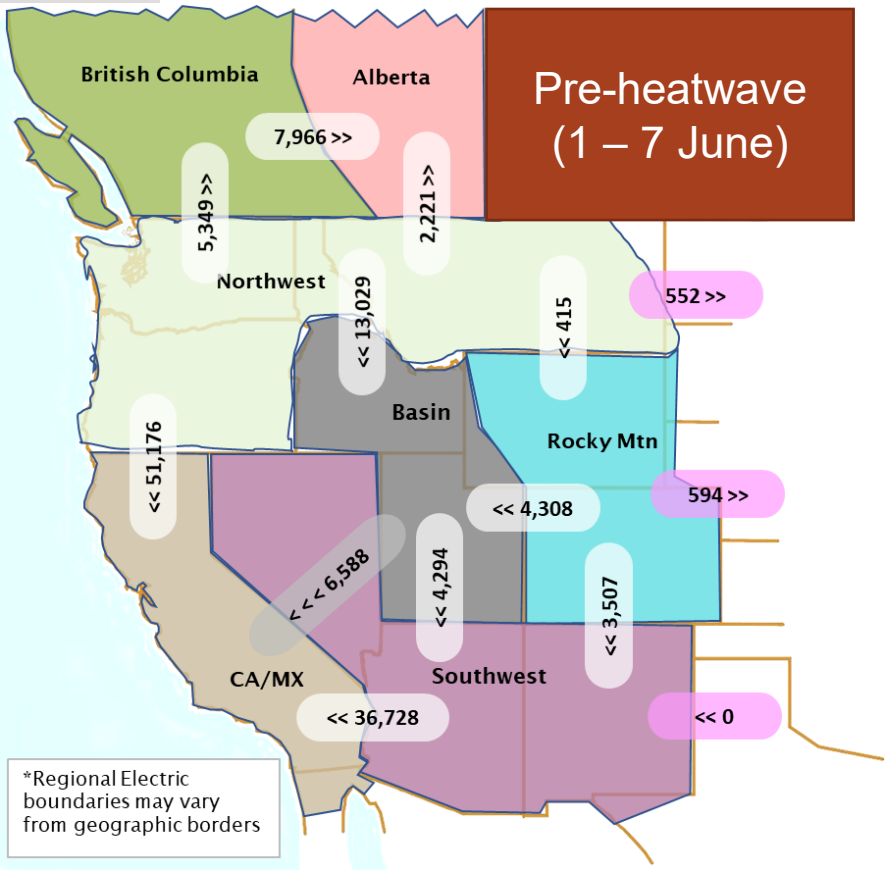


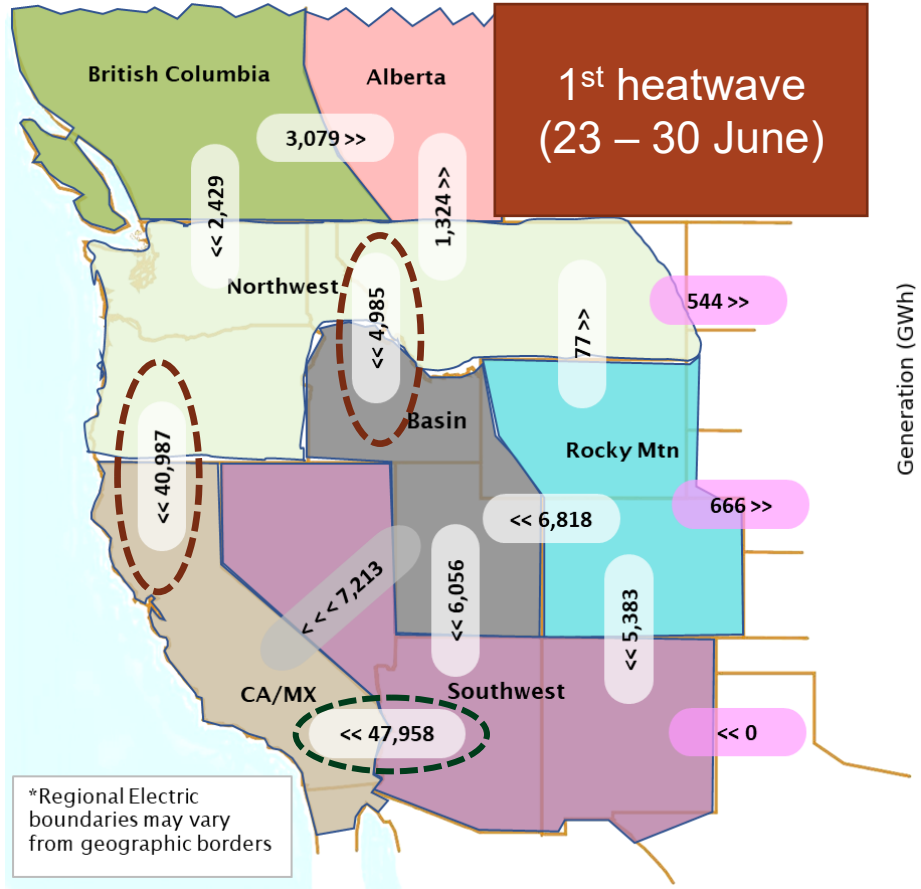


More hydropower (favorable snow water melt) and natural gas resources are utilized to supply the increased PNW demand during the Heatwave in June.

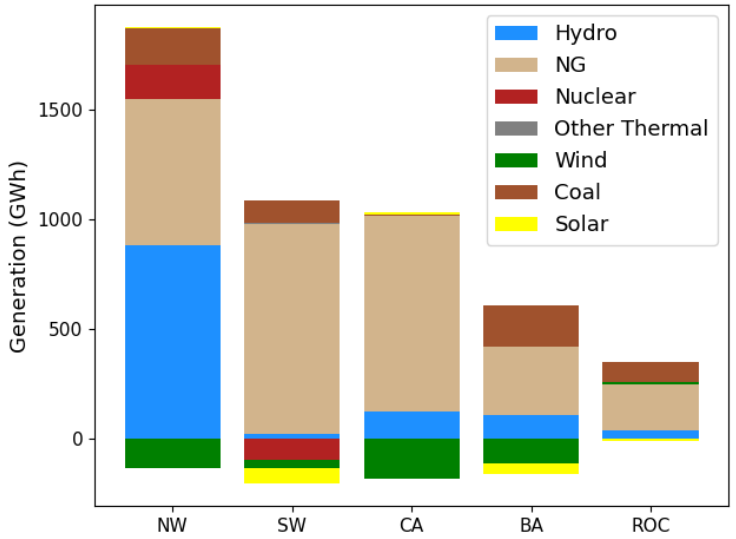


Average Net Regional Transfers (GWh)

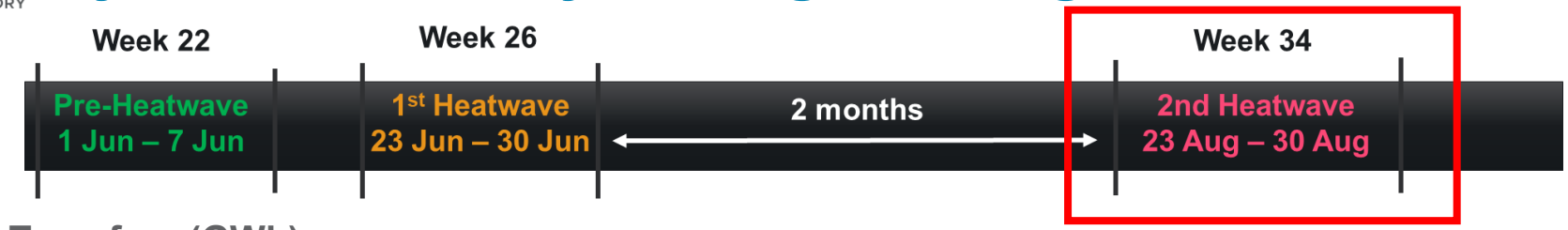




Generation Difference (GWh)



Increased natural gas-based generation compensates for limited hydropower generation in the PNW due to limited hydro availability during the August heatwave



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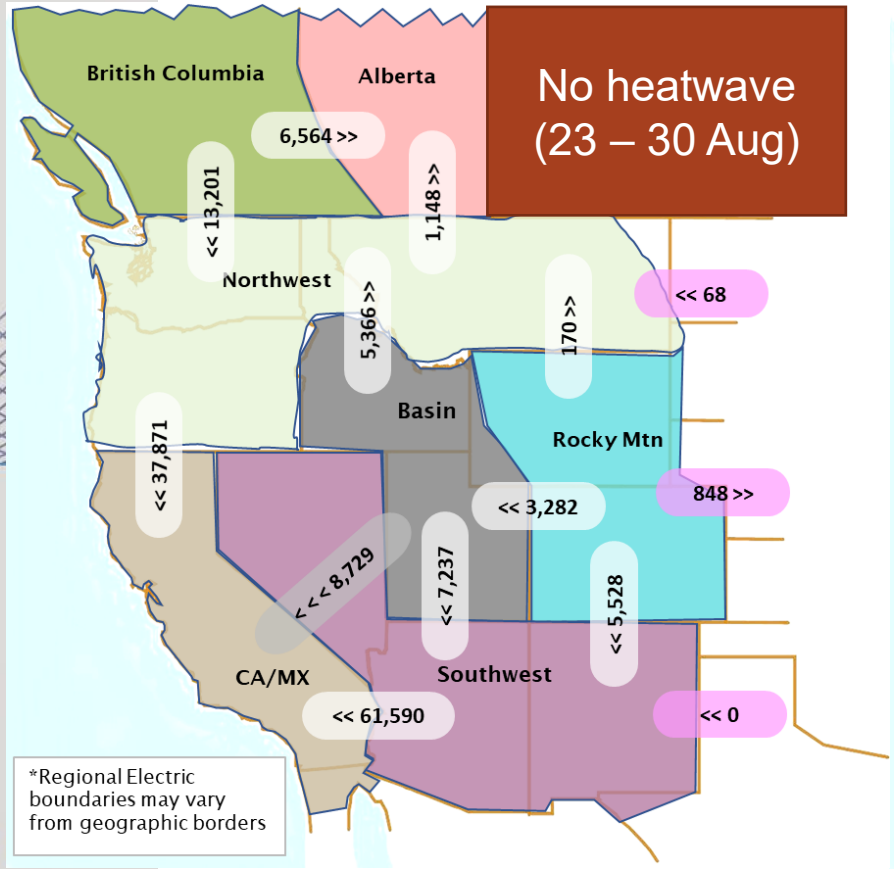

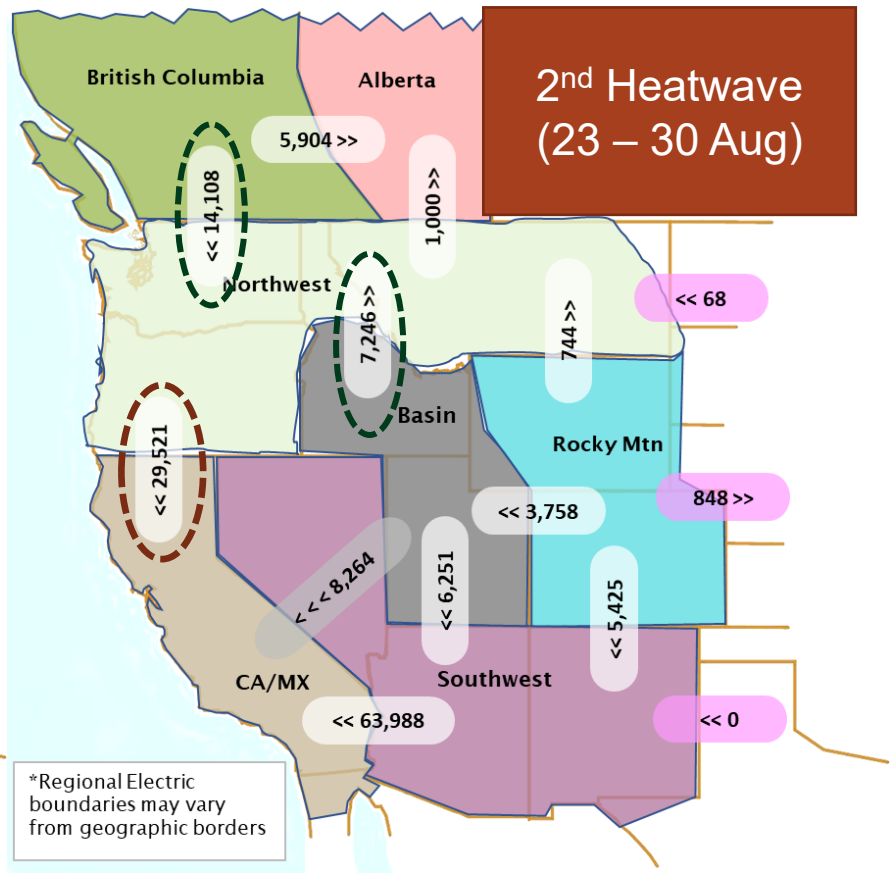

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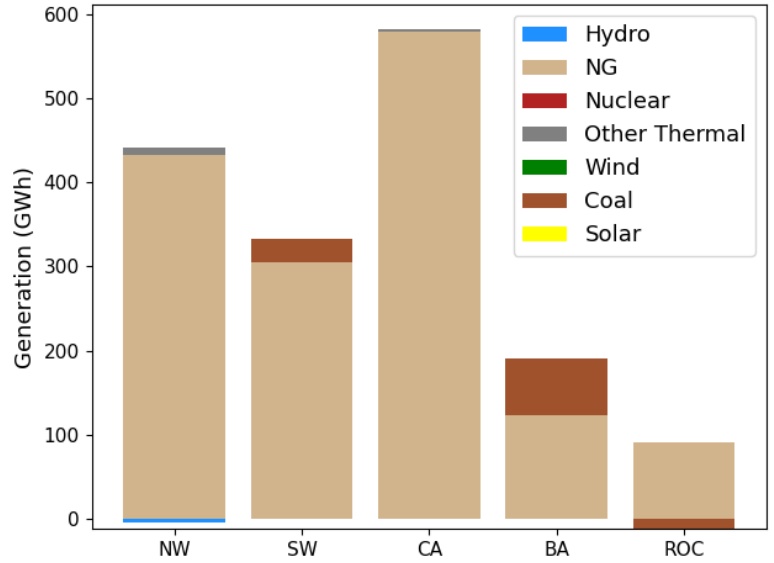

Frequency response capability of hydropower diminishes over time, due to lower water availability as the year progresses

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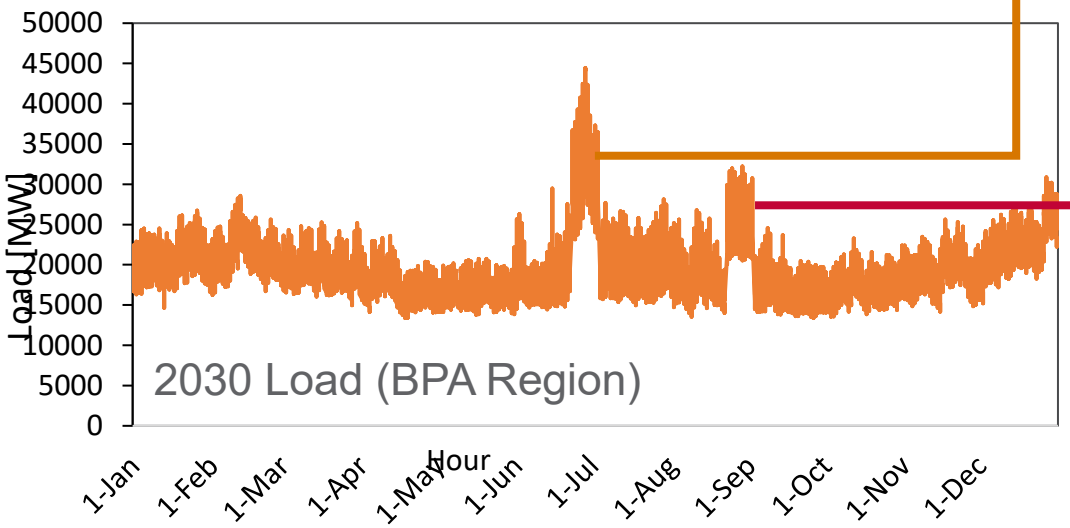

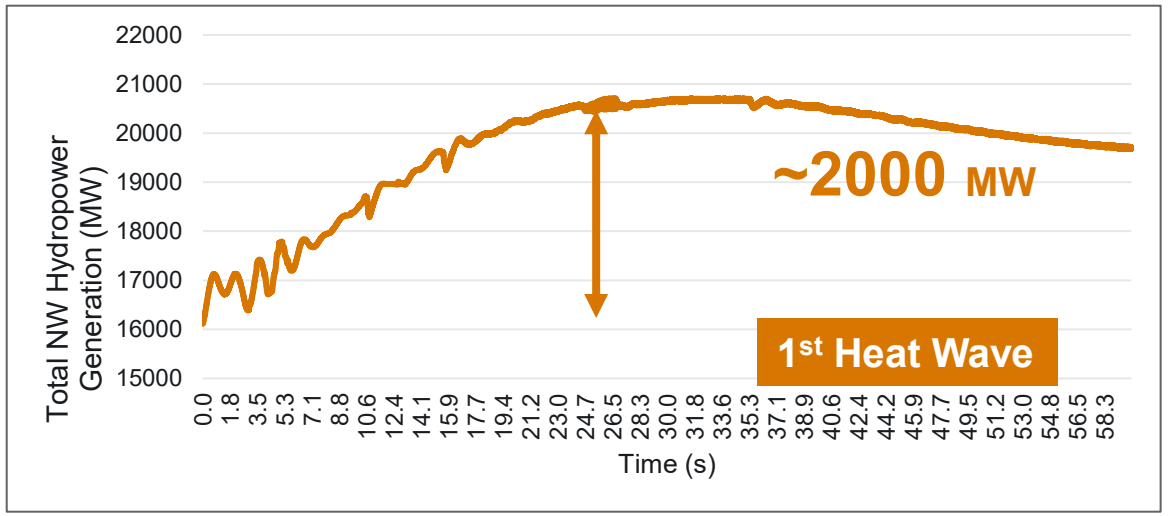

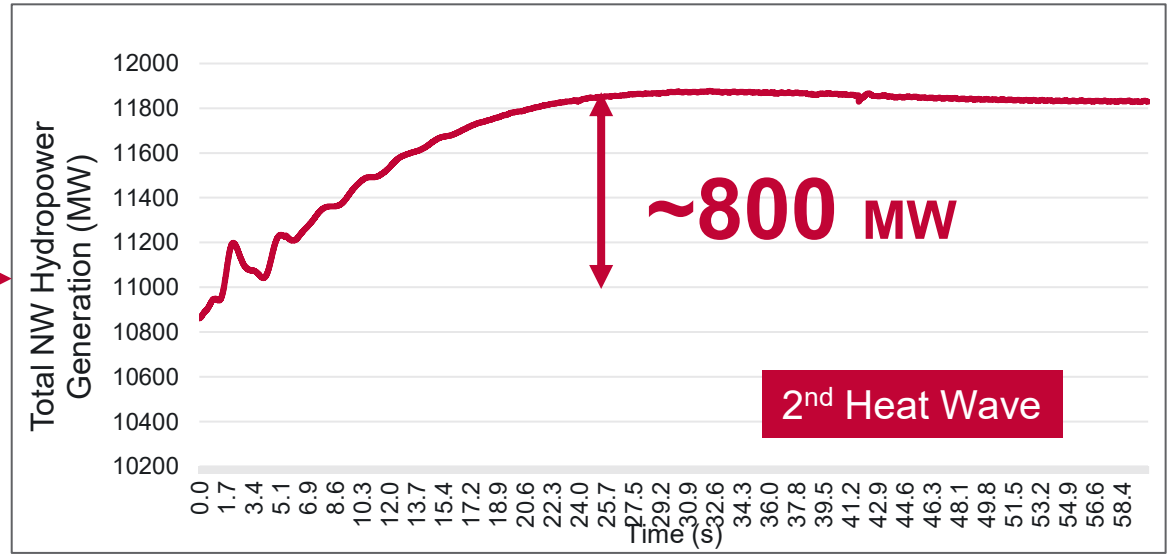

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Key Takeaways

- The chain of tools provides a comprehensive framework to develop planning cases under stress conditions as well as improve hydropower representation in the models.

Next Steps

- HYDAT tool will be used to update power and dynamic model parameters to quantify the impact of hydropower representation.
- Steady state and dynamic contingency analyses studies to be done across multiple scenarios with different hydro availability.
- Share results, power flow, and dynamic models with the industry for feedback.

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Thank you

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