Wind Energy Resources Modeling and Analysis

Technical Presentation

By
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August 6th, 2019

Wind Energy Resources Modeling and Analysis

For Different Locations in the U.S.

Four U.S. Locations are Chosen for Comparison of Wind Energy Modeling

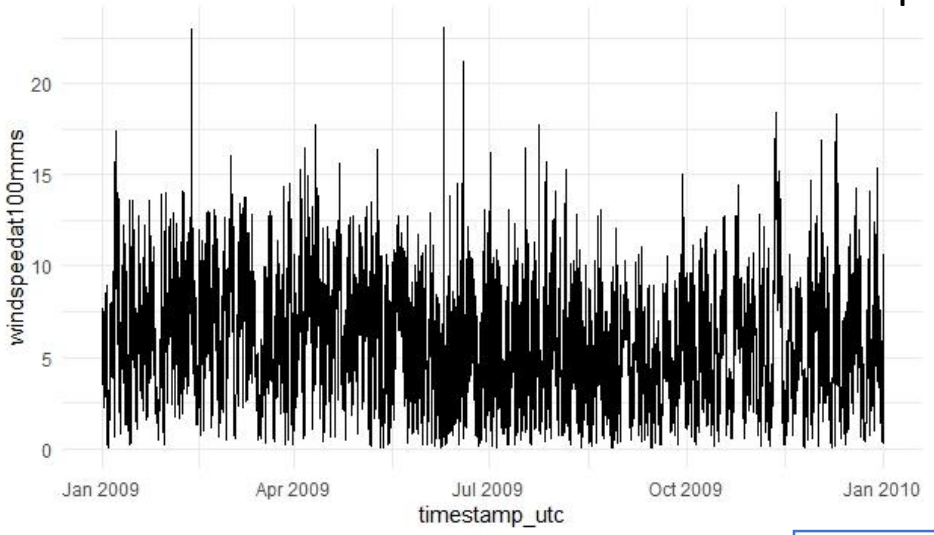
Charlotte NC, Boston MA, Boulder CO, Tucson AZ.

Data are retrieved from NREL's Developer Network: https://developer.nrel.gov/

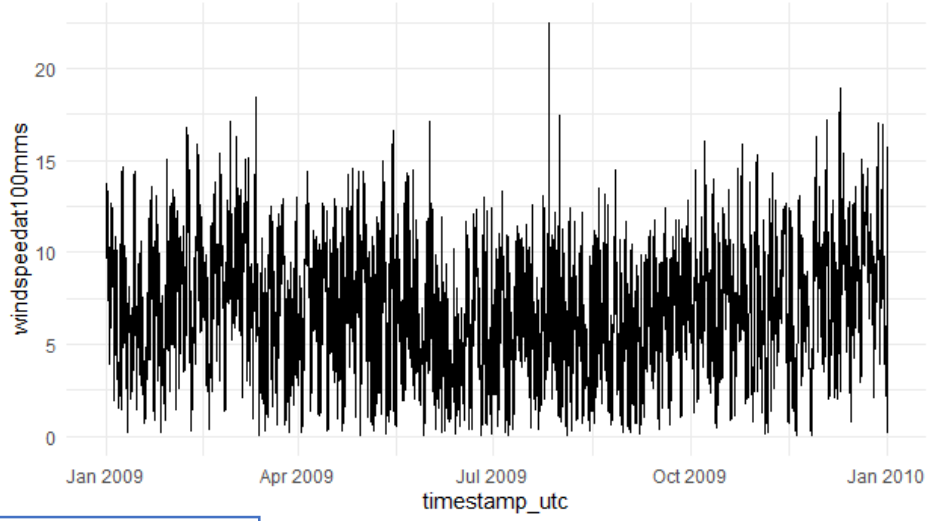
Wind Energy Resources Modeling

Time series of wind speed at height 100m (m/s)

Charlotte, NC

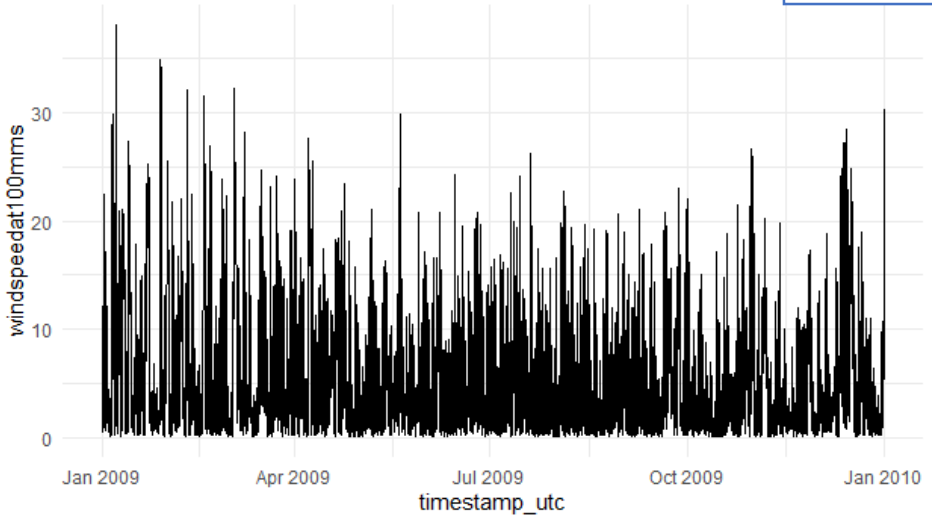


Boston, MA

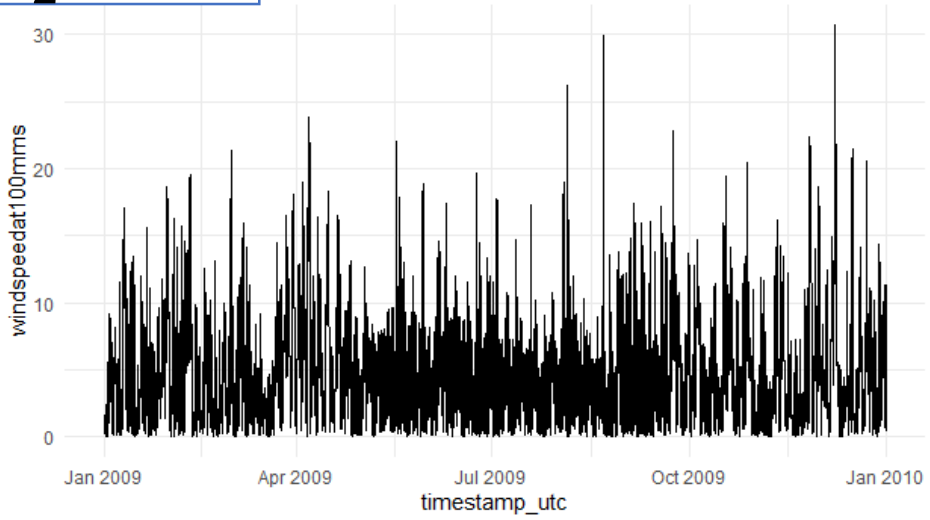


$$Pw = \frac{1}{2}\rho A v^3$$

Boulder, CO



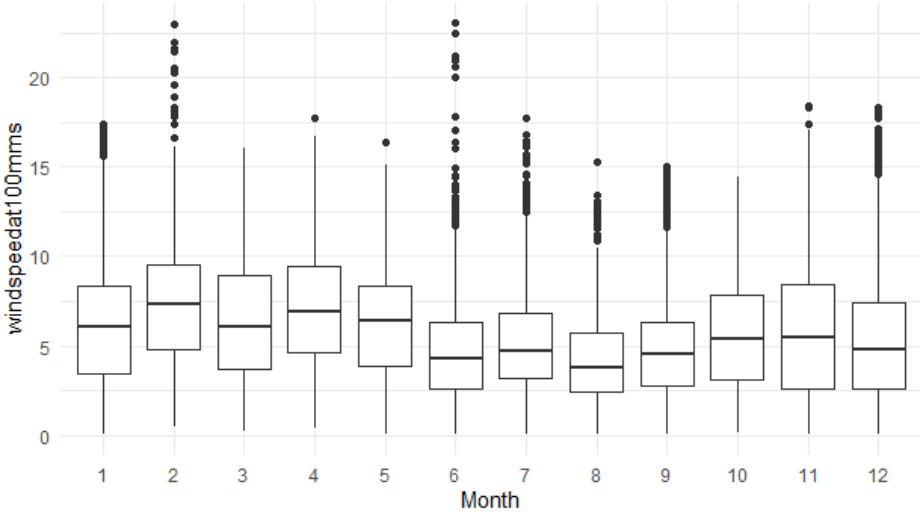
Tucson, AZ



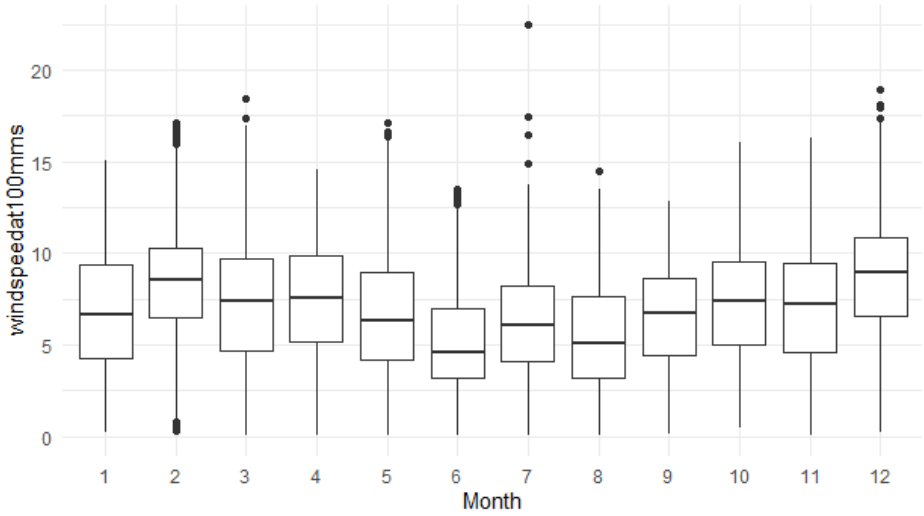
Wind Energy Resources Modeling

Boxplots of monthly distribution of wind speed

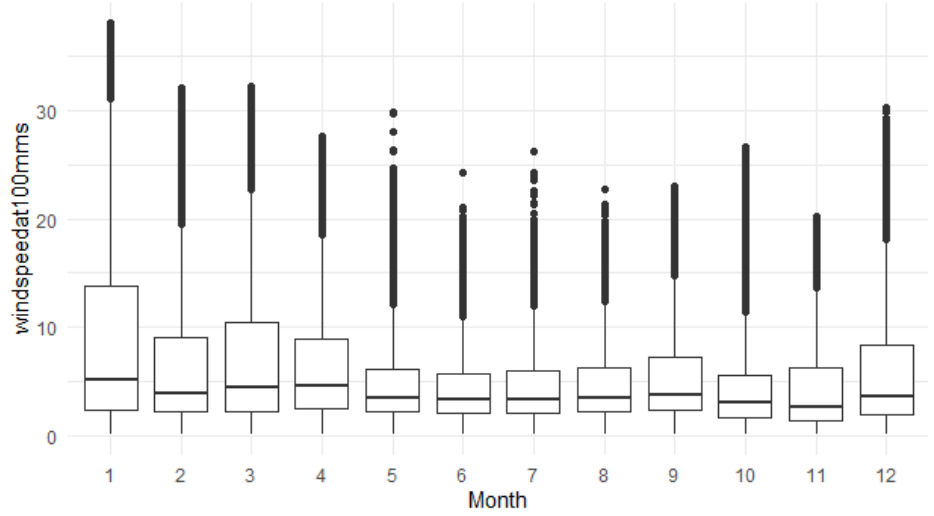
Charlotte, NC



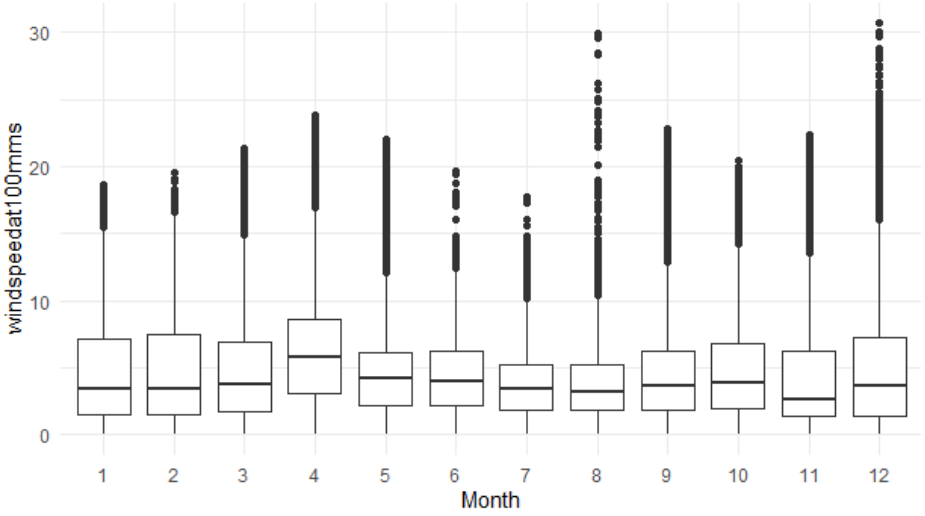
Boston, MA



Boulder, CO



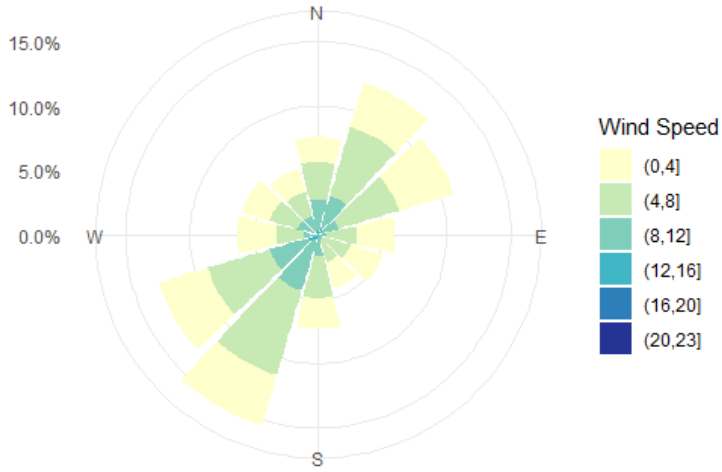
Tucson, AZ



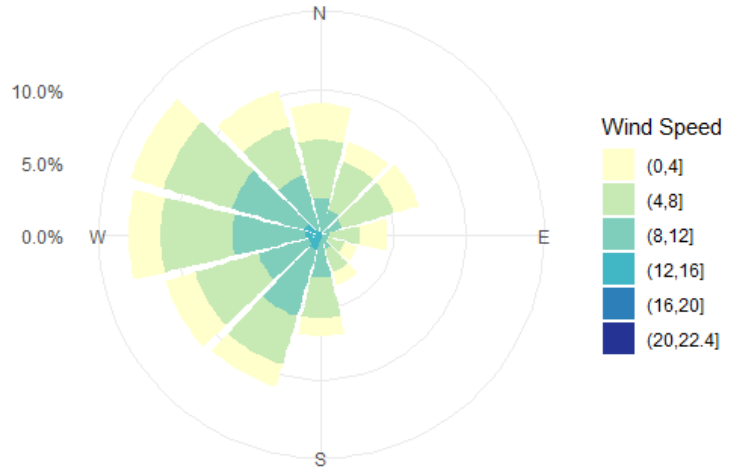
Wind Energy Resources Modeling

Wind Roses of Wind Speed

Charlotte, NC

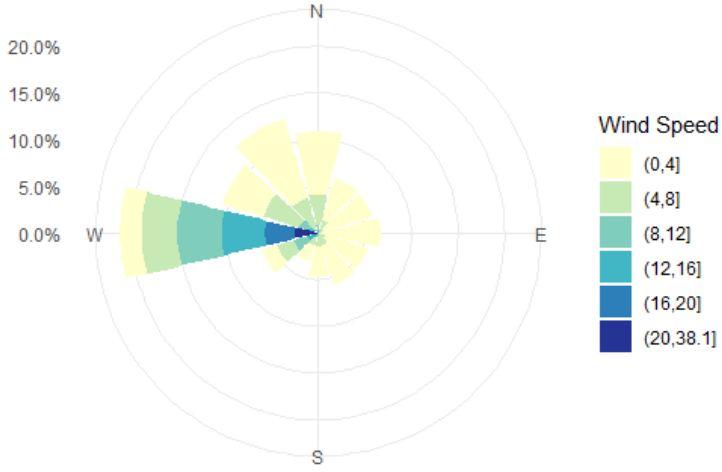


Boston, MA

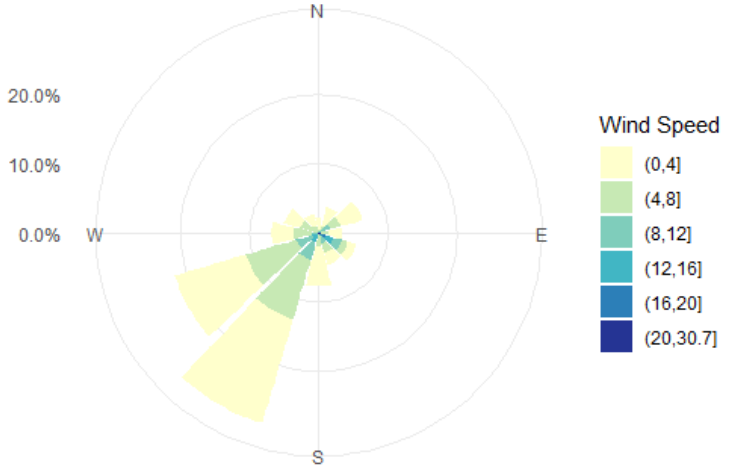


Distribution of wind direction and speed

Boulder, CO



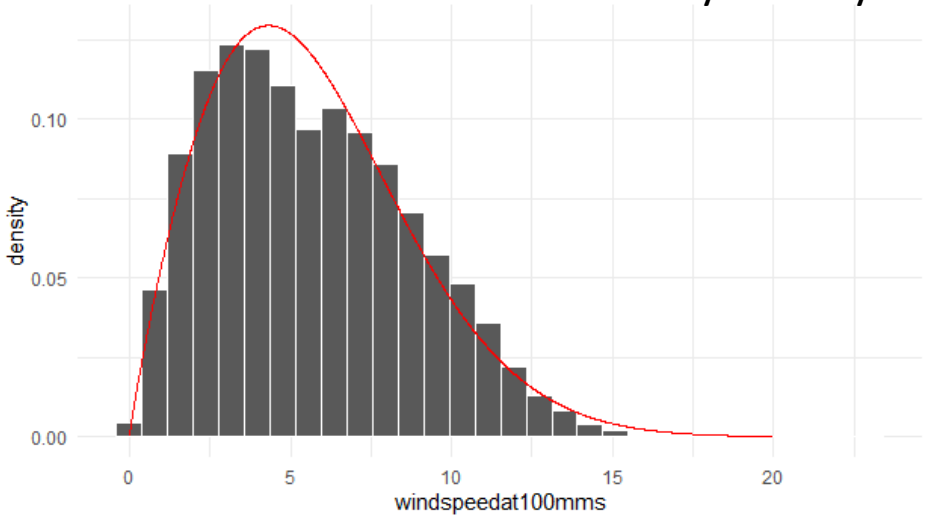
Tucson, AZ



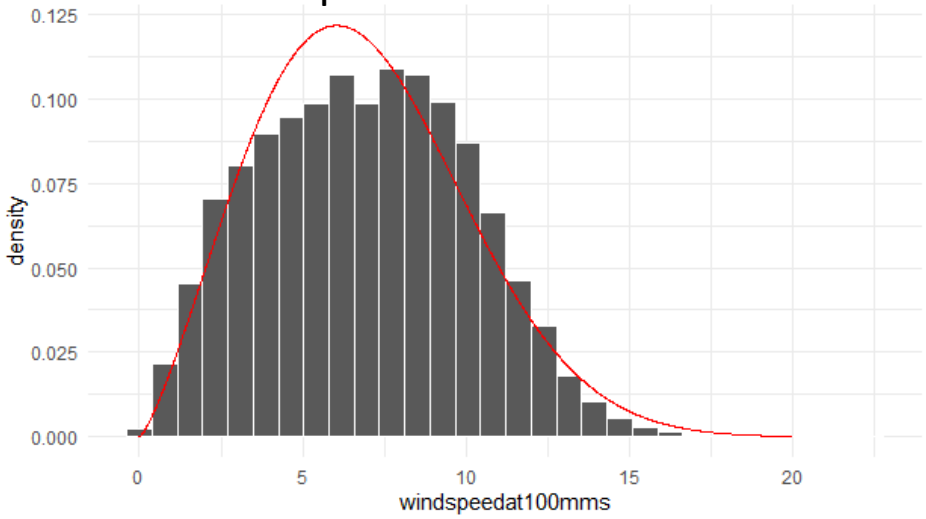
Wind Energy Resources Modeling

Probability density distribution of wind speed

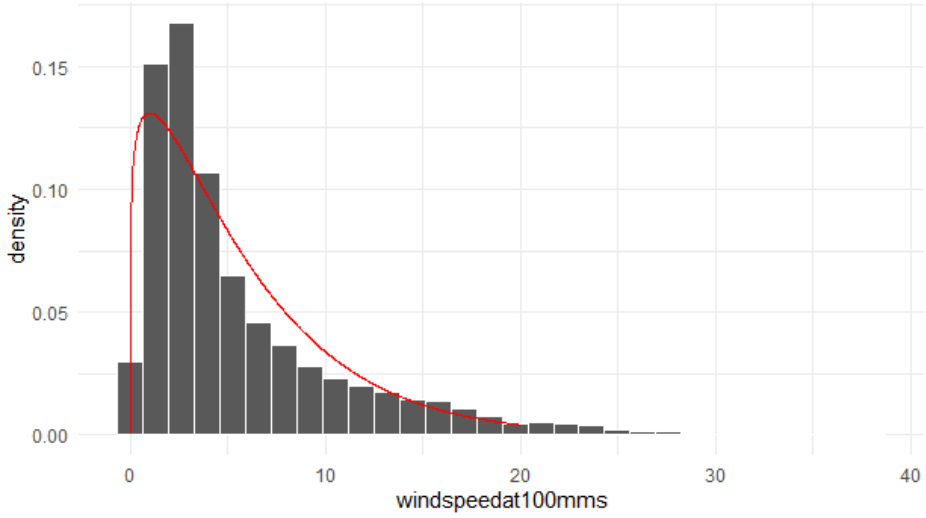
Charlotte, NC



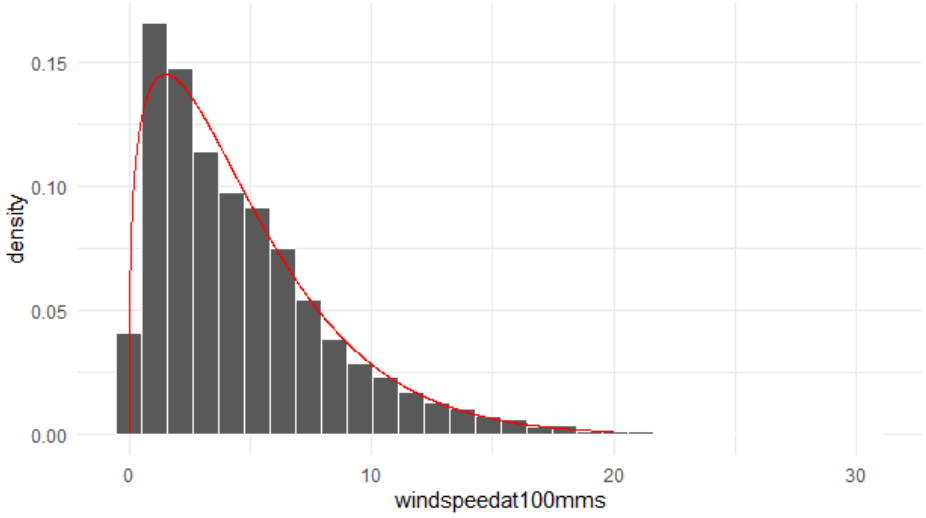
Boston, MA



Boulder, CO



Tucson, AZ

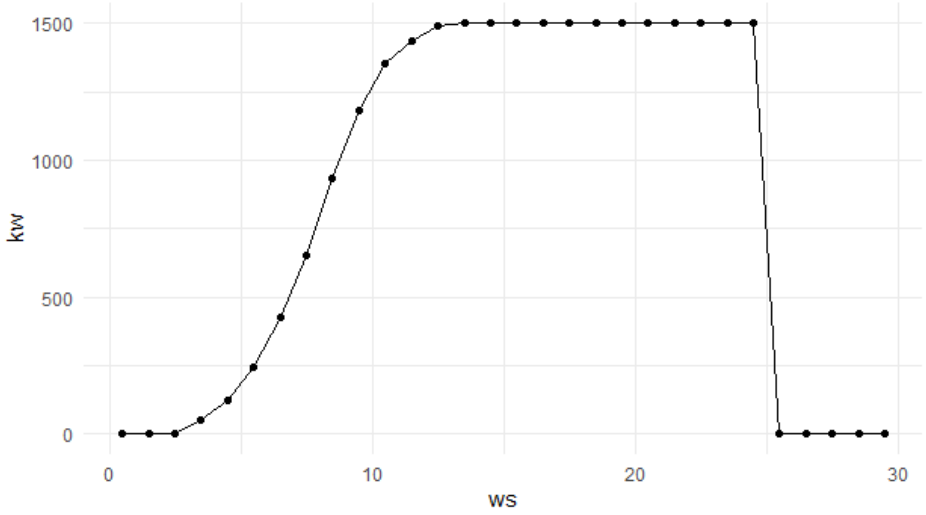


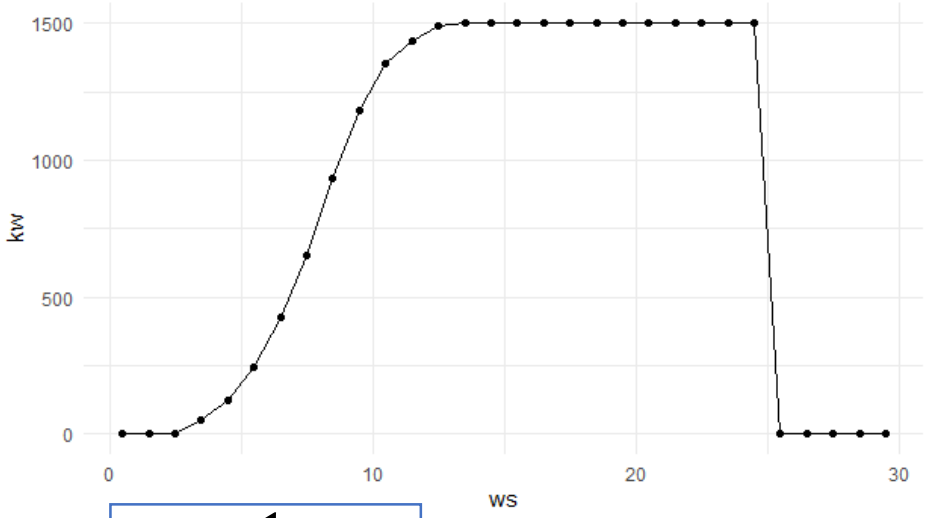
Wind Energy Resources Modeling

Charlotte, NC

Wind turbine GE 1.5SLE 77m is utilized for modeling

Boston, MA



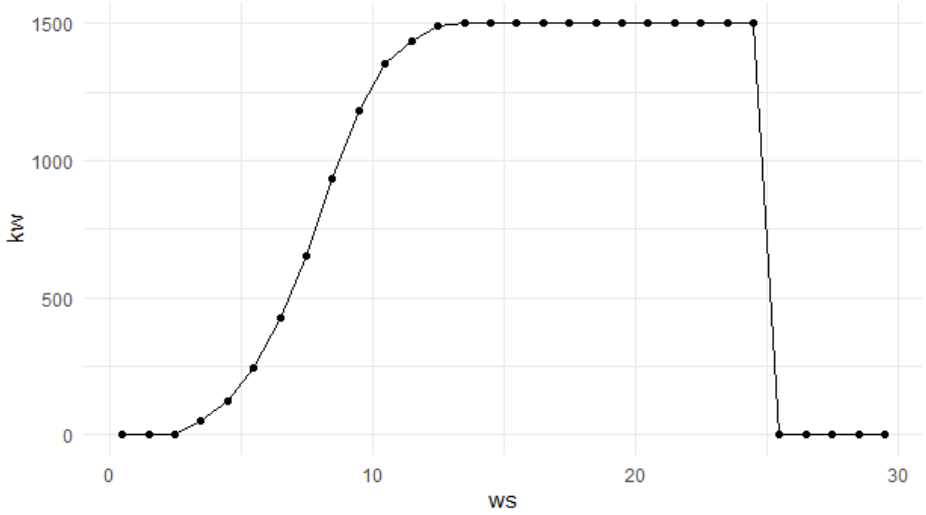


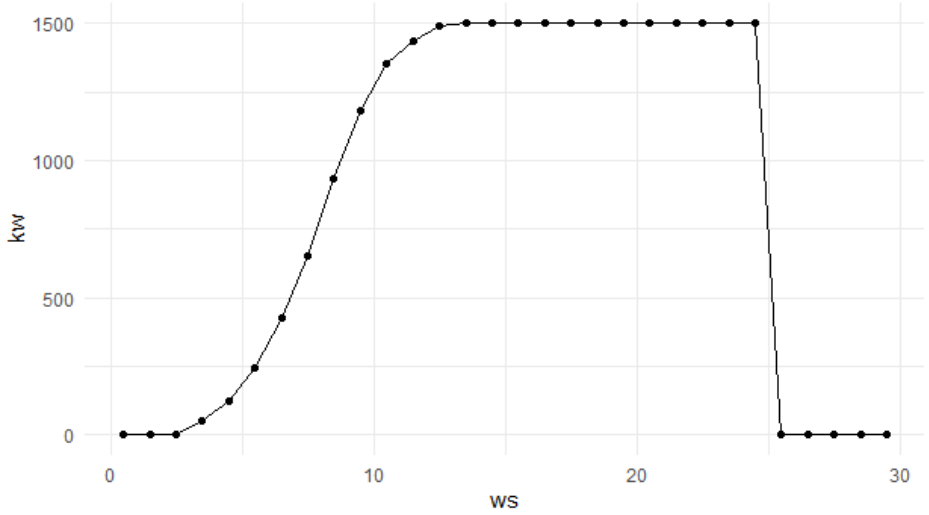
The wind power curve for GE 1.5SLE 77m to covert the wind speed to wind power

$$Pw = \frac{1}{2}\rho A v^3$$

Boulder, CO

Tucson, AZ





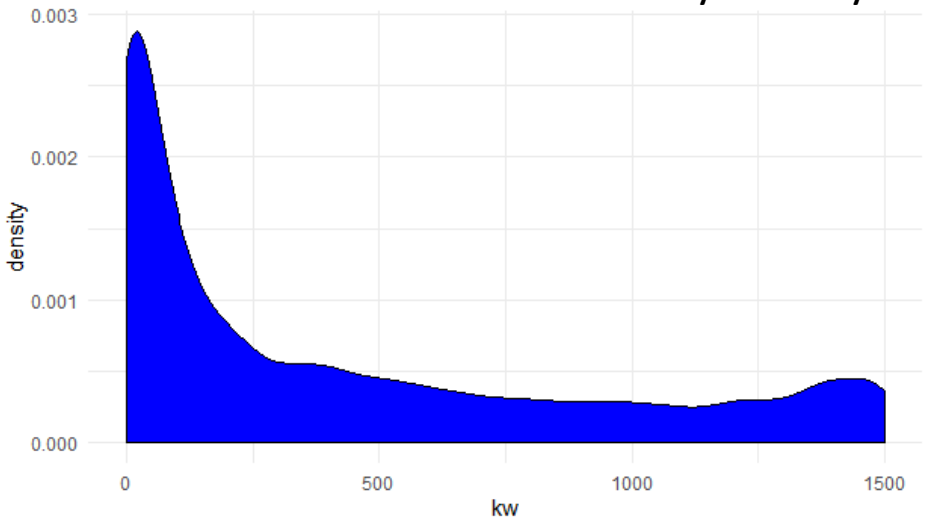
http://www.wind-power-program.com/Downloads/Databasepowercurves(May2017).zip

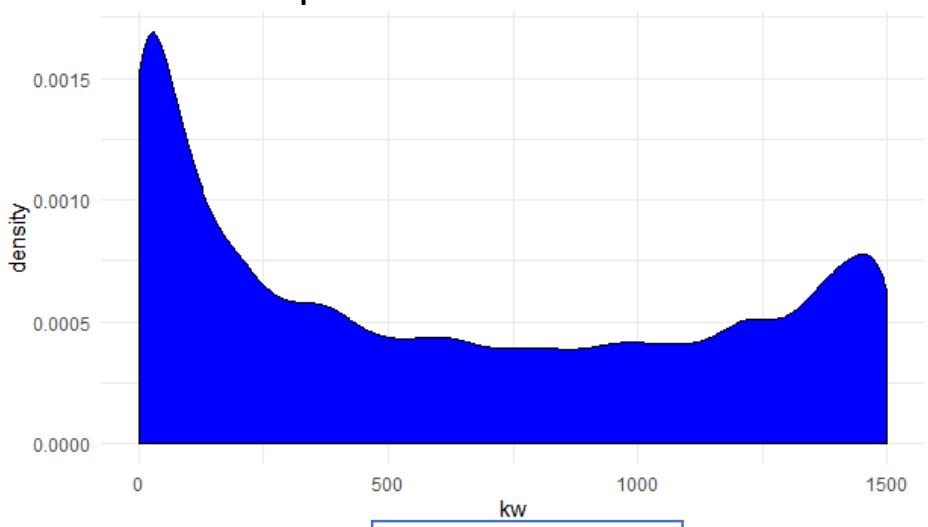
Wind Energy Resources Modeling

Charlotte, NC

Probability density distribution of wind power

Boston, MA



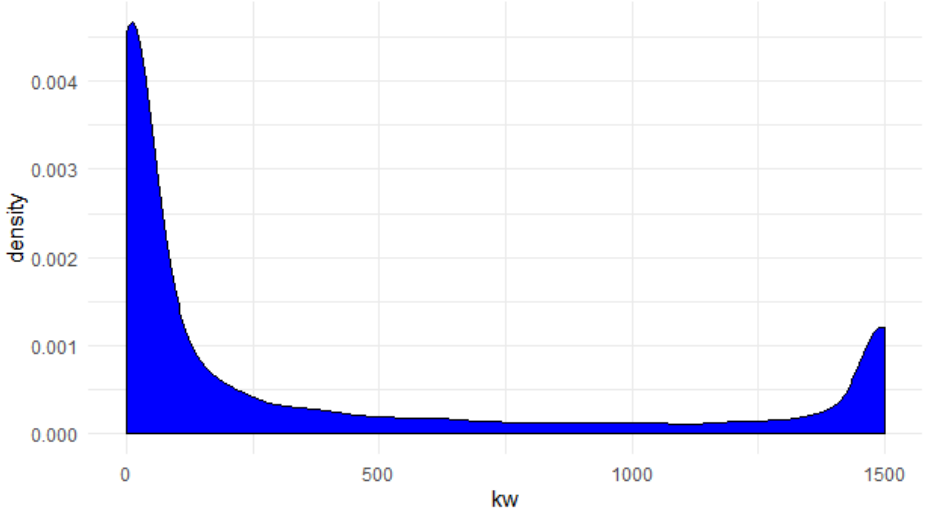


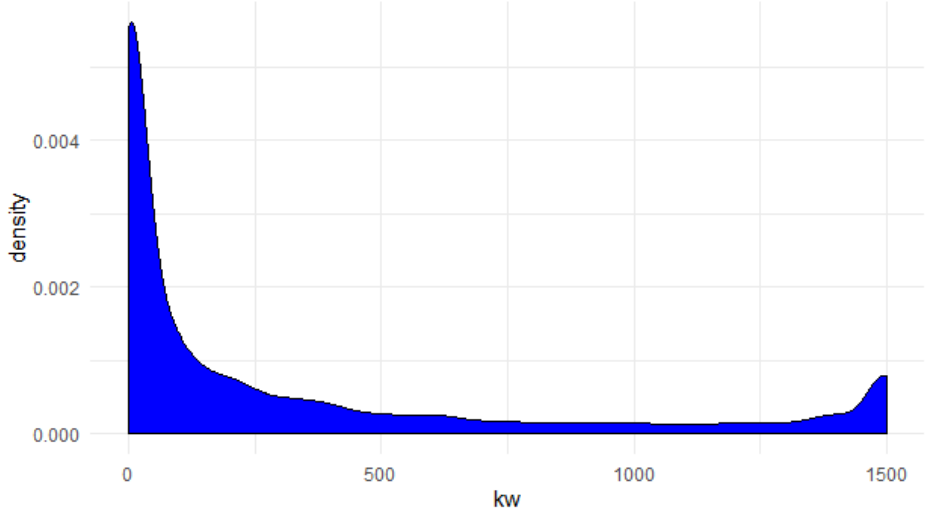
Considering other parameters such as air pressure, temperature and density at the given height=100m

$$Pw = \frac{1}{2}\rho A v^3$$

Boulder, CO

Tucson, AZ





Wind Energy Resources Modeling

Wind Energy Modeling
in 2009

Calculating the net capacity factor (NCF)
for each month, then over the entire year

$$NCF=\frac{The\ actual\ energy\ generated}{The\ possible\ maximum\ energy\ that\ could\ have\ been\ generated}$$

$$NCF=\frac{The\ actual\ energy\ (MWh)}{The\ capacity * time\ (MWh)}$$

Charlotte, NC

Month	MWh	NCF
1	387.574	34.70%
2	455.725	45.20%
3	410.236	36.80%
4	456.256	42.20%
5	381.352	34.20%
6	193.475	17.90%
7	230.690	20.70%
8	141.379	12.70%
9	197.738	18.30%
10	310.630	27.80%
11	355.663	32.90%
12	298.279	26.70%

Boulder, CO

Month	MWh	NCF
1	413.396	37.00%
2	288.217	28.60%
3	382.094	34.20%
4	339.568	31.40%
5	222.077	19.90%
6	187.928	17.40%
7	216.100	19.40%
8	215.737	19.30%
9	268.648	24.90%
10	206.966	18.50%
11	224.898	20.80%
12	312.770	28.00%

Boston, MA

Month0	MWh	NCF
1	467.945	41.90%
2	584.361	58.00%
3	510.499	45.70%
4	512.191	47.40%
5	420.662	37.70%
6	239.808	22.20%
7	354.663	31.80%
8	285.923	25.60%
9	396.328	36.70%
10	504.488	45.20%
11	471.683	43.70%
12	691.553	62.00%

Tucson, AZ

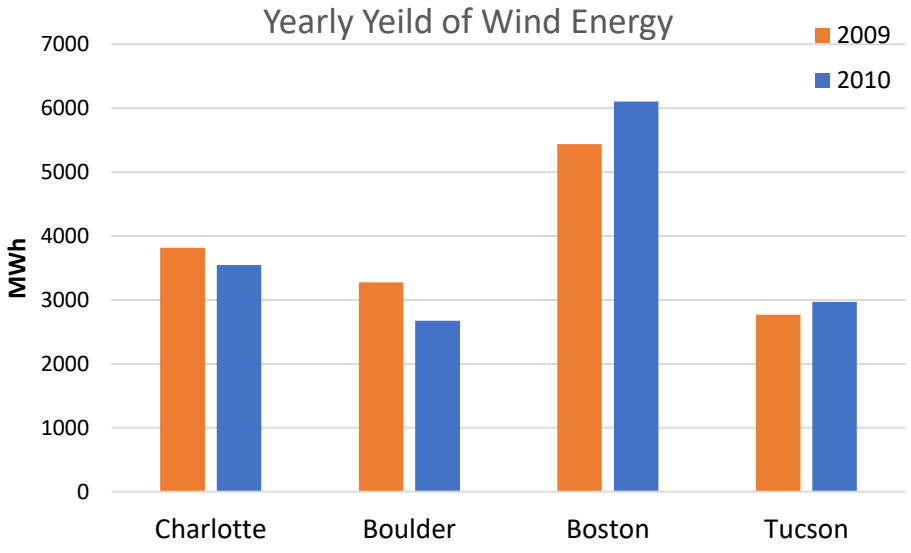
Month0	MWh	NCF
1	262.764	23.50%
2	247.664	24.60%
3	259.804	23.30%
4	378.228	35.00%
5	184.679	16.50%
6	188.630	17.50%
7	111.523	10.00%
8	143.448	12.90%
9	223.078	20.70%
10	258.261	23.10%
11	236.885	21.90%
12	274.958	24.60%

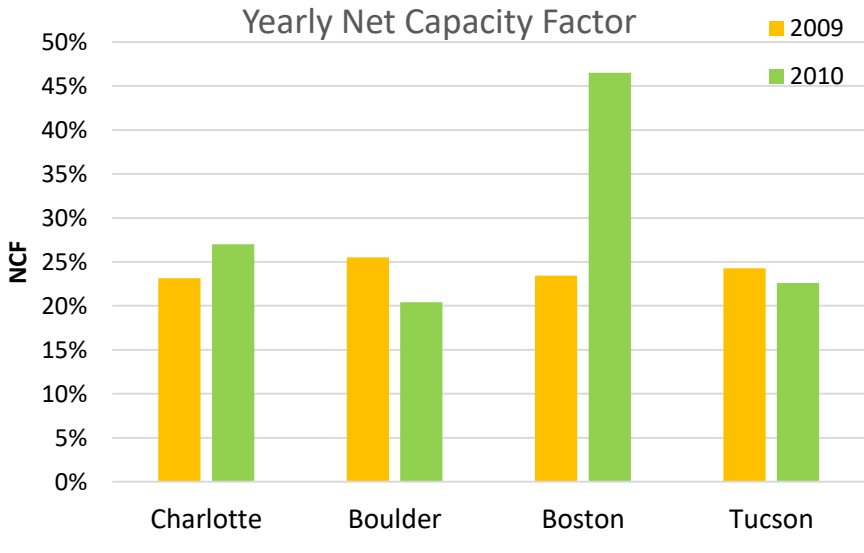
Wind Energy Resources Modeling

Wind Energy Modeling
in 2009 and 2010

2009	MWh	NCF
Charlotte	3818.9	29.1%
Boulder	3278.4	24.9%
Boston	5440.1	41.4%
Tucson	2769.9	21.1%

2010	MWh	NCF
Charlotte	3544.6	27.0%
Boulder	2676.9	20.4%
Boston	6107.7	46.5%
Tucson	2969.9	22.6%





Conclusion

The performance of wind energy resources depends significantly on their location and weather conditions.

Further Work

Modeling and evaluate the wind resources backed up by energy storage systems.

References

1. https://www.r-bloggers.com/time-series-analysis-with-wind-resource- assessment-in-r/
2. https://github.com/mhdella/AWEA_WRA_Working_Group/blob/master/Example_Wind_Resource_Assessment_Using_R.md