Wind Energy Generation at Skit College

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Abstract: Wind energy continues to be one of the fastest growing power generation sectors. This trend is expected to continue globally as we attempt to meet a growing electrical energy demand in an environmentally responsible manner. As the number of wind power plants (WPPs) continues to grow and the level of penetration becomes high in some areas, there is an increased interest on the part of power system planners in methodologies and techniques that can be used to adequately represent WPPs in interconnected power system studies. This project is part of an overall industry effort to develop, validate and implement generic positive sequence stability models for wind power plants (WPP). Although the models are designed specifically to meet Western Electricity Coordinating Council (WECC) modeling requirements, the results also benefit the industry as a whole. These goals represent challenges, some of which are described below:

- There are currently four major different types of wind generators, and all of them are fundamentally different from conventional generators. It is necessary to have different types of wind turbine generator (WTG) dynamic models to closely represent each of the four types.
- Wind turbine generators are a relatively new kind of technology where significant technical innovation is still occurring. Thus, planning models were not readily available until recently. From an engineering point of view, representing WPPs as negative loads or conventional generators is unacceptable. With the recent development and implementation of WECC generic models of WTGs, wind power plants can now be represented more properly.
- Validation of dynamic models is needed to verify that the models closely match the dynamic behavior of actual equipment. Field measurement can be used to validate WPP models. Since suitable field data is difficult to obtain, model verification by comparison to manufacturer specific, higher order (more detailed), and validated dynamic models can be used.

2. INTRODUCTION:

Wind energy is a source of renewable power which comes from air current flowing across the earth's surface. Wind turbines harvest this kinetic energy and convert it into usable power which can provide electricity for home, farm, school or business applications on small (residential), medium (community), or large (utility) scales. Wind energy is one of the fastest growing sources of new electricity generation in the world today. These growth trends can be linked to the multi-dimensional benefits associated with wind energy. The exponential growth in the rate of energy consumption is the main cause of energy shortage, as well as energy resources depletion worldwide. Electricity shortage is very common in countries like India where most of the population (i.e. over 40 percent) has no access to modern energy services. On an average, electricity demand is expected to raise 7.4 percent annually for next 25 years. According to International Energy Agency, more than 28 percent share of the world’s total energy will be consumed in India and China by the year 2030. Therefore a significant amount of energy must come from renewable sources. National Action Plan on Climate Change (NAPCC) was formed in 2008 for climate change control, has also considered role of renewable energy in total energy production of India.

NAPCC has also set a target to increase the renewable energy share in total energy production up to 15 percent till year 2020, which clearly shows India’s commitment towards a sustainable development. The huge gap between demand and supply requires more energy resources. The basic challenge is to fulfill the energy requirements in a sustainable way and one of the best available options in current scenario is renewable energy sources, so it is required to intensify Renewable energy and energy efficiency program. By moving towards renewable energy production, which must be indigenous in nature and must have low generation cost, we can enhance energy security condition, reduce our import dependency, solve problem of fuel price instability etc. Carbon dioxide emissions can be reduced on an average 3.3 million tons in a year by adding 1 GW energy.
4. DESCRIPTION:-

Description of Wind Turbine Generator Technologies Despite the seemingly large variety of utility-scale WTGs in the market, each can be classified in one of four basic types, based on the generator topology and grid interface. The distinctive topological characteristics of each type are shown in Figure 1 and are listed below:

- Type 1 – Fixed speed, induction generator
- Type 2 – Variable slip, induction generators with variable rotor resistance
- Type 3 – Variable speed, doubly-fed asynchronous generators with rotor side converter
- Type 4 – Variable speed generators with full converter interface

5. BLADE:-

This Instructable will give you a step by step process on how to carve a real wind turbine blade out of wood (not those fake ones from a 4” PVC pipe, but they are cool too.). This was designed by me, a real Aerospace Engineer, using real airfoils, and optimized for a small wind turbine at lower starting wind speeds.

6. ROTOR:-

Supports the structure of the turbine. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity.

7. DYNAMO:-

A dynamo is an electrical generator that produces direct current with the use of a commutator. Dynamos were the first electrical generators capable of delivering power for industry, and the foundation upon which many other later electric-power conversion devices were based, including the electric motor, the alternating-current alternator, and the rotary converter. Today, the simpler alternator dominates large scale power generation, for efficiency, reliability and cost reasons. A dynamo has the disadvantages of a mechanical commutator. Also, converting alternating to direct current using power rectification devices (vacuum tube or more recently solid state) is effective and usually economical.

8. TOWER/STAND:-

The tower of the wind turbine carries the nacelle and the rotor. Towers for large wind turbines may be either tubular steel towers, lattice towers, or concrete towers. Guyed tubular towers are only used for small wind turbines (battery chargers etc.)

9. SHAFT:-

a long, narrow part or section forming the handle of a tool or club, the body of a spear or arrow, or similar.

10. FLANGE/BRIM DIFFUSER:-

The wind lens is a modification on the wind turbine created by Professor Ohya from the Kyushu University as an attempt to be more efficient in production of electricity and less invasive to both humans and nature. While still in progress, the wind lens has a few changes in design which have led to impacts on how wind energy can be used and harnessed while changing how it impacts the world around us.

11. ANEMOMETER:-

This Wind Speed Temperature Gauge Anemometer with LCD digital display is ideal for weather enthusiast or professional to measure air velocity and air temperature accurately. This portable anemometer with strap for convenient carrying.

12. CALCULATION:-

Over a thousand years ago, windmills were in operations in Persia and China, see. Post mills appeared in Europe in the twelfth century, and by the end of the thirteenth century the tower mill, on which only the timber cap rotated rather than the whole body of the mill, had been introduced. In the United States, the development of the water-pumping windmill was a major factor in allowing the farming and ranching of vast areas in the middle of the nineteenth century. The wind pumps (sometimes called Western mills) are still common in America and Australia. They have a rotor with about 30 vanes (or blades) and the ability to turn itself slowly. Of the 200,000 windmills existing in Europe in the middle of the nineteenth century, only one in ten remained after 100 years. The old windmills have been replaced by steam and internal combustion engines. However, since the end of the last century the number of wind turbines (WT) is growing steadily, and is beginning
to take an important role in power generation in many countries.

We first show that for all wind turbines, wind power is proportional to wind speed cubed. Wind energy is the kinetic energy of the moving air. The kinetic energy of a mass \( m \) with the velocity \( v \) is

\[
E_{\text{kin}} = \frac{1}{2} m v^2
\]

The air mass \( m \) can be determined from the air density \( \rho \) and the air volume \( V \) according to

\[
m = \rho V
\]

Then,

\[
E_{\text{kin, wind}} = \frac{1}{2} V \rho v^2
\]

Power is energy divided by time. We consider a small time, \( \Delta t \), in which the air particles travel a distance \( s = v \Delta t \) to flow through. We multiply the distance with the rotor area of the wind turbine, \( A \), resulting in a volume of

\[
\Delta V = A v \Delta t
\]

which drives the wind turbine for the small period of time. Then the wind power is given as

\[
P_{\text{wind}} = \frac{E_{\text{kin, wind}}}{\Delta t} = \frac{\Delta V \rho v^2}{2 \Delta t} = \frac{\rho A v^3}{2}
\]

The wind power increases with the cube of the wind speed. In other words: doubling the wind speed gives eight times the wind power. Therefore, the selection of a "windy" location is very important for a wind turbine.

The effective usable wind power is less than indicated by the above equation. The wind speed behind the wind turbine can not be zero, since no air could follow. Therefore, only a part of the kinetic energy can be extracted. Consider the following picture:

![Diagram of wind turbine](image)

of wind turbine

The wind speed before the wind turbine is larger than after. Because the mass flow must be continuous, the area \( A_2 \) after the wind turbine is bigger than the area \( A_1 \) before. The effective power is the difference between the two wind powers:

\[
P_{\text{eff}} = P_1 - P_2 = \frac{\Delta V \rho}{2 \Delta t} \left( \frac{v_1^2 - v_2^2}{v_2} \right) = \frac{\rho A}{4} \left( \frac{v_1 + v_2}{v_1} \right) \left( \frac{v_1^2 - v_2^2}{v_2} \right)
\]

If the difference of both speeds is zero, we have no net efficiency. If the difference is too big, the air flow through the rotor is hindered too much. The power coefficient \( c_p \) characterizes the relative drawing power:

\[
c_p = \frac{P_{\text{eff}}}{P_{\text{wind}}} = \frac{(v_1 + v_2) (v_1^2 - v_2^2)}{2 v_1^3} = \frac{1 + x}{2}
\]

To derive the above equation, the following was assumed: \( A_1 v_1 = A_2 v_2 = A (v_1 + v_2) / 2 \). We designate the ratio \( v_2/v_1 \) on the right side of the equation with \( x \). To find the value of \( x \) that gives the maximum value of \( C_p \), we take the derivative with respect to \( x \) and set it equal to zero. This gives a maximum when \( x = 1/3 \). Maximum drawing power is then obtained for \( v_2 = v_1 / 3 \), and the ideal power coefficient is given by

\[
c_p = \frac{P_{\text{eff}}}{P_{\text{wind}}} = \frac{16}{27} \approx 59\%
\]

Another wind turbine located too close behind would be driven only by slower air. Therefore, wind farms in the prevailing wind direction need a minimum distance of eight times the rotor diameter. The usual diameter of wind turbines is 50 m with an installed capacity of 1 MW and 126 m with a 5-MW wind turbine. The latter is mainly used off shore.

The installed capacity or rated power of a wind turbine corresponds to an electrical power output of a speed between 12 and 16 m/s, with optimal wind conditions. For safety reasons, the plant does not produce greater power at the high wind conditions than those for which it is designed. During storms, the plant is switched off. Throughout the year, a workload of 23% can be reached inland. This increases to 28% on the coast and 43% off-shore.

More details can be found in the Internet pages wind and in the pages of the American Wind Energy Association.

The installed capacity of wind power in the United States was in 2014 about 70 GW. This capacity is exceeded only by China (over 90 GW). The Alta Wind Energy Center in California is the largest wind farm in the United States with a capacity of 1.32 GW. The electricity produced from wind power in the United States amounted to about 180 TWh (terawatt-hours) in 2014, or 4.3% of all generated electrical energy. The U.S. Department of Energy’s report 20% Wind Energy by 2030 envisioned that wind power could supply 20% of all U.S. electricity, which included a contribution of 4% from offshore.
wind power. Detailed information about the present state in the US can be found in Wikipedia. A crucial point about wind power is that the times of peak electricity demand and the times of optimal wind conditions rarely coincide. Thus, other electric power producers with short lead times and a well-developed electricity distribution system are necessary to supplement wind power generation. Why have the wind turbines of today lost one blade in comparison to the old four-blade windmills? The rotor power \( P_{\text{mech}} = 2\pi M n \) is proportional to the torque \( M \) acting on the shaft and the rotation frequency \( n \). The latter is influenced by the tip speed ratio \( \lambda \), which is calculated according to \( \lambda = v_1 / v_t \) from the ratio of peripheral speed (tip speed) \( v_1 \) of the rotor and the wind speed \( v_t \). The torque \( M \) increases with the number of blades. It is therefore largest for the many-vaned Western mills, smaller for wind mills with four blades, and smallest for today’s wind turbines with 3 blades. However, every blade, as it rotates, reduces the wind speed for the following blades. This “wind shadow” effect increases with the number of blades. The optimal tip speed ratio is about one for the Western mill, barely over 2 for the four-bladed type, and 7–8 for the three-bladed rotors. At their optimal tip speed ratio, three-bladed rotors achieve a \( c_p \) value of 48% and come closer to the ideal value of 59% than wind turbines with 4 blades. For wind turbines with two blades or weight-balanced one-bladed rotor configurations, the yield is smaller in spite of a higher tip speed ratio, because of the smaller torque \( M \). Therefore, wind turbines today have three blades.

13. CONCLUSION AND FUTURE SCOPE:--

Wind turbine technology has demonstrated the potential for contributing to the energy needs of the United States. If the sites with acceptable wind characteristics were fully utilized, they could contribute up to about 10 percent of the nation’s electrical energy needs. The limitation is based on utility system stability issues rather than available site locations. As in all energy investment decisions, the ultimate penetration level will be driven by the cost of energy that is produced. In turn, this is decided by the initial cost of the wind energy plant and the annual cost for maintenance and operation.

Since a number of U.S. electric power utilities are continuing to add capacity, there will be an opportunity to introduce a new, longer-lasting design for a wind turbine system. Moreover, renewed interest by the public in environmental issues associated with power generation gives a special advantage to wind power. A new wind turbine system probably will take advantage of advances in semiconductor power electronics to improve energy production as well as provide reactive power control, which will make wind-generated electric power more amenable for use by the electric utilities. New speed control schemes will be introduced, but the major advance must come through the design of less expensive, longer-lived, and higher-efficiency rotors. A guiding principle in creating this design should be that knowledge of aerodynamic forces must be carefully integrated with the structural response of the material, all balanced by the practicalities of field experience and tempered by the need to manufacture a consistently high-quality product at reasonable cost.

This committee has examined the experience base accumulated by wind turbines, and the accompanying R&D programs sponsored by the Department of Energy and has concluded that a wind energy system such as described above is within the capability of engineering practice. However, certain gaps in knowledge exist. The achievement of this goal without costly and inefficient trial and error requires certain critical research and development. Because of the fragile nature of the wind power equipment producers in the United States, this will require an R&D investment by the Department of Energy.

The committee cannot conclude without commenting on the status of the wind power equipment industry. Because of the decrease in the number of machines installed in the past 5 years, since the tax incentives expired, there currently is only one major integrated manufacturer in the United States. In addition, only a few companies are actively producing blades. Moreover, in recent years, a major Japanese manufacturer has entered the world market to join the European manufacturers who have been participants for some time. As a result, the U.S. industry is not in a financial position to engage in the R&D necessary to gain worldwide technological leadership for what the committee sees as a future growing worldwide market for wind power. The committee believes that the United States is facing a future major reduction in fossil fuel sources of energy. When this is coupled with a resurgence of public concern for environmental issues in energy production, the need to develop wind power energy to the fullest extent possible seems compelling.

In the recommendations below, specific research tasks are listed that need to be carried out. Within each category of research—materials, manufacturing, structural response, etc.—these research tasks are listed in approximate order of priority. However, we
wishes to emphasize that the overall goal of an R&D program should be to develop a system to produce longer-lived, less expensive, and more efficient wind turbine rotors. Increased knowledge of the fatigue properties and fatigue failure mechanisms of blades should take precedence, but this cannot be separated from the search for better manufacturing processes or from design innovations that will either minimize the likelihood of failure or ease the aerodynamic constraints of blade shape that impede process innovation. The committee wish to emphasize that the four factors of fatigue, manufacturing, advanced materials, and design are closely interrelated in the quest to produce a more cost-effective blade.

Wind power is an affordable, efficient and abundant source of domestic electricity. It's pollution-free and cost-competitive with energy from new coal-and gas-fired power plants in many regions. The wind industry has been growing rapidly in recent years. The Ministry of New and Renewable Energy (MNRE) has fixed a target of 10,500 MW between 2007–12, but a and additional generation capacity of only about 6,000 MW might be available for commercial use by 2012. The MNRE has announced a revised estimation of the potential wind resource in India from 49,130 MW assessed at 50m Hub heights to 102,788 MW assessed at 80m Hub height. The wind resource at higher Hub heights that are now prevailing is possibly even more India has set a target of achieving overall wind energy installed capacity of 27,300 MW by 2017 and 38,500 MW by 2022. As per NOVONOUS estimates, this creates an US$31.25 billion opportunity in the wind energy market

14. References:-


1. BWE Bundesverband WindEnergie, German Wind Energy Association http://www.wind-energie.de/de/die-technik/