

Usage of Wind Turbines for Generating Energy

Serkan Solmaz

Mechanical Engineering - Faculty of Mechanical Engineering

030090237

English 201

ISTANBUL TECHNICAL UNIVERSITY

December 25, 2013

**Thesis:** The wind turbines which are used for generating energy from wind power should be used due to economic gains, environmental effects and technical conveniences.

I. Economic Gains

A. Low Cost Energy Production In Long Term

1. Innovations in Production Technology
2. Reduction in the cost of production

B. Government Support

1. Tax Incentives
2. Energy Production Payment

II. Environmental Effects

A. Protection of Natural Sources

1. Fossil Fuel Saving
2. Water Saving

B. Avoided Global Warming Pollution

1. Production of Clean Energy
2. Reduction of Green House Gases

III. Technical Convenience

A. Variety of Turbine Structures

1. Benefits of Horizontal Axis Wind Turbines
2. Benefits of Vertical Axis Wind Turbine

B. Ease of construction

1. Modularity of Applications
2. Wide Range of Applications

Energy is the basic element of life cycle which never disappears. It turns to alternative form through processes for energy balance. People have been doing these processes consciously or unconsciously since the beginning of life on earth. Wind is important, favorable and renewable source that is used for generating alternative energy forms from natural sources. “The possibility of using wind as an energy source was identified a long time ago. The first known windmill was built by Heron of Alexandria in the 2nd century AD. By the 8th century large horizontal axis windmills with four blades were in use in eastern Europe. During the 12th and 13th centuries the use of windmills became widespread for pumping water and grinding grain”(Jones & Bouamane, 2011, p. 7). According to application guideline of American Wind Energy Association, lately studies are about development of excellences of wind turbines which produces electricity from wind power (2001, p. 1). The wind turbine is used for generating electricity from wind power which is an alternative way to transforming energy. The wind turbine system includes different parameters. These are generally associated with efficiency of the system because economic and structural parameters directly affect efficiency. Wind is a renewable source and has no fuel cost for generating electricity. It provides low cost energy production and avoids environmental pollution. The application of wind turbines will surely be supported by government such as payments and tax incentives which encourage investors. Besides, technical improvements about wind turbines provide greater systems and wide usage areas. The wind turbines which are used for generating energy from wind power should be used due to economic gains, environmental effects and technical conveniences.

The first and most important usage field which can benefit from wind power system is economic gains. Above all, wind turbines produce low cost energy, which provide great economic gains in long term. Primarily, structure of wind turbines are improved with new

technological innovations and it causes low cost energy productions. Sahin indicated, “cost reduction is assumed to be the result of further up scaling, reduced weight and material use, improved production. In all, future technological developments can be characterized as incremental, including the introduction of flexible two- or three-bladed turbines and variable speed operations” (2004, p. 529). It is also stated by technological innovations about wind production system have basic points which are correlated with upgrading dimension efficiency of wind turbines. Capital investments and government sanctions have a big effect on technological evolutions of wind power system (p. 535). Nowadays, the advancing wind turbine systems have an important role in energy production at low cost. Energy production of the wind turbines that can be improved will cause prices to drop further. Thus, the technological investments of wind turbines should be increased day by day. Another, wind energy is economic profit that can be gained by the reduction in the cost of production. Blanco argues that In Strategic Energy Review of 2007, the EU published its composite consequences by making assessment on renewable. It shows that the base cost of wind energy probably will fall to around 826€/kW by 2020, 788€/kW by 2030 and 762€/kW by 2050. The same formation also looks likely for offshore wind energy (2009, p. 1380). Sahin asserts that %20 of cost is reduced for past 5 year period. In any case, new coal-fired facilities make the wind low-cost and competitive and in some geographies it can be alternative for gas which is, in fact, the cheapest source recently. New methods are being improved for the production of wind energy and that reduces the cost and improves the productivity (2004, p. 524). Briefly, the reducing in the cost of energy production is provides a very important economic gains. Prices have been falling every year because of advanced technology. Trying to reduce the cost of production should not be lagging for the innovations. Technical incentives and reducing in the cost of production systems provide low cost energy production in long term. With these

reasons wind turbines are the most economic power generating system than the other generating systems.

A second remarkable benefit of wind turbine is reduced expenditure of installation with government supports. To start with, Governments support investors with tax incentives with decrease cost of production energy. Primarily, tax incentives are important for investors which produce economic gains and encourage them to investments. According to fact sheet of U.S. Department of Energy, The federal renewable energy Production Tax Credit (PTC) was founded in accordance with the Energy Policy Law and enables eligible owners of energy plants to obtain tax credits for every kilowatt hour (kWh) of electricity produced by their plants over a ten year time. Wind energy projects satisfying the terms can take kWh what is 2.2 cent (2011, p. 1). As IRENA indicates that the enterpriser is supplied by government with a yearly revenue tax credit which includes the amount of fund invested in that plant or the quantity of the energy which it has produced in that current year and provides opportunity for the investments in RE to be fully or partially reduced from the tax liabilities or income (2010, p. 7). Kahn evaluate that the policies can take into account the incentive scheme for specific production objectives, based on the market and technical hardships on finding and improving alternative technologies. The tax incentives provided have strong impact on private power sector in US. Said tax credits have seriously subsidized the development of wind turbine industry, in particular. However, the importance of the incentive policies was questioned many times (1992, p. 427). Obviously government encourages investors with tax incentives and these incentives have a high influence for markets and investments. The tax benefits in this developing sector will attract the interest of investors. Tax benefits should encourage for investors in this sector. Furthermore, energy production payment is the other basic advantage for investor and it provides high amount decreases for installation cost. U.S. Department Of

Energy claimed that the Renewable Energy Production Incentive (REPI) extends yearly financial incentive payouts of 2.2 cents per kWh for electricity generated. It is given out to market by new modifier renewable energy production plant for the first ten-year period of their engagement (2011, p. 1). Columbia University's research showed that US electricity market has been dominated by conventional fossil fuel energy for a long time and enjoyed financial advantage over Renewable Energy in spite of the fact that recent technological advancement has been achieved in the latter. In fact, Renewable Energy Payments (REPs) are financial subsidies to bolster the production and widespread use of RE by the people. REPs are expected to encourage qualified RE producers to sell their electricity into the system for higher price. The regulators which are set into the system for a period of 15 to 20 years are aimed to determine the rates to assure the guaranteed return on investments (2007, p. 9). RENEW Wisconsin reported by renewable energy production payments are primary service purchase-back rates which are projected to promote the purchaser or third supplier installations of small-size electric power supplies which are powered by such renewable energy sources as solar, wind, biogas, hydro and biomass(2008, p. 1). Clearly, energy production payment encourages investor which decreases the cost of installation and production. Production cost of wind energy compared to fossil fuel is low so, investors may be interest. States should consider the renewable energy in their future plans. All things considered, wind turbines have a lot of economical supports by governments which are stated as tax incentives and payments.

The first reason for using wind turbines is to generating from other resources nature susceptibility because using wind energy is almost harmless for nature. To start with, there are not limitless natural resources on the world therefore, humanity has to protect of natural sources. One reason for that, fossil fuel is running short expeditiously and one day it will be

finished so individuals must save fossil fuel sources. Kondili and Kaidellis stated that Wind energy is one of the most important environmental benefit is to reduce the importance of thermal power plants besides the theoretical state of the fossil fuel savings 'mf' depends on factors in the formula  $M_f = E_{wind} / (\eta \times H_u)$  (2012, p. 507) American Wind Energy Association reported that there are nearly 4 billion cubic feet (Bcf) interruption at the gas flow each day and wind turbines produced roughly 17 billion kilowatt hours (kWh) in other saying 0.5 BcF/day of gas from fossils each year (U.S Department of Energy, 2005, p. 2). "Besides, the exploitation of wind energy improves energy supply security, since it minimizes the significant hidden cost of fossil fuel utilization, like political dependency, cost of 'controlling' the existing fossil fuel reserves, and so on. On top of these, wind energy contributes in reducing the exploitation of fossil fuel reserves, prolonging, in this way, their operational life " (Kondili and Kaidellis, 2012, p. 507). Thus, it is obvious that wind turbines decrease the consumption of fossil fuels. Also, wind turbines use renewable power sources for generating energy and it protect nature sources. Moreover, wind power system protects water because it uses air to generate electricity and it is not consume water to recirculating system. According to fact sheet of Windustry, turbines produce no particulate reduction that contribute to mercury contamination in our lakes and streams also in the production of an equal amount of energy, nuclear power plants makes 600 times more water consumption (n.d., p. 1). U.S. Department of Energy stated that water is required in almost all electric power plants in order to be able to operate these stations, and using water in western United States where wind power system can find lots of drought stricken areas constitutes a very big problem. However, system does not need water in order to generate electricity from wind. It is estimated that the cumulative water utilization would be reduced by 8% or 4 trillion gallons of water if a wind energy establishment of 20% could be achieved by 2030 (2011, p. 1).

Therefore, wind power systems not have to consume water to getting energy from their sources. Low water consumption is one of the biggest advantages of wind power system. Also it prevents the loss of large amounts of water. For all these reason, wind turbines are environmentalist energy systems and it provides to protect natural sources which are exposed to exhaustion.

To begin with, global warming is one of the world's biggest problem. One of the ways to prevent global warming is to use renewable energy sources. For instance, wind power doesn't harm during energy production and distribution stages. According to the fact sheet of Windustry, while the use of wind energy production is free of pollution, there are other electricity sources with significant emissions which damage and impair global climate and cause destructive change in the climate (n.d., p. 2). The use of wind will significantly contribute in the protection and preservation of our resources for it is not necessary to give damage to the nature by destructive resource mining or to make any transportation of fuels to processing facilities (Windustry, n.d., p. 2). U.S. Department of Energy stated that the production of electricity with wind turbines does not lead to drinking water or air pollution because when electricity is generated by wind the amount of smog, acid rain and greenhouse gas emissions is reduced in a significant degree when compared to conventional systems, it is possible to reduce the amount of carbon dioxide emission by 1800 tons/ year with only one 1-MW wind turbine. This amount can be compared with the contribution of one square mile of forest, in case that by 2030 it can be achieved to generate electricity with wind energy by 20%, the electric sector will be able to eliminate 825 millions of tons of CO<sub>2</sub> emission, what will be a very important benefit for the environment and the whole world.(2011, p. 2) Since wind energy is a clean source and accordingly will reduce air pollution, also related health care and environmental protective costs will be reduced in a significant amount. Obviously,

clean energy is very important for the conservation of nature. Consumption of energy increases day by day therefore renewable energy is not used can be natural disasters. Additionally, a high amount of greenhouse gases occurs in production energy system. Wind power can generate energy without greenhouse gas emissions. The use of wind energy in terms of the environment and human health would be a major obstacle in danger. According to Kondili and Kaldellis, the largest carbon footprint can be seen in technologies using fossil, because these technologies use combustion for the production of power, clean energy sources do not diffuse CO<sub>2</sub> because it contains small amounts of carbon. (2012, p. 504). Lew stated that the difference of wind power compared to conventional power generation is, a very important factor since it does not lead to emissions of carbon dioxide or other air pollutants like sulfur oxides and nitrogen oxides. Compared to conventional power generating stations, negligible emissions only do occur during the production of the wind turbines and the establishment of wind farms (Lew, n.d., p. 2). Clearly, air pollution is very dangerous and will affect the whole of nature so must be very careful not to pollute the air. All things considered, wind turbines have a lot of ecologic advantages which can basically considered as reduction greenhouse gases and production of clean energy. The demand of wind energy increases which is the main result of being environmentalist. Because of these ecologic factors and, wind turbines have a wide spread usage area and they can supported from social organizations and governments.

Finally, wind turbines have technical conveniences for different applications of systems. To start with, wind turbines have a variety of structures for generating energy with different parameters. Primarily, horizontal axis wind turbine which is the first main types of wind turbines has important benefits about structure applications. According to the lecture notes published by The University of Queensland, blades which are placed on turbine provide the center of gravity and the balance of the system. The wrap skill of blade provides the best

operating angle for blades and increases ability of the remote control to get the highest quantity of wind power. Horizontal axis wind turbine which is higher than tree length could be constructed in woods and this turbine generally has a self-powered system (n.d., p. 2). Patnaik states, "High efficiency, since the blades always move perpendicularly to the wind, receiving power through the whole rotation. In contrast, all vertical axis wind turbines, and most proposed airborne wind turbine designs, involve various types of reciprocating actions, requiring airfoil surfaces to backtrack against the wind for part of the cycle. Backtracking against the wind leads to inherently lower efficiency" (2009, p. 3). Surely, efficiency of a system has an important role on economic gain and application rate which can be explained as technical gains. As Dundee and Angus Collage indicated, another benefit of horizontal wind turbines is that high columns provide powerful wind conditions. Also, wind speeds up 20% and the power output rises to 34% with each 10 meters (n.d., p. 2). In the light of all these facts, it is undeniable that horizontal wind turbine has important benefits for generating energy. System can be designed for different applications and situations without any losses. Moreover, vertical axis wind turbines are the other main type of wind turbines which have various structures and benefits. According to The University of Queensland, the structure does not require a lot of bearing and it decreases the cost of system because rotor wings are horizontal and system does not required a yaw mechanism (n.d., p. 2). Vertical axis wind turbines are suitable for use in areas with different wind aspects because wind does not have to come directly to the system and vertical axis wind turbines are used for all aspects (Dundee and Angus Collage, n.d., p. 4). Besides, manufacture, assembly and shipping stages of system have a low expenditure. Vertical axis wind turbine has a low possibility of injuring birds because wing speed is low and it is useful for harsh weather conditions at high regions (Li, 2012, p. 21). Patnaik stated that vertical axis wind turbine creates a lower sound pollution. Also for the easy care of the moving parts, it is installed close to the ground level (2009, p. 4).

Thus, it is obvious that vertical axis wind turbines have a lot of benefits for power generating systems. The build is designed in various structures and new applications are evolved for vertical axis wind turbines. It can be concluded that with new technological development, wind turbines have a lot of structural convenience and produce solution for different structures and wind conditions. Due to the many benefits, there is no doubt that wind turbines can be widely used for power generating systems.

Not only structural variations, but also ease of construction is a main reason for generating energy with wind power technologies. Primarily, Modular applications have a significant role on installation of wind turbine with a lot of technical solutions. As Walford declared in 2006:

Another aspect of maintainability that has gained increased attention in recent years is the advantage of modularity. Several turbine configurations are being developed that utilize multiple generators and gear units in the drive train instead of one larger unit. The primary argument for this arrangement is that it is possible to remove and replace the units using the rigging that is permanently installed in the nacelle, thus avoiding the high costs of bringing in a mobile crane. Secondary advantages are the possibility of running at reduced power if only one modular unit fails, and the reduced inventory cost for smaller units (p. 13).

As Kaygusuz stated, wind power plants have a short installation time which is lower than 6 months and it is established more quickly than the basic power plants (2004, pp. 103, 104). According to Technical Application Papers of ABB, Usage time of wind turbines is 20 to 25 years and fragmentation is easy at the end of this period (2011, p. 11). Thus, it is obvious that modular structures have important technical conveniences for wind turbine systems and also it is effective on economic factors. The main advantages of modularity are short installation and

dismantling period. As seen from the examples, structures of wind farm are more modular than structures of other power plants. Furthermore wind farms have wide range application areas because of variety construction types and mechanisms. According to Wind Energy Application Guide published by American Wind Energy Association, wind power plants can be installed different places to supply energy through various structural features (2001, p. 1). U.S Department of Energy examined mini wind turbines could be used for supplying energy to houses, farmsteads and workplaces. Fluid pumping systems, telecommunications plant and similar structures are generally far away from power plants and wind turbines are ideally suited for applications in distant site. Developers are working on different wind power system projects such as project for educational Institutions and countryside energy cooperatives (2005, p. 2). As The NEED Project indicated there are many offshore wind farms. Wind has a more powerful and stable flow on liquid than part of the land because there are items that may prevent the wind on a part of land (2012, p. 2). Surely, offshore power plants have natural conveniences and large application areas. According to web document broadcasting by Boston University, wind power plants require large areas for energy production and turbines do not prevent the use of the land. These areas can be farming zones (n.d., p. 7). In the light of all these facts, it is undeniable that wind power plants have wide range application areas. Due to the structural variations, plants can be used for different zones. So, Wind power systems have wide range sitting areas than other power plants which are result of technical incentives. It is obvious from the above that the wind energy is growing trend in recent times due to ease of construction wind power plant. The modular structures and wide range usage areas of wind turbines can be shown to be key factor of tendency to them.

In conclusion, wind turbines have a lot of convenience to generate electricity from wind power by offering many useful features. First of all, wind power systems have economic gains. System is supported by governments and produces low cost energy in long term. Wind

turbines have important effects on environment. It is avoided global warming pollution and natural sources are protected thanks to renewable source. Finally, they have technical conveniences about installation of systems. Variety of turbine structures and ease of construction are main conveniences of the applications. For all these reason, wind power has an important effect on energy markets and investments. It seems inevitable that wind energy becomes trendy for countries who want to take advantages of wind turbine systems and investments will gradually increase. Thus, advantages of wind turbines should be well examined by governments and investors because they have several applications for different parameters. With the help of further studies on wind power systems by researchers, types of wind turbines have special features which need technical innovations and experimental results.

## REFERENCES

ABB INC. (2011). *Technical application papers no.13: Wind power plants* [Fact Sheet].

Retrieved from

[http://www05.abb.com/global/scot/scot209.nsf/veritydisplay/92faf0c1913f5651c1257937002f88e8/\\$file/1sdc007112g0201.pdf](http://www05.abb.com/global/scot/scot209.nsf/veritydisplay/92faf0c1913f5651c1257937002f88e8/$file/1sdc007112g0201.pdf)

American Wind Energy Association. (2001). *Wind Energy Applications Guide*. Retrieved

from <http://www.awea.org/Resources/index.aspx?navItemNumber=506>

Blanco, M. I. (2008). The economics of wind energy. *Renewable and Sustainable Energy Reviews*, 13(6-7), 1372-1382. doi: 10.1016/j.rser.2008.09.004

*Wind Turbines*. Retrieved from Boston University web site:

[http://people.bu.edu/noahb/files/wind\\_turbine\\_main.pdf](http://people.bu.edu/noahb/files/wind_turbine_main.pdf)

*Renewable energy payments: A policy guide to feed-in tariffs in America* [Fact Sheet].

Retrieved from Columbia University web site:

<http://mpaenvironment.ei.columbia.edu/news/projects/spring09/renewEnerPayReport.pdf>

*Domestic wind*. Retrieved from Dundee College web site:

<http://www.dundeecollege.ac.uk/Microgeneration/Assets/Uploads/Domestic%20Wind.pdf>

International Renewable Energy Agency. (2012). *Evaluating policies in support of the deployment of renewable power*. Retrieved from

[http://www.irena.org/DocumentDownloads/Publications/Evaluating\\_policies\\_in\\_support\\_of\\_the\\_deployment\\_of\\_renewable\\_power.pdf](http://www.irena.org/DocumentDownloads/Publications/Evaluating_policies_in_support_of_the_deployment_of_renewable_power.pdf)

- Jones, G. & Bouamane, L. (2011). *Historical trajectories and corporate competences in wind energy* [Working Paper]. Retrieved from <http://leeds-faculty.colorado.edu/bhagat/WindEnergyCorporateCompetency.pdf>
- Kahn, A. (1996). The production tax credit for wind turbine powerplants is an ineffective incentive. *Energy Policy*, 24(5), 427-435. Retrieved from <http://www.sciencedirect.com/science/article/pii/0301421596000146>
- Kaygusuz, K. (2004). Wind energy: Progress and potential. *Energy Sources Journal*, 26(2), 95-105. doi: 10.1080/00908310490268901
- Kondili, E. & Kaldellis, J. K. (2012). Environmental-social benefits/impacts of wind power. *Comprehensive Renewable Energy*, 2, 503-540. doi: 10.1016/B978-0-08-087872-0.00219-5
- Lew, D. J. (n.d.). *Environmental impacts of wind power*. Retrieved from <http://www.eolss.net/sample-chapters/c09/E4-23-04-02.pdf>
- Li, Li. (2012). *Vibration analysis of vertical axis wind turbine* (Unpublished master's thesis). Massey University, New Zealand.
- MECH7350 Rotating Machinery: Study book*. (2009). Retrieved from The University of Queensland website: <http://www.mech.uq.edu.au/courses/mech7350/lecture-notes-in-pdf/mech7350-12-wind-turbines.pdf>
- Patnaik, I. (2009). *Wind as a renewable source of energy*. Retrieved from [http://ethesis.nitrkl.ac.in/1420/1/thesis\\_of\\_ishan\\_patnaik\(10502038\).pdf](http://ethesis.nitrkl.ac.in/1420/1/thesis_of_ishan_patnaik(10502038).pdf)

RENEW Wisconsin. (2008). *A primer on renewable energy producer payments* [Fact Sheet].

Retrieved from

<http://www.renewwisconsin.org/policy/ARTS/MISC%20Docs/Renew%20Wisconsin%20Primer%20REPP%20Q+A.pdf>

Ridlington, E., Schneider, J., Sargent, R. & Abrams, C. (2012). *Wind power for cleaner America: Reducing global warming pollution, cutting air pollution and saving water.*

Retrieved from

[http://www.environmentamerica.org/sites/environment/files/reports/EnvAm\\_Wind\\_v7\\_print\\_1.pdf](http://www.environmentamerica.org/sites/environment/files/reports/EnvAm_Wind_v7_print_1.pdf)

Sahin, A., D. (2004). Progress and recent trends in wind energy. *Progress in Energy and Combustion Science*, 30. 501-543. doi: 10.1016/j.pecs.2004.04.001

The NEED Project. (2012). *Wind energy* [Fact Sheet]. Retrieved from

[http://www.cleanlineenergy.com/sites/cleanline/media/resources/students/renewable/Wind\\_Energy\\_Infobook-Middle\\_School.pdf](http://www.cleanlineenergy.com/sites/cleanline/media/resources/students/renewable/Wind_Energy_Infobook-Middle_School.pdf)

U.S. Department of Energy. (2011). *Wind and water power program: Wind energy benefits.*

Retrieved from <http://www1.eere.energy.gov/wind/pdfs/49053.pdf>

U.S. Department of Energy. (2005). *Wind energy benefits.* Retrieved from

[http://wind.jmu.edu/vwec/Fact%20Sheets%20&%20Presentations/Fact%20Sheets/wpa\\_factsheet\\_series.pdf](http://wind.jmu.edu/vwec/Fact%20Sheets%20&%20Presentations/Fact%20Sheets/wpa_factsheet_series.pdf)

U.S Department of Energy. (2011). *Federal incentives for wind power deployment.* Retrieved

from <http://www1.eere.energy.gov/wind/pdfs/51452.pdf>

- Walford, C. A. (2006). *Wind turbine reliability: Understanding and minimizing wind turbine operation and maintenance costs* (Sandia Research Report). Retrieved from <http://prod.sandia.gov/techlib/access-control.cgi/2006/061100.pdf>
- Wind Powering America. (2005). *Wind powering America fact sheet series: Wind energy benefits* [Fact Sheet]. Retrieved from [http://wind.jmu.edu/vwec/Fact%20Sheets%20&%20Presentations/Fact%20Sheets/wpa\\_factsheet\\_series.pdf](http://wind.jmu.edu/vwec/Fact%20Sheets%20&%20Presentations/Fact%20Sheets/wpa_factsheet_series.pdf)
- Windustry. (n.d.). *Wind basics: Why wind energy*. Retrieved from <http://www.windustry.org/sites/windustry.org/files/2.8%20Wind%20Basics%20PDF.pdf>