

The Evolving Role of Extreme Weather Events in the U.S. Power System with High Variable Generation Penetrations

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Power System Notes from PNW Heat Wave

- PNW is typically a winter peaking region
- 2021 is a lower-than-average water year, but still able to allocate water specifically to this period
- Nuclear plant brought back online from spring maintenance
- Deferred transmission maintenance to avoid congestion and limit flow on lines
- Rolling blackouts occurred, but tended to be local issues with infrastructure rather than broader system failures
- Fires have severely limited the flow on the Oregon-California interties
- California has implemented measures from learnings of August 2020

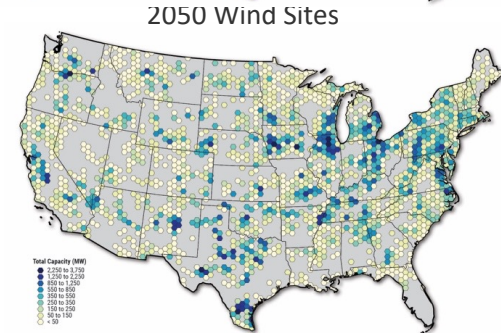
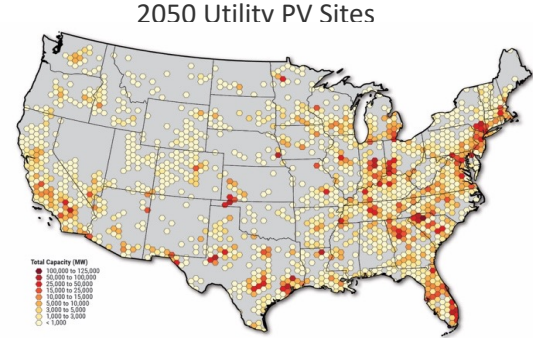
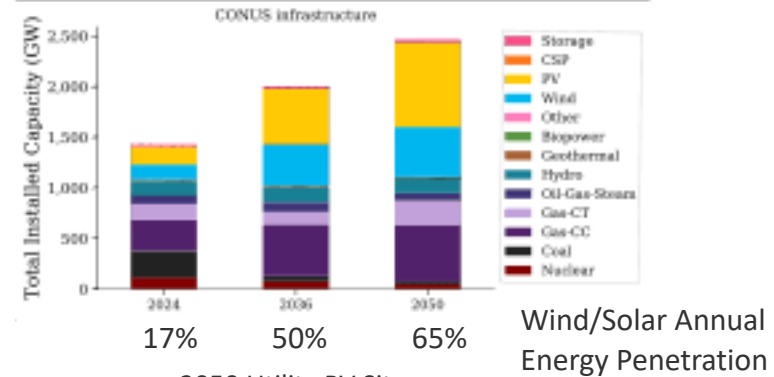
Objectives and Motivation

Identify weather events for deeper meteorological analysis and variable generation resource assessment

- News-Worthy (Cold/Heat Waves, Major Storms)
- Challenges to Planning in High Variable Generation System

Model operations of system during events under increasing penetrations of Variable Generation using Production Cost Model

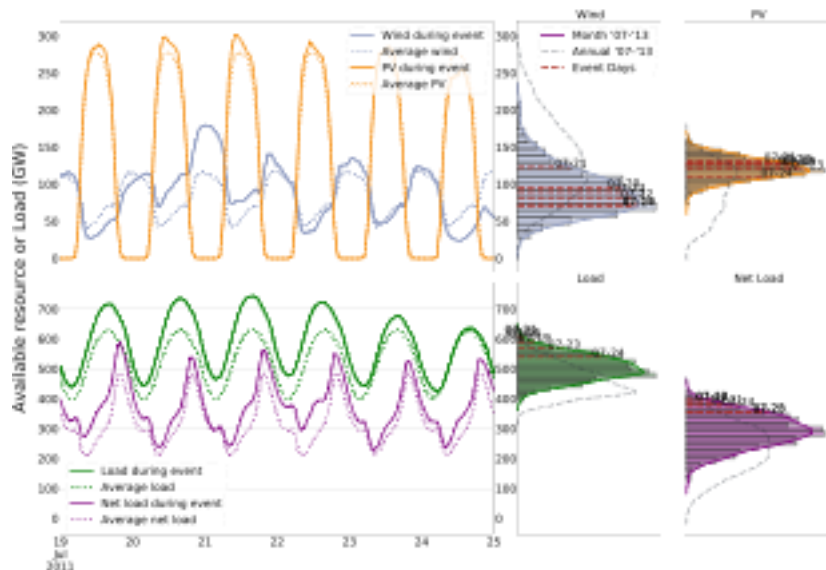
- Three infrastructure scenarios designed by NREL's ReEDS model: 2024, 2036, 2050
- Hydro and wind icing & cold temperature cut-out sensitivities on 2050 infrastructure.



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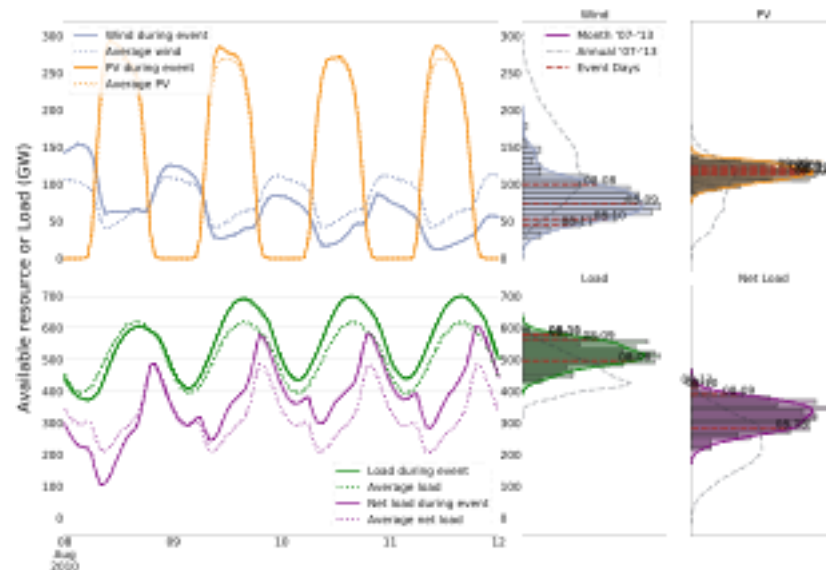
Operations in heat waves change due to PV, but adequacy concerns driven by wind

Heat Wave 1 (July 19th - 24th, 2011) Eastern Interconnection
Time Series Daily Probability Density



Highest EI load days in dataset are mitigated by average wind and PV resource.

High Net Load 4 (August 8th - 11th, 2010) Eastern Interconnection
Time Series Daily Probability Density

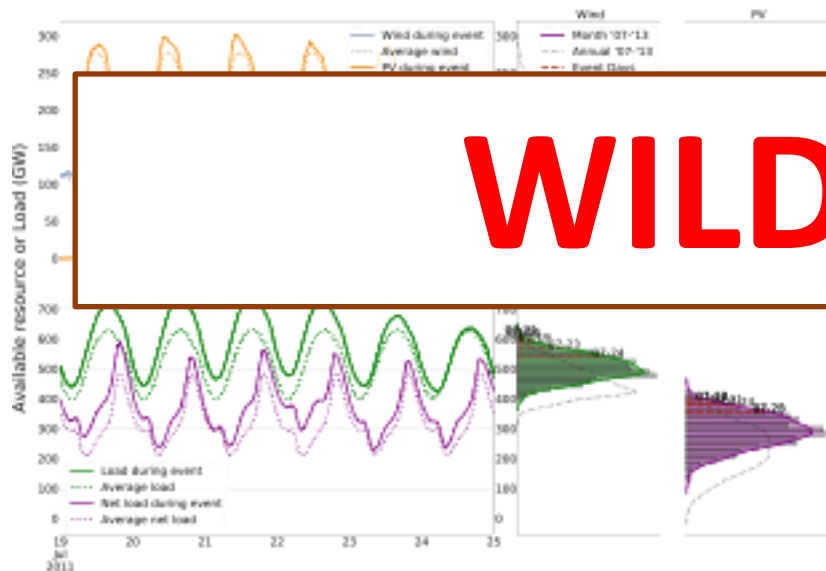


High, but not extreme high, EI load become extreme high net-load days with below average wind but average PV resource.

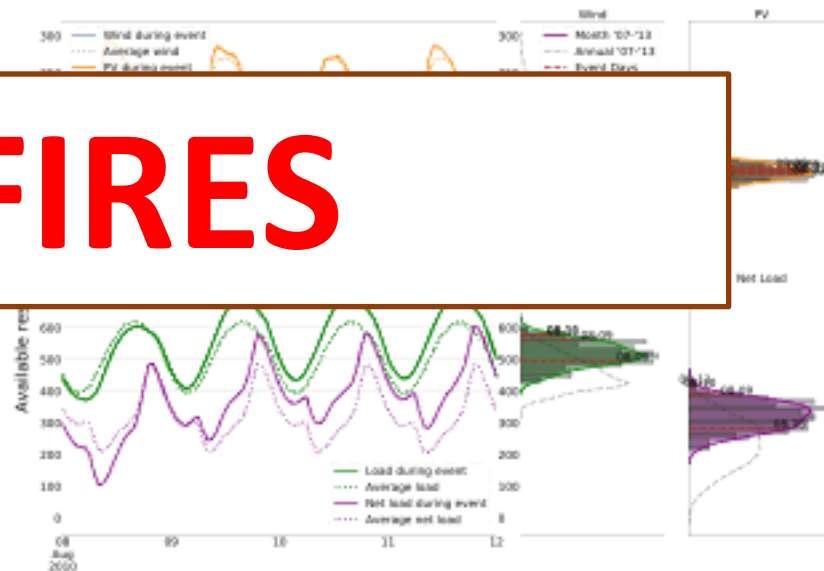
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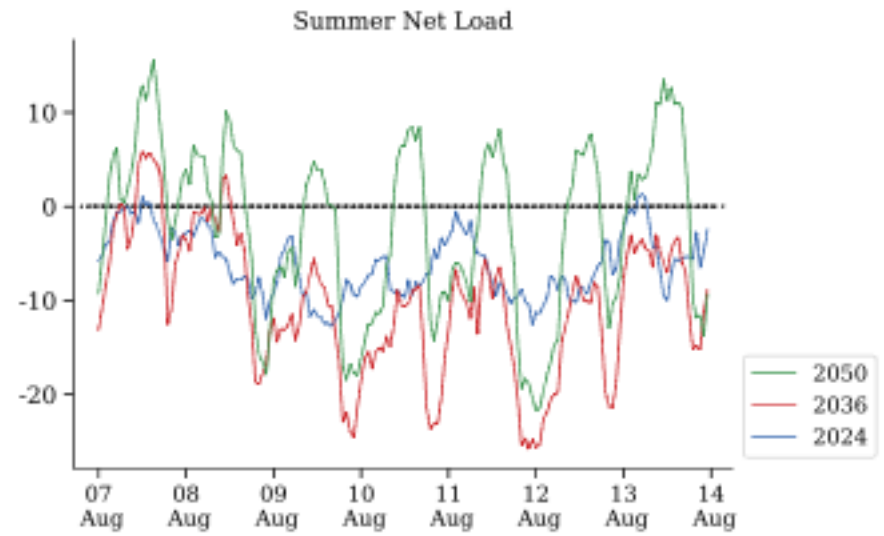
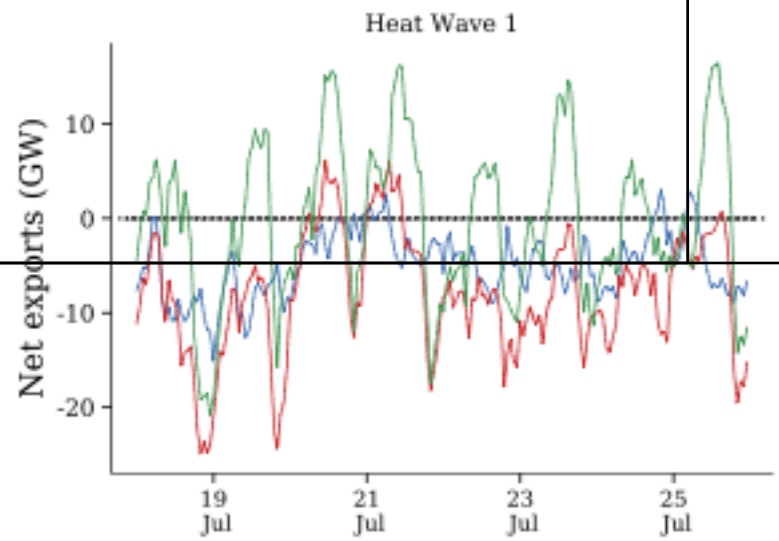
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Net exports from MISO to its neighbors

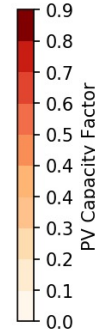
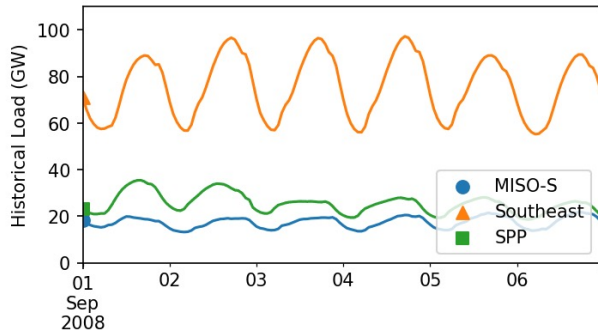
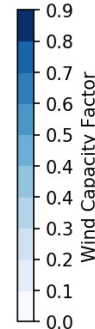
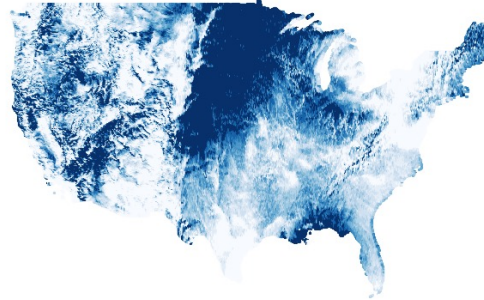
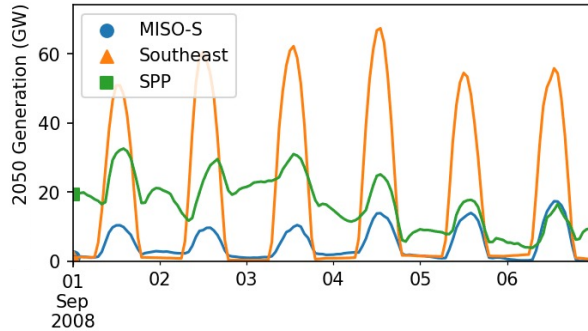


Transmission in both heat waves is operated more dynamically. MISO, typically an exporter of wind power, requires more imports during **Summer Net Load** event.

Heat Wave Future Takeaways

- Heat waves are correlated with clear sky, and PV potential is generally average.
- Stronger heat waves tend not to be associated with continental scale high pressure systems, and thus wind output tends to be seasonally average.
 - Hot, but not hottest days can have weather that leads to well below average wind over large areas.
- Hydro availability and flexibility are uncertain in the future but are valuable to allow for adequate supply.
- Net load peak (after sunset) is what we care about for future heat waves. This is different than other events, such as cold waves.
- The transition to a decarbonized system may lead other weather events to be more concerning.

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Thank you

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