



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

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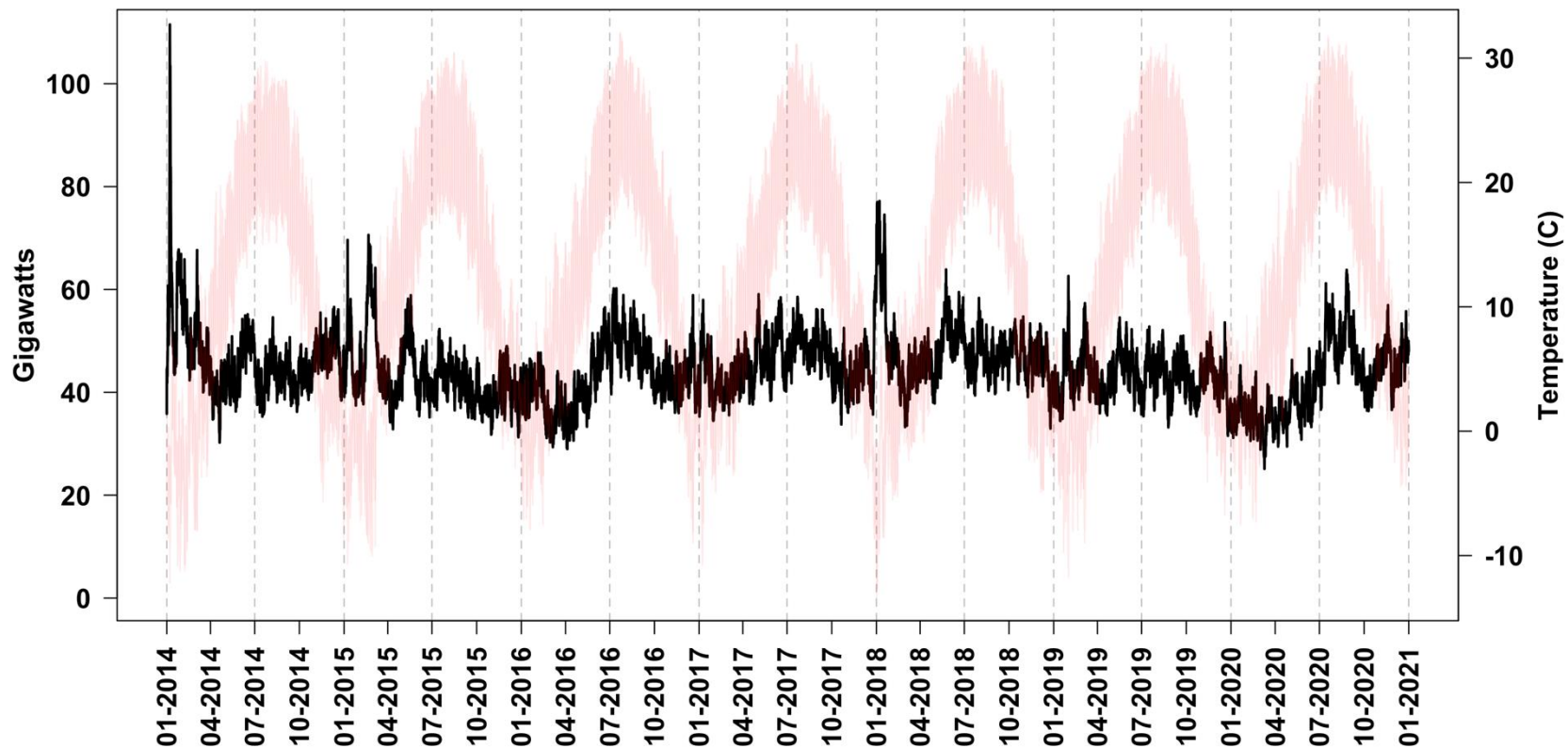
Laboratory Program Manager - Grid Integration

Living with Climate Change: The Polar Vortex
Anticipating Threats and Building Preparedness
Wednesday, April 13, 2022 12:00pm - 1:30pm EDT

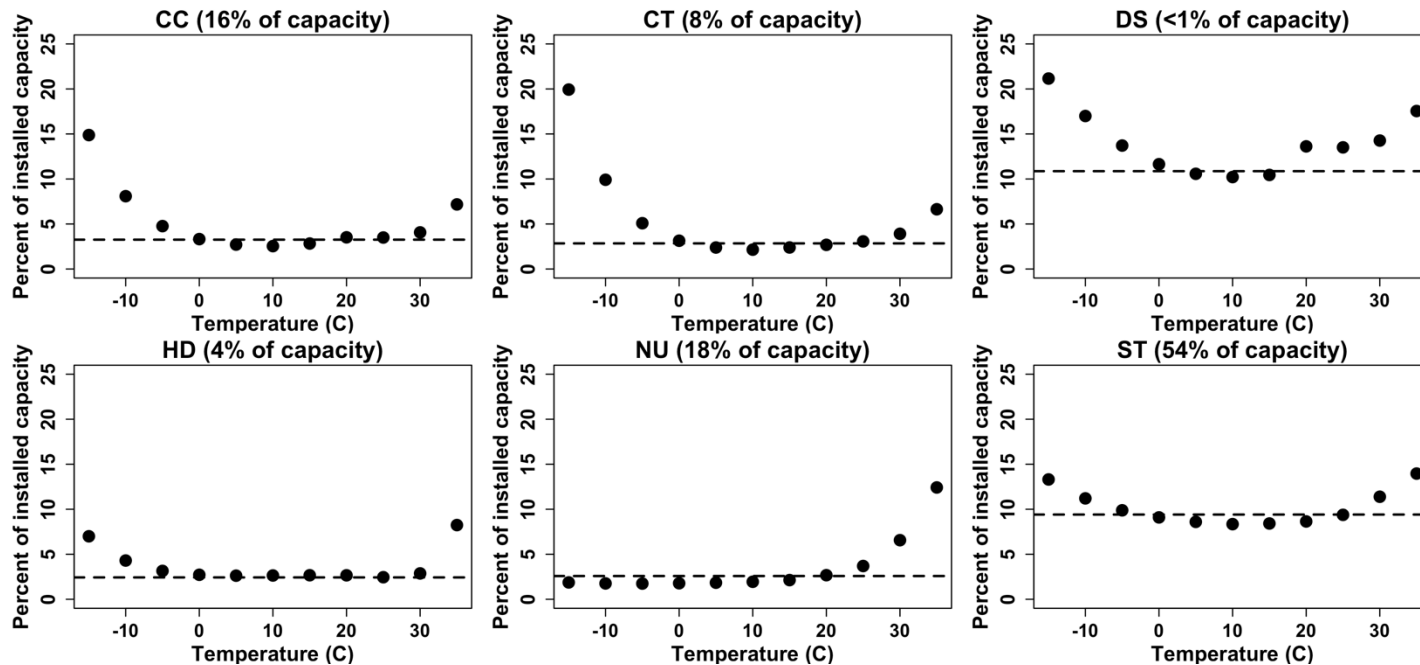
Aggregate unavailable generation capacity with temperature overlay

All plots are:

- Hourly time series
- Unscheduled events only
- CONUS generators only



Temperature dependence in PJM thermal/hydro generators

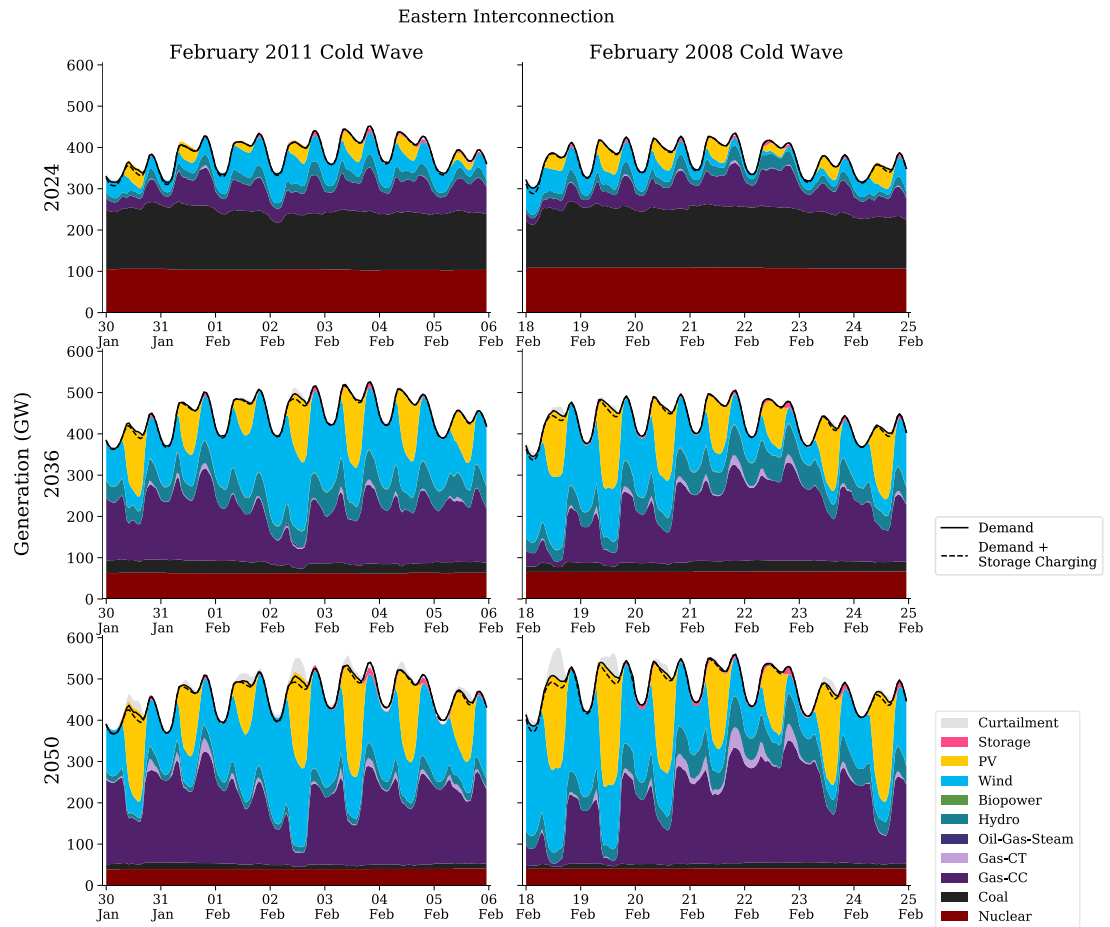


Murphy, S., Sowell, F., Apt J. "A time-dependent model of generator failures and recoveries captures correlated events and quantifies temperature dependence." Applied Energy. November 2019. <https://doi.org/10.1016/j.apenergy.2019.113513>

Unit type key:

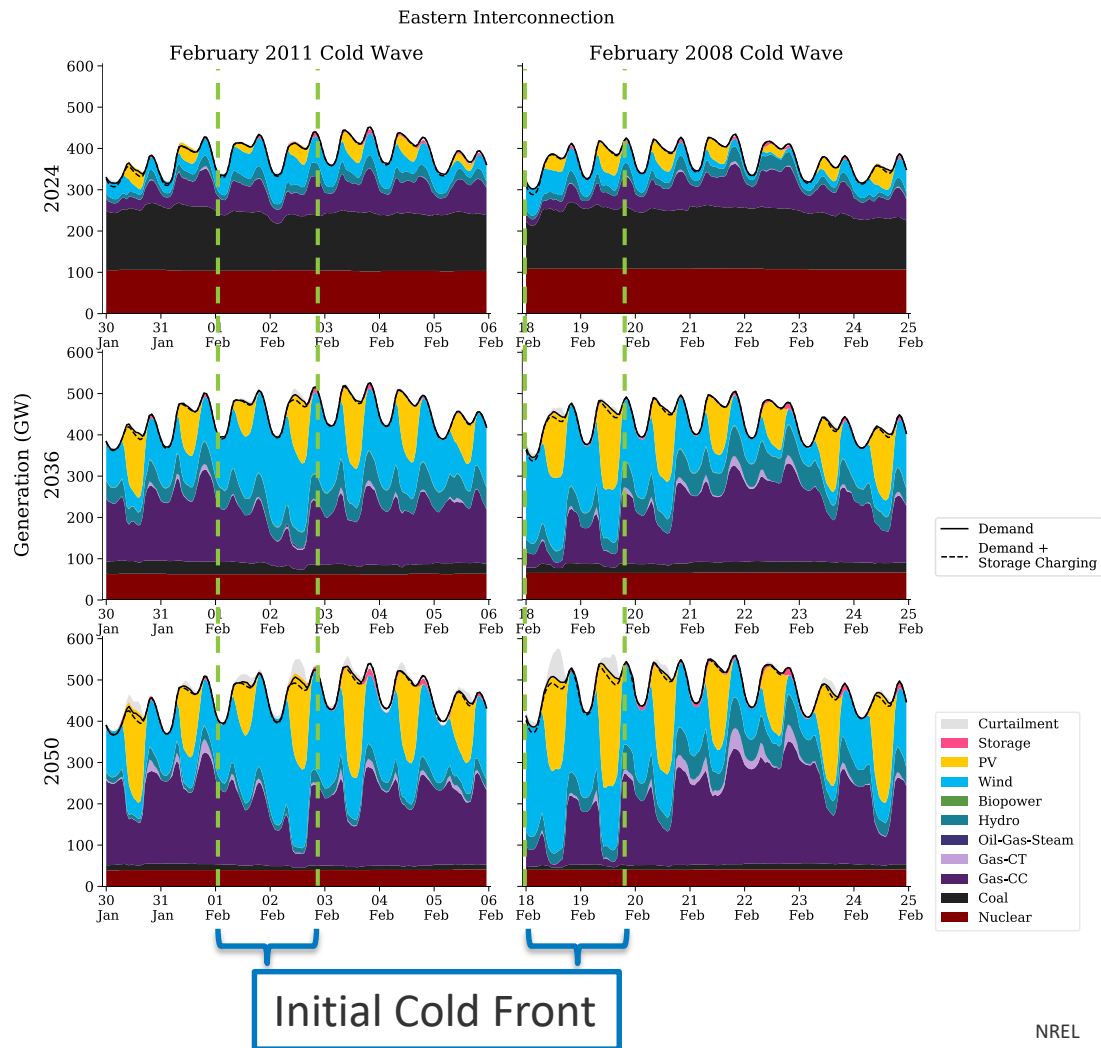
CC: combined cycle gas HD: hydroelectric
 CT: simple cycle gas NU: nuclear
 DS: diesel ST: steam turbine (coal)

Evolution of operations during cold waves driven by wind dynamics



Evolution of operations during cold waves driven by wind dynamics

In both cold waves, wind and solar generation provide >80% of generation in the EI even as load increases as the cold front moves across the continent.



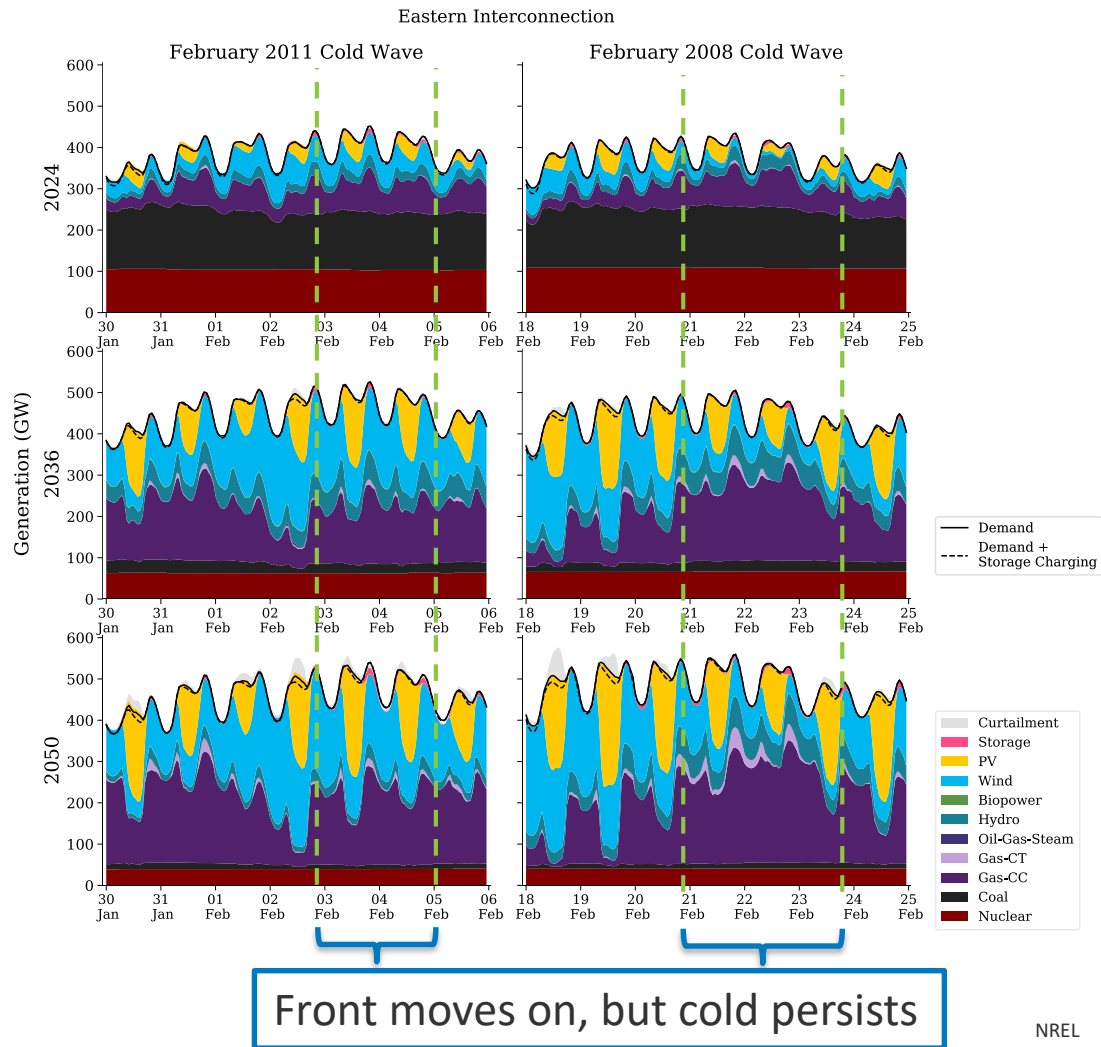
Evolution of operations during cold waves driven by wind dynamics

2011 Extreme Cold Wave

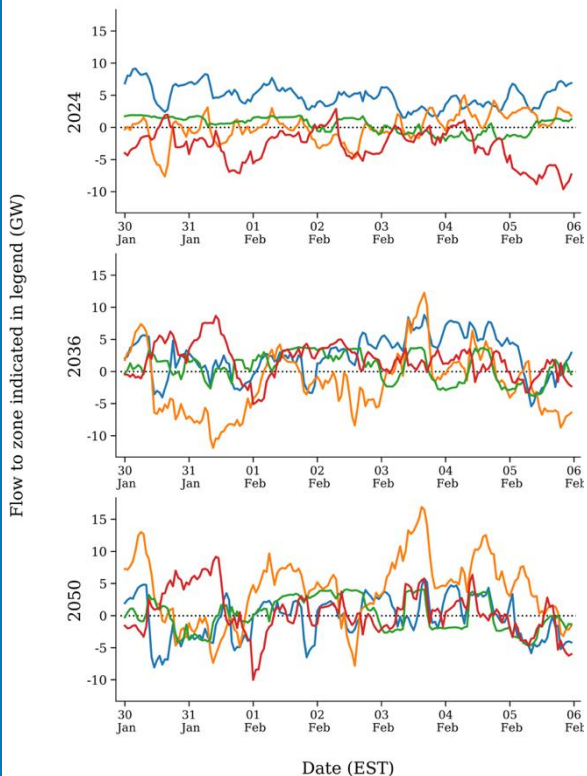
Wind and solar continues to serve ~50% of load after front moves through and load is elevated.

2008 Milder Cold Wave

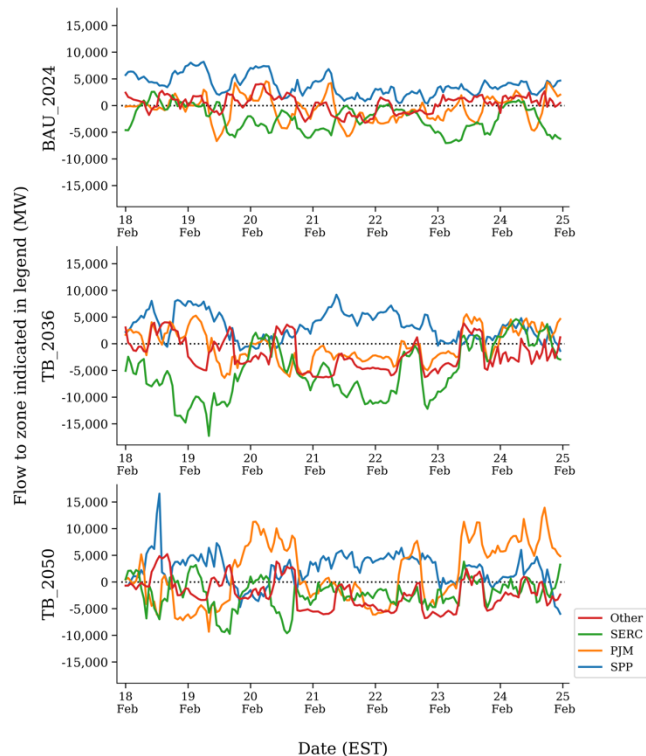
Overnight wind penetrations drops below 10% of all generation. Offline thermal reserves drop in MISO and SPP.



February 2011 Cold Wave



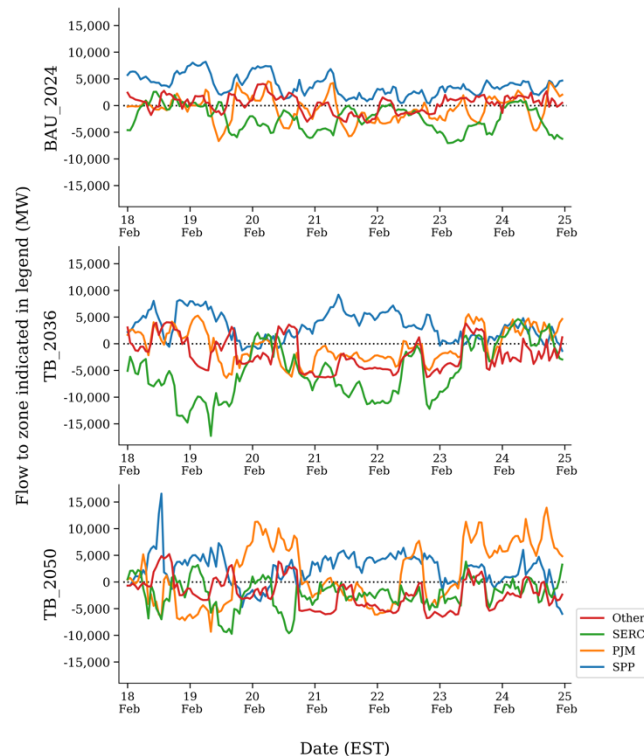
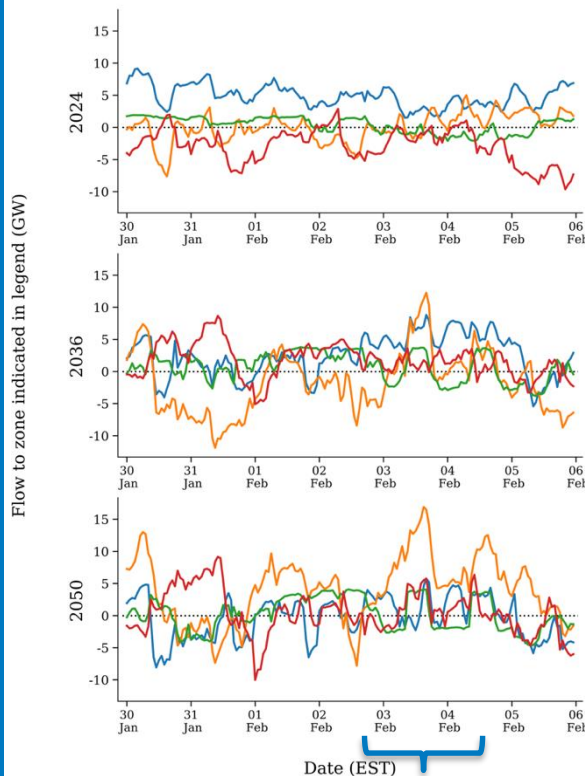
February 2008 Cold Wave



Evolution of
operations during
cold waves driven
by wind dynamics

February 2011 Cold Wave

February 2008 Cold Wave



Swing in MISO exports to PJM used to serve SERC and NYISO

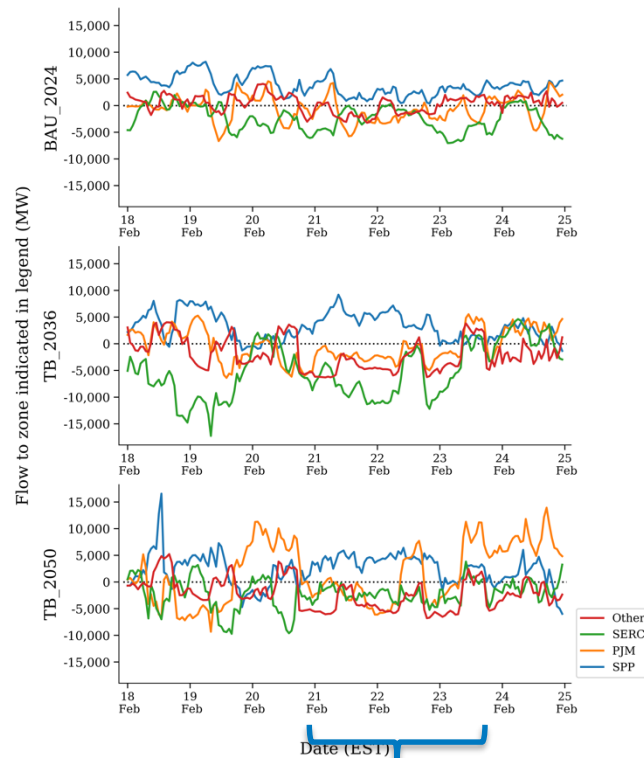
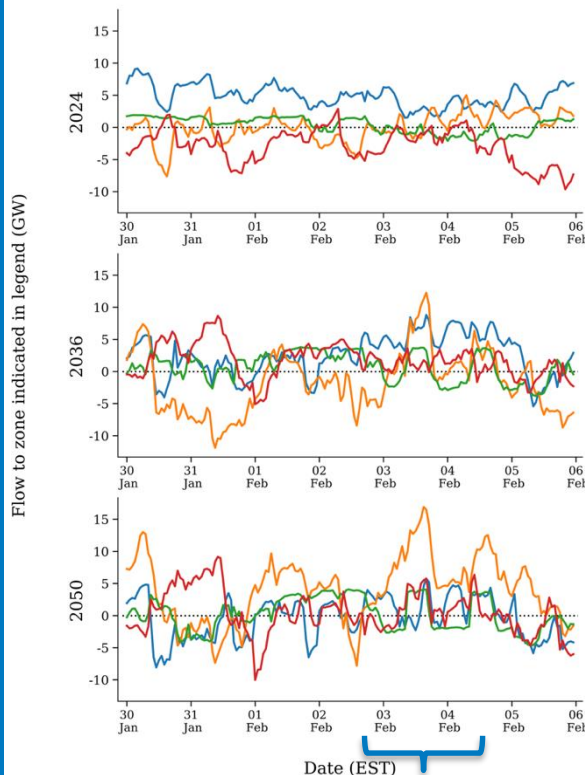
Evolution of operations during cold waves driven by wind dynamics

2011 Extreme Cold Wave

Transmission enables usage of geographic diverse wind and solar resources.

February 2011 Cold Wave

February 2008 Cold Wave



Swing in MISO exports to PJM used to serve SERC and NYISO

Thermal, wind, and PV less impacted in Atlantic states

Evolution of operations during cold waves driven by wind dynamics

2011 Extreme Cold Wave

Transmission enables usage of geographic diverse wind and solar resources.

2008 Milder Cold Wave

Transmission also enables geographic diverse thermal fleet.

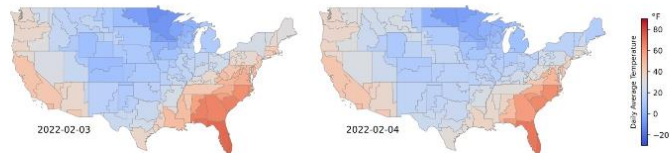
NAERM Cold Wave Report

Severe cold weather risks in Texas and other central states

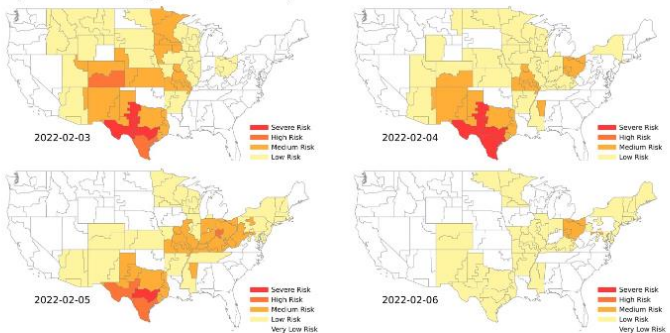
Very cold weather is expected to move south through the central U.S. and into Texas, leading to higher outage rates at thermal generators in many states and higher electricity demand

- Temperatures expected to be 10-15 degrees warmer in Texas for this period compared to the Feb 2021 cold wave, but similar to the cold wave in February 2011.
- Impacts likely to be spread over 3 days, but February 4 may be the worst in Texas. This is much shorter than the 10-days of below-freezing temperatures in 2021.
- In addition to Texas, several other states are expected to see temperatures that may lead to high loads and/or increased risk of forced outages at thermal generators over the coming days.

Regional daily average temperature forecast for February 3 and 4, 2022



February 3-5 shows high electric sector risk (combination of generation loss and peak load) in the central U.S. This combined risk reaches a severe level in parts of Texas for all three days before subsiding with warmer temperatures

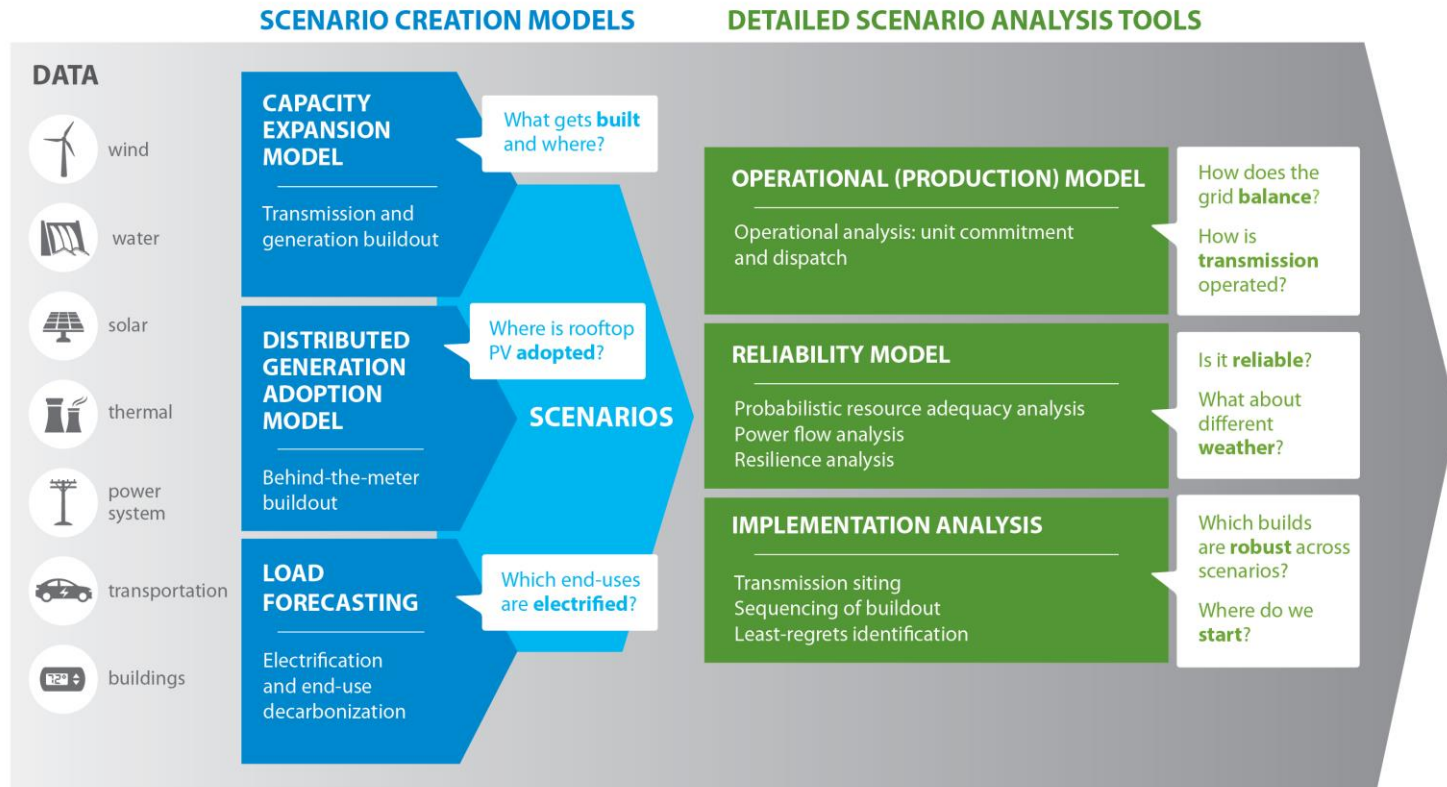


In addition to the cold temperatures, significant snow and ice is expected to disrupt many aspects of grid operations, likely causing reduced production from wind and solar PV sites, as well as distribution-side power outages.

The North American Energy Resilience Model (NAERM) is a multi-lab effort to identify resilience risks across the energy sector. NAERM is developing a beta version of a **cold wave report** to provide system operators awareness of forecasted cold weather and winter storms and the associated power system risks.

- Increased generator outage
- Regions with above normal forecasted load
- Snow and ice impacts on T&D infrastructure, wind power, and solar power

National Transmission Plan and NAERM



Key Takeaways

- Corelated Modeling
- Planning
- Operational Forecasts vs. Resource Adequacy
- Transmission Flexibility
- Longer Duration Storage (day long or multi-day storage)

Thank you

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