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Recent Trends in the Hybrid HVDC with Wind Energy a Solution to the Future Challenges in Power Transmission

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Abstract

As per the recent scenario the wind energy generation is the key source of energy to avoid the greenhouse effect, since the greenhouse effect as well the global warming is a serious threat to the environment. As the current research more predominantly address the greenhouse effect, this paper concentrates more on the Green power. Hence, popular to the investors, government, and general public since the 1970s. The awakening of higher investments in wind energy was caused by growing need for energy security. There are, however, numerous problems and challenges, both short and long term, with developing wind power generation. The importance of wind speed Kinetic energy in wind can be captured by wind turbines and converted to mechanical energy. Generators produce electricity from the mechanical energy. Simply, wind turbines work like a fan operating backwards. Instead of electricity making the blades turn to blow wind from a fan, wind turns the blades in a turbine to create electricity The U.S. Department of Energy identifies several key challenges in wind power energy development: risk perception, the transmission and grid limits, the low competitiveness of wind energy, low speed wind location usage, lack of Infrastructure for transmission, regulatory policy, environmental policy, environmentalists, and general public opinion. Risk perception is a challenge since wind energy is perceived risky since it depends on the presence of wind. For example, globally agriculture too depends on whether (rain and sunny days), but for agriculture we have a long history and large data sample from which to estimate the risk.

Keywords: *Wind energy, greenhouse effect, global warming*

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INTRODUCTION

The technology for installing wind energy at better locations is cost efficient compared to other technologies, the market has a high risk perception of availability of new technologies Transmission channels operate under strict regulations and operational policies. These transmission restraints and the lack of knowledge of wind generated energy's impact on the grid; suspend wind energy development. Therefore, developing wind energy without the development and research of transmission is inefficient.

The wind energy itself is still costly. The cost of wind energy is competitive to the latest conventional (Conventional refers to all non-renewable energy resources, primarily: ie Fossil fuels, viz Coal, Natural Gas, and Nuclear) technologies; nonetheless, the system cost of wind energy's technical development is still too high. Reduction of these costs will enable the wind energy to be used at an even more competitive rate.

The low speed wind locations are economically not as risk-safe as high speed wind locations due to perception of higher wind location yielding more energy than lower wind location. Nonetheless, they too are a resource and while the excellent wind locations are being used and attached to grids there is a need to prepare cost-effective access to low wind generating areas.

The existing transmission network is limited. The network needs to be expanded to reach out to the distant locations at which often renewable energy resources are located.

The regulatory agency has set up regulations previously adjusted to non-renewable energy resources and now they need to be adjusted for the renewable energy sources. The regulatory energy approvals are confined to unclear predispositions; even more so, the separate regulatory procedures exist across local, state, and federal levels increasing costs of wind energy farm installation.

One can therefore conclude that wind energy and transmission development are closely related. The fall in cost of wind energy yields only a limited result if such energy may not reach its consumers cost-efficiently. Transmission development is encouraged by wind power energy growth which cannot develop without cost-efficient transmission. Developing domestic energy production will ultimately help "secure (the US) energy economy".

GOVERNMENTAL INCENTIVES AND PROGRAMS

There are multiple incentives; monetary and logistical, that government provides to foster growth of wind power energy development: research, development, and deployment co-operation (RD&D), production tax-credit (PTC), wind energy program (WEP), wind powering America (WPA), distributed wind technologies (DWT), energy policy act 2005 (EPA), energy and policy conservation act (EPCA), federal energy management program (FEMP), renewable portfolio standards (RPS), advanced energy initiative (AEI), advanced wind turbine program (AWTP), and clean renewable energy bonds (CREB).

The RD&D programs are fostered to develop new technologies in a manner that would help investors manage wind power farms that are economically feasible. This is achieved by conducting research that reduces the technology cost. The department of energy also aims to conduct basic research in high-risk energy sources in order to make them more attractive to investors in long term. Therefore what would be the fixed preliminary costs in research for wind power investors; is now conducted by the governmental agency, resulting in lower cost of research; more so, companies can now re-allocate research money for more concrete research. Any such governmental research is the public access of that information, reduces competitive advantage of investors in wind power.

Some research requires high risk heavy capital investment where in current government needs to step in the market economy. There are turbine testing projects that require such facilities and infrastructure. The program helps the government develop data to estimate national standard parameters while reducing the commercial risk for investors. Such projects are usually run either by the Federal agencies or in public-private partnerships. Since the project has benefits for the government and significantly reduces risk of sink cost in preliminary research for investors, the public-private testing projects may be economically justified.

WEP is part of the wind and hydropower technologies program, and concentrates on research that would develop the reliability of wind technology, cost-efficiency of wind production, and small-scale wind technology to ultimately show the feasibility of investing in wind. Aware of importance of the grid to wind energy distribution, WEP also concentrates on researching the challenges behind the integration of the power grid, transmission and technological compatibility with energy from wind production farms. There are four main sub programs of WEP. One program is a technological viability research of large-scale wind turbines: large wind technologies (LWT). Second program addresses the research of “smaller distributed wind technology”. Third program conducts technology application research addressing the research in transmission and system integration (SI). Fourth program is technology acceptance, seeks the outreach activities with different groups such as state-based organizations, environmental studies, and utility partnerships. Ultimately WEP explores solutions to natural variability of wind energy production, the interconnection of such volatile energy source with the grid, and transmission of the energy to appropriate load centers.

The LWT in addition to mentioned activities specifically works on low wind speed technologies as well as the off-shore wind turbines. The strong wind areas are becoming more interesting, yet the low wind speed areas are actually also usable yet more research needs to be conducted. DWT also examines low speed areas but that is because the research in DWT examines possibilities of local usage of wind turbines that would release burden on the grid. By ‘local’ one means schools, farms, factories, and general public and private facilities. Also DWT can help some secluded, isolated, remote, and/or rural areas. The research of energy supply in remote areas on small scale can save huge costs of developing a power line to the national transmission grid. On the other hand, developing small scale remote wind power generators can have immense costs; after all, 1 MW turbine has an approximate cost of 1 million dollars. System integration part of WEP serves mostly the government through collecting data from wind farms, analyses the grid operations; develops grid regulations, and plans transmission and grids. Through SI, researches are encouraging transmission industries to have more wind power clean energy passing through the power lines to final consumer, the federal and states’ officials to implement more policies favoring this action by transmission firms. A mentioned previously the perception of high risk is a ‘red light’ in wind energy, and SI works on educating the energy industry of real state of development of wind energy.

The WPA project that started in 1999 concentrated on the ‘America’ aspect: the project encouraged a higher federal involvement to encourage national not just regional development. Prior to the program California and Minnesota were most advanced wind power developers due to state initiatives. This information from DOE does not however back-up WPA’s direct impact on the development of wind power.

There are programs that DOE claims to have had significant impact in attracting wind power capacity expansion. Renewable portfolio standards (RPS) are state-based initiatives helping the development of wind energy. The percentage of wind power capacity built in 1999 was around 55% for that to rise to 75% by 2007. The data shows that states without state-based policies dropped their percentage from 45 to 25%. However, the information does not take into account that states have significantly different levels of maximum possible wind power capacity and that in between 1999 and 2007 more states might have started RPS policies. Nevertheless, a jump from 55 to 75% is a sign that more wind power capacity facilities have been built. Knowing that wind energy growth is so recent that we have risk of perception problems due to lack of data, the growth could have been impacted by other policies.

The production tax credit (PTC) on the other hand has left behind some interesting effects that show how after its first implementation it had significant impact of wind power capacity growth. The PTC was founded in 1992 and since had a few modifications; PTC supports energy generated through renewable energy sources by allocating 2 cents per kWh for first 10 years of operation. The program was not active every year and was suspended in years 2000, 2002, and 2004. The years the PTC was not enacted there was a significantly strong drop in wind capacity growth, while all the other years 1999, 2001, 2003, 2005, and 2006 there was a much higher capacity growth . Therefore the PTC is highly stimulating federal incentive. The DOE estimates that PTC stimulated the production of nearly 12 GW of wind power.

The PTC data gave much encouraging data to officials but resulted in a disaster for the turbine industry. The swings in wind power growth have made the demand for turbines very volatile, which then resulted in higher costs and shift of consumption of turbines to foreign based companies. What is interesting is that this negative effect could have been predicted. In the 1986 in California there was a cut of tax credits and other incentives resulting in bankruptcies of turbine manufacturers. The negative effects the tax credit incentive can cause are thus very dangerous. The effort tax credit allocates to increase the growth of wind energy capacity can be economically diminished by the risk of wind infrastructure productivity drops.

In the aftermath of the bankruptcies in the turbine manufacturing industry, advanced wind turbine program (AWTP) was launched in 1990. The program induced the corporations to have their wind turbine designs include newer technologies that the program recognizes as necessary for maintaining competitiveness on the market. In the second phase, the program provided logistics in testing turbines for Class 4 wind which targeted the gap sector in turbine development: between earlier and future-new-generation turbines. The AWT efforts might be able to be a good way of encouraging domestic industry to develop innovations without directly affecting their cash flow with direct financial incentives.

LOCAL, STATE, REGIONAL, FEDERAL ORGANIZATION AND REGULATION

The administration however in some situations causes problems, challenges, and disruption to the incentives producing a counter effect. One regulatory problem is that incentives may not be same across state borders. While some states are favorable to RPS other states have no advanced initiative towards wind power generation; meanwhile, in all states the PTC is available. What is worse, certain areas of the country may be underdeveloped in terms of technology and logistics in planning and helping transmission companies that help the distant wind power plants transmit wind power generated electricity to other states.

The DOE realizes that a federal support is necessary in encouraging developing the wind technologies across states. So state-by-state expands to be region-by-region, according to SI, aware that each region in US has different grid networks with different expectations, regulations, scheduling, reserves, and line voltage. In recent years the problem was approached both on regional and national level. Energy policy act of 2005 (EPA) assigned federal energy regulatory commission (FERC) to "approve proposed new transmission facilities in (corridors reported by the National Electric Transmission Compression Report (NETCR)) if the states fail to do so within one year". These corridors are the Southwest Area National Interest Electric Transmission Corridor and the Mid-Atlantic Area National Interest Electric Transmission Corridor.

On the other hand regulation charges across states is different where in some states the wind power operator needs to pay the regulation charges in some states and regions "(regulation is a service provided by the power system or regional transmission organization with costs paid by the load-serving entities)". Therefore creating a corridor does not mean that wind operators or load-services can feasibly build these networks when regulation and policy changes state-by-state.

Another regulation that is wind power specific is height limit. Some counties and/or local authorities limit the height of the turbine. The technological development resulted in greater energy yield in new wind turbines that are higher, and therefore more economically feasible than the older lower turbines. Therefore, wind energy faces legislation that blocks the possibility of technological development in such areas, slowing down the competitiveness to conventional and other renewable energy generators.

TRANSMISSION

FERC also adjusted the order penalties to costs for energy imbalance that was a burden for wind energy. The transmission companies too are affected by the same, FERC order. Transmission companies are required to undergo "open transmission planning" with regional and local authorities; furthermore, if a firm tries to use point-to-point transmission and that service cannot be provided by the transmission company, the transmission company needs to examine alternative transmission possibilities. The 'examine' definition does not imply an 'obligation.' The FERC order might downturn the possibility of investment in transmission due to uncertainty the transmission companies of costs in alternative transmission requirement in case of lack of extra capacity.

The transmission lines have to be capable of directing energy from different energy producers to specific consumers. This is true in Sweden where consumers have the possibility of choosing their electricity provider based on whether or not the provider's electricity has some "green"(Green" refers to electricity generated from a renewable energy source) or all "green" energy. In the case of electricity from "green" providers there was a premium consumers had to pay. Such measures may be effective in areas where the public has a strong positive attitude towards renewable energy, but previous research shows that one cannot expect the number of those willing to pay more for "green" to be high. Treating "green" energy as a slightly different product with a different price may be justified yet such action does not help the wind power energy becoming more cost-effective. People are free to choose their providers in such markets and can therefore shift back to lower-cost energy providers in hardship; such price policy makes "green" power more of a luxury good.

THE IMPORTANCE OF WIND SPEED

As explained earlier, kinetic energy in wind can be captured by wind turbines and converted to mechanical energy. Generators produce electricity from the mechanical energy. Simply, wind turbines work like a fan operating backwards. Instead of electricity making the blades turn to blow wind from a fan, wind turns the blades in a turbine to create electricity. As in the Jimma University, Research center on the renewable energy, Ethiopia and as well in some the governmental institutions have a problem with turbines being set up in their neighborhood. One difficulty is that turbines may inflict with the radar systems As a result of an interim policy by the department of defense and the department homeland security there were hundreds of projects that had to be stopped. These events are important as they send negative signals to investors that there are policies that might be implemented on a trial-error basis. Meaning, there are now higher variable future costs that companies might use in calculating the cost of investment that might turn down their interest in wind energy. The DOE mentions that there is a "lack of understanding of wind turbine technology, dynamics, available resources" resulting in lack of information for both the public and investors. Lack of information for investors increases risk, and higher risk results in less investors.

The environmentalists too are concerned in turbines affecting the nature in the nearby areas. Nonetheless, the lack of concrete knowledge of the environmental impacts complicates additionally the approval of projects due to incapability of the authorities to predict the environmental effects. These uncertainties increase time and expenses so that firms cannot predict well the economic feasibility of the projects they want to invest in. Moreover, the local and state officials to lose data with which to justify their support in wind energy development support in areas where the public might be reluctant towards wind power generation.

The wind power does however generate zero-emissions that can encourage the states to encourage the development of wind power energy generation in order to lower the air pollution level. The states have to comply with federal limitations on nitrogen oxide. The NO_x cap encourages investment in wind power as investors do not have to incur present and future possible taxations, fees and cap policies for air pollution.

There are supplemental environmental projects that let companies redirect their penalty for air pollution into investment of renewable energy development, future pollution prevention and/or community environmental projects (United States Environmental Protection Agency, "Supplemental Environmental Projects, National Renewable Energy Laboratory, "Supplemental Environmental Projects Using Renewable Energy). The policy does not affect the cost-efficiency of specific wind power companies, yet promotes clean air power generation.

The uncertainties may be the explanation why no top Fortune 100 companies invest in wind energy, while there are companies in solar energy generation field. The DOE goes further and uses this information to state that lack of Fortune 100 companies is why wind does not get as much publicity necessary to raise public awareness. Such a conclusion does not have any more significant statistical backup.

THE MARKET

Wind power market also depends on the transmission market. Therefore the transmission development and cost-efficiency also comes afloat. The time needed for an investor to develop the wind farm is often shorter than the lengthier time necessary for new transmission lines to be set-up. One to three million USD is the DOE estimate of one mile of new transmission line for wind power generated electricity. Furthermore, once the transmission line is built there is a possibility of not reaching optimal capacity usage due to low wind yield. So for companies that have to develop their own transmission network, the wind energy itself might be extracted cost-efficiently yet the transportation may increase the costs to a non efficient level. Similarly, the more cost efficient the wind capacity the greater the space for the cost of transmission in maintaining the cost-efficiency. One way measure DOE suggests is to reduce current average distance between national load centers from 500 to 100 miles, reducing the transmission cost upper bracket and lowering the risk of transmission blockage of next generation wind development. These problems are addressed in EPA where there DOE is in charge of developing a dialogue among all levels of elected authority (local through Federal) and other groups that will result in consensus decision on development of transmission infrastructure.

Wind as a renewable energy source that constantly becomes more and more can be effected not only by policies concerning the wind and/or other renewable energy resources but also by policies in conventional energy resources. The fact that the wind energy is not a constant source of electricity, being open to variability levels, supports wind energy facing different challenges than other energy sources. Federal plans for future energy development allot 50% of the 10 billion budget to coal and 20% to nuclear energy industry alone. These industries have a competitive advantage of being close to the utility grid and have the ability to comply with current market rules. What DOE refers to is the fact that most wind power farms are distant from load centers and final users and have to develop whole networks of transmission. The current market rules have costs for instable supply of electricity. The wind energy produces very unstable quantities of electricity while the conventional energy resources supply a stable level of electricity. Regulation exists, as mentioned, where stability of supply is essential or else the operator has to pay charges.

Nonetheless, some of these problems can be avoided or worked around. The offshore turbines yield at the right locations the most wind power electricity. The offshore wind power farms are often close to the mainland and the load centers, shortening the costs of transmission. Offshore turbines may be greater in diameter and yield comparatively more energy than mainland turbines at same wind speeds. Due to high initial expenses in the offshore projects, the US might have to wait another decade for this project to develop. However, experience in Europe has shown that the ‘shallow-water’ projects cost 1.3 to 1.5 times as much due to maritime environmental costs; not to mention, the accessibility of land and turbines themselves at the sea is more expensive than mainland construction and operations.

In order to receive a permit to build a wind turbine one needs to conduct preliminary work and higher whole staff that will develop a proper application. The offshore sites in the USA have a greater chance of being refused than mainland sites.

The risk of applying to offshore becomes an economical problem for the companies will prefer to apply to less energy yielding energy generating power farm locations in order to avoid sunk costs from an offshore turbine project rejection.

Wind power energy generation has significantly risen since 1999, and lacks historical development conventional energy generators had experienced. Lack of data causes low reliability of turbines; nonetheless, being a young energy industry, wind power lacks maintenance and logistical support. In addition to previous gaps in information, the risk level was such that the investors willing to invest in wind energy are the ones that in 2007 have been affected by the credit crisis (DOE Annual, 14).

CO-OPERATION

One proposal DOE exemplifies might solve quite some problems. There is a possibility of cooperation between the wind power and hydroelectric power plants. The two could be united into one group where, when wind would generate electricity the hydropower plant could fill the reservoir and then when wind power is not generating enough electricity, the hydro power could fill in the gap. Such a project could help the investor make a more reliable estimate of daily electricity production, enabling him/her to make a clearer estimate of income for kWh supplied. Nonetheless, there is real possibility that now the hydropower plant would not operate at its optimal level. Also, hydropower plants are very demanding and heavy fix cost power plants requiring much space and water resources.

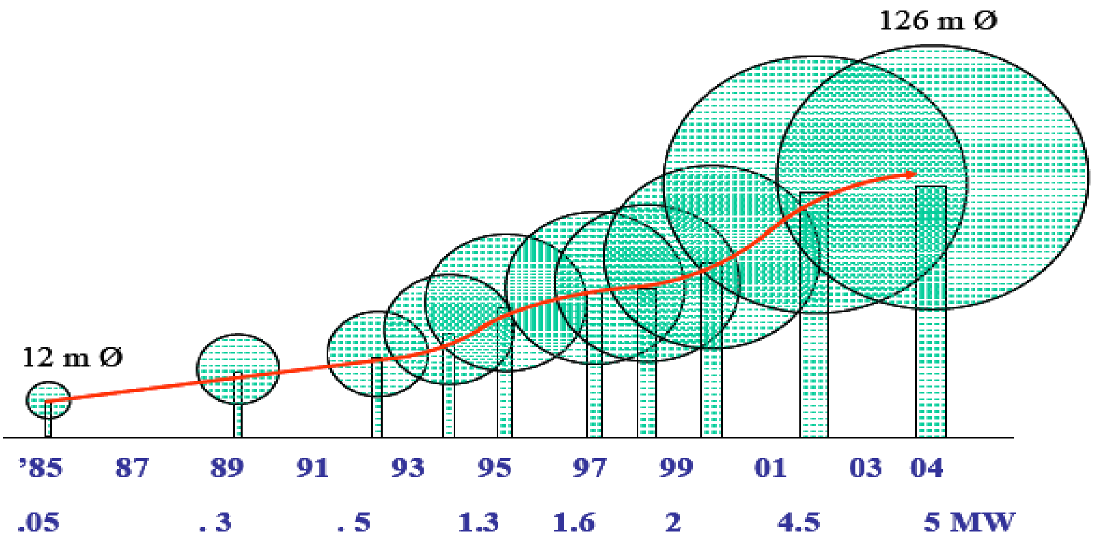

Fig. 1: *Development of the Wind Turbine Size.Wind Turbines Diameter as a Function of Size in MW of Power.*

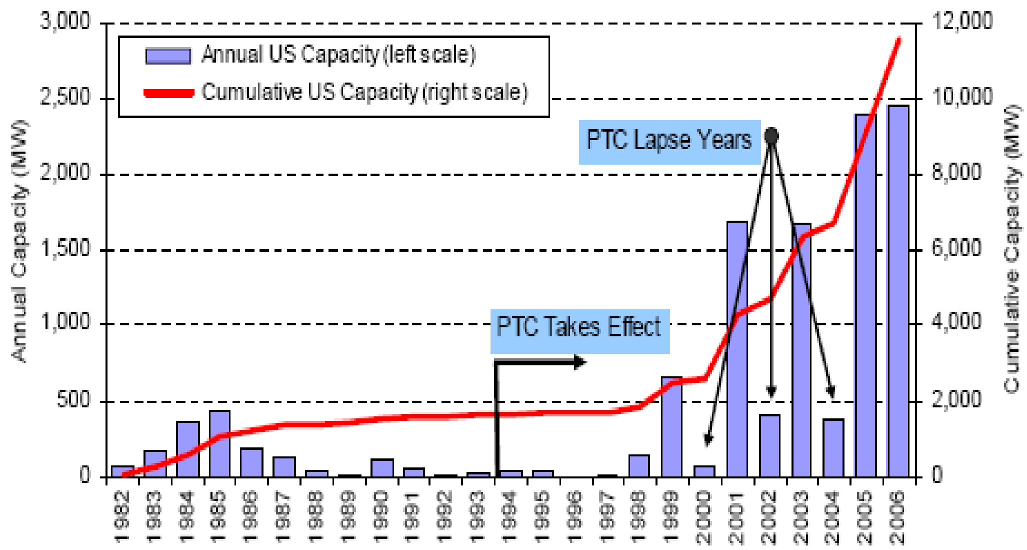

Fig. 2: *Analysis of the Fluctuation is Demand with the Function of RPTC. (RPTC: Renewable Electricity Production Tax Credit)*

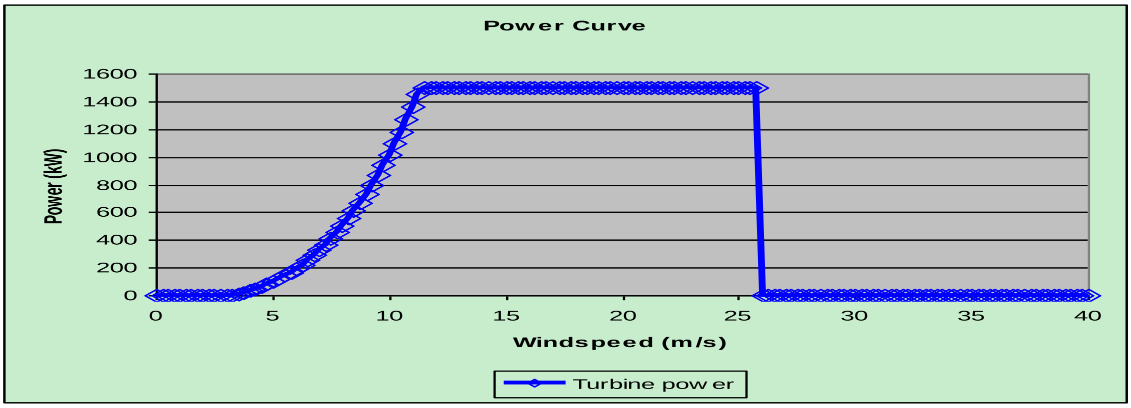

Fig. 3: *Power Curve for a 1.5-MW Turbine that is Characteristic of Current Technology.*

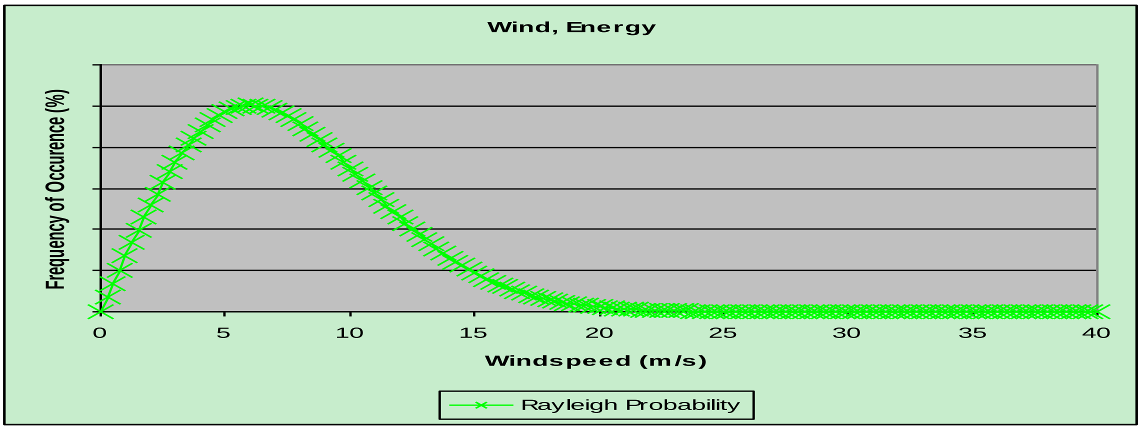

Fig. 4: *Dr. HBS et .al Analysis Describes How Many Hours (or Probability) Each Year the Wind at a Given Site Blows at a Particular Wind Velocity.*

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