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Wind Energy: The Sustainable, Clean and Green Energy for Mitigation of Climate Change Effect

KEYWORDS: Wind turbine, wind energy, wind power plant, climate change

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ABSTRACT *Climate change effect is most serious effect in modern days. Everyone is trying to reduce the adverse effect of climate change. Our conventional power plant produces more greenhouse gases and also consumes lots of water. Ultimately this results on the environment. This paper describes how electricity generation by wind energy is useful for mitigation of climate change effect.*

1. BASICS OF WIND ENERGY

From the olden days, ships were driven by wind power. Windmills were used to lift water from the wells for irrigation and for grinding the grains. With the help of wind turbine the kinetic energy in wind can be converted to mechanical energy. Generators produce electricity from the mechanical energy. Wind turbines range in size from a few hundred watts to as large as several megawatts. The amount of power produced from a wind turbine depends on the length of the blades (or the term of swept area) and the speed of the wind. The power in the wind is proportional to the cube of the wind speed; the general formula for power in the wind is:

$$P = \frac{1}{2} \rho A V^3$$

Where P is the power available in watts, ρ is the density of air in Kg/m^3, A is the cross-section or swept area of a windmill rotor in m^2 and V is the instantaneous wind velocity in m/s. Due to this cubic relationship, the power availability is extremely sensitive to wind speed. A doubling the wind speed increases the power availability by a factor of eight. Even a small variation in wind speed converts to a substantial difference in power output. The same turbine on a site with an average wind speed of 8 m/s will produce twice as much as electricity as an on a site with 6 m/s.

The cut in speed is the speed at which the wind turbine starts generating electric power. It is usually 5 m/s and full-load attained above 12 m/s. The cut out speed is the speed at which the wind turbine stop working, usually it is 25 m/s. Thus developers expend considerable effort to identify and secure the sites which are most consistently in the optimum range. Wind speed is partly a function of height ($V = H^{1/7}$) and generally weaker near the ground due to friction between earth's surface and air flow. So placing turbines on hills and on large towers gives access to higher wind speeds. A taller tower not only makes it possible to reach faster winds but also accommodate a bigger rotor for a larger swept area.

All these factors have driven manufacturers to make ever bigger turbines. The turbines of the mid-1990s swept ten times the area of earlier machines. The size of wind turbines has doubled approximately every 4~5 years. Turbines with an installed generator capacity of 5 to 6 MW and a diameter of 110-120 m diameter are running as prototype, figure 1. Represents the development of rotor diameter and size of turbine.

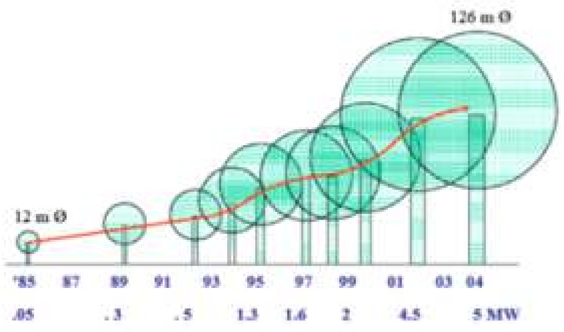

Figure 1. Development of rotor diameter and size of turbine

2. OPERATION

Turbines produce DC or AC power, depending on the generator. However, neither way is 100 percent efficient at transferring wind power. The rotor will deliver more power to the generator than the generator produces as electricity. This leads to another fundamental consideration on the size of wind turbines. The size of a generator indicates only how much power the generator is capable of producing if the wind turbine's rotor is big enough, and if there's enough wind to drive the generator at the right speed. Thus further confront the fact that a wind turbine's size is primarily governed by the size of its rotor.

Wind speeds are crucial for generating utility-compatible electricity. To adapt wind speed variation, electrical generators can be operated either at variable speed or at constant speed. In the first case, the speed of the wind turbine rotor varies with the wind; in the second, the speed of the wind turbine rotor remains relatively constant as wind speed fluctuates.

In nearly all small wind turbines, the speed of the rotor varies with wind speeds. This simplifies the turbines' control while improving aerodynamic performance. When such wind machines drive an alternator, both the voltage and frequency vary with wind speed. The electricity they produced isn't compatible with the constant-voltage, constant-frequency AC produced by the utility. Electricity from these wind turbines cannot be used in most our daily equipment. The output from these machines must be treated or conditioned first, usually equipped with features to produce correct voltage and constant frequency compatible with the loads.

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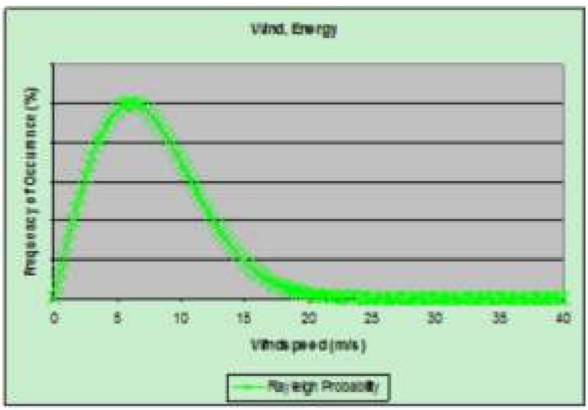
Although nearly all medium-size wind turbines, operated at constant speed by driving standard, off-the-shelf induction generators, a number of manufacturers of megawatt-size turbines today have switched to variable-speed operation. Many of these use a form of induction generators, which may improve aerodynamic performance.

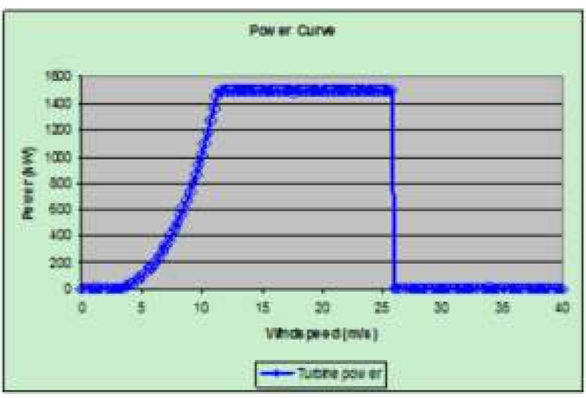
3. ESTIMATING OUTPUT

Annual energy production (AEP) is calculated by applying the predicted wind distributions for a given site to the power performance curve of a particular wind turbine. Figure 2(a) represents the site wind distributions are normally based on a Rayleigh distribution that describes how many hours (or probability) each year the wind at a given site blows at a particular wind velocity.

The second step in this process requires the power curve for the chosen turbine. Figure 2(b) is an example of a power curve for a 1.5-MW turbine that is characteristic of current technology.



(a)



(b)

Figure 2 (a) (b) Power curve method of calculating annual energy output

What may not be stated upfront is that wind speeds of 10-25 m/s are necessary to reach a 1,500 kW output. The power output of a turbine for wind speeds must be determined specific to a specific site. Wind turbine developers can properly install a turbine that is well-suited for each site.

4. ENVIRONMENTAL EFFECT

It is the fact that water scarcity is pressing and will be worsened by climate change and population growth in the near future, it is vital to preserve water resources. Wind energy uses virtually no water. Replacing thermal and nuclear power stations with wind energy is therefore a key step in the fight to conserve and protect water resource and hence against future power shortages due to water-dependent electricity production. Move away from water-intensive technologies like thermal power plants to technologies such as wind energy which use virtually no water to maximize wind energy's water protection benefits. Water consumption for cooling in power generation varies according to the type of system and generation technology. The choice of the cooling system is often site-specific and depends on water availability, local environmental regulations and other factors. Non-thermal technologies such as wind or PV have the lowest operational and lifecycle water consumption of water per unit of electricity generated. Wind power plants, for instance, might only need water only for cooling purposes of generator, transformer, inverter and occasional blade washing– and even then, the blades are already washed by the rain. On the other hand, estimates of water use for gas power plants are around 0.7 m^3/MWh, for coal estimates range between 1.7 to 2 m^3/MWh and for nuclear 2.7 m^3/MWh.

5. FOSSIL FUEL IMPORT REDUCTION AND CO2 EMISSION REDUCTION

Wind energy has significant potential for reduction of greenhouse gas (GHG) emissions in nearby 2020 and long-term 2050. A variety of wind energy technologies are available, but the primary aim of wind energy should be related to mitigation of climate change effects. It needs to generate electricity from larger, grid-connected wind turbines, deployed either onshore or offshore. Focusing on these technologies, the wind power capacity installed by the end of 2009 was capable of meeting roughly 1.8% of worldwide electricity demand, and that contribution could grow to in excess of 20% by 2050. If ambitious efforts are made to reduce GHG emissions and to address the other obstacles to increased wind energy deployment. Onshore wind energy is already being adopted at a rapid rate in many countries, and no unbeatable technical barriers exist that prevent increased levels of wind energy penetration into electricity supply systems. Moreover, though average wind speeds vary considerably by location, ample technical potential exists in most regions of the world to enable significant wind energy deployment. In some areas with good wind resources, the cost of wind energy is already competitive with current energy market prices, even without considering relative environmental impacts. Nonetheless, in most regions of the world, policy measures are still required to ensure rapid deployment. Continued advances in on- and offshore wind energy technology are expected, however, further reducing the cost of wind energy and improving wind energy's GHG emissions reduction potential.

The wind power does however generate zero-emissions that can encourage the development of wind power energy generation in order to lower the air pollution levels. Wind power can encourage investment if investors have not to suffer 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. The policy does not affect the cost-efficiency of specific wind power companies, yet promotes clean air power generation.

6. CONCLUSION

The availability of turbines is ~98%, which means that during 2% of the time they cannot produce due to maintenance or failures. In general, elementary design rules dictate that the bigger the turbines are to deploy as much as possible. Wind electricity penetration levels that approach or exceed 10% of global electricity supply by 2030 are feasible, assuming that cost and policy factors are favorable towards wind energy deployment. The scenarios further suggest that even more ambitious policies and/or technology improvements may allow wind energy to reach or exceed 20% of global electricity supply by 2050, and that these levels of supply may be economically attractive within the context of global climate change mitigation scenarios.

The major environmental benefits of wind energy result from displacing electricity generation from fossil fuel-based power plants, as the operation of wind turbines does not directly emit GHGs or other air pollutants. Similarly, unlike some other generation sources, wind energy requires insignificant amounts of water, produces little waste and requires no mining or drilling to obtain its fuel supply. Nonetheless, it is clear that the direct impact of wind energy is to reduce air pollutants and GHG emissions. Depending on the characteristics of the electric system into which wind energy is integrated and the amount of wind energy supply, the reduction of air pollution and GHG emissions may be substantial.

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