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# Study of Wind Energy and Wind Turbine Analysis: A Review

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***Abstract:*** ***There is huge activity in wind power, pan-India with the installed capacity increasing to 10,000 MW. India today has the fifth largest installed capacity of wind power in the world with 11087MW installed capacity and potential for on-shore capabilities of 65000MW. However the plant load factor (PLF) in wind power generation is very low, often in the single digits. The increase in interest in wind energy is due to investment subsidies, tax holidays, and government action towards renewable energy playing a big part in nation's energy system. There is a need to generate environment friendly power that not only raises energy efficiency and is sustainable too. The capital cost of wind power is third higher than conventional thermal power; further electrical problems like voltage flicker and variable frequency affect the implementation of wind farm.***

## I. INTRODUCTION

The wind turbine first came into being as a horizontal axis windmill for mechanical power generation, used since 1000 AD in Persia, Tibet and China. Transfer of mechanical windmill technology from the Middle East to Europe took place between 1100 and 1300, followed by further development of the technology in Europe. During the 19th century many tens of thousands of modem windmills with rotors of 25 meters in diameter were operated in France, Germany and the Netherlands, most of the mechanical power used in industry was based on wind energy. Further diffusion of mechanical windmill technology to the United States took place during the 19th Century.

The earliest recorded (traditional) windmill dates from the year 1191 at the Abbey of Bury St Edmunds in Suffolk. It replaced animal power for grinding grain and other farm activities like drawing water from well, the popularity of wind turbines increased tremendously and they soon dotted the landscape.

The advent of DC electric power in 1882, and introduction of 3-phase AC power production in the early 1890s, provided a technological basis for constructing wind turbines that generated electricity. The Danish scientist and engineer Poul La Cour is the most widely known pioneer of electricity generation using wind power. In 1891 in Askov, Denmark he introduced a four shuttle sail rotor design generating approximately 10kW of DC electric power. He also applied the DC current for water electrolysis, and utilized the hydrogen gas for gas lamps to light up the local school grounds. La Cour's efforts started research, development and commercialization of wind electricity in Europe and thus Europe gained its leadership role in wind energy electricity generation. Though less recognized than La Cour, Charles F. Brush in 1888 introduced in Cleveland Ohio the first automatically operating wind turbine generator, a 12kW, 17-meter-diameter machine, operated for 20 years.

By 1908 there were several wind mills in operation for electricity generation, with capacities ranging from 5-25 kW. By 1930's wind turbines with capacity of 500kW were developed which found wide spread use in inaccessible areas. Today wind turbines are considered to be the most developed form of renewable energy technology, with industrial giants such as Siemens and GE amongst the leading manufacturers. In 2006, some 11,000 turbines were produced with a combined capacity of 16,000 MW and the global market was worth an estimated £13,000 million. Installed capacity is expected to pass 100 GW in 2008, the equivalent of 50-100 nuclear power stations.

## II. LITERATURE REVIEW

### *A. Multi-Criteria Decision Making On Strategic Selection Of Wind Farms*

With maturity of advanced technologies and urgent requirement for maintaining a healthy environment with reasonable price, China is moving toward a trend of generating electricity from renewable wind resources. How to select a suitable wind farm becomes an important focus for stakeholders. This paper first briefly introduces wind farm and then develops its critical success criteria. A new multi-criteria decision-making (MCDM) model, based on the analytic hierarchy process (AHP) associated with benefits, opportunities, and costs and risks (BOCR), is proposed to help select a suitable wind farm project. Multiple factors that affect the

success of wind farm operations are analyzed by taking into account experts' opinions, and a performance ranking of the wind farms is generated.

*B. Experimental Investigation Of Vertical-Axis Wind-Turbine Wakes In Boundary Layer Flow*

In this experiment, a small scale vertical-axis wind-turbine (VAWT) is immersed in a boundary-layer in a wind tunnel and stereo particle image velocimetry is employed to quantify the 3D characteristics of the wake. The measurements show that the wake is strongest behind the sector of the rotor which turns into the wind. Two counter-rotating vortex pairs in the wake induce crosswind motion which reintroduces stream wise momentum into the wake. Terms of the mean kinetic energy budget are computed and demonstrate that this crosswind flow has a significant influence on the redistribution of momentum in the wake. A similar analysis of the turbulence kinetic energy budget identifies shearing at the boundary of the wake as the primary contributor to the production of turbulence. An analytical model is developed in order to obtain a theoretical basis from which to understand how the aerodynamic behavior of VAWTs induces crosswind motion consistent with the production of counter-rotating vortex pairs.

*C. Study Of Decision Framework Of Wind Farm Project Plan Selection Under Intuitionistic Fuzzy Set And Fuzzy Measure Environment*

Project selection plays an important role in the entire life cycle of wind farm project and the multi-criteria decision making (MCDM) methods are very important in the whole wind farm project plan selection process. There are problems in the present MCDM methods decrease evaluation quality of the wind farm project plans: first, the information loss exists in the wind farm project plan evaluation process. Second, it is difficult to satisfy the independent assumption of the multi-criteria decision making methods used in the wind farm project plan evaluation in fact. Third, the compensatory problem of performance scores of the wind farm project plans is processed unreasonably. Hence the innovation points of this paper are as follows: first, the intuitionistic fuzzy numbers are used instead of fuzzy numbers or numerical values to reflect the experts' intuitive preferences to decrease the probability of information loss; second, the fuzzy measure is used to rate the important degrees of criteria in order to avoid the independent assumption and to increase the reasonability; third, the partial compensatory problem of performance scores is well processed by using intuitionistic fuzzy Choquet (IFC) operator and generalized intuitionistic fuzzy ordered geometric averaging (GIFOGA) operator. These operators can deal with the compensatory performance scores and non-compensatory performance scores respectively. Finally, a case study demonstrates the effectiveness of decision framework.

*D. Wind Energy*

The energy that can be extracted from the wind is directly proportional to the cube of the wind speed, so an understanding of the characteristics of the wind (velocity, direction, variation) is critical to all aspects of wind energy generation, from the identification of suitable sites to predictions of the economic viability of wind farm projects to the design of wind turbines themselves, all is dependent on characteristic of wind. The most striking characteristic of the wind is its stochastic nature or randomness. The wind is highly variable, both geographically and temporally. Moreover this variability exists over a very wide range of scales, both in space and time. This is important because extractable energy from wind varies with the cube of wind velocity. This variability is due to different climatic conditions in the world also the tilt of earth on its axis and its own spinning results in different wind distributions across the world. Also within any climatic region, there is a great deal of variation on a smaller scale, which is dictated by several factors such as ratio of land and water, presence of mountains etc. The type of vegetation also affects wind distribution through absorption of moisture, temperature moderation and reflection of sun's energy. Generally. For any location there is variation of wind pattern, wind speed may vary from year to year, also wind distribution will change from decade to decade. These long-term variations are not well understood, and thus make it difficult to make predictions of the economic viability of wind-farm projects. Wind distribution is more predictable over shorter time spans like a year, but on shorter time frame like few days the wind energy is difficult to predict. These variations are due to the weather systems. Depending on location, there may also be considerable variations with the time of day (diurnal variations), which are fairly predictable. These variations are important to be considered because they can affect production of large scale wind energy and consequent integration into grid, also associated power generation systems must be prepared for these variations. Also we must take into account the fact that short term turbulence cause variations in the quality of power delivered.

*E. Summary*

Major factors that have accelerated the wind-power technology development are as follows:

*1)* Development of high-strength fiber composites for constructing large low-cost blades.
*2)* Reduction in prices of the power electronics components such as converters.
*3)* Variable-speed operation of electrical generators to capture maximum energy.
*4)* Improved plant operation, pushing the availability up to 95 percent.
*5)* Economy of scale, as the turbines and plants are getting larger in size.
*6)* Accumulated field experience (the learning curve effect) improving the capacity factor.

The total power generating capacity has grown to about 11087MW as of March 2010 thus placing India at fifth place in terms of installed capacity.

## III. CONCLUSION

The potential of wind power generation is immense, a historical source of energy, wind can be used both as a source of electricity and for irrigation and agricultural uses. In today's world, where a greener source of energy is the need of the hour, wind energy is a promising resource, waiting to be harnessed to its true potential. The study of wind turbine and its characteristics showed that how it can be properly designed and used to get the maximum output, even with the variable wind speeds. The development of offshore wind farms, which have both a better energy density and lesser interference with the local systems, is a definite step forward in realization of the wind potential. The Indian scenario is agog with Suzlon making rapid strides, and a lot of multinationals investing heavily.The study of Aggregation technique, being used in the UK, has shown us a path forward towards a realization of an independent wind farm.

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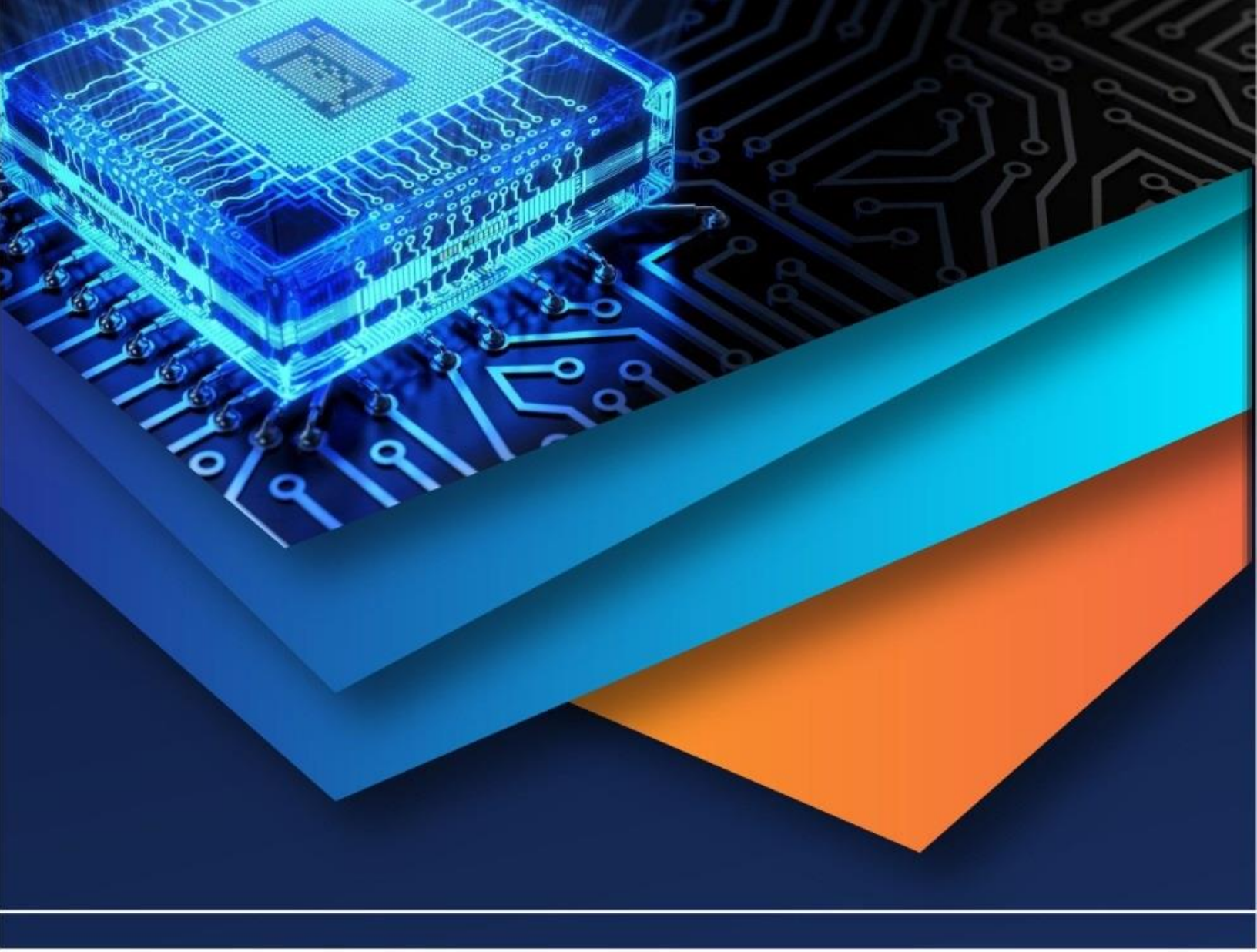

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