

## Design of Wind Power Blades Using off-the-Shelf Software

Abdullah Buali<sup>1</sup>, Abdullah Al-Jaafari<sup>1</sup>, Ali Alsaffar<sup>1\*</sup>

<sup>1</sup>Department of Electrical Engineering, Prince Mohammad Bin Fahd University, Saudi Arabia

\*Corresponding author

### Abstract

In the simulation there are different things you can change like the length of the windmill and the position of the windmill on ground, hills, and near the sea you can also change the blade design in this simulation you can change blade length, blade pitch, blade twist, tip shape, and air foil shape. In addition, there were different types of pieces you can add to the windmill it can improve the efficiency of the windmill however; there are some parts that will decrease the efficiency of the windmill. After you finish making your windmill in the simulation it is going to show you the results of it like how many watts of electricity has been generated and how many houses it powered.

**Keywords:** Use Wind, Energy, Renewable, Blade, Power, Turbines computer modeling and simulation

### 1. Introduction

Energy is one of the most important things in our lives. Without energy we cannot use the internet, cars, and many other things. One of the biggest problems with energy is that it mostly does not come from renewable sources. We cannot use coal, oil, and gas forever since they are limited resources, and also these non-renewable sources cause a lot of CO<sub>2</sub> emissions that pollutes our air and environment. That is why we need to find renewable sources for energy that's cleaner and more sustainable for us. We also need to increase the production of such renewable energy, especially wind energy or solar energy due to their abundance. Although, a lot of progress has happened in the last few years, it is still not enough to meet the world energy demand and at the same time keep their environment cleaner. Many studies have show that the earth's temperature is steadily rising each year which is a major concern. Although,

renewable energy is an old idea, it still has not reach its full potential it term of wide utilization and efficiency. If we increase the amount of wind turbines worldwide, which is the most reliable method of getting renewable wind energy, it will have a very positive effect on our lives. Firstly, renewable energy will decrease the amount of CO<sub>2</sub> in the air which will let us live healthier. Secondly, another reason for supporting renewable energy is that it will create lot of jobs especially in engineering fields and technology. Thirdly, renewable energy will never run out, the wind will always be there all the time. On the other hand, fossil fuels need millions of years to regenerate. Lastly, renewable energy is cheap and affordable, that is because renewable energy is free unlike fossil fuel sources [1].

Although, renewable energy seems perfect it still has some challenges/issues, such as efficiency and wide distribution network, which needs to be resolved. These challenges are very serious, and we need to deal with them and solve them as soon as possible. Many think that because renewable energy relies on the environment makes it better than fossil fuels. They think that because wind energy gain their energy from the wind which makes the energy created free unlike fossil fuel. Although there is some truth to this it is not the full story. Renewable energy relies on the environment which is perfect because we will never run out of the wind, because most of the time its windy. Sadly, this can also be a weakness, because what happens when the wind is not strong enough? What happens if the wind is blowing the other way? All of these scenarios decrease the amount of energy we make. Another problem for renewable energy is that it cannot be stored. For example, if we produce a large amount of energy, but we only need half of that energy that means that the other half will be wasted, because it cannot be stored and used later. Another issue is that renewable energy takes a lot of space. When it comes to wind turbines, this is a big issue, because wind turbines hurt the environment that surround it. Lot of studies have shown that wind turbines will often kill or divert birds when they fly near them. Another issue is that wind turbines are remote, which means that they are far from the city. This means that you need lot of expensive infrastructure to get the renewable energy to the people in cities so they can use it.

Even though renewable energy has a lot of issues, challenges and problems, we can not just give up on it and try not to solve these problems. Lot of these issues can be solved if we invest more into research and development. For example, we can solve the weather issue by using advanced forecasting. This will give us the ability to predict weather patterns for the days ahead. We will know when its windy or not windy, this will help us predict the amount of energy that the wind turbines can generate. This will not eliminate the problem completely, because weather forecasting is not 100% accurate. However, most of the time it is accurate which means that it will help a lot in solving some issues. Another issue that has a solution is energy conserving. This issue is easily solved by using battery storage. Battery storage might be the way

forward for renewable energy because it can store large amounts of energy that can be used later. Even though setting up wind turbines can be expensive but after that it has very low maintenance cost. This means that wind turbines usually do not need any maintenance during their life span [2].

## **2. Literature survey**

Renewable energy has many forms hydro, solar, wind, biomass. In this paper, we will review a specific type of renewable energy, which is wind energy. It is considered the most affordable option in comparison with all types of other renewable energy sources. Our lives will be much harder if we do not use energy. There are some countries in the world that does not have access to energy because they cannot afford the bills to use that energy and one such country is India. So, how can India fix their energy problem? The Indian government solved this problem by using renewable energy and they used wind power because it was the most efficient option, from their point of view. Wind energy can be used to generate energy without worrying about high costs. In addition, wind power is considered to be the best type of renewable energy because it has the best features in all types or renewable energy the first reason is it has a low cost between all types of RE (renewable energy). Second reason it does not take a lot of time to install it. Third reason is that it does not require fuel to use it. Fourth reason is it does not require a lot of money to fix it if it is not working properly. Fifth reason it does not cause global warming. The sixth reason is does not rely on fossil fuel. Among all types of renewable energy wind, hydro, solar, and biomass, wind energy is considered to be the most common or well-known of renewable energy in terms of volume. In 2014 a huge amount of renewable energy has been produced by top countries who use renewable energy like, China, USA, Germany, India, Spain, UK, Canada, Italy, France, and Denmark. China is considered to be the best country to produce wind power followed by USA, Germany, fourth place is India, and final place is Spain.

India shared 73% of it wind power to other countries. In addition, wind project increased because of the reduction of the price of controlling wind power. The Indian government worries about the adverse effect and that is why India created the national action plan on climate change. So we can see that India need to use wind energy to solve major problems. Pakistan does not have much oil and fossil fuel and it cost a lot to produce nuclear energy so they had to find another method i.e., renewable energy. The Pakistan Meteorological Department (PMD) made a survey to find the best areas of the country to produce wind energy. They located areas where wind turbines can be installed around the whole country. According to the surveys a good wind energy generator will be in the cost line of Sindh and Baluchistan provinces.

Before they start to plant a wind generator they must check some things like the price, and potential of energy these two factors must be checked before installing wind energy system in order for it to work in full potential without any errors. Researchers did some research in order to study wind data. Weibull and Rayleigh were the best match for wind data collected. Researchers have studied ways to estimate and optimize wind data all over the world. Others have studied the ability of wind energy over different areas [3].

One of the studies that has been carried out showed the wind data of Alacati region in Izmir, which was looked into by using Weibull graph. The measurements were taken on different altitudes 70,50 cm, and 30 cm in 10 min time span over five years. Different studies were done in different areas of Pakistan researchers have examine different features of wind data collected from different times, the examination was done in Hawksbay, Karachi. Other study in Karachi was made and wind energy potential was investigated, areas like Keti Bander. Techno-economic evaluation was performed for Hawksbay and Babur. The purpose of this is to guess the wind power potential accurately. So that is how renewable energy can help countries that can't have access to electricity. Many countries around the world use it because it cannot harm the environment. Wind turbine should be installed in places where the weather is good or it will cause a serious problem like damaging the windmills or even break them which can harm people [4].

Wind energy is one of the most important things in this world, as it has many benefits in various types of fields. Wind energy is characterized by its low price, as it costs 1-2 cents per kilowatt-hour after tax deduction for production. Electricity from wind farms is sold at a fixed price over a long period of time, and the fuel for them is also free. And not only is it free, it's clean too. Where it differs from power plants that depend on the combustion of fossil fuels. When fossil fuels are burned, they produce particulates, nitrogen oxides, and carbon dioxide, and then cause health problems and many economic damages. But in wind energy it does not cause any problems as it depends on wind turbines.

At the level of countries, wind energy is one of the most important sources that every country must rely on it, as wind supplies are abundant and inexhaustible. In the past ten years, the United States of America has relied on wind energy, and wind energy has grown by 15% annually. Now, wind energy is the number one source and the largest renewable energy in the United States of America. On the individual level, wind turbines may benefit farm owners and add additional income to them. As the farm owners can rent the owners of wind power plants and then take monthly or annual payments from them. Wind turbines are important for generating wind energy and do not harm the farms, as the owners of farms and

livestock can continue to work on the land because wind turbines use only a very small part of the land. This method may benefit rural areas and may raise their economy. As mentioned earlier, the renewable energy of wind energy is clean. The United States of America seeks to compete in the clean energy economy. Wind energy enables the growth of US industry and new wind energy projects represent annual investments of more than \$10 billion in the US economy. Because it has enormous local resources and highly skilled labor [5].

### **3. Simulation and Analysis**

Wind energy is the fastest growing renewable source out there. Wind power has a lot of advantages that are not available in solar panels or fossil fuels. Wind Turbines are also getting cheaper with every passing year. Although the results of wind turbines are impressive, they still can get better results and be more efficient. A lot of engineers and scientists are always looking to improve the wind turbine through many aspects, but in this research paper we are going to focus on one aspect and that is blade designing. We are going to use an online simulation to design a blade with different characteristics and see if does well or not. Wind turbine blades are a tricky subject, because there is no superior blade design. Blade designing heavily depends on the environment it is in, wind speed, and the weather. That is why in this research paper we are going to design the wind turbines blades in the plains environment of North America. We decided to do this to make sure there is no room for error in our research, and that we can get accurate results in our simulation. We are also designing the blade for wind turbines that only have three blades, and we will also use some of 3M products in the simulation that focus on enhancing the blade and maintaining it [6].

### **4. Designing the Blades**

In this design we are going to focus on all the variables that go into designing the blades. Firstly, we are going to focus on the height of the turbine. Although it has nothing to do with blade designing, it will effect the results if we change the height of the wind turbine. That is why we decided to make the height of the turbine in this design at 100 meters. Secondly, we are going to add a blade twist, this will be twisting the blade to change angles of the wind on the blade. Twisted blades will be more durable and lighter than straight blades. Thirdly, we are going to add a blade pitch of 3 degrees. We do a blade pitch so that the wind hits the right fraction thus making more energy output, but it is also important to make sure that the blades don't reach it is maximum rotational speed, because it might damage the blades and

the wind turbine. Fourthly, we are going to add a thin airfoil shape. Airfoils might be the most important part in blade designing, because it plays an important role the aerodynamic performance and it also helps to control the noise of the wind turbine. Fifthly, we are going to add a thin tip shape. Thin tip shapes are used in wind turbines to increase the maximum energy produced, because a thin tip is going to move the blades faster than a wide tip. Sixthly, we are going to make the blade length 45 meters, because the larger the blade length the larger the surface area. This will make the wind hit the blade at a much larger surface area which will make the blade spin faster and produce more energy. Below we can see a picture that will show clearly all the blade variables.

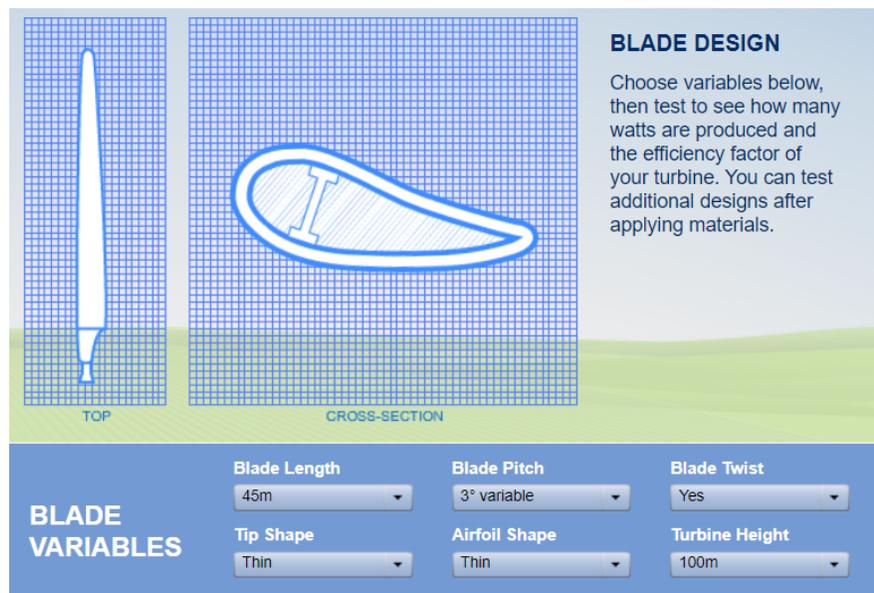


Figure 1 Variables for Blade Designing

Now that we finished designing the blade, we are going to add 3M products to improve and maintain the blades. Firstly, we going to add a 3M protection tape on the blades. This tape will protect the blade from hail, rain, and dust, but it will also decrease the performance of the wind turbine. We made the choice that maintaining the blade while losing a little energy is better than changing the blade every time it is damaged. Secondly, we added a 3M filler that balances the blade and make the blade surface and edges smoother which in return will make the blade spin faster and make more energy. Thirdly, we added a 3M riblets film. Riblets film will help organize air turbulence and friction on the blade which will make it produce more energy. Below we can see from Figure 2, which summarizes the inputs and the outputs. Form Figure 2 we can see our inputs and their outputs. The wind turbine blades that we designed produce 686576 Watts per year when the air density is 1.15 and the velocity is 7.5 m/s. we can also see that the wind turbine supplies energy for 458 American houses per year.

INPUTS							
Location	Blade Length	Blade Pitch	Blade Twist	Tip Shape	Airfoil Shape	Turbine Height	3M Material
Plains	45m	3° variable	Yes	Thin	Thin	100m	Resin:No Riblets:Yes Filler:Yes WPT:Yes WPA:No

OUTPUTS						
Watts Produced	Swipe Area	Air Density	Air Velocity	Eff. Factor	Watts/ Unit Cost	Homes Powered
686576	6362	1.15	7.5	0.44	0.44	 458

Figure 2: Input and output of wind energy

## 5. Conclusion

Wind energy is a cheap and environmental friendly source for generating energy. This work has discussed the importance of wind energy in a number of countries such as India, Pakistan, USA, etc. A through discussion was also made at the individual level, and discussed how wind energy will save a lot of time, effort, and money. It will benefit the world as a whole in terms of caring for the environment. In this paper we have also used a free off-the-shelf software to determine the shape of the blade to obtain the best possible results. We placed the turbines at a height of 100 meters and used blades that were slightly more durable. We made the inclination by 3 degrees and added the shape of the wing and the tip of the wing thin. Then we made the blade 45 meters long. We found the best possible result: wind turbine blades produce 68,6576 watts per year and power 458 American homes annually. It is strongly recommended to invest more money to overcome the challenge of wind energy's full potential to make it more efficient and widely distributed to all regions of a country.

## References

- [1] Battery Storage Paves Way for a Renewable-powered Future. (2020, March 26). IRENA. Retrieved February 18, 2022, from <https://www.irena.org/newsroom/articles/2020/Mar/Battery-storage-paves-way-for-a-renewable-powered-future>

- [2] Bird, L., Milligan, M., & Lew, D. Integrating Variable Renewable Energy: Challenges and Solutions. United States. <https://doi.org/10.2172/1097911>
- [3] Gul, M., Tai, N., Huang, W., Nadeem, M. H., & Yu, M. (2019, March 6). Assessment of wind power potential and Economic Analysis at Hyderabad in Pakistan: Powering to local communities using wind power.
- [4] Subhumid Dawn Prashant Kumar Tiwari Arup Kumar Goswami Ankit Kumar Singh Rajesh Panda, Subhumid Dawn, Kumar Tiwari, P., Kuma r Goswami, A., Kumar Singh, A., Rajesh Panda, Wind power: Existing status, achievements and government's initiative towards renewable power dominating India
- [5] Advantages and challenges of wind energy. Energy.gov. (n.d.). Retrieved May 18, 2022, from <http://www.energy.gov/eere/wind/advantages-and-challenges-wind-energy>
- [6] 3M Wind Energy Virtual Lab. (n.d.). Retrieved May 18, 2022, from <https://www.youngscientistlab.com/sites/default/files/interactives/wind-energy/>