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WIND ENERGY CONVERSION SYSTEMS - A CASE STUDY

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Abstract

Growth in wind power is tremendous, with capacity more than doubling every three year. In 2009, global installed wind capacity reached around 160 GW, rising 40 GW on the previous year, according to the World Wind Energy Association, which estimates that by 2020 global capacity could reach 1900 GW. Wind power has negligible fuel costs, but a high capital cost. The estimated average cost per unit incorporates the cost of construction of the turbine and transmission facilities, borrowed funds, return to investors (including cost of risk), estimated annual production, and other components, averaged over the projected useful life of the equipment, which may be in excess of twenty years. Although the wind power industry will be impacted by the global financial crisis in 2009 and 2010, a BTM Consult five year forecast up to 2013 projects substantial growth. Over the past five years the average growth in new installations has been 27.6 percent each year. In the forecast to 2013 the expected average annual growth rate is 15.7 percent.[96][97] More than 200 GW of new wind power capacity could come on line before the end of 2013. Wind power market penetration is expected to reach 3.35 percent by 2013 and 8 percent by 2018

Index Terms: *Wind power technology; Non-renewable energy; Wind Turbine Generator.*

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1. INTRODUCTION

Non-renewable energy is limited, expensive and pollutes the environment. Public and policymakers must understand the nature of global energy crisis and should have an appreciation of the underlying science. Increased world population and integrated global economy contribute to larger demands of electricity. Many countries are still heavily dependent on oil and gas, which will eventually get depleted within next few decades, and the cost of extraction will skyrocket for the remaining oil deposits. In 2008 World Energy Outlook, International Energy Agency (IEA) predicts that average price of crude oil will reach $100 per barrel by 2015, and about $120 by 2030 [1]. From these predictions, it appears oil prices are not going to decrease further and that price fluctuation will continue [2][3]. Coal is still by far the major source for energy generation. If such a high dependence on coal continues and energy demand continues to increase, coal will be depleted during the lifetimes of children born today. Combustion of coal is one of the largest causes of carbon dioxide emissions and acid rains leading to global warming.

2. PARTS OF WIND TURBINE

Wind turbines come in many sizes and configurations and are built from wide range of materials. In simple terms, a wind turbine consists of a rotor that has wing shaped blades attached to a hub; a nacelle that houses a drive train consisting of a gearbox, connecting shafts, support bearings, the generator, plus other machinery; a tower; and ground-mounted electrical equipment. The wing shaped blades on the rotor actually harvest the energy in the wind stream. The rotor converts the kinetic energy in the wind to rotational energy transmitted through the drive train to the generator. Generated electricity can be connected directly to the load or feed to the utility grid.

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Fig.-1: A 600 kW Wind Turbine Generator (Wind mill)

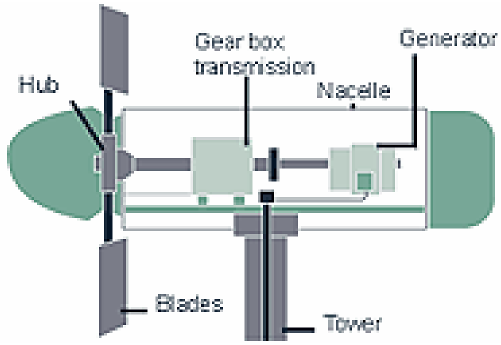

Fig. - 2: Nacelle Components.

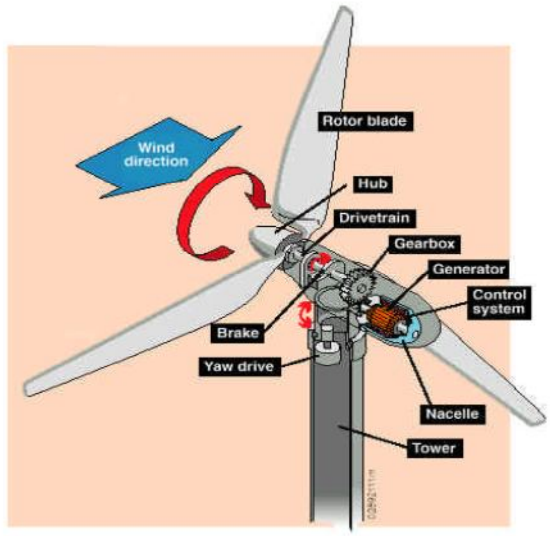

Fig.- 3: Wind Turbine Nomenclature

Table-1: Turbine Component Weight and Cost

Sr. No	Component	% of Machine Weight	% of Machine Cost
1	Rotor	10-14	20-30
2	Nacelle and machinery, less	25-40	25
3	Gearbox and driven train	5-15	10-15
4	Generator systems	2-6	5-15
5	Weight on Top of Tower	35-50	N/A
6	Tower	30-65	10-25

3. WHY WIND ENERGY

- Wind energy is the fastest growing energy source in most parts of the world.
- The future of wind energy depends more or less on political and technological developments.
- Power production incentives in terms of tax credits will make wind-generated electricity competitive with fossil fuels.
- Technological progress should be made in terms of managing wind power, energy storage, smart grid integration, and automation.

- It is also essential that new advancement occur in wind turbine and tower design, rotors, energy loss reduction, smart grid integration, wireless sensors, real time data analysis and sharing.
- According to the India Wind Association, the installed wind power capacity was 30 MW in 1990. It increased to 2 117 MW in 2002, the fifth largest in the world. Installed capacity increased to 3 000 MW in 2004.
- The first wind power development was a government supported demonstration plant in 1986. India had notable wind power developments by the late 1990s, largely due to incentives such an accelerated depreciation allowance of capital costs and exempt ions from excise duties and sales taxes, and regionally administered feed-in tariffs.
- Centre of Wind Energy Technology (C-WET) in Chennai is a specialized institution for research and development, standardization, testing and certification, along with resource assessment. Riso National Laboratory provided technical assistance for its establishment.
- With rapid growth in wind power development in the 1990s, the capacity of the grids in the wind farm regions in Tamilnadu and Gujarat was insufficient to accommodate the wind power.
- In 1998, Riso and C-WET collaborated on a research project to study wind power integration in weak grids in India.
- India has developed indigenous wind energy equipment manufacturing with a capacity of about 1 000 MW per year.

4. BENEFITS OF WIND POWER

Wind power has many benefits that make it an attractive source of power for both utility-scale and small, distributed power generation applications. The beneficial characteristics of wind power include:

- **Clean and inexhaustible fuel**: Wind power produces no emissions and is not depleted over time. A single one megawatt (1 MW) wind turbine running for one year can displace over 1,500 tons of carbon dioxide, 6.5 tons of sulfur dioxide, 3.2 tons of nitrogen oxides, and 60 pounds of mercury
- **Local economic development**: Wind plants can provide a steady flow of income to landowners who lease their land for wind development, while increasing property tax revenues for local communities.
- **Modular and scalable technology**: Wind applications can take many forms, including large wind farms, distributed generation, and single end-use systems. Utilities can use wind resources strategically to help reduce load forecasting risks and stranded costs.
- **Energy price stability:** By further diversifying the energy mix, wind energy reduces dependence on conventional fuels that are subject to price and supply volatility.
- **Reduced reliance on imported fuels**: Wind energy expenditures are not used to obtain fuels from abroad, keeping funds closer to home, and lessening dependence on foreign governments that supply these fuels.

5. CHALLENGES IN FRONT OF WIND ENERGY

The high-energy returns on investment (EROI) for wind power do not guarantee that wind will play the major role in the world's power generation system. There are a number of technical, social and environmental challenges surrounding wind energy that requires resolution before that happens.

- The uncontrolled, intermittent nature of wind poses unique challenges to grid management relative to operator-controlled resources such as coal, gas, or nuclear generation.
- Much of the wind resource base is located in remote locations, so it will cost to bring the wind-generated electricity from the local point-of-generation to distant load centers.
- At about 6 or 7 MW per square kilometer of net power potential, wind plants are necessarily spread-out over a significant land area. Thus, wind plants must compete with alternative uses of these land resources.
- Dramatic cost reductions in the manufacture of new wind turbines that have characterized the past two decades may be slowing due to a variety of economic, financial, and technical reasons. This is particularly true in light of the rising energy and commodity prices, which are slowly escalating turbine costs.
- One of the immediate challenges common to all support structure designs is the ability to predict loads and resulting dynamic responses of the wind turbine and support structure when subjected to combined stochastic wave and wind loading.
- Extreme weather conditions, which in general restrict access for routine maintenance, give rise to the need for more robust turbine parts. This in turn means higher costs, which are not always

offset by the higher productivity due to the higher offshore winds. Installation, repair, and maintenance costs are significantly higher for offshore systems than onshore systems simply because of the assembly and access constraints characteristic of working in water. Floating wind turbines will be the only economical way to access the vast area of deep-water sites. But very few floating wind turbines are under research and development in the world today.

- New foundations, towers, and wind turbine configurations are needed to make floating wind turbines, as well as the offshore market in general, commercially successful. There has also been a concern for visual impact of wind turbines.
- In order to minimize such concerns, innovative design techniques should be tried. Better design techniques have made wind turbines much quieter.
- The noise emitted from wind turbines is less when compared to road traffic, trains, construction activities and many other industrial activities. For offshore wind this is not a major concern since people do not live close to the offshore wind farms Wind power forecasting is also one of the most critical aspects in wind power integration and operation.
- It is needed to estimate the long, medium, and short-term power production.
- Forecasting approaches are usually based on time-series prediction, neural networks, artificial intelligence, knowledge based systems and fuzzy intelligent system approaches. The forecasts are used as inputs to the operators for switching on/off the turbines.

6. SITE DETAILS

I have visited number of time at Suzlon Wind Farm Complex, Kevasa Dongar Site at Supa, Dist. Ahmadnagar. Maharashtra India with my students as a Subject In charge of “Non conventional energy sources” at TE/BE (Mechanical) level.

- Total Area: 15 Sq. KM
- Total Site Capacity: 60 MW
- Product of different capacity at our site: 1000KW (54 No’s) , 1250 (9 No’s)
- Major Customers at Site: Bajaj auto Ltd, Tata Groups of Companies, Varroc Engg Ltd, Anurange Engg Ltd, Endurance Systems Ltd
- Suzlon Energy Limited, an Indian Company that specializes in the development, manufacturing, marketing and operations of wind turbines, was incorporated in1995.
- The company is currently ranked as fifth leading wind turbine maker in the world, with a global market share of 7.7 % in 2006 and 2725MW installed globally as of January 2008
- A giant in the Asian market, Suzlon maintains a presence in 15 countries across five continents and employs over 13000 people. Through its corporate headquarters are based in Pune, India the company has been developing its business from Amsterdam to leverage location and operational advantages.

7. CONCLUSIONS

Remarkable advances in wind turbine design have been possible due to developments in modern technology. The advanced wind turbine technologies have been reviewed as follows.

- The factors such as selection of site, height, choice of wind generators, wind velocity, wind power potential have been considered as an objective function of probabilistic models.
- Selection of windy site for wind power generation requires meteorological data for installation of wind generator.
- Experimental and theoretical methods are used to analyze vibration problems of wind Turbines.
- The aero elastic and structural dynamic aspect helps in understanding various loads used for design and fatigue damage.
- Computer-based supervisory control is used to identify operating characteristics of wind Turbines.
- Static reactive power compensator is used to improve stability of large wind farms.
- Wind field modeling is an important part of a structural analysis of wind turbines.
- In aerodynamic modeling blade element moment theory is used for calculation of Aerodynamic forces acting on the rotor blade.

Control system modeling is used to keep the operating parameters of the wind turbine within the specified limit. These developments and growing trends towards wind energy Signal is a promising future for the wind energy industry. With this improved Technology wind turbine can be designed for its optimum power production at less cost.

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