Renewable energy has become critical to our planet. Just think of CO2 emissions and depletion of non-renewable energy sources like oil. It’s estimated that by 2050 Solar and Wind energy may supply up to 2/3 of the world’s energy needs. Wind energy “will surge from today’s 7% to 26% in thirty years”

<https://www.enelgreenpower.com/media/news/d/2019/07/bloomberg-new-energy-outlook-2019>

This project addresses a miniscule slice of the Wind Energy Universe.

There are two primary audiences for this information: small investors and communities/property owners/politicians.

1 - The first group: Small Investors. I say small because a large investor like a state retirement fund will have done extensive research prior to investing.

Wind farms are a great source of renewable energy but upfront costs are massive.

About $2 million per megawatt turbine rating.

<http://www.windustry.org/how_much_do_wind_turbines_cost>

So, a small wind farm with, say, a 100 MW maximum capacity would cost about $200 million. Investors would probably have to ante up at least one-million to participate in a project. Say you have a million lying around and you see a prospectus for this very wind farm. It presents some simple math from a Pollyannaish perspective.

With the wholesale cost per MWh (megawatt hour) currently about $26 in California…

<http://www.energyonline.com/Data/GenericData.aspx?DataId=20>

the prospectus shows wind farm income as 24 hours x 365 days x $26/MWh x 100= $22,776,000.

Of course, there are ongoing expenses like maintenance and insurance but the prospectus shows a 20% annual return on your investment. Great news. Even if the return is only 15%, you’re all in. So, not only do you invest the $1 Million lying around -- you mortgage your recently paid-off and now have $2 Million to invest.

But wait – no one told about the “mean capacity factor.” These turbines do not produce max rated energy 24 hours a day. In 2018 the average capacity factor for California was 28.5%

<https://www.energy.gov/sites/prod/files/2019/08/f65/2018%20Wind%20Technologies%20Market%20Report%20FINAL.pdf>

Now the wind farm revenue is down to about 6.5 Million and your expected return is down from 20% to 5.7%. Maybe time to reconsider.

2 – Community/Property Owners/ Politicians

These people/groups likely need all information available concerning any potential wind farm in their community. This report will make them aware of one small but important dimension of any project – “mean capacity factor.”

My primary source of data is The U.S. Wind Turbine Database

<https://eerscmap.usgs.gov/uswtdb/data/>U.S.

They maintain detailed information on every wind turbine in the USA + Guam+ Puerto Rico – all 60,577 of them. Data includes GPS coordinates, turbine max capacity, date installed, turbine manufacturer, height etc. The only thing missing is the mean capacity factor for each turbine.

That can be found at Renewables.ninja

<https://www.renewables.ninja/>

This is great site where they have put together GPS wind data and the power curve for most wind turbines by manufacturer to derive the mean capacity factor for the turbine. You enter GPS coordinates, manufacturer and height for a wind turbine and get the mean capacity factor.

Unfortunately, you can only enter information on one turbine at a time so adding this data to each of the 60, 577 turbines are a full-time job, not a class project.

So, I am going to radically reduce the dataset down to 60 turbines in California, randomly chosen -- 30 from northern California – 30 from southern California.

I will add the mean capacity factor from Renewables.ninja to each of the 60 turbines.

My hypothesis is that there is a statistically significant difference between mean aggregate capacity factor for the northern turbines and the mean aggregate capacity factor for the southern turbines. The null, of course, being that there is no difference.

Math:

I will be using the following:

stats. Describe

T-test

QQ-plots

Shapiro-Wilk

Histograms