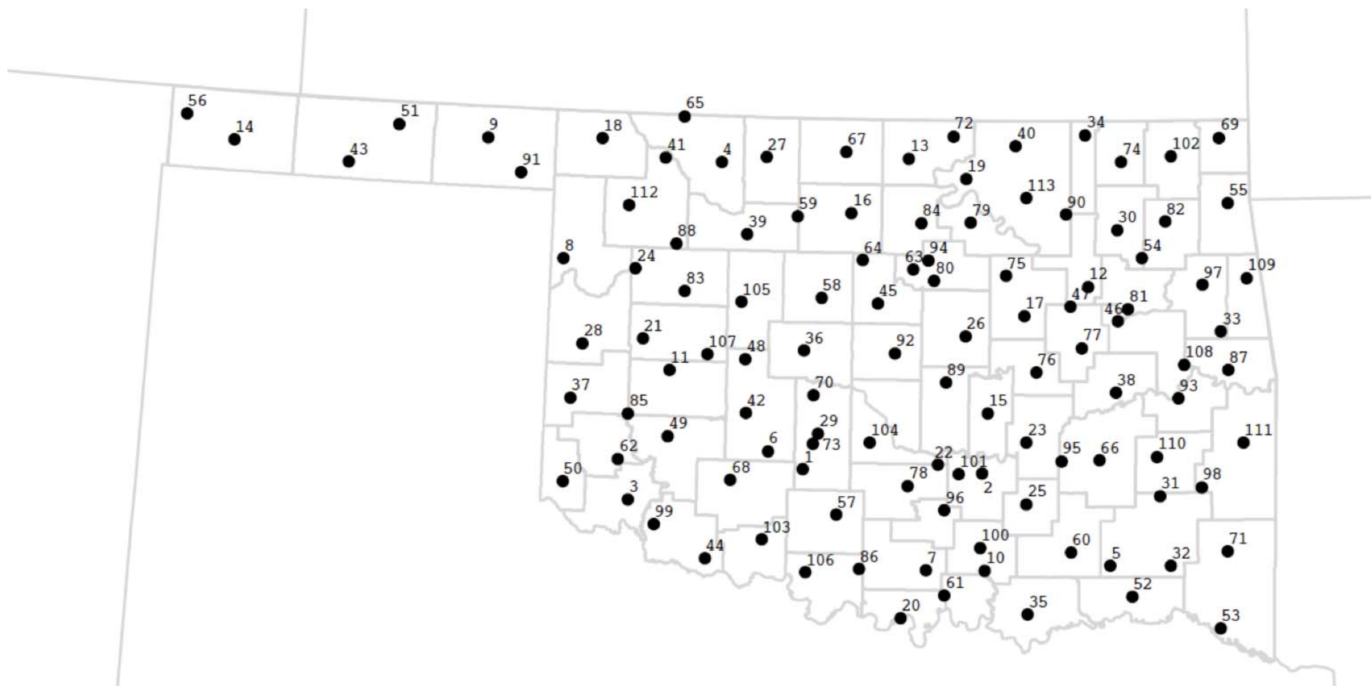
Variance Minimizing Site Selection Process for Interconnected Wind Farms



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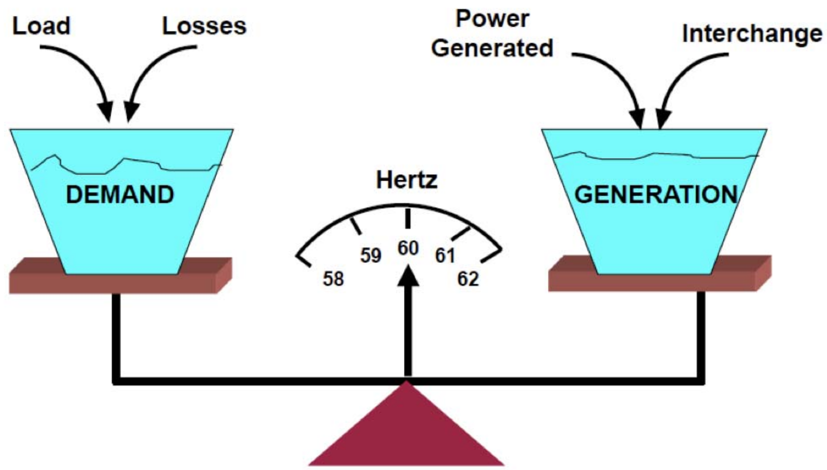
Basics

- Demand and supply need to be balanced at all times



- Electricity cannot be stored economically on a large scale
- Large amount of wind power creates problems for system operators because of it intermittency
- US wind policies and Renewable Portfolio Standards – encourage more quantity – implicitly mean high profit location are best for the electricity system.

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Problem Statement

What Criteria to use to decide where to put a wind farm from given available locations?

- **Revenue**
- **Interconnection/Transmissions cost**
- **Intermittency**

In our study, we focus on intermittency. We compare profitable wind investments with those that most lower the system intermittency.

Higher variance implies higher system costs (regulation costs) to compensate for the intermittency.

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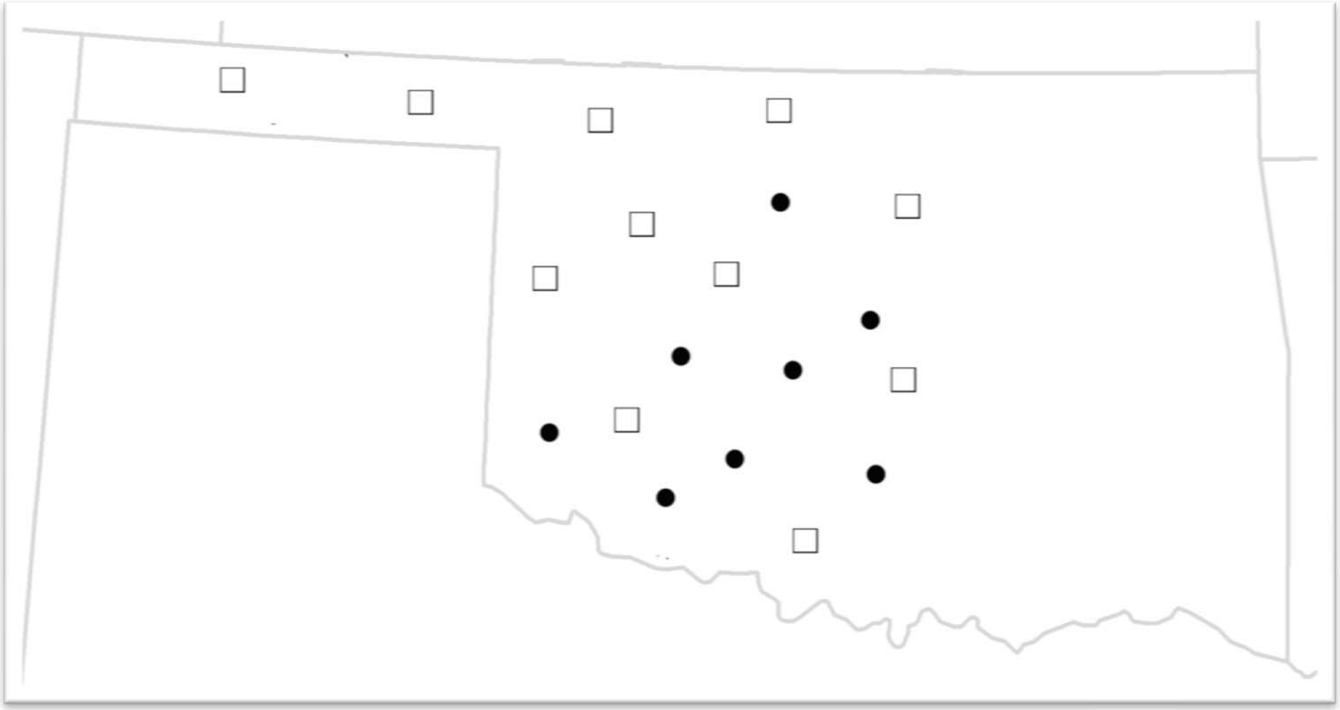
Algorithm

- There are some existing wind farms; many new available sites
- Which one to select for minimizing system variance?
- We assume the group of existing wind farms as one unit
- Sequentially add wind farms at sites that minimize the existing group's variation (least correlated with existing power output)



Other ways to Connect

We also considered

- **Nearest Station Connection:** we sequentially put wind farms at locations that have minimum distance from the centroid of the locations of existing wind farms

- **Most Profitable First:** we estimate the revenues at potential sites using Locational Marginal Prices (LMP). Then we connect stations in order of their revenue (highest revenue first)

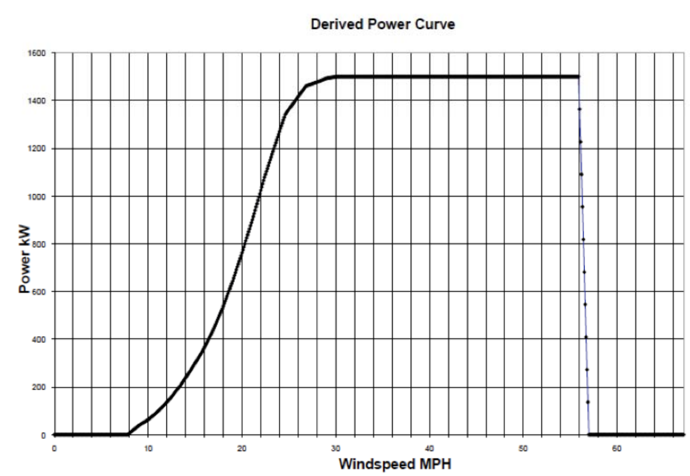
Data

- 113 Mesonet weather stations in Oklahoma for year 2002
- 5 minute averaged wind speed data
- Wind speed measured at 10m hub height

To convert this to power

- Estimate the wind speed at 80m hub height using logarithmic wind profile (Surface roughness lengths – Z_o)
- Use GE 1.5S wind turbine power curve

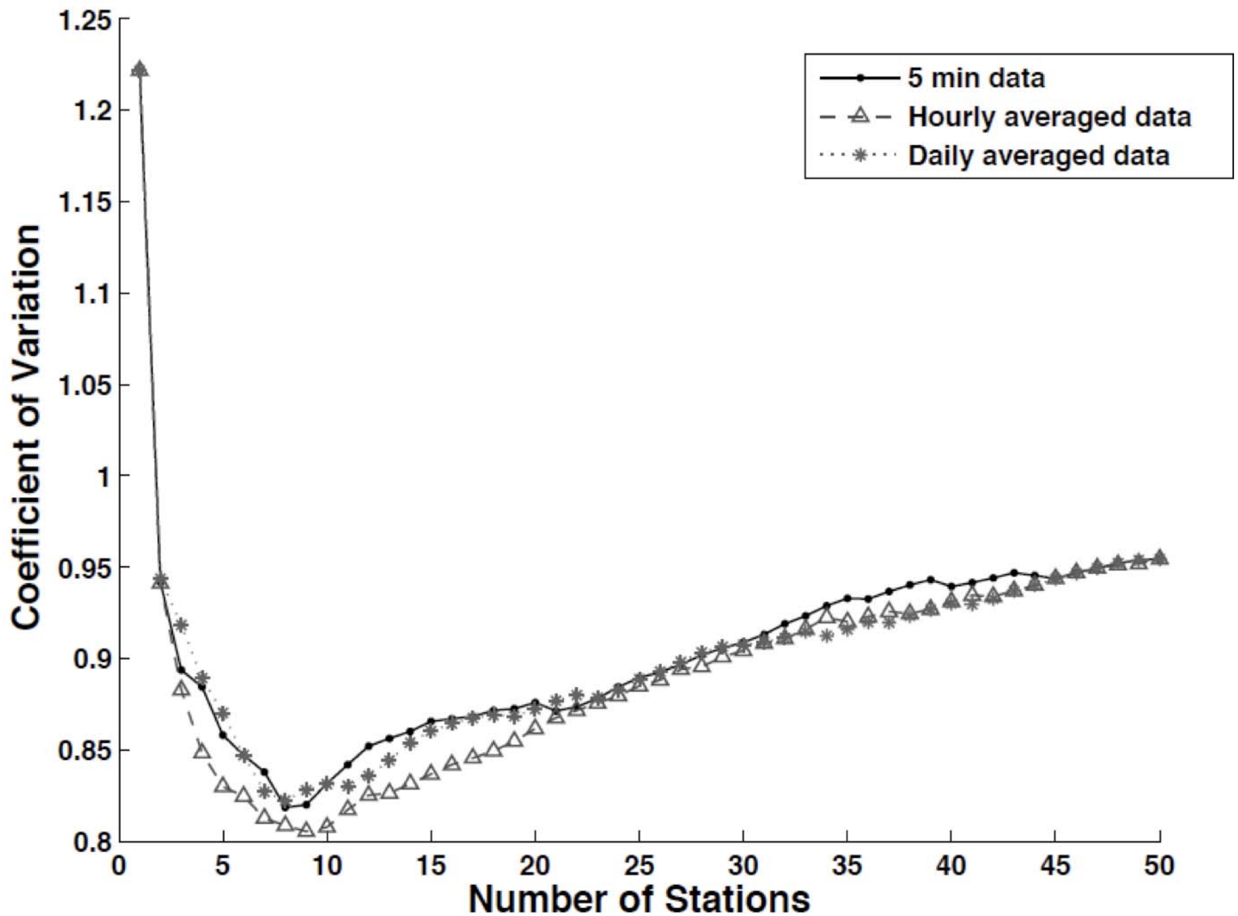
$$\bar{u}(80m) = \bar{u}(10m) \frac{\ln \frac{80}{Z_o}}{\ln \frac{10}{Z_o}}$$



- Select top 50 power stations based on average power

Results

• Wind farm connection sequence with variance minimizing algorithm. South eastern side of OK is low power region.
• Coefficient of Variation over different time scales



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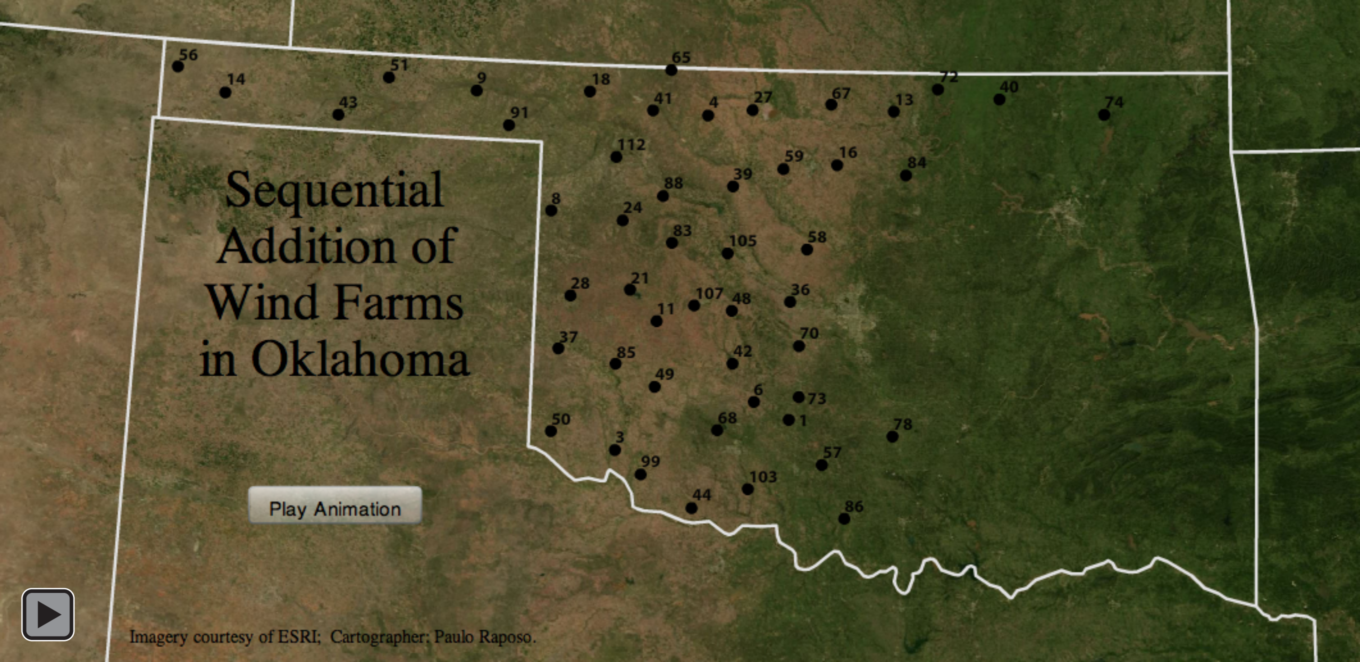
Sequential Addition of Wind Farms in Oklahoma
Play Animation
Imagery courtesy of ESRI; Cartographer: Paulo Raposo.
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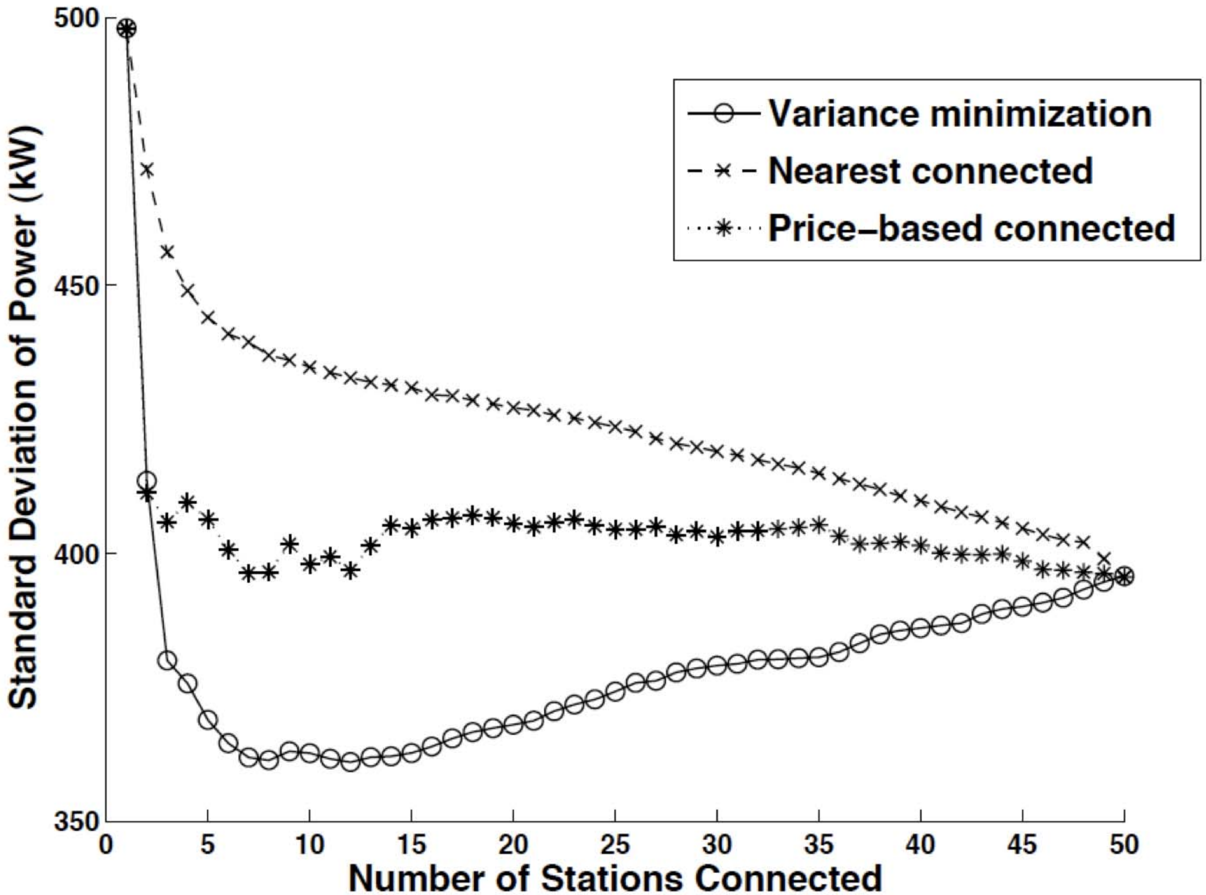
Results II

- Comparison of variances when we connect wind farms using
  - Variance minimizing algorithm
  - Connect nearest stations first
  - connect based on estimated revenue



Conclusions and future work

- When we connect the wind farms as per variance minimization algorithm, we get a 27% decrease in standard deviation and 33% decease in coefficient of variation after 8 grouping of stations

- These values are 12% and 13% when we connect wind farms based on closest distance

- For our future work, we will include locational prices, transmission costs and the ancillary services' costs in the decision criteria.

- The wind investment patterns from these decision rules will be compared to the variance-minimizing investment rule.

Acknowledgements

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