DISCLAIMER

Empirical Assessment of Interregional Coordination to Support Resource Adequacy

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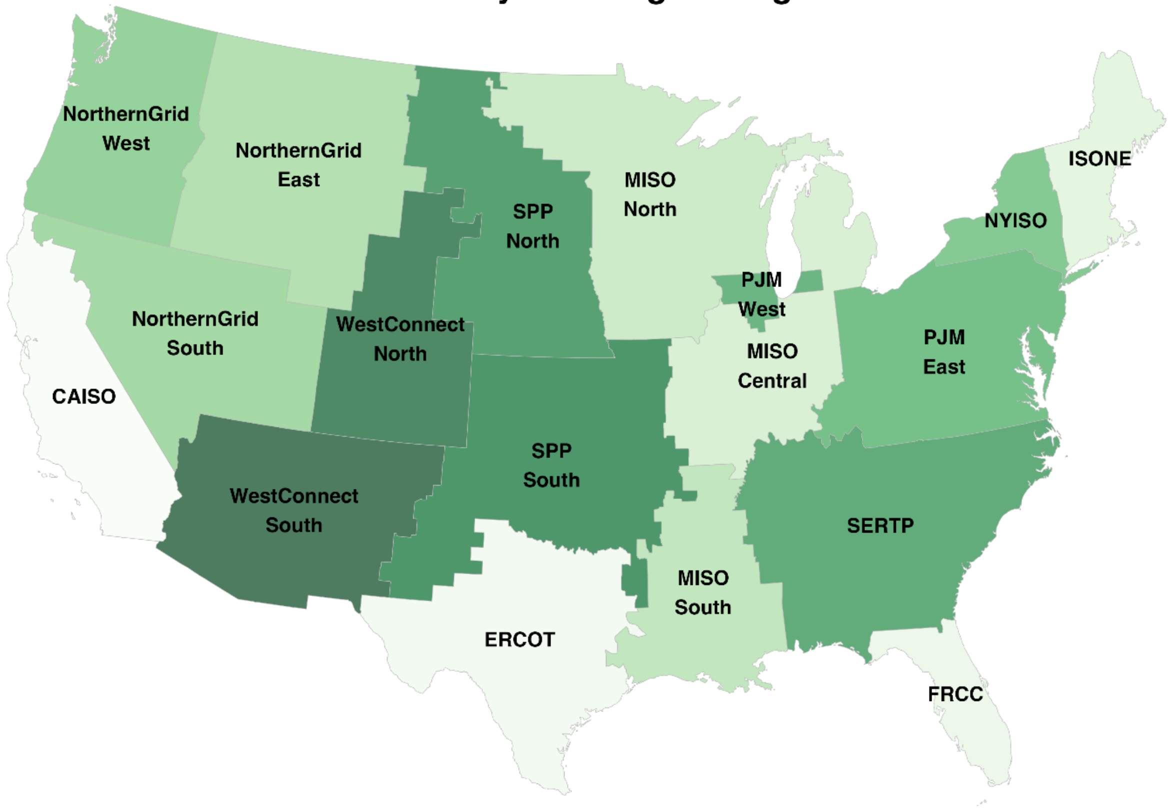
Research Question: To what extent can transmission contribute to resource adequacy?

Resource Adequacy (RA) Definition	The ability of a power system to meet aggregate electrical demand at nearly all times.
Geographic Scope	The contiguous U.S. divided into 18 planning regions that provide greater granularity than FERC Order 1000 planning regions while maintaining alignment with established jurisdictional boundaries.

Needs Study Planning Subregions



Data-driven approach: Compare historical periods of greatest need between regions to measure the degree to which high-need periods are overlapping (limited RA contribution) or offset (greater RA contribution)

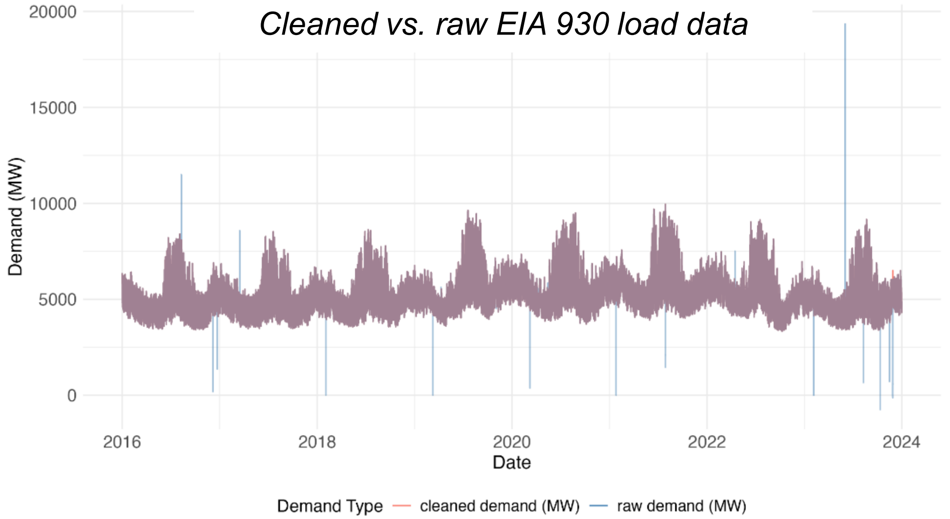
Metrics used to identify high-need periods

- Net load (MWh)
  - Definition for hour *h* in region *x:*
    - $NetLoad_h^x = Load_h^x - (WindGen_h^x + SolarGen_h^x)$
  - Focus on 100 highest net load hours each year

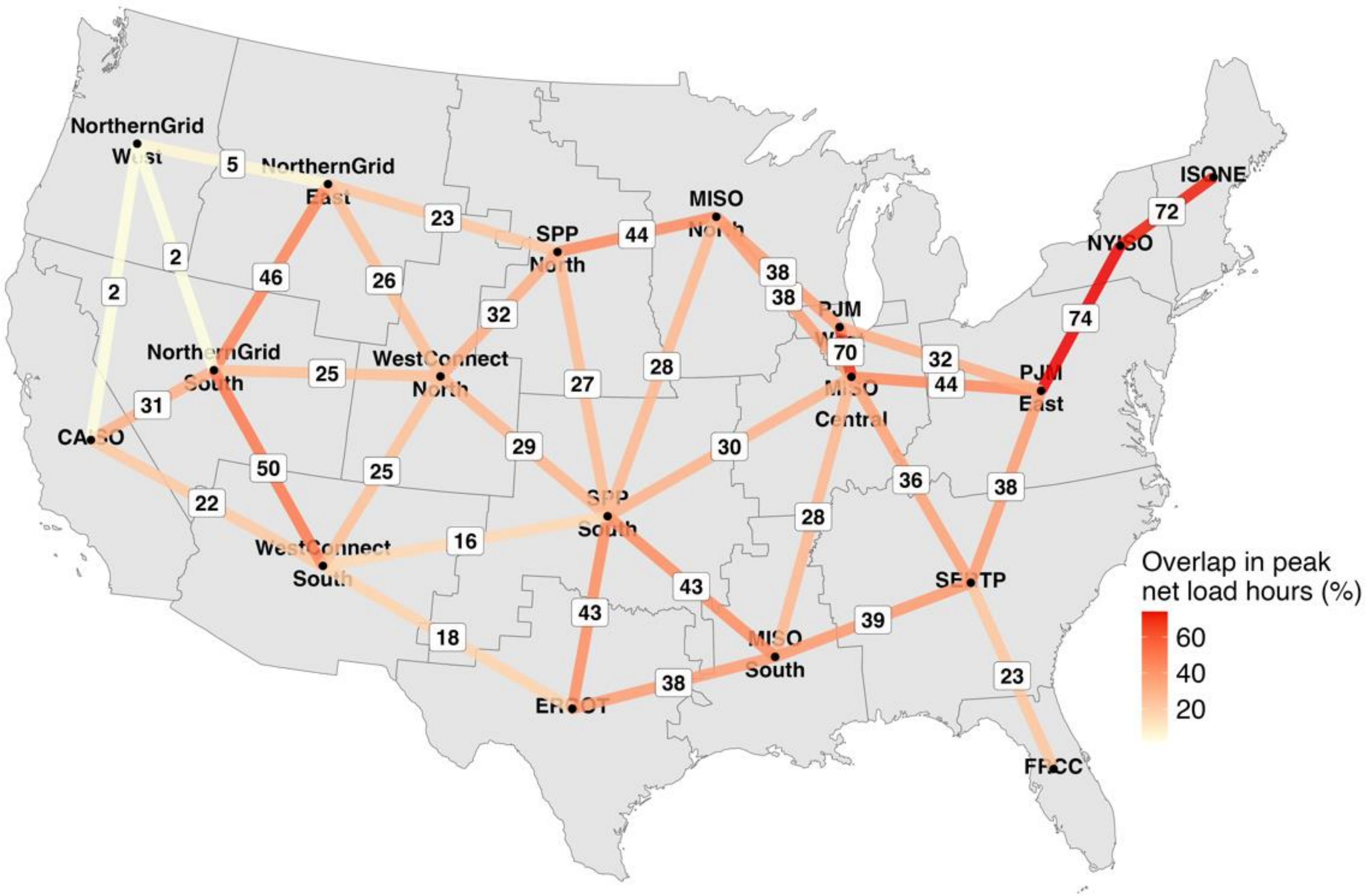
- Price ($/MWh)
  - Wholesale electricity prices are an indirect measure of the balance between supply and demand.
  - Very high prices indicate scarcity and a low reserve margin (i.e., the market clears near the righthand side of the supply curve, which is often described as having a hockey stick shape with a slowly increasing slope for most of the curve and then a sudden sharp increase.)
  - Focus on 100 highest-price hours each year

Data sources (2016-2023)

- Load: Form EIA-930; zonal load data from SPP, PJM, and MISO
- Solar & wind generation:
  - ISO/RTO regions: Reported empirical generation data
  - Elsewhere: *prior to July 2018* – modeled generation data; *July 2018+* – EIA-930
- Electricity prices: Real-time prices from ISOs, RTOs, and imbalance markets (no data for SERTP or FRCC)



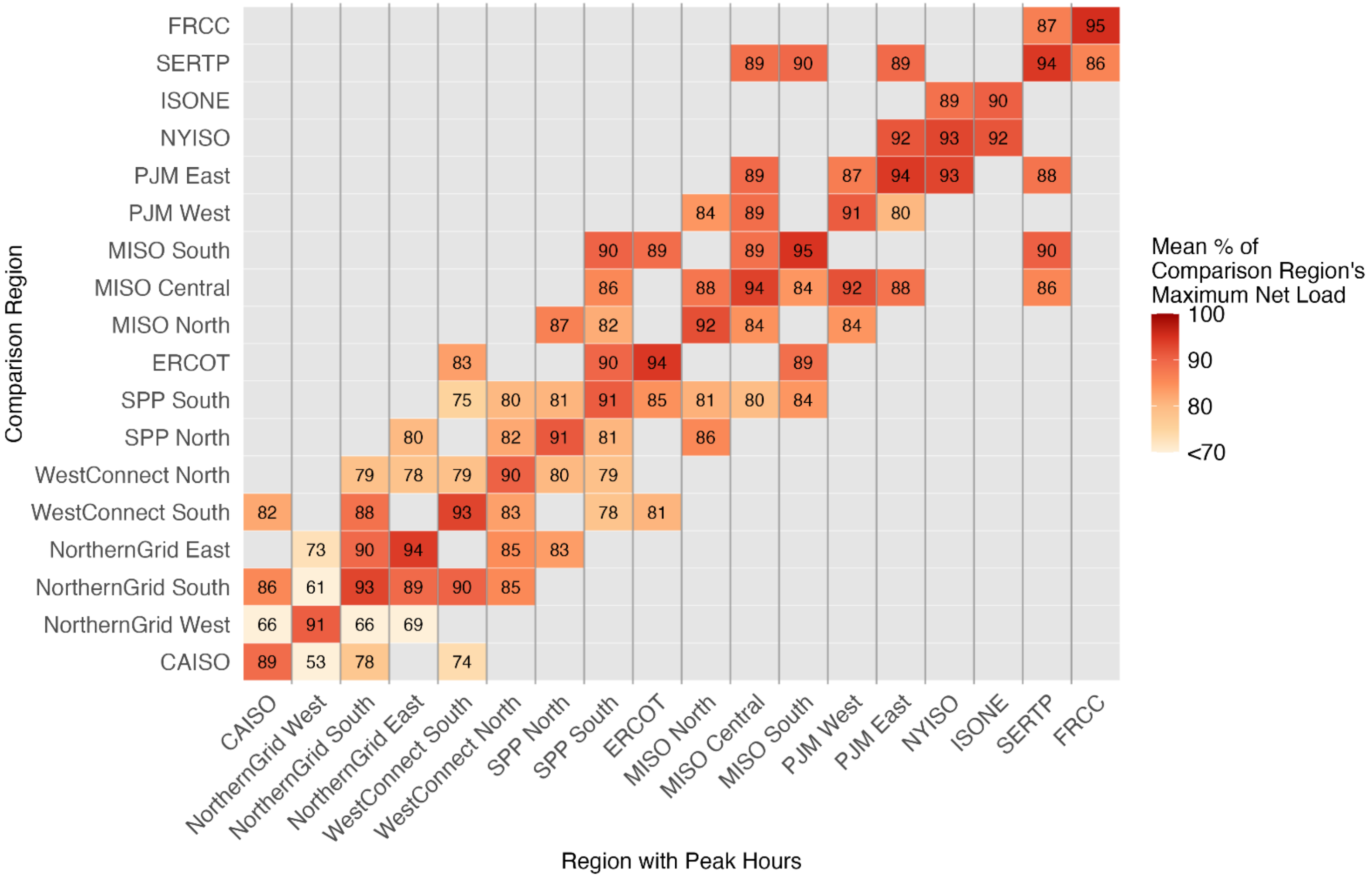
Results
Do neighboring regions have different high net load hours?



- Plot shows the average percent overlap between regions of the top 100 net load hours per year
- Lower numbers indicate less overlap → greater ability for transmission to alleviate grid stress

Results
How stressed is one region's grid when a neighbor is experiencing high net load?

$$Net\ load\ coincidence_{A,B} = \frac{1}{Y \times 100} \sum_{y=1}^{Y} \sum\nolimits_{h \in Top100_{B,y}} \left(\frac{NetLoad^{A}_{h,y}}{MaxNetLoad_{A}} \times 100 \right)$$



- "Net load coincidence" captures the average percentage of Region A's maximum net energy needs occuring during Region B's peak demand hours.

Figure Interpretation

- Each column represents a specific region during its 100 highest net load hours per year. Reading down a column shows what percentage of their own maximum net load other regions were experiencing during those same critical hours.
- Higher percentages (dark colors) indicate regions that tend to peak simultaneously
- Lower percentages (light colors) identify pairs of regions with complementary net load patterns (i.e., greater potential for interregional resource sharing)

Results
How regularly can neighboring regions provide power during peak net demand?

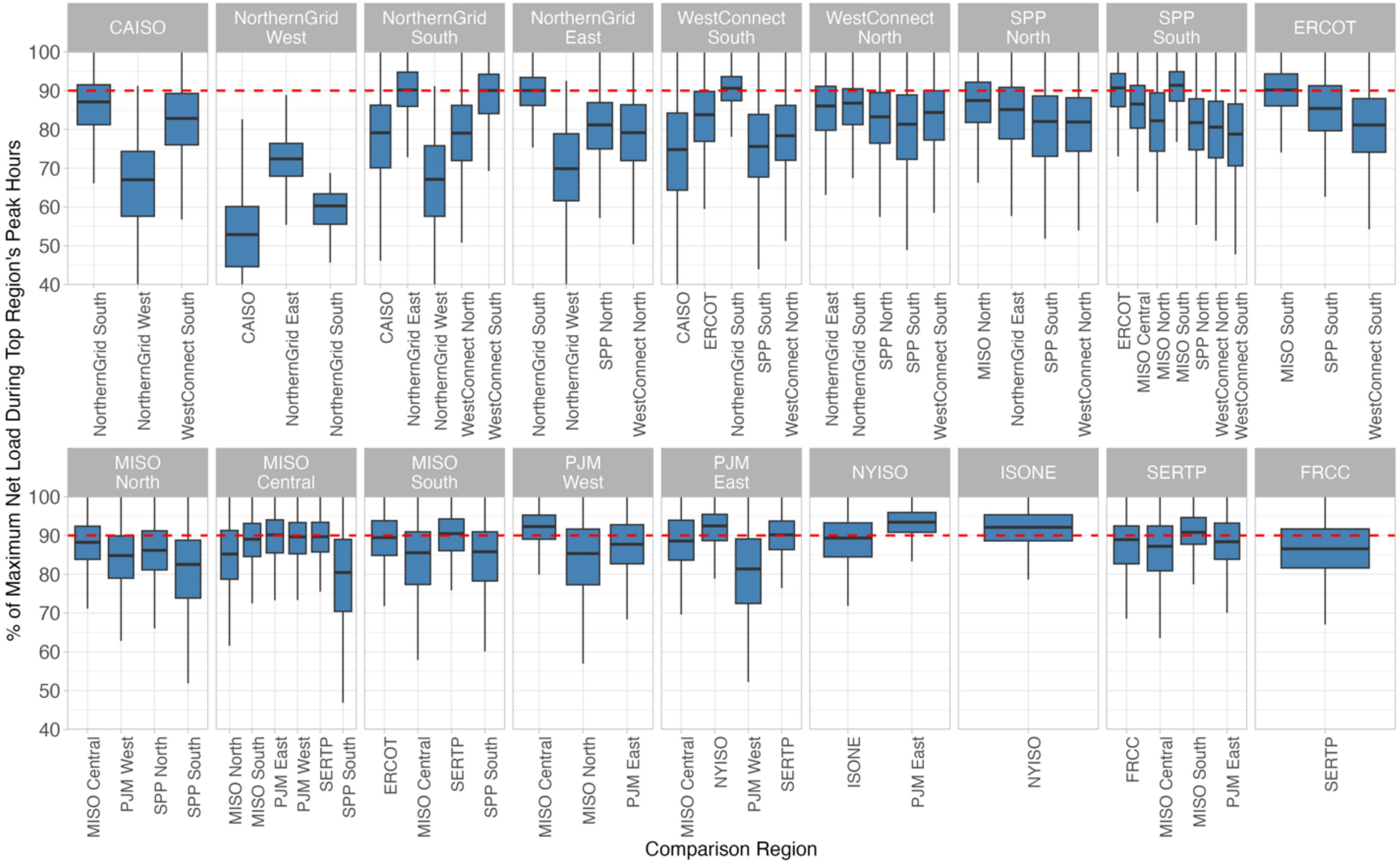


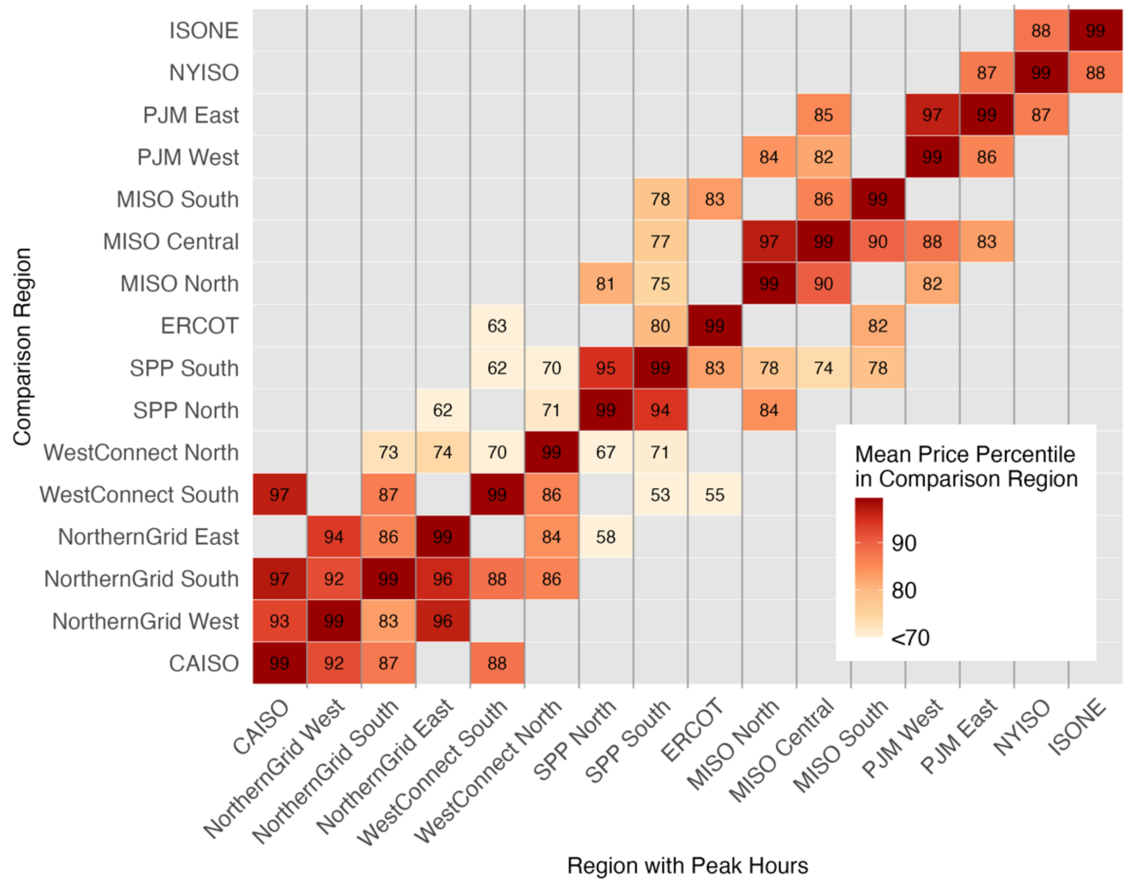
Figure Interpretation

- Each boxplot provides the distribution of the percent of the bottom region's maximum net load during the boxed region's peak net load hours
- This visualization is helpful because two region pairs with identical net load coincidence might have different reliability implications.
  - For example, a region that consistently operates at 70% of its maximum net load during a neighbor's peak hours (a short box plot) would be a more predictable capacity resource than one that fluctuates between 45% and 95% (a tall box plot with the same average).

Results

How stressed is one region’s grid when a neighbor is experiencing high electricity prices?

$$Price\ rank\ overlap_{A,B} = \frac{1}{Y \times 100} \sum_{y=1}^{Y} \sum_{h \,\in\, Top100Price_{B,y}} PR_{A,y}(h)$$



- Because real-time prices are extremely right-skewed, with just a few hours per year that are far more expensive than all other hours, we focus on the average normalized percentile rank of peak price hours.

Figure Interpretation

- Each column represents a specific region during its 100 highest price hours per year. Reading down a column shows what average normalized percentile rank other regions were experiencing during those same critical hours.
- Higher percentages (dark colors) indicate regions that tend to peak simultaneously
  - For example, when a region in the western U.S. is experiencing its highest prices, nearby regions also tend to have high prices. The Western Energy Imbalance Market facilitating price convergence may contribute to this phenomenon.
- Lower percentages (light colors) identify pairs of regions with complementary times of stress

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