Persistence of High Net-Load in High Renewable Grids

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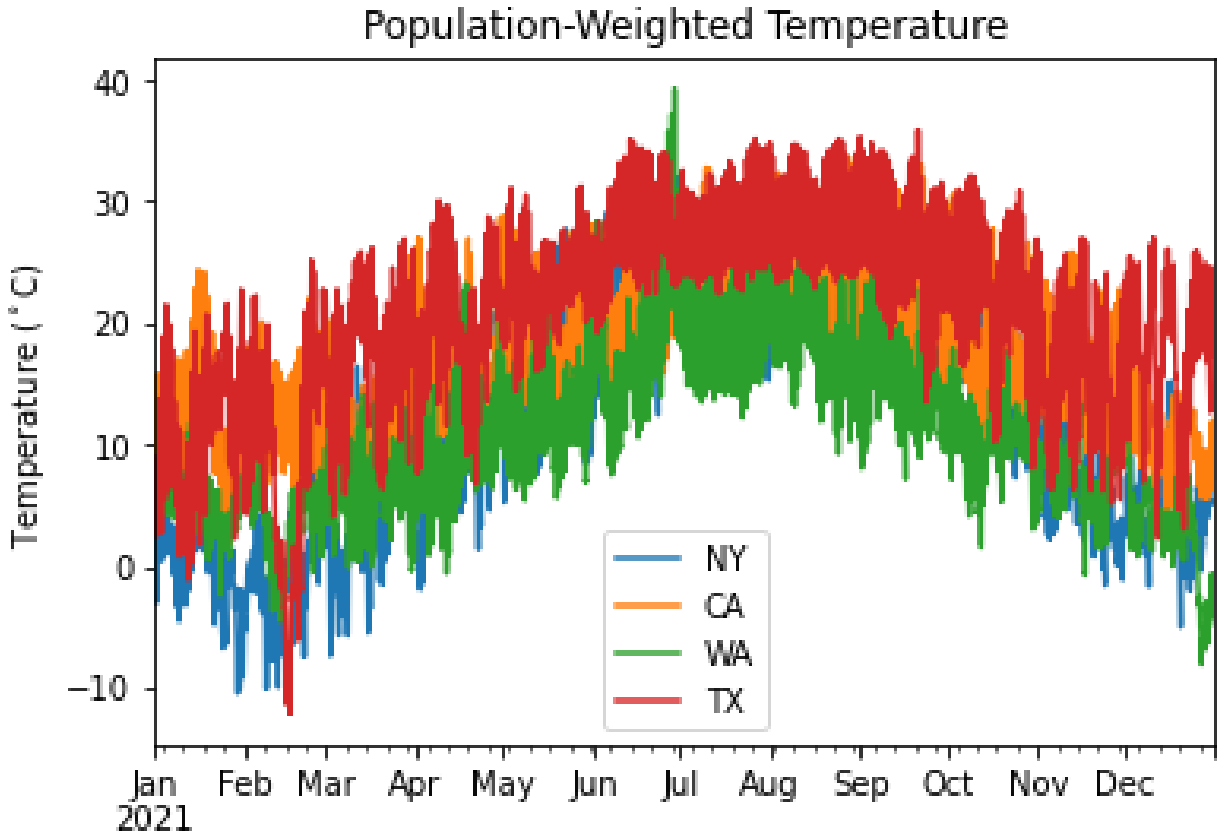
Generating Long Timeseries

To generate weather-driven net load time series, we need to be able to generate time series at arbitrary locations, so we turn to the ERA5 reanalysis performed by the ECMWF, using output from 1950 to the present. Surface temperature, 100 m wind speed and surface downwelling solar irradiance are used to drive electrical load, wind and solar generation variability. Electrical load is calculated by using a fixed function of population-weighted temperature sensitivity (piece-wise linear, increasing above 68 F and below 60 F). Wind and solar generation are sited at permissible locations using a global land-use map and terrain characteristics from a digital elevation map, as well as 100 m wind, ghi, temperature and pressure from the ERA5 reanalysis. Generic power curves are used, and wind and solar generation are scaled to generate enough combined power to satisfy the annual mean load.

We can now start to explore correlations of load and wind and solar generation.



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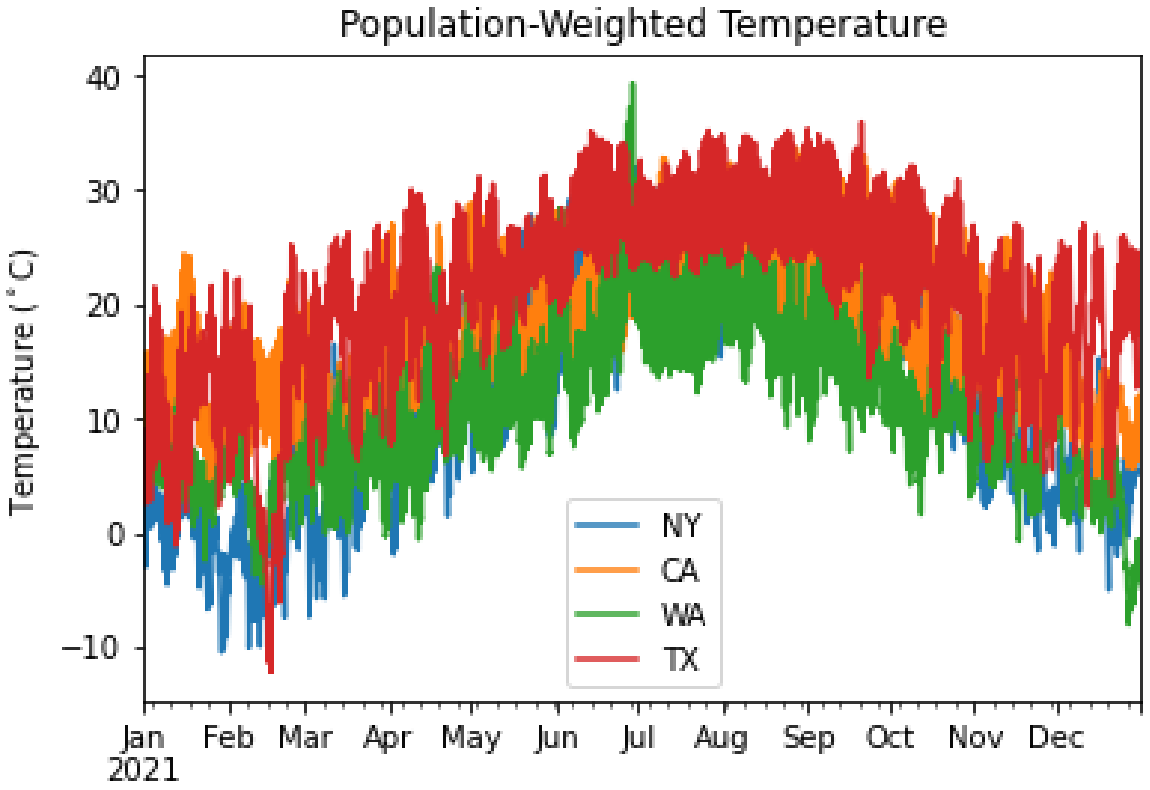

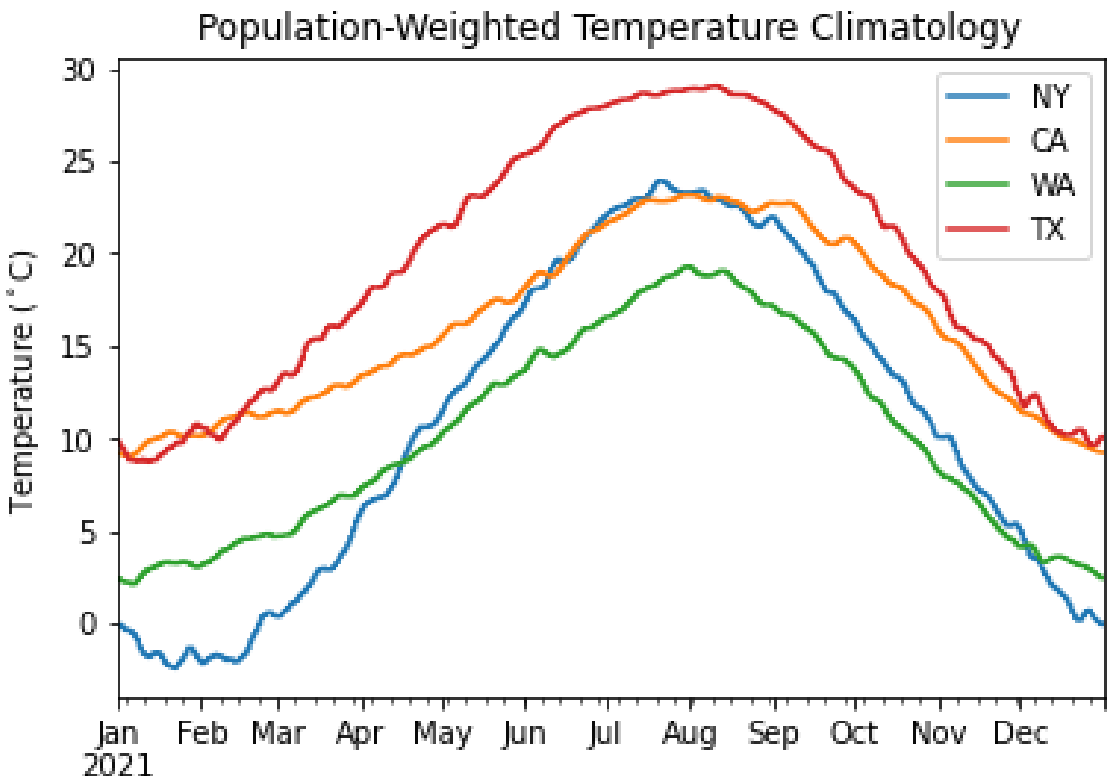

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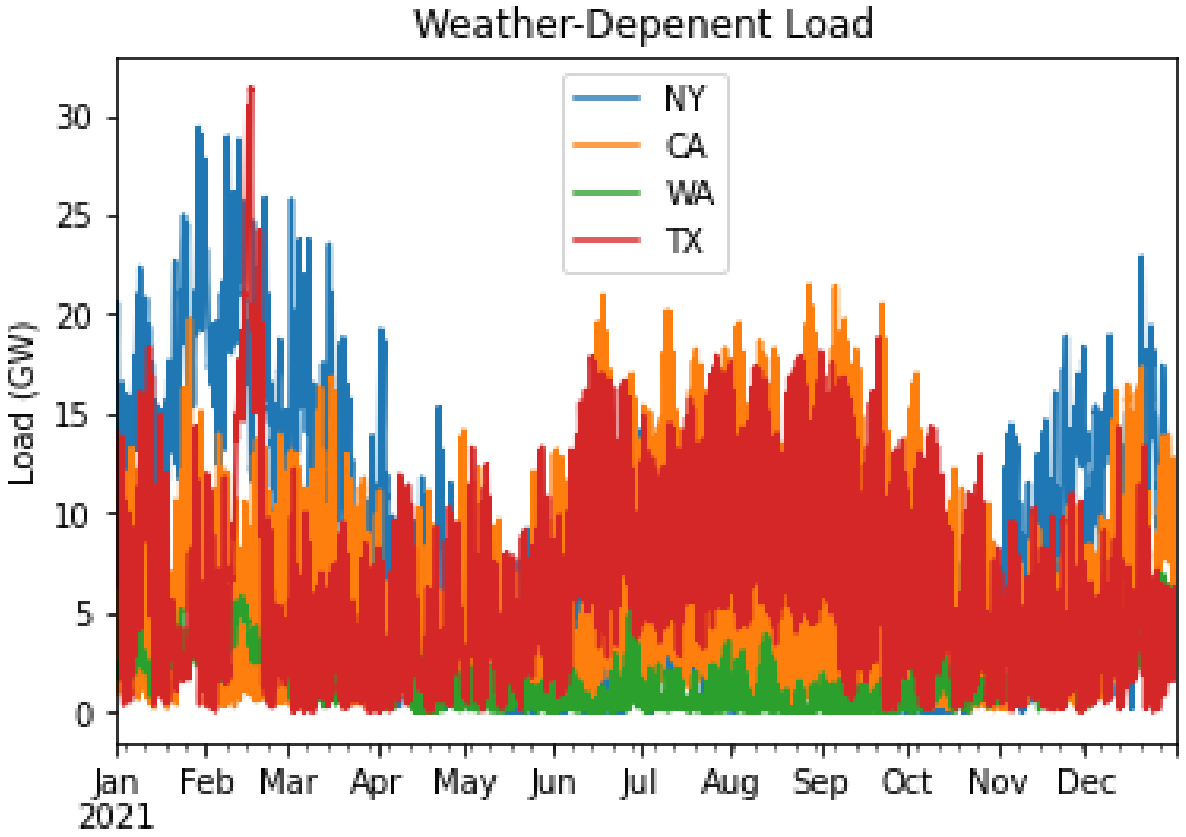

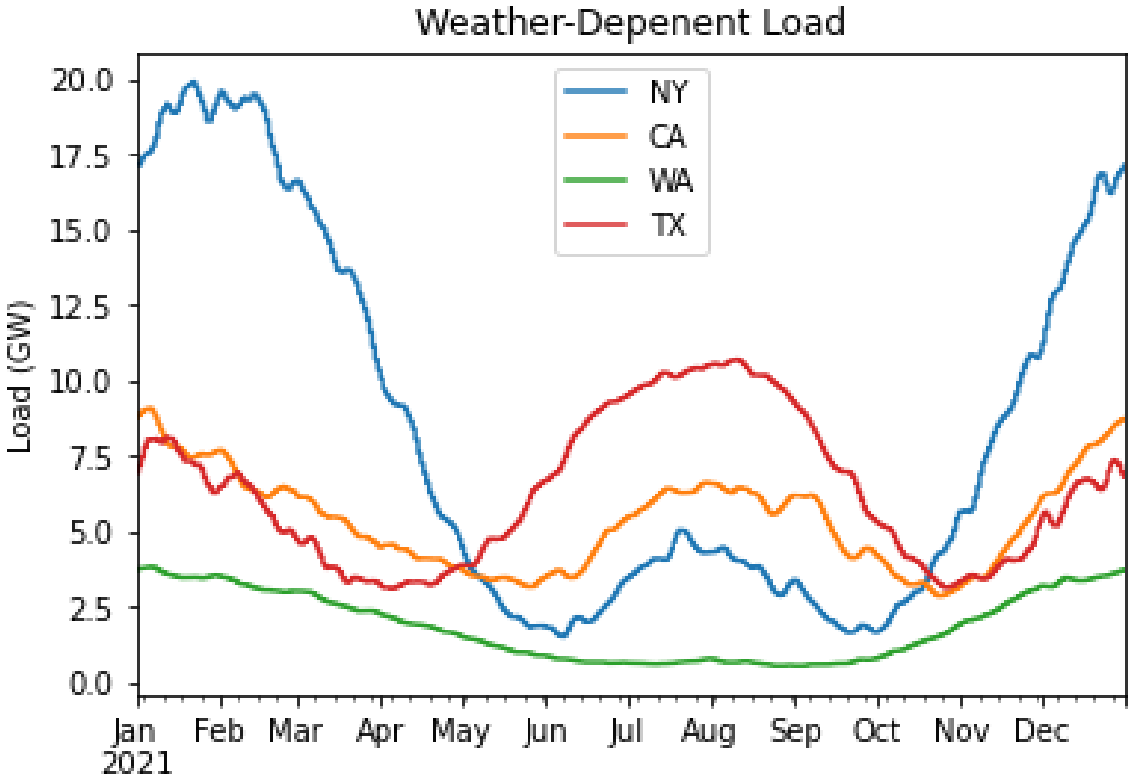

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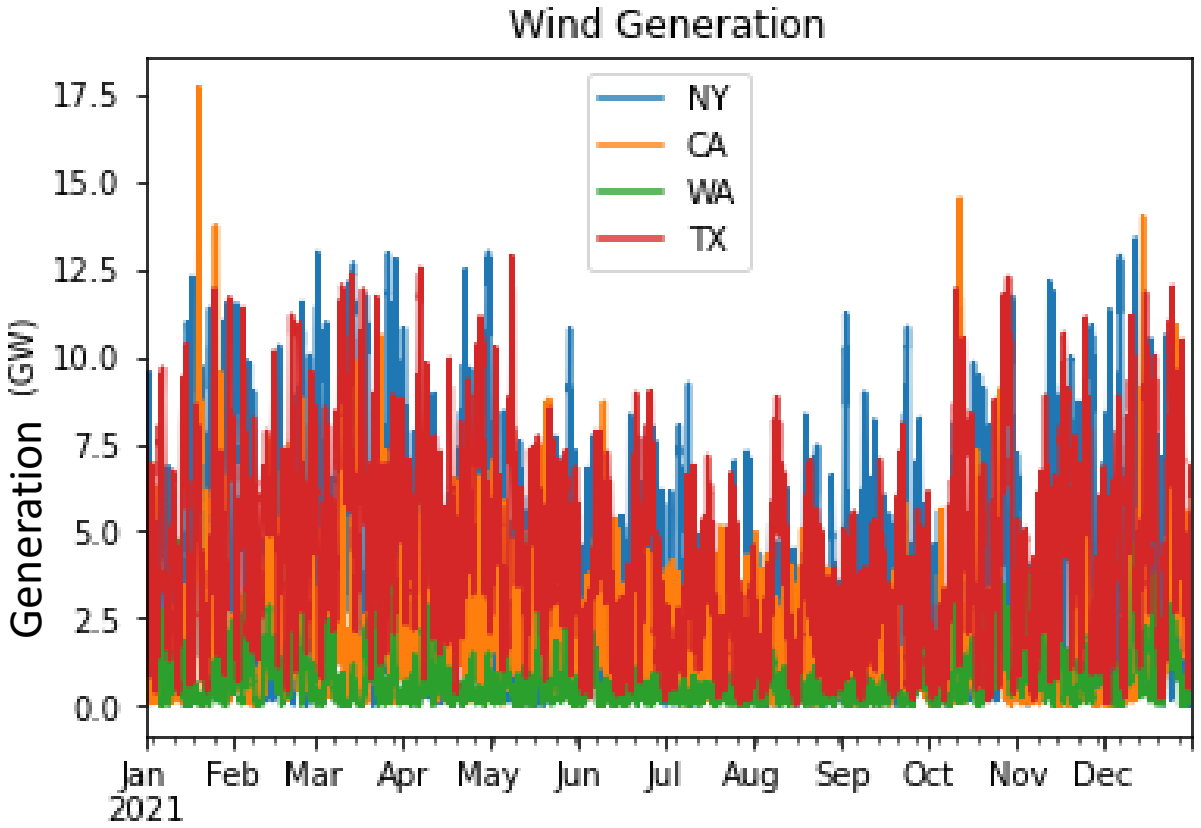

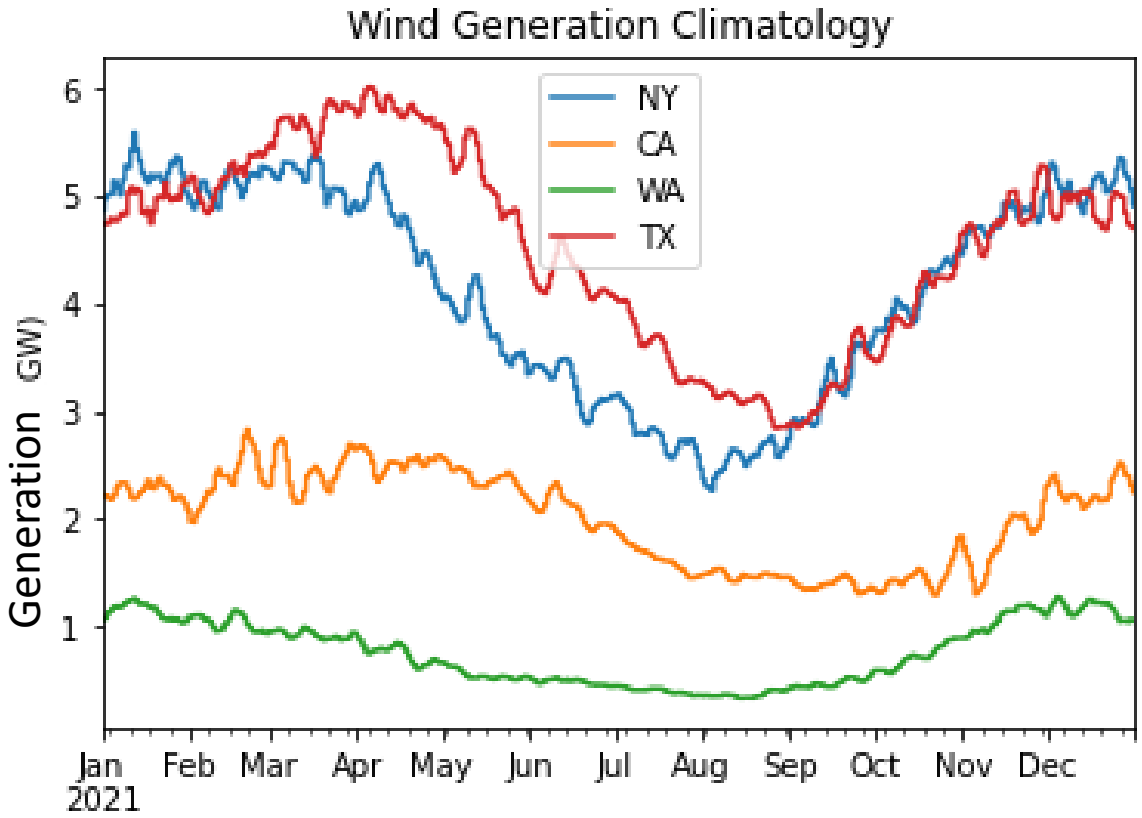

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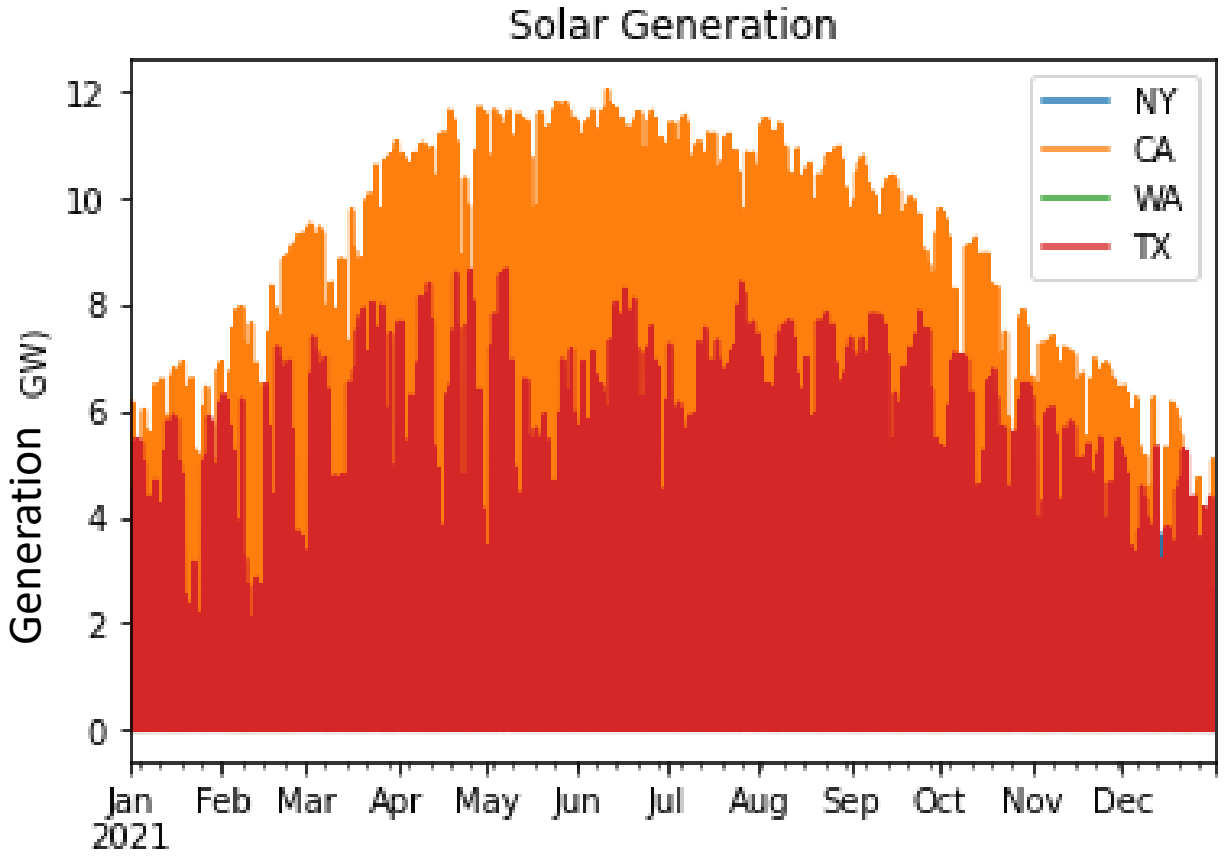

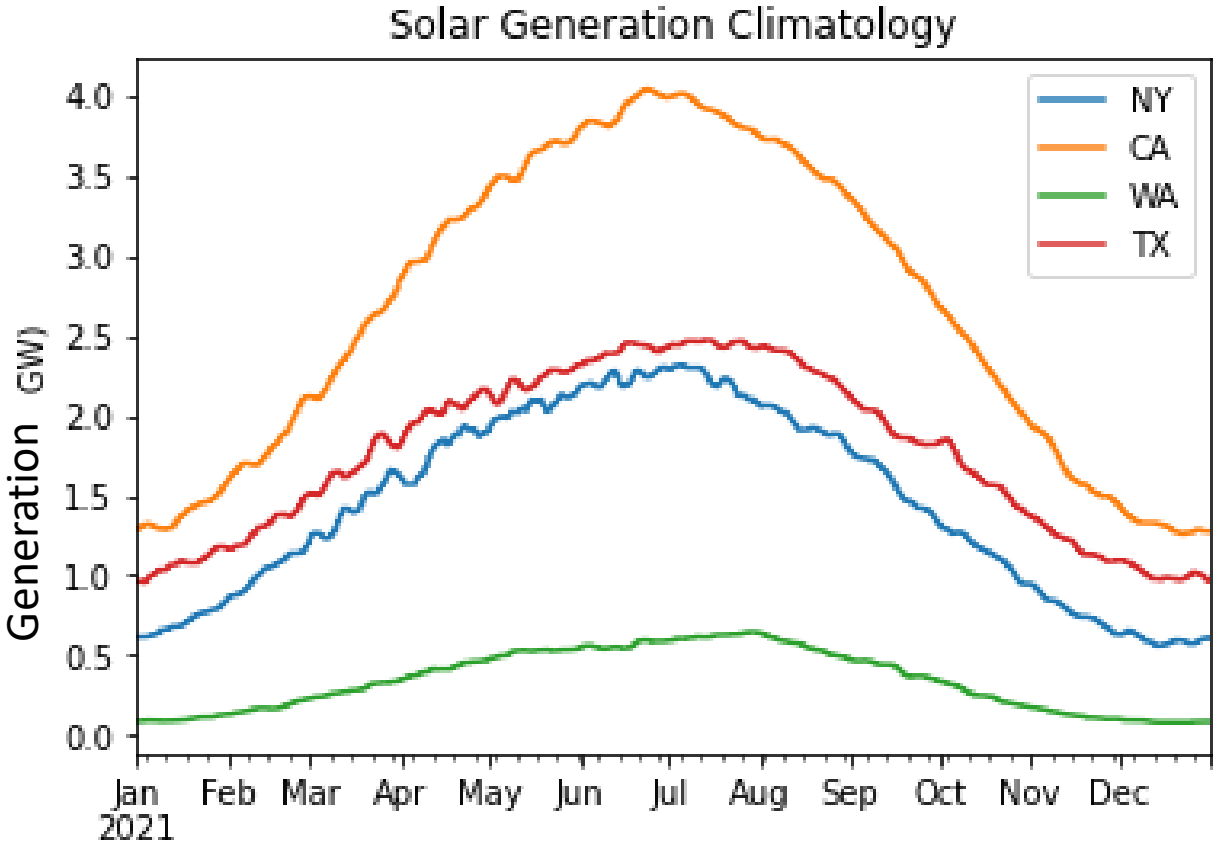

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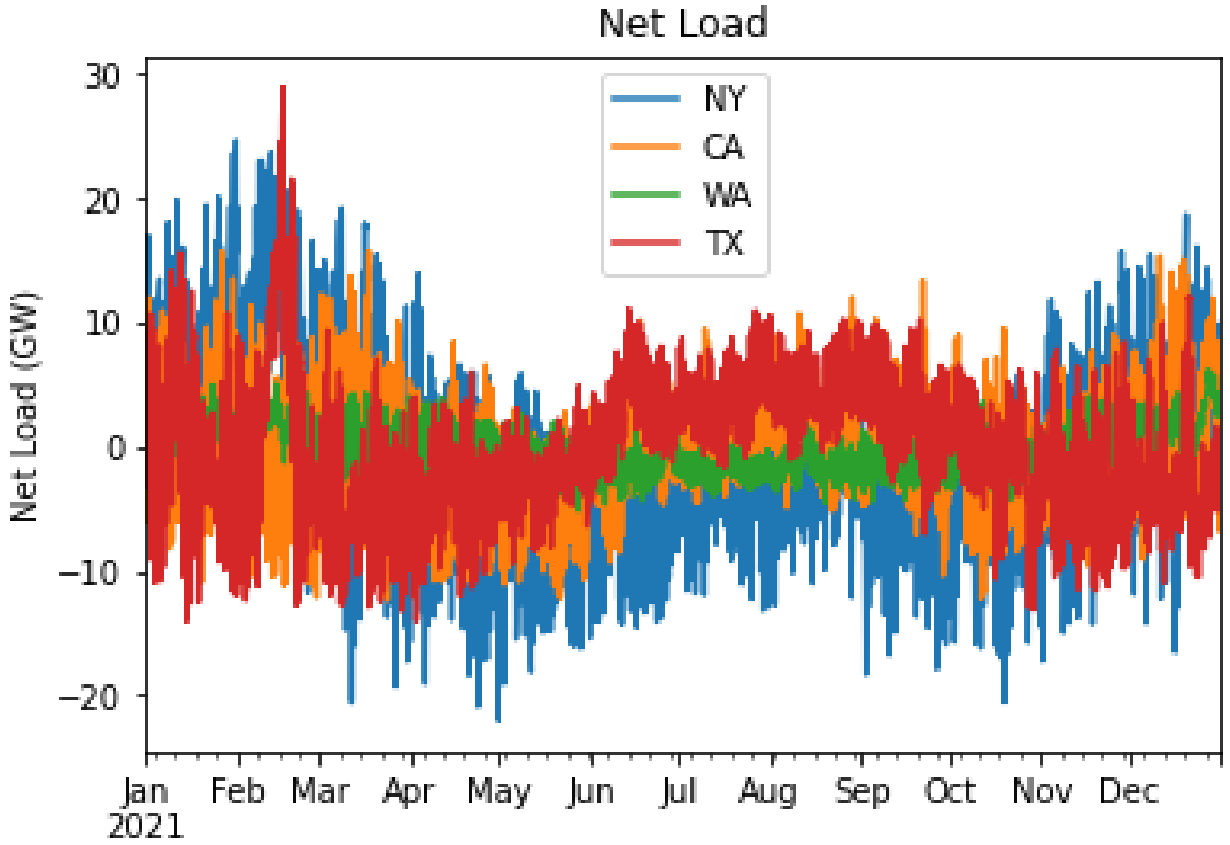
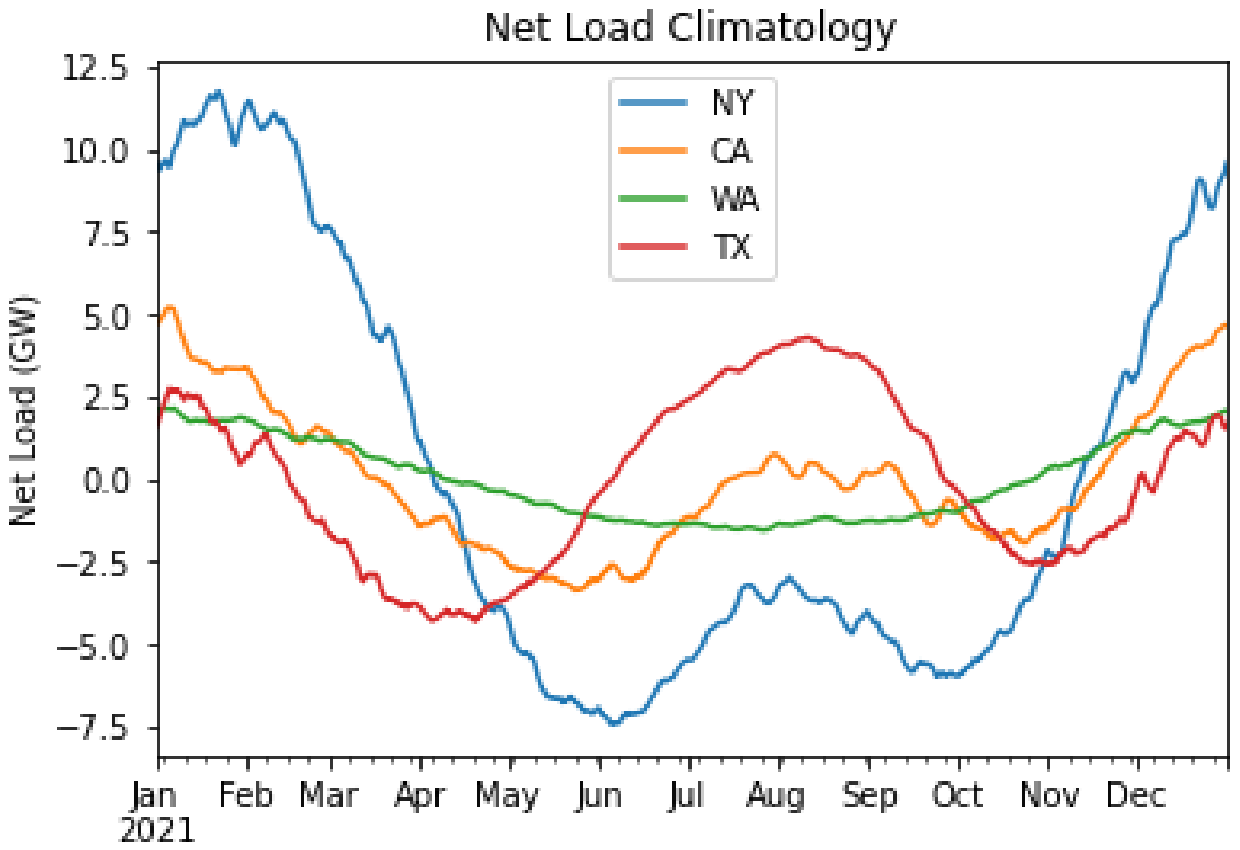


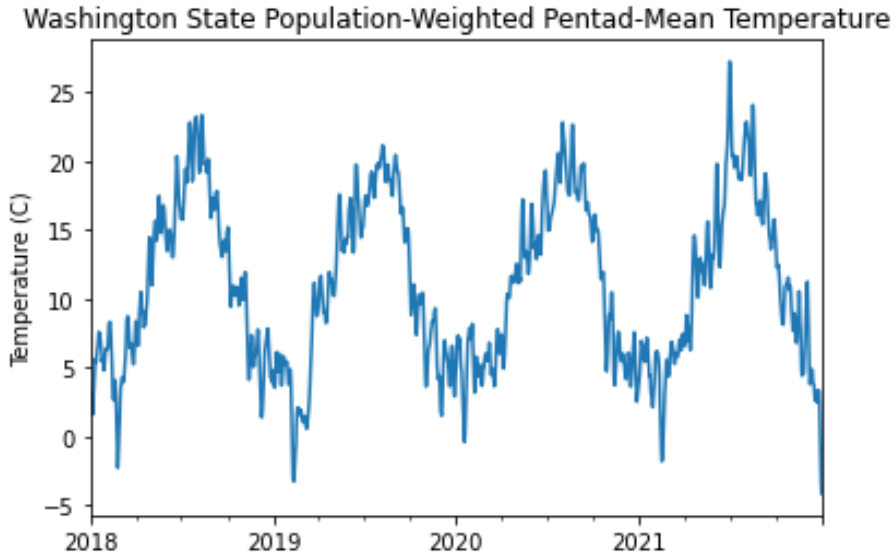


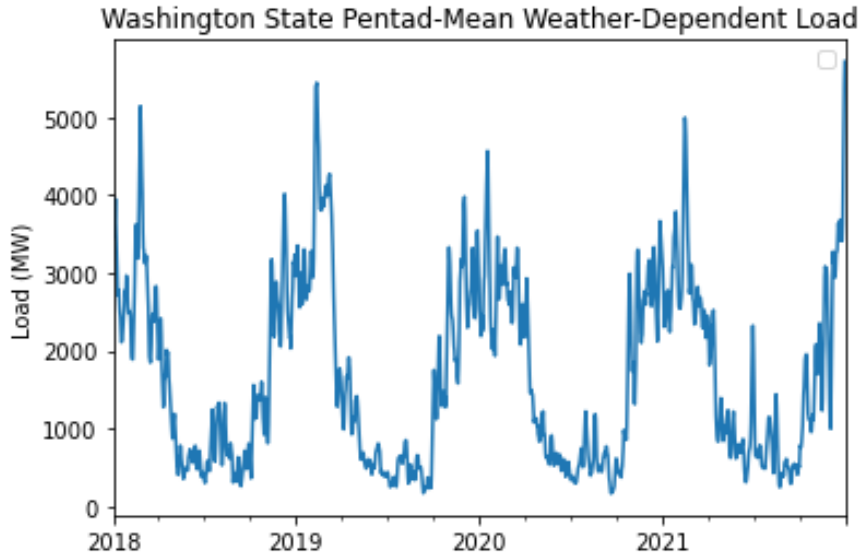
Extended Periods of High Load

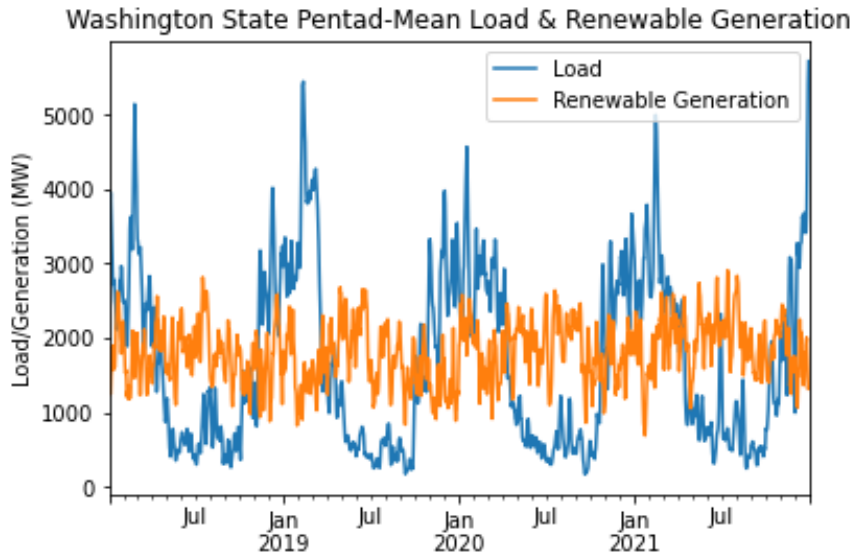
How does renewable generation typically add to the variability of weather dependent load?

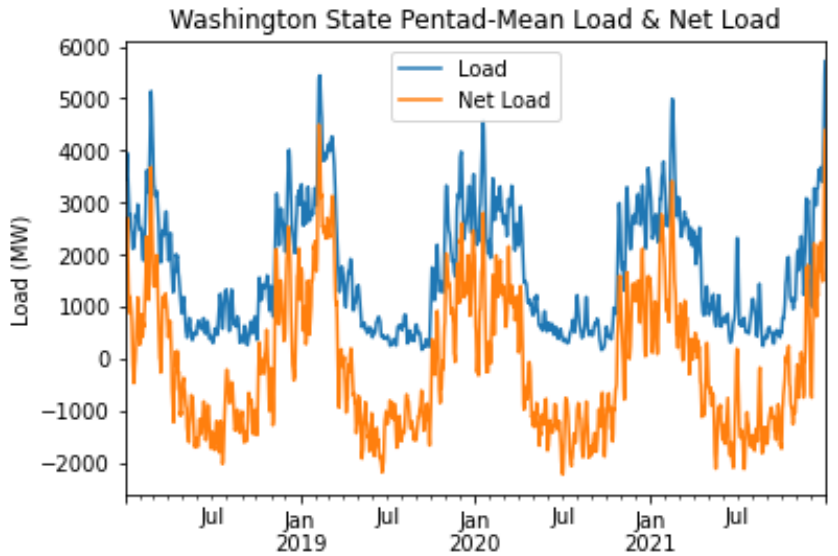
An example from Washington State: note the spike in pentad temperature and load in June/July of 2021.

Renewable generation's pentad-mean variability is such that very high net-load events are typically due to very high load, but week-to-week netload variability is strongly related to renewable generation variability.









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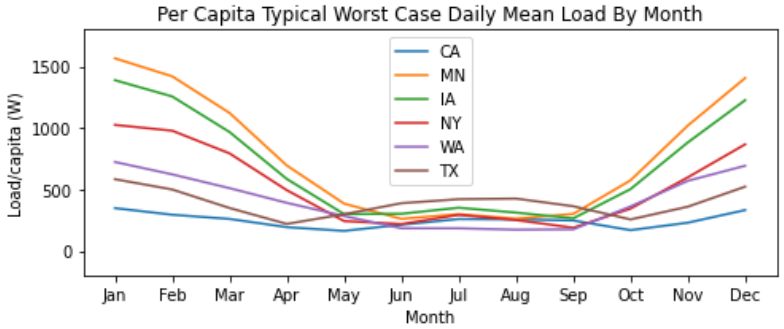

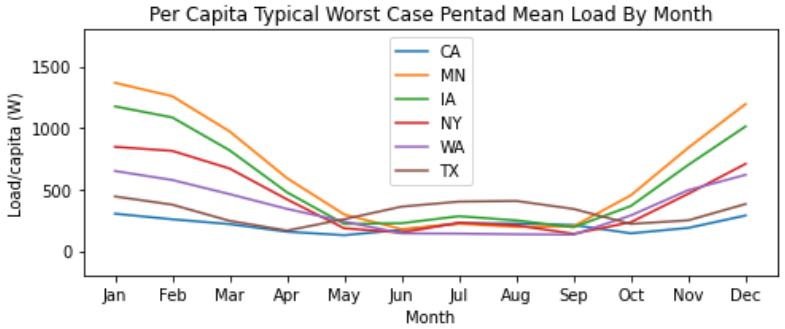

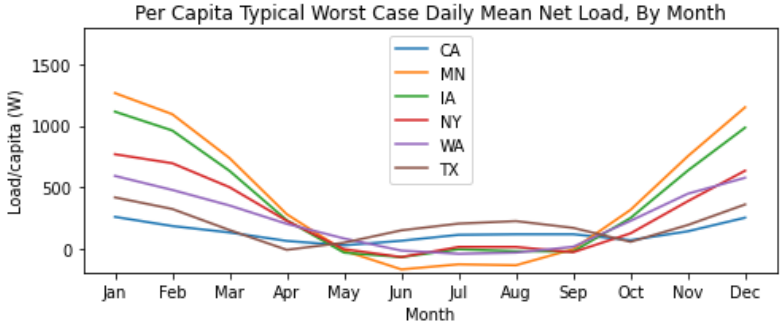

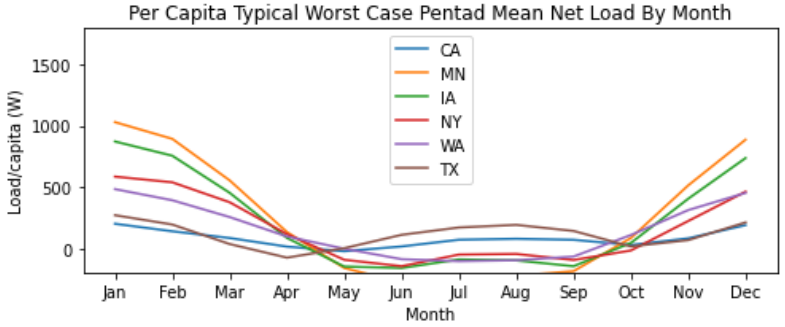

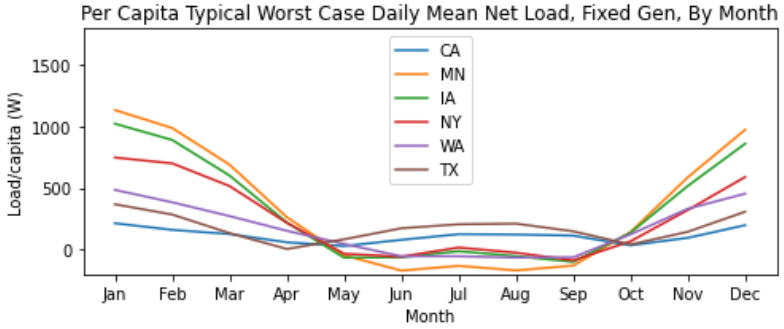

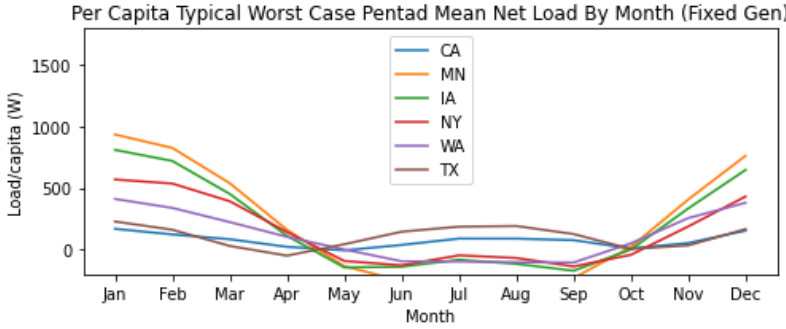

Average Monthly Maximum Load and Net Load for Daily and Pentad Means

Conclusion

Correlations between renewable generation and extreme heat or cold exist, but they're generally weak enough for daily to weekly timescales that the accumulated load over periods of high or low temperatures, in grids with high renewable penetration, is not very much different from what would occur with an equivalent amount of fixed generation.

Long-term storage or else sufficient excess renewable capacity to address seasonal load variability is the primary problem we need to solve – worrying about Dunkeflaute may be a distraction.

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