Good essay on wind power

[Environment](), [Electricity]()

Introduction

While non-renewable energy sources, notably fossil fuels, comprise the main sources of energy today, concerns over sustainability, high oil prices and climate change, have forced the issue on need for alternative energy sources. The increased contribution of renewable energy sources across all economic sectors means that these technologies can assist countries to meet their respective policy objectives for secure, affordable and reliable energy. Renewable energy technologies remain in their infancy, but are fast gaining ground because of the unsustainably high costs, carbon footprint and pollution caused by fossil fuels. Renewable energy is defined as that which is derived from resources such as wind, solar, geothermal, water and bioenergy, which can be replenished through natural processes and within a humanly feasible timescale. On the other hand, non-renewable energy describes energy sources that cannot be replenished naturally and/or can be replenished, but not in a humanly feasible timeline. Wind is, basically, a current of atmospheric air. It results from the differential absorption of solar radiation by the earth's surface, which in turn creates convective processes because of temperature/pressure differences that set air in motion. This paper argues that while wind power should not replace non-renewable energy sources just yet, because it remains unreliable, it should supplement and gradually replace it as better technology becomes available.

Generation of Electricity

Generation of electricity from wind requires the wind's kinetic energy to change into mechanical energy, which is in turn turned into electrical energy, as efficiently as possible. The wind's harvestable kinetic energy increases with the wind speed to the power of three, but turbines can only capture a fraction of the available energy, depending on the number of blades and the rotor diameter and the tower height. A wind turbine comprises one to three blades attached to a hub and the main shaft, which transfer mechanical energy either directly, or with the help of gears, to the generator and a control system. Modern turbines incorporate numerous design elements aimed at achieving greater efficiency and reliability. For instance, to prevent turbine towers from blocking the airflow from reaching the blades and mitigate noise emissions, modern turbine designs comprise three-blade, upwind rotor configurations. Further, in order to generate as much mechanical energy as possible, the upwind turbines' rotor blades must always face in the wind's direction, and thus a yaw a motor (that powers the yaw drive) and a pitching system are incorporated into the turbine to always orientate the nacelle to ensure it faces in the right direction.

The electricity generation technology behind a wind turbine is simple. As shown in Figure 1, when wind blows against the rotor blades, its force rotates the slightly pitched blades, forcing them to rotate, thereby transferring the kinetic energy in the wind into mechanical energy. The blades rotate the main or low-speed shaft, which engages the high-speed gear that multiplies the rotation speed. The low-speed shaft spins the generator that converts the mechanical energy into electrical energy, using an electromagnetic field. The electricity flows through cables to a substation where a transformer steps up the electricity generated by the turbine(s) into high voltages to transmit through the grid.

Figure 1: Wind turbine components. The controller starts and shuts off the turbine to ensure it operates at wind speeds of between 8-55 miles per hour

Advantages of Wind Energy

Unlike fossil fuels, solar and other energy sources, the wind is everywhere, and it can be leveraged to provide energy in regions without grids, solar, tides, and rivers. It offers considerable potential, despite the fact that it remains relatively more expensive. With increasing improvements in the technology involved, it is reasonable to expect capital maintenance costs of wind energy, which have reduced by 80% since 1970, would fall even further. In addition, technological improvements should ensure more efficient harvesting of wind energy, better storage, and intelligent grids, to enable wind energy become more competitive than fossil-fuel generated energy by the end of 2025. Even most importantly, the high costs of wind energy are partly because of failure to monetize the resultant environmental benefits, coupled by a similar failure to internalize the externalities caused non-renewable energy sources. However, carbon trading programs are quickly gaining ground and government subsidies across the world, are helping achieve marked reductions in the initial capital on investment in wind energy. When coupled with the fact that the unit cost of fossil-fuel energy is bound to increase in the long-term if fossil fuel prices increase, then it should be easy to expect that wind energy will become equally or even more competitive.

Wind energy also has net environmental benefits, arising primarily from displacing fossil-fuel-based electricity generators, which have a high carbon footprint and other environmental problems. This reality should be seen in the context of the fact that even though wind power and other renewable sources of energy remain on the margin, they will become important sources of energy as the current power plants age. As environmental issues come to the fore, wind energy’s green attributes will give it an advantage. It is estimated that 160 Gigawatts of wind power capacity can generate up to 340TWh/year of electricity, enough to replace 0. 2 Gigatonnes of CO_2 emissions per year as well as air pollution that would otherwise have been emitted if fossil fuels were used to produce the same power. Life-cycle assessments based on ISO 14044 and ISO 14040 for greenhouse gasses emissions per unit of electricity generated from wind energy ranges between 8g and 20g of CO_2eq/kWh. Wind turbines must operate for an average of 5. 4 months within the 25th and 75th percentile to generate enough energy as it is used in the production, transportation, installation and decommission wind plants. Wind energy means relatively lower noise pollution, smaller carbon footprints, and long-term sustainability compared to fossil fuels.

Disadvantages

Wind plants require relatively higher maintenance and operating costs, which mean that the electricity produced this way is more expensive compared to that generated from traditional energy sources. In major wind markets, operational and maintenance costs amount to between $0. 01/kWh and $0. 025/kWh, with the costs for offshore plants being as high as $0. 048/kWh. However, given the rapid improvements in the relevant techonologies and policies, coupled by the growing scale of wind energy production, the prospects for capital and operational cost reductions exist, which may just render wind energy competitive. There is evidence of this already happenning, as shown by the the continuing elimination of supply side bottlenecks and increased competitiveness among suppliers, which should have a downward pressure on the capital cost, further reducing the levelized cost of wind energy by as much as 6%.

A further challenge stems from the fact that wind power output is highly variable and unpredictable. While forecasting technologies have increased considerably, there remain difficulties in making long-term forecasts and the choice of sites, and such unpredictability makes wind energy less reliable. The total uncertainty and variability is partly dependent on the degree of correlation between the outputs of varied geographically dispersed power plants, and thus it is possible to mitigate the effects of greater geographical dispersion. The limited predictability and temporal variability of wind energy reduce its GHG emissions advantages because it necessitates the reliance on short-term balancing reserves in order for electric system operators to ensure reliability. Fossil fuel operators synchronized with the grid, most of which are usually part-loaded and running throughout meet these short-term demands. Part-loaded generators reduce the efficiency of wind power and its beneficial GHG emissions. In addition, the capacity of wind power plants varied considerably, and from one location to the next, depending factors that include the wind resource quality and weather.

The ecological impact, namely poor aesthetic quality of wind turbines, and deaths of bats/migratory bats, is a highly publicized challenge, even though these factors vary from one region to the next. Bird fatalities are likely to increase with the increased adoption of wind power. Raptors and songbirds are worst affected. Other challenges include the possible need for new transmission infrastructure to tap into the offshore plants, as well as slow and cumbersome planning (bureaucracies) necessary to ensure that such infrastructure is in place could delay the actual deployment of wind, and other alternative energy sources.

Conclusion

Wind energy holds immense potential, but at present, it comes short of fossil fuels and nuclear energy in regard to the setup and maintenance costs, efficiency, predictability, reliability and scale economies. However, technological improvements have shown wind’s promise, which when supported by government subsidies and monetization of environmental benefits can make it competitive. Even most importantly, while it is evident that wind energy cannot be used exclusively as an energy source, the existence of intelligent grids mean that wind energy can still be deployed to leverage its environmental benefits. While the variability of supply is an important factor, for instance, it does not render electricity grids less manageable. Even most importantly, the sustainability (even with difficulties with birds) is a strong claim, and must be treated as such. Compared with hydroelectricity that kills fish and the pollution associated with fossil fuels, and catastrophic nuclear accidents, wind energy is by far the safest. As long as its reliability remains dubious, it should not replace, but should must be used to supplement fossil fuels to the extent practicable.

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