Analyzing Potential Wind Turbine Locations Using Automated Weather Station Data

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Scoping

Motivation:

> Revolution LLC is looking for a potential location in the state of California to set up its first wind farm.

Objectives:

> Analyze weather data in California to find areas with optimal wind speeds for wind turbines.

Scoping

Constraints:

- Land prices are an important factor for calculating cost of initial investment.
- Not all locations are available - some optimal areas are already occupied
- Zoning ordinances forbid wind farms in certain locations.

Additional data needed for next phase of study:

Data on existing wind farms, land prices for potential wind farm locations, and zoning data for CA would be required for Revolution to ascertain economic feasibility.

Scoping

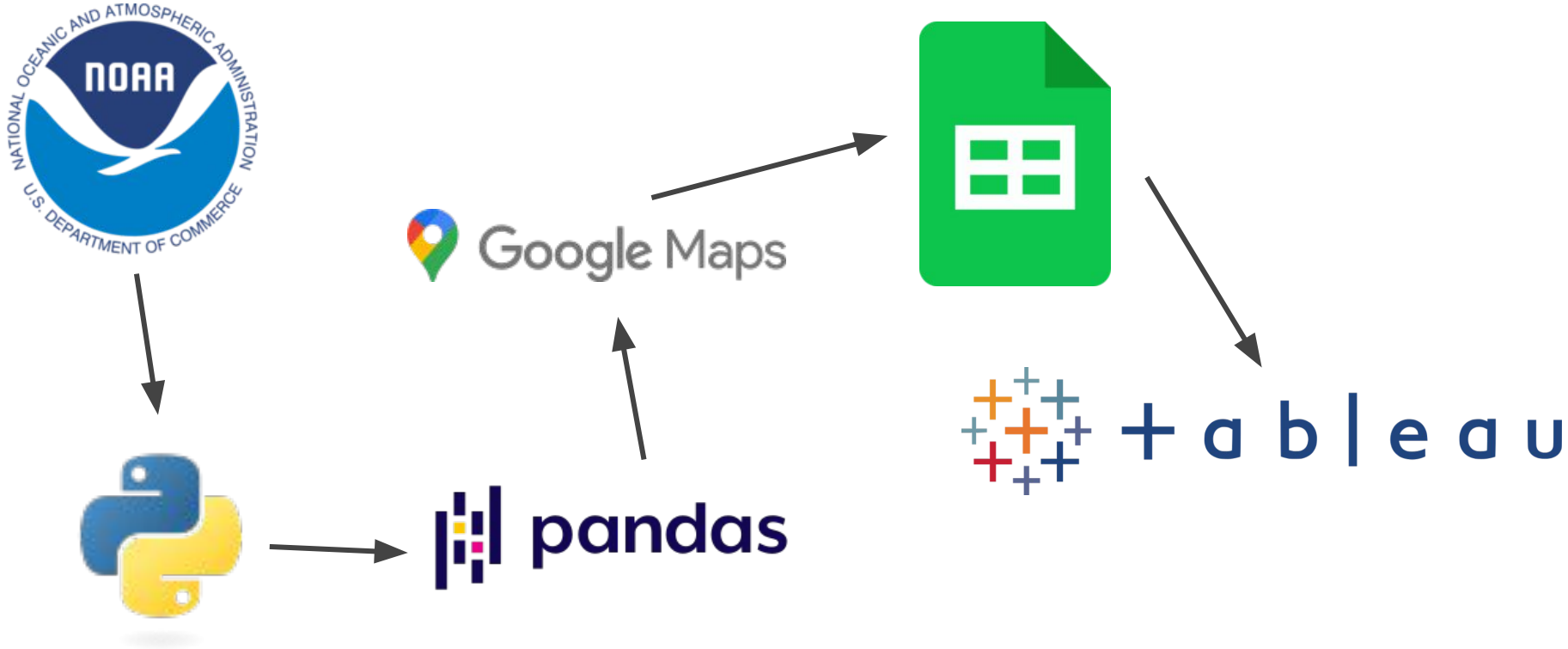
Data Science Solution:

Leverage data clustering models to group the most attractive locations together.

Success metric:

Revenue

Tools utilized



Methodology

Data:

- From NOAA
- 2020 California weather data
- 1,348,152 datapoints
- 56,490 station-days

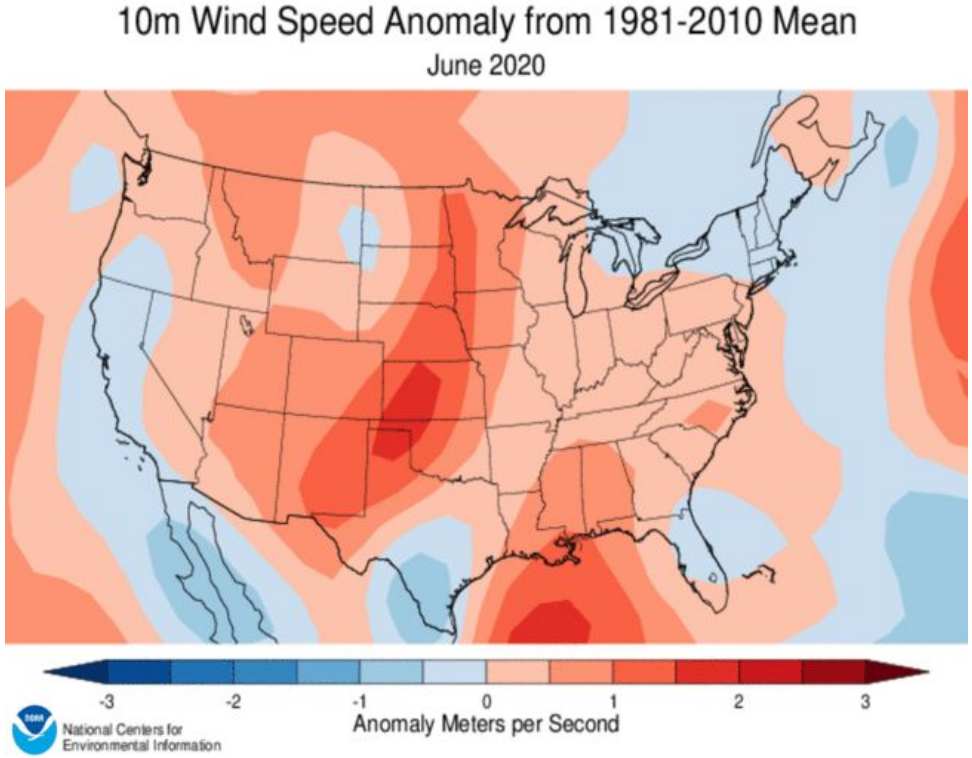
Relevant features:

- Wind speed: You need wind to generate electricity
- Elevation: The thinner the air is, the less power a turbine can generate.
- Location: You can’t build an industrial-grade turbine in the middle of LA even if wind is strong there.

Why only 1 year of data?

Over 2020, CA wind speed departed from the historical average by ±1 meter/sec or less.

Google Sheets is unable handle 30 years of historical weather data.



Source: https://www.ncdc.noaa.gov/societal-impacts/wind/w-mean/202106

Turbine Model

In order to calculate power generated, we need a specific wind turbine model.

I settled on the General Electric 1.5 MW model, which is widely used in the US.

Source: https://www.esig.energy/wiki-main-page/general-electric-1-5-mw-series/

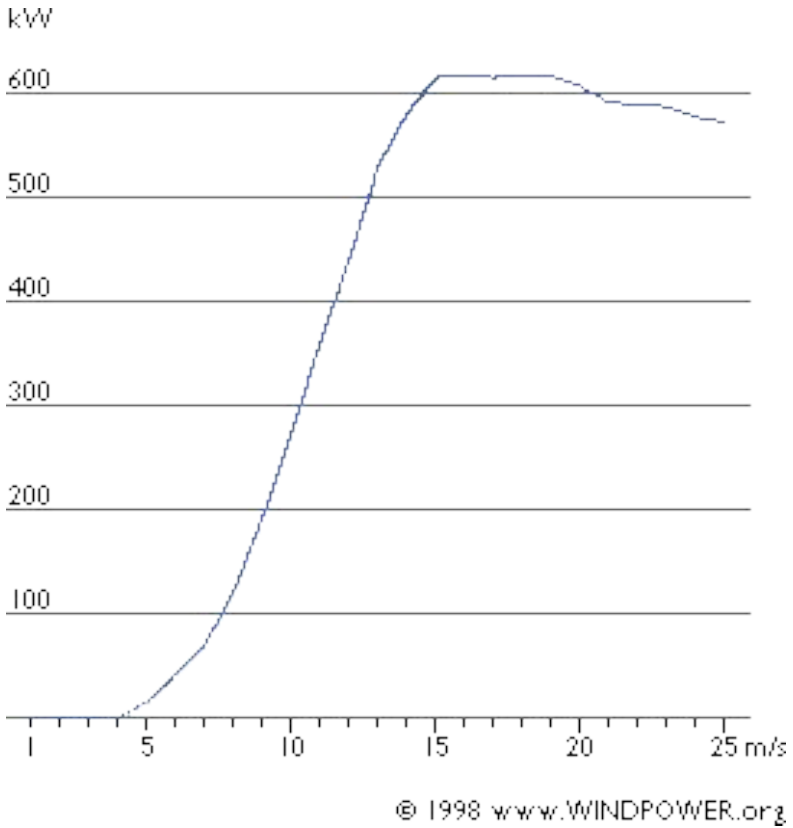
Calculating Power Generation

(Power) $\propto$ (Wind Speed)^3

(Power) $\propto$ (Air Density)

Power has a cubic relationship with wind speed, making wind the most important factor to consider.

Power curve of a representative 600 kW turbine

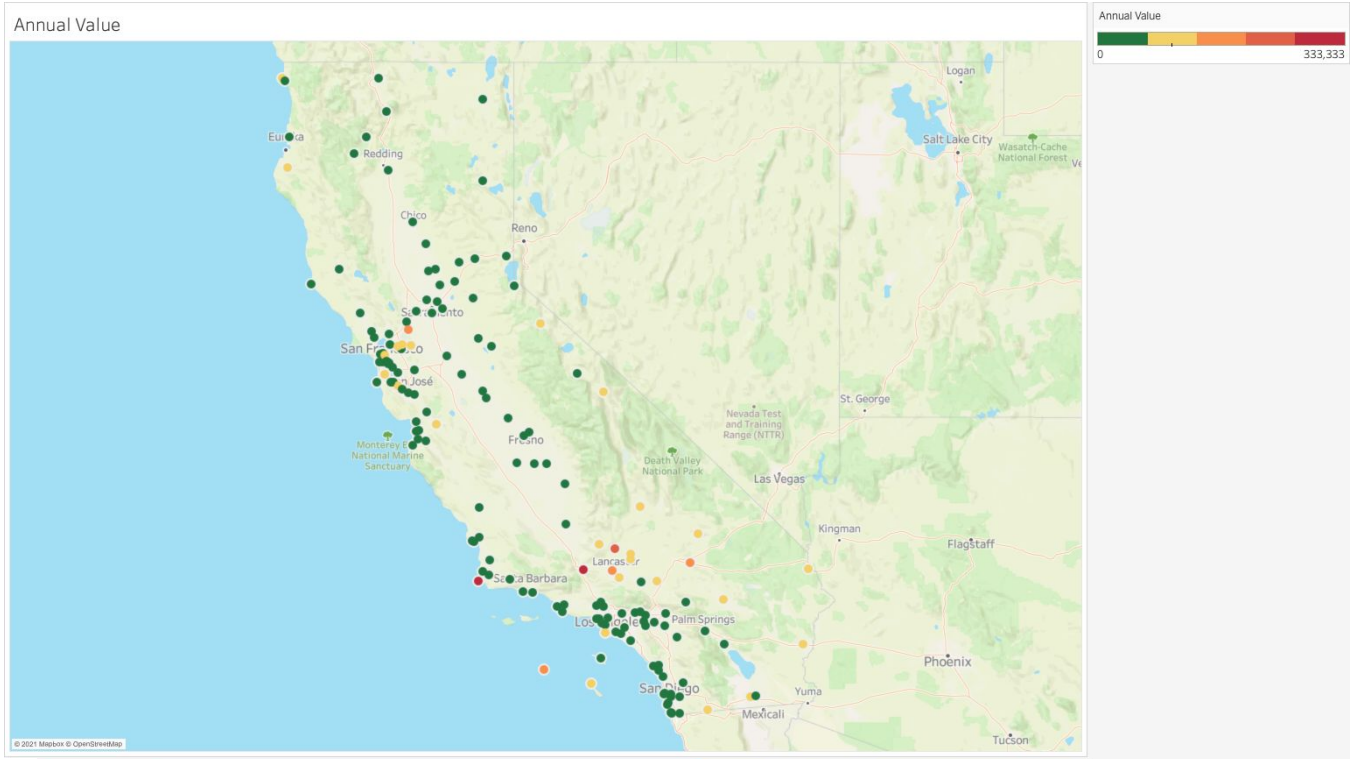


Source: http://drømstørre.dk/wp-content/wind/miller/windpower%20web/en/tour/wres/pwr.htm

Revenue Potential

Power generated can by calculated using air density and wind speed metrics.

The potential value of a turbine in each location is calculated using average US electricity price of $0.1058/KWh.



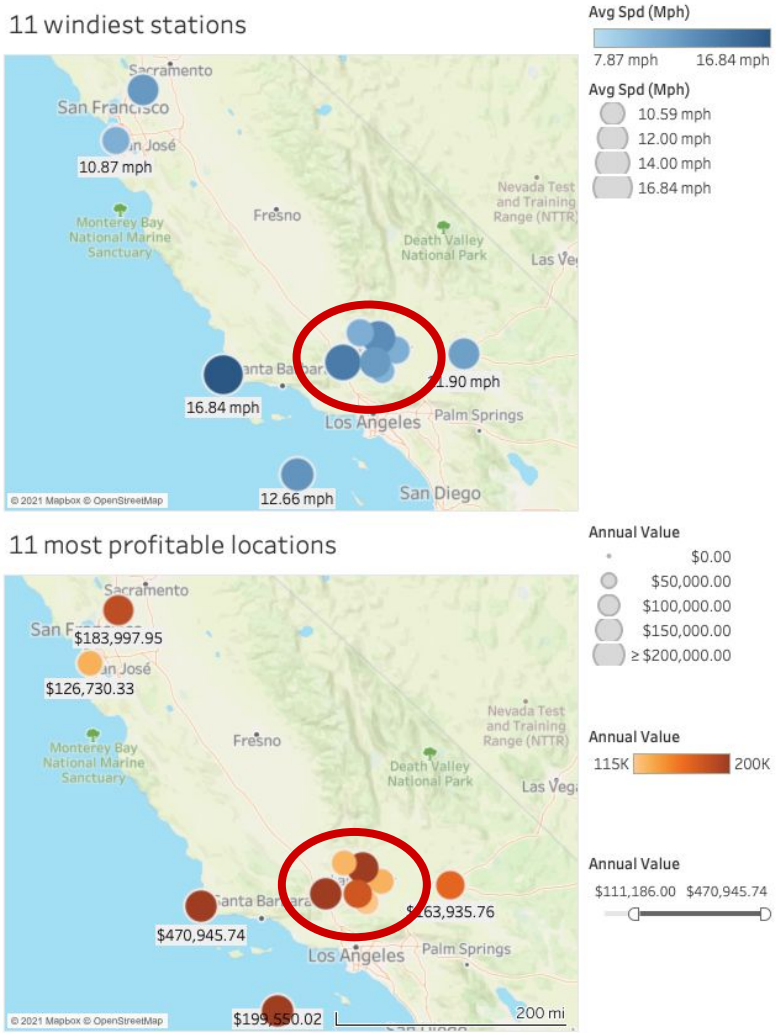
Most attractive locations: by wind speed and revenue potential

Unsurprisingly, locations with the highest average wind speed tend to generate the most power, and therefore, the most revenue.

The “land station” in Lompoc is actually in the Pacific Ocean and inaccessible.

Of the top 10 stations, one is within San Francisco City, and another in an Air Force Base.

Most of the remaining stations are near Lancaster, which seems to have the most potential for a wind farm.



Conclusion

Out of the accessible locations, Lancaster, CA has the highest wind quality for a wind farm and should be considered as a promising location for installing turbines.

Link to Tableau Dashboard

Future Work

Using data on existing wind farms, land prices, and zoning ordinances to narrow down potential locations is necessary before deciding on a location to build turbines.

Thank you!

Appendix

Turbine Mechanics

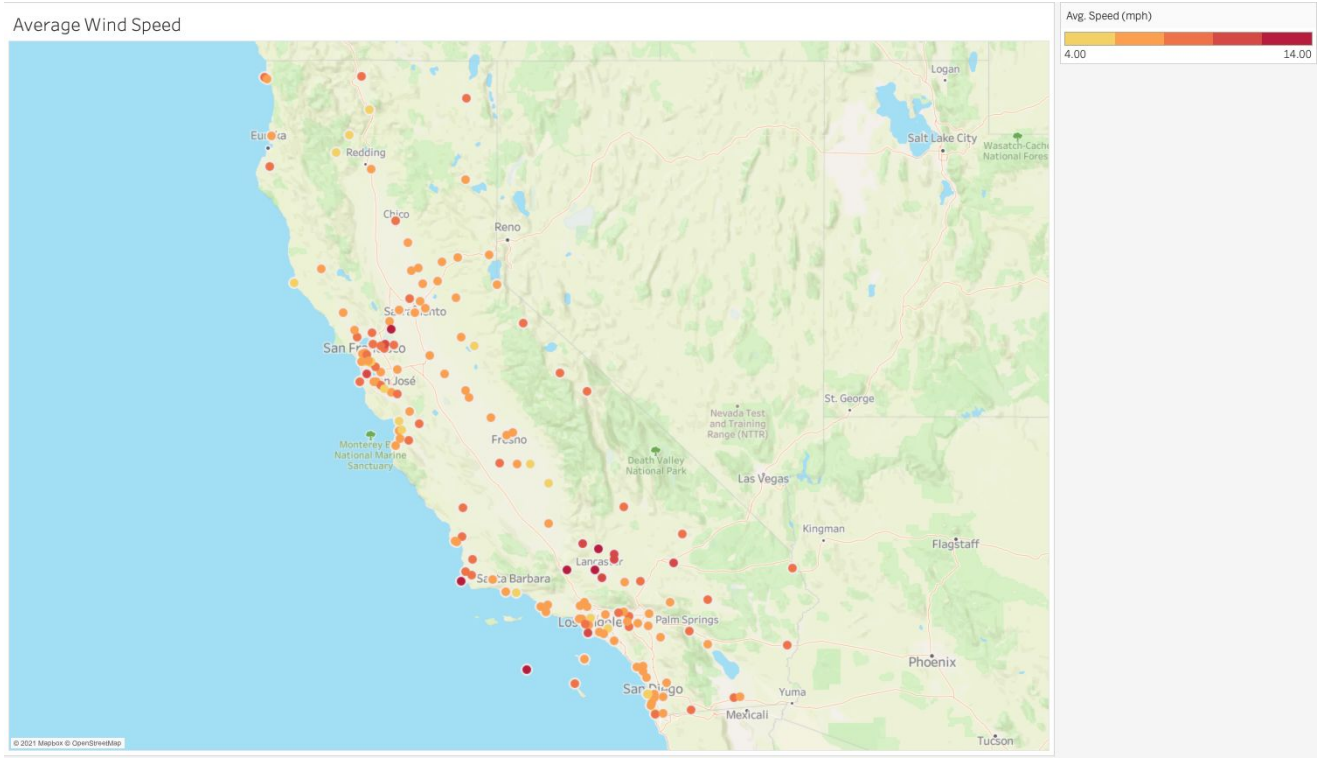
Some key metrics:

- Blade Length
- Efficiency
- ~~Cut in Speed~~
- ~~Cut back Speed~~
- ~~Cut out Speed~~

For the sake of simplicity, we'll ignore the cut-in speed.

The maximum recorded daily average wind speed in California in 2020 was 36 mph; we don't have to worry about the cut-out speed.

Wind Speed in California



Air Density

Air density can be calculated using elevation. The higher the altitude, the lower the air density.