Wind Energy as the Future Renewable Resource

Anthony Seto

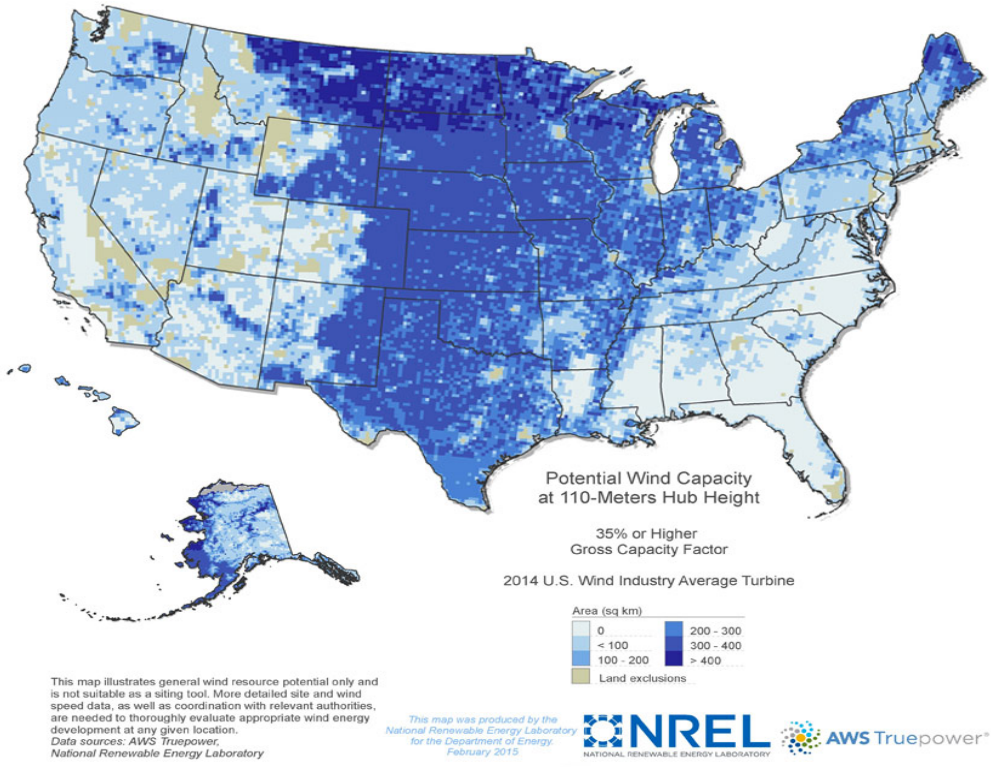
April 28, 2016

The United States has developed a dependency on various fossil fuels in the past years. It is important that we begin to merge into a new era of renewable resources. One of the top choices on interest include wind energy. In this paper, the reasons for wind energy is explained in detail as well as potential problems that we currently have with wind energy.

I. Abundance

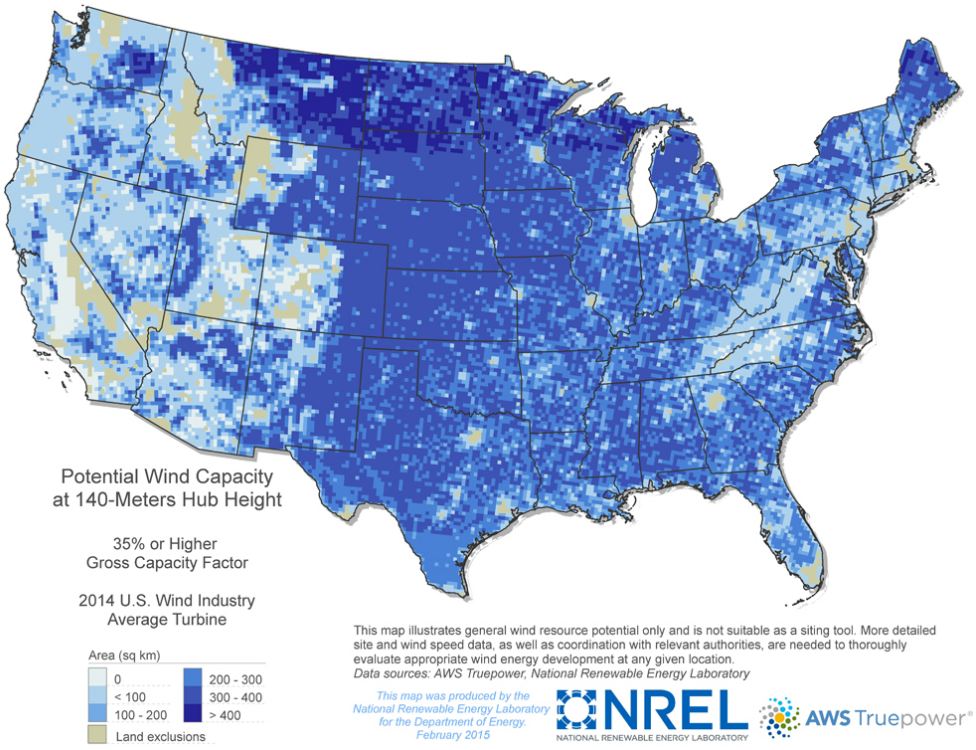
The main advantage of wind energy is its high abundance in the United States. In Figure 1, the National Renewable Energy Source Lab (NREL) created a map of potential locations for wind turbines at a height of 110 meters. The amount of potential locations for wind energy is extremely high, even at areas where current wind sources are not located. The darker blue regions represent areas of higher potential as a building site. NREL also recognizes that there are areas where wind turbine energy is not feasible, such as urban areas, national parks, and also federal regulations on certain locations. These locations are already accounted for the map. Although the United States has many urban areas, the map shows the high potential of wind turbine implementation at the mid-western part of the country. It's important to note that the average wind turbine size is around 110 meters. The map in Figure 1 is a model of wind turbines at a higher than average height. However, when the NREL produces the same type of math with a different wind turbine height, it is still clear that the United States can expand their investments in wind technology.

Figure 1 – Graph of Potential Wind Capacity at 110-Meters Hub Height



In Figure 2, the NREL produces a similar map as Figure 1. This graph shows the potential wind capacity at a much higher height of 140 meters. While this type of wind turbine is not mass produced yet, it represents a near future technology that could well increase the potential for wind turbine energy. In the map, the proportion of dark blue areas is much higher than the amount represented in Figure 1. Again, the NREL attempts its best to account for the urban areas where wind turbines cannot be installed.

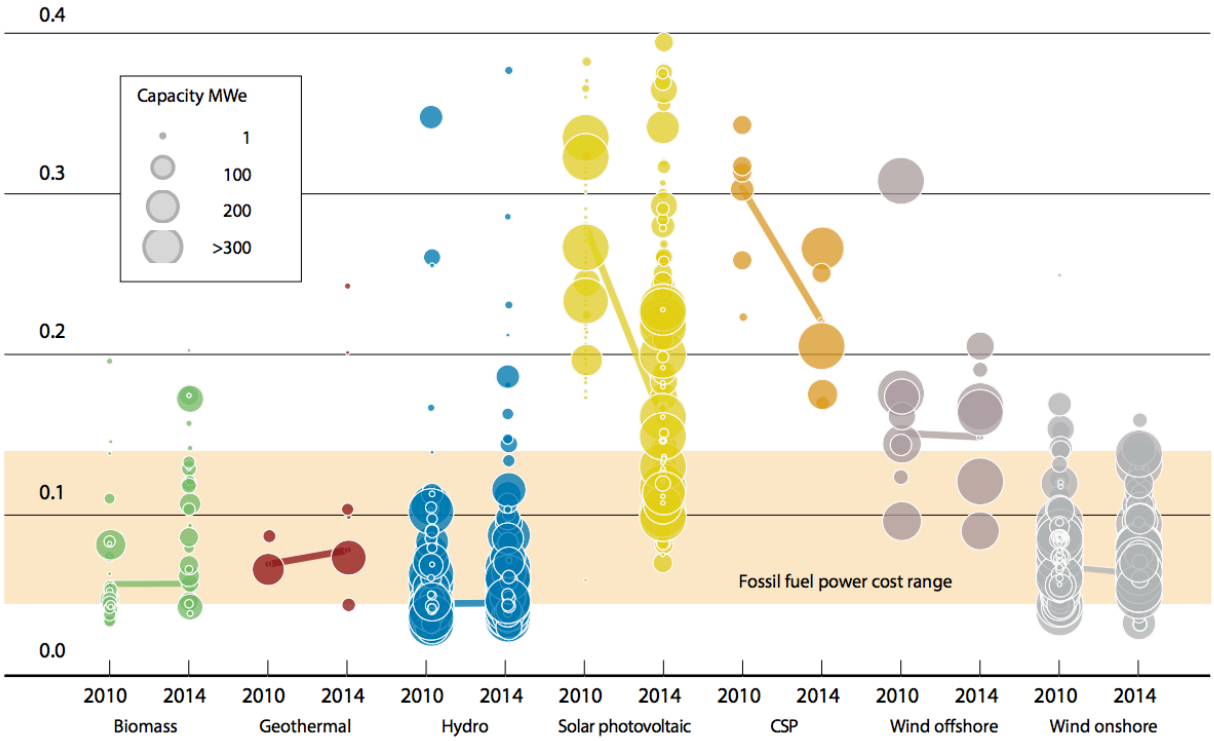
Figure 2 – Graph of Potential Wind Capacity at 140-Meters Hub Height



II. Cost

The main problem with renewable energy sources is its high costs. However, wind energy seems to be around the same price range as fossil fuels. This is partly due to recent improvements in wind energy. The improvements in optimization electricity generation contributes greatly towards the price of wind energy. When comparing wind energy to the prices of the other renewable energy sources, it seems that wind is significantly cheaper than the other renewable energy sources. Figure 3 shows the cost of wind energy in comparison with other energy sources. Primarily, looking at onshore wind, it lies at the same price range as the fossil fuel cost range, but at the same time, it Is fairly low compared to the other energy sources.

Figure 3 – Price History of Renewable Energy Sources



III. Technology

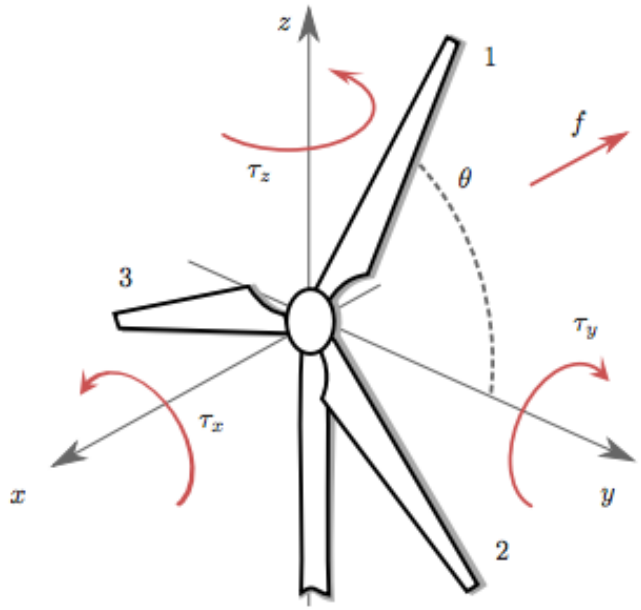
It is important to understand the technology behind wind turbine before recognizing its high potential for improvements in the future. The wind turbine has a very simple mechanism. It has only one input, and that is the wind in the air. When wind meets the turbine blades, the blades rotated which effectively spins a shaft connected to a generator. The generator utilizes the rotating motion to produce electricity. Because wind turbines must be able to capture wind with its best efficiency, there is a lot of room for research in wind turbines. Factors such as capturing air optimization and also creating the electricity are reasonable areas of interest.

There are many different factors that affect the efficiency of wind turbines. The height of wind turbine can affect the speed of the turbine. At a higher height, the wind turbine is able to capture more air. This is useful because more air would lead to a faster rotating blade creating more energy. The length of the turbine blades also affect how fast the blades are able to spin. This is because a larger surface area captures more air, thus creating a faster motion. Even without a faster motion, a higher turbine and longer blades increase the likelihood of creating a rotating motion in the blades because wind is not always present.

IV. Pitch Angle Optimization

One recent publication on research of wind energy produced by the NREL involves the pitch angle of the wind turbine. The pitch angle is the angle of the rotary blades with respect to the turbine itself. The blades are not located directly perpendicular to the ground because it is not the best optimization angle. Researchers have found that by changing the pitch angle, the overall power output is directly affected. This is useful in knowing because wind energy can further be improved upon in the future. In Figure 4, the angle Ø represents the pitch angle on a 3 bladed horizontal axis wind turbine.

Figure 4 – Diagram of a Wind Turbine and its Pitch Angle



The research on pitch angle has begun several years ago. However, only until recently, the NREL finally made great progress. The idea is simple. During turbine operation, two periods of rotations will be analyzed for its power output. The data obtained will be useful in understanding the best pitch angle for the wind turbine. When the second period produces a higher power output, a pitch increment will be made to the blades. On the other hand, if the second period of rotation generates less power than the first, a pitch increment will be subtracted. By understanding the periods of rotation and the power output, a control signal can be produced activating blade pitch actuators. The actuators are responsible for adjusting the pitch angle of the wind turbine. This process is extremely useful. It can increase the power output of the wind turbines, and it can also limit the amount of power needed in case of an over supply of energy.

V. Emissions

Wind energy is a completely renewable resource. The benefit for choosing wind energy is that it does not require inputs such as water in hydropower, or bio in biomass energy. The only input is wind, which will never run out. Because it is a completely renewable resource, there are no emissions of carbon dioxide, sulfur dioxide, or methane gas. These are dangerous gasses produced from fossil fuels, and it's important to understand renewable energy sources aim to not damage the environment.

The downside with wind energy is its production emissions. The materials used for wind energy is primarily fiberglass, steel, and copper. The two metals are used for the generator and the complete mechanism of the turbine. The steel is used for the frame of the windmill, ensuring its strength of over 100 meters tall. This also makes up for the majority of the cost of a wind turbine. While wind energy is renewable, producing the steel and copper from mining is dangerous to the environment. The gasses released are fairly high, in considering that the

windmills are over 100 meters tall, it requires lots of steel to create a tall frame. On the bright side, fiberglass is chosen as the main material for the frame due to its low cost and the fact that it is an ecofriendly material.

VI. The Bird Controversy

One of the main concerns with wind turbines is its complications with the bird traffic. Because wind turbines are often placed at such a high location, and even future projections show an even taller wind turbine, bird traffic is a main issue that must be dealt with. However, bird mortality rate is one externality that can definitely be avoided. This is because there are many factors that affect the mortality rate of birds. These include the height of the wind turbine, the size, and also the location. Location is extremely important in most cases. In field studies show that the bird mortality rate of turbines varies greatly. In the past year, there were approximately 234,000 reported bird deaths. Through calculations of the number of turbines present, this is around 2.3 birds per turbine. However, the data is not very realistic. Because turbine bird deaths are correlated with the location of the turbine, there are some turbines that do not kill any birds throughout the year, while others located in higher bird traffic areas are problematic.

The problem with bird mortality is that the birds killed are not always common species. There are many wind turbines that are located at areas where endangered and rare species birds reside. This is problematic because the turbines can kill these birds that we would prefer to preserve.

The solution to the bird controversy is simple. Before final installations of the wind turbines, it is important to survey the area for bird traffic. One possibility is through field testing, and analyzing the traffic of birds in a specific area. The team can then decide whether or not it is a feasible location for installing wind turbines.

VII. Grid Integration

The energy grid is a massive network of the different energy sources a country has. To be able to incorporate a renewable energy inside the grid is complicated. The problem with wind energy is that it is dependent on time and weather. Both of which are variables that change over time. This can be problematic because it is more difficult to understand the energy output on a daily basis. Being able to understand the energy output is extremely important due to problems in energy storage. The French Islands, Guadeloupe faces the energy grid problem and has developed tactics to combat the problem.

The French Islands are very small. However, their location makes them well suited for wind energy. Currently, the main source of energy is from fossil fuels. Although their location is well suited for wind energy, it is not a preferred energy source. In fact, the federal government placed a limitation on wind energy limiting its consumption rate from exceeding 30% of the nations total energy. This is primarily because wind energy is such a highly variable energy source. By limiting the wind energy consumption, the government can safely import a certain amount of fossil fuels. Utilizing too much wind energy can cause the fossil fuels to go to waste, while utilizing too little wind energy will lead to higher imports of fossil fuels. Being able to maximize the usage of fossil fuels and wind energy can be useful in saving money for the country. To model the energy output of the wind turbines, it is important to be able to forecast the weather and predict the amount of wind present that will drive the wind turbines. By improving the grid

integration of wind energy, it is possible for renewable energy source firms to convince the federal government to lift off the regulation on wind energy.

While it is very difficult to be able to model the stochastic nature of weather, a research team attempted to model the weather and to create a suitable method to increase the energy consumption of wind energy. The team did this by attempting to analyze the wind energy forecasts a day ahead of time. By doing so, the one day ahead forecast is useful to interlink with the idea of an energy storage system. This can be done by understanding how much energy is needed to store and the amount of energy needed for consumption. Implementing such a model is vital for the energy grid system, and can definitely assist in optimizing the energy imports and consumption rates.

VIII. Final Remarks

Wind energy has many benefits. Its low cost can be a main deciding factor when choosing between different energy sources. Because it is a renewable energy source, wind energy will never run out. It has little to no emissions, and more importantly, there are lots of concurrent improvements being made and investment in wind energy to optimize energy output.

References

http://energy.gov/eere/wind/how-do-wind-turbines-work
https://stanford.edu/~boyd/papers/pdf/wind_turbine_pitch_opt.pdf
http://techportal.eere.energy.gov/patent.do/ID=21746
https://www1.eere.energy.gov/wind/pdfs/birds_and_bats_fact_sheet.pdf
http://onlinelibrary.wiley.com/doi/10.1002/we.1680/full
http://www.aamanet.org/general/1/435/green-and-sustainability
http://www.madehow.com/Volume-1/Wind-Turbine.html