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An Study on Current Status and R&D of Wind Energy Technology

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Abstract

Electricity from wind turbines is one of the fastest-growing sources of energy in the United States. More than 5,200 MW of solar power were installed in the United States in 2007, and experts expect the same amount to be installed in 2008. On December 31, 2007, the United States had 16, 596 MW of installed capacity. Over the past two decades, wind turbines have expanded in size from 100 kW to over 2.5 MW, a dramatic increase. Technology for wind turbines has been evolving for the past two decades, and this is projected to continue for the next two decades as well. Wind turbine technology's cost effectiveness is predicted to improve in the future thanks to the creation of cutting-edge rotors, motor systems, towers, and controls.

Renewable and ecologically friendly energy sources like wind, solar, hydropower, geothermal, hydrogen, and biomass are being developed as a replacement for fossil fuels because of mounting worries about global warming, environmental pollution, and energy security. Wind power can help alleviate the world's energy and environment crises. With wind power, emissions of CO 2, SO 2, NO 2, and other harmful wastes are virtually eliminated as in traditional coal-fuel power plants or nuclear power plants with radioactive wastes.

Keywords: Wind Energy, Wind Energy Technology, Improvements.

1. Introduction

Wind power has grown rapidly during the last three decades all around the world. By the end of 2009, there were 158 GW of installed wind power capacity around the world. This was a record-breaking amount. Renewable, clean, and dependable wind power is likely to account for a considerably larger share of electricity generation in the future decades.

Electricity from wind turbines is one of the fastest-growing sources of energy in the United States. More than 5,200 MW was installed in the United States in 2007, and experts expect the same amount in 2008. As of December 31, 2007, the total installed capacity in the United States was 16,596 MW. Over the last decade, wind power generation capacity has increased at a 20-30% annual pace in the United States and Europe. In spite of this remarkable development, wind power presently accounts for barely 1% of total US electricity consumption.

Wind energy potential abounds in the United States, which is fortunate for the country. Wind power, both on land and at sea, has been predicted to be more than enough to provide all of the country's electrical energy requirements. Figure 2 depicts the abundance of wind energy resources in the Midwest, which extends from Texas to North Dakota. Today's wind turbines have 70- to 80-meter-diameter three-blade rotors set on 60- to 80-meter towers, as depicted in Figure 3. About 1.5 MW of electrical power can be

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generated by the typical turbine installed in the United States in 2007. With relation to the relative wind, "blade pitch control" (the rotation of the blades on their long axis) affects turbine power production by changing the angle of attack with respect to the wind.

With a 10% increase in wind speed, the quantity of energy that can be extracted from the wind by the turbine rises by 33%. This cubic increase in energy, however, can only be captured by a turbine since the electrical system has been constructed to handle power levels above the "rated power" (as will be described later). The size and height of wind turbines have increased to take advantage of the more powerful winds that can be found at greater altitudes. Land-based wind turbines' dimensions aren't projected to expand as rapidly as in the past. Land-based turbines aren't expected to grow much larger than 100 metres in diameter, with power outputs of 3 to 5 MW, by several turbine designers It's physically conceivable to make larger components; however, getting them across the highway and obtaining cranes large enough to lift them pose logistical hurdles.

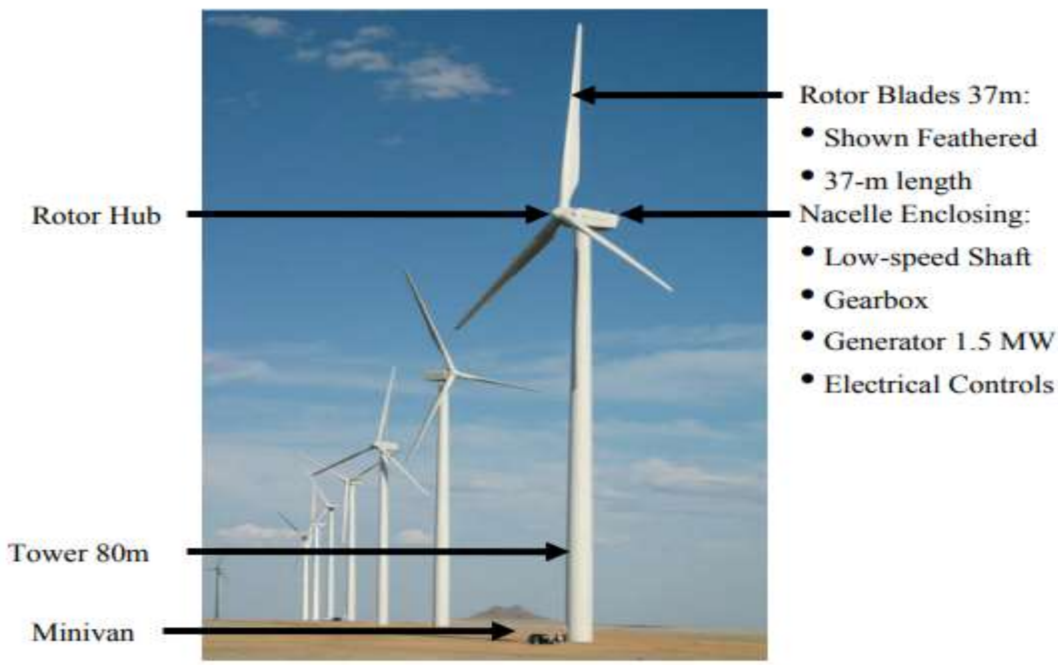

Figure: 1. A modern 1.5 MW wind turbine installed at a wind farm (photo by Mark Rumsey, Sandia National Laboratories).

2. Wind Energy

Hydrogen (H) and helium (He) are fusion products in the core of wind turbines, which transform solar energy into wind energy. Heat and electromagnetic radiation are generated in the sun's HHe fusion process and are emitted into space in all directions. Even though the earth only receives a tiny fraction of the sun's energy, it's enough to power the planet's whole population.

In the global energy industry, wind power is a major player and a major source of new power generation. Wind power's technical maturity and speed of deployment, as well as the fact that there is no practical upper limit to the percentage of wind that can be integrated into the electricity system, are recognised as leading energy technologies [1]. [2] It has been estimated that the Earth receives around 1.8 10 11 MW of solar electricity per day. Fewer than 2% (3.6 10 9 MW) of the sun's energy is converted to wind energy, and roughly 35% of it is lost within 1000 metres of the earth's surface [2]. Consequently, 1.26 10 9 MW of wind-generated electricity can be turned into other sources of power. Wind power might theoretically supply all of the world's energy demands if it could produce 20 times as much energy as the world currently consumes.

Wind energy provides several advantages over more traditional forms of energy. There are no harmful emissions from wind power, unlike fossil fuels and nuclear power, which produce radioactive waste. As a renewable and free source of energy, it can be found in most parts of the world. Using wind power more extensively would also help to lessen the need for fossil fuels, which, at the current rate of usage, may be depleted by the end of this century. In addition, wind power costs less per kWh than solar power [3].

To put it another way, in the 21st century, wind energy is expected to play a major role in global power supply.

3. Wind Technologies Of The Future

"In 2030, wind energy will be a key modern energy source, reliable and cost competitive in terms of cost per kWh," according to the European Wind Energy Technology Platform5. As previously stated, wind energy in the European Union (EU) is expected to supply between 21 and 28 percent of the EU's total electricity demand. According to the European Wind Energy Technology Platform (EWETP), wind power needs to become cost competitive by 2030 in order to be a viable option. Referring the reader to reference 5 is the best way to learn more about this demanding multi-disciplinary research project. Neither the United States nor Europe are anticipating a "breakthrough" in wind technology. However, a series of technological advancements over the next two decades could result in a 30 to 40 percent improvement in wind technology's cost-effectiveness.

3.1. Advanced Rotors

Large dynamic loads require rotors with enhanced structural efficiency in order to prevent the costly cubic weight rise that has been detailed previously. Efforts are being made to reduce these high levels of stress or to produce more resilient designs. Carbon fibres with a high strength-to-weight ratio are currently being used in wind turbine blades to reduce overall weight.

In an effort to save money, new blade airfoil forms can be developed that are significantly thicker in the areas where the blade needs it most.

Reducing fatigue loading on the blade is another way to increase blade length while limiting weight and cost growth without increasing the weight or cost. In fibreglass blades, a 10% reduction in cycle stress can enhance fatigue life by an order of magnitude, thus this strategy has the potential to pay off handsomely.

Transport expenses can be reduced through the use of ideas like on-site manufacturing and segmented blades. Segment moulds and move them to temporary buildings adjacent to the location of a significant wind installation to make the blades near or at the wind farm site may be possible.

3.2. Advanced Drive Trains

Several new ideas are being worked on to lower the weight and expense of the drive system while increasing its reliability. WindPACT design studies have looked into these issues, as documented in the reference 10 report. Building a gearless direct drive generator is one way to increase the generator's reliability. A high pole count 14 and a huge diameter are the price of a slowly revolving generator. The diameter of the generator can range from 4 to 10 metres and it can be rather hefty depending on the design. The size and cost of future permanent-magnet generator designs are projected to be considerably affected by the fall in price and rise in supply of rare earth permanent magnets.

The single-stage drive using a low-speed generator is a promising hybrid of the direct-drive approach for future large-scale projects. Using a low-speed generator that is substantially smaller than a comparable direct-drive design is possible because of this. The National Wind Technology Center at NREL developed and tested this method, which decreases the diameter of a 1.5 MW generator to 2 m10.

The distributed drive train is another solution with the potential to minimise size, weight, and cost. In order to power multiple generators in series, this design divides the rotor's driving route.

3.3. Innovative Towers

The cost of huge cranes and the transportation costs for massive tower sections and blades is encouraging the investigation of novel tower design concepts. Cranes may no longer be necessary for large, heavy lifts in the future, according to a number of new ideas being developed or proposed. The telescoping or self-erecting tower is an example of this type of design. Alternatively, tower-climbing cranes or lifting dollies can be used to hoist the nacelle and rotor to the top of the tower using tower-mounted rails.

4. Wind Energy Characteristics

The direction and speed of the wind are two critical factors to consider. The wind vane is an instrument that can be used to determine the direction of the wind. A weather vane is another name for it. The front and back of every wind vane are separate components. An arrow-shaped wind vane is a typical design. Front is the arrow's tip, while back is the arrow's tail. This is then attached to a vertical column that can be swayed by the wind as needed. Smaller surface area in front compared to behind.

The wind vane's back section has a larger surface area, so it bears the brunt of the wind's force. Therefore, the arrow is positioned so that its tip points toward the direction of the wind. You'll be able to see where the wind is coming from on the wind vane. The rooster is yet another popular design for a wind vane. The wind's direction is indicated by the direction the bird's head points. Ideally, the wind vane should be situated high above the ground, away from trees and other structures that could affect the wind direction.

A unique type of kinetic energy in the air as it moves is wind energy. Pumping water, sailing ships, or grinding grain can all be powered by wind energy, which can be transformed to electrical energy in a power conversion unit.

5. Conclusion

The price of electricity generated by wind turbines is expected to fall in the future. Larger, more efficient wind turbines are the way to go in order to accomplish this. The "square-cube law" states that increasing the size is restricted. There are numerous new materials (concrete) and innovative approaches to reducing the cost of a wind turbine's tower.

In the last decade, wind power generation has advanced at a breakneck pace. Commercial market product is now competitive with conventional power generation due to lower capital costs, higher dependability and significantly increased energy efficiency. Commercial wind farms have been able to attract funding thanks to R&D investments and the 19 development of robust design requirements.

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