

Mitigation of Wind Power for the Energy Crisis and Future Trends

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Abstract. The energy crisis is an influential topic in today's world, and fossil energy consumption and emissions are the focus of international attention. The use and emission of fossil energy has been built into a very sophisticated system by mankind, and despite the many drawbacks it is still not in a position to be outlawed on a large scale. The development and practical application of new energy sources are increasingly valued, and new energy sources are seen as alternatives to fossil energy sources. The elimination of the traditional method of burning fossil fuels through new ways of generating electricity is perfectly in line with the international trend towards reducing emissions. New energy is strongly advocated, but because the development and use of new energy does not have enough history and experience, there is still a gap in the maturity of use.

Keywords: Sustainable energy resources, Fossil energy emissions, Wind power electricity.

1. Instruction

Climate change is a global issue that has long been in the spotlight. There is already an international consensus on most aspects of the issue. Most of the major components of greenhouse gas emissions, such as carbon monoxide and carbon dioxide, are created by the anthropogenic burning of fossil energy. This has led to a challenging increase in global warming rather than a decrease.

There is a limit to energy, and the demand for energy between nations is unlimited. For geographical reasons, the energy reserves in the territories under the control of each country are not the same. Saudi Arabia holds the most oil-rich Middle East plate, while Russia's territory has more natural gas resources [1]. This oligopoly-like approach allows these resource-owning countries to manipulate the development and control of their resources. This puts resource-poor countries in a passive position to explore new sources of energy in order to cope with the economic crisis caused by climate change. Developing and developed countries also have different levels of dependence on different forms of energy. The industrial development of the industrialized world was made possible by coal and oil. Fast-developing nations are now traveling down the same road in an effort to achieve parity in living standards. Even less environmentally friendly energy sources, like charcoal, are still the only choice for the impoverished in the least developed nations [2].

The development of new energy sources is urgent for developed countries, and there is as much economic and commercial scope for the development and use of new energy sources as there is for fossil fuels, while at the same time being greener. With the introduction and development of globalization, wind power technology is no longer a technology specific to individual countries, but a global mode of energy production. Europe, China, and the United States have all matured in the use of this technology [3]. But as we enter the new 21st century, the demand for electricity is growing rapidly, and the scale of wind power generation is not able to meet the needs of mankind. However, through continuous technological innovation and awareness, the European countries have followed each other's example so that wind power generation has been recognized as a need. Because of its low cost and environmentally friendly way of use, wind power generation equipment is needed on a large scale and the resulting supply exceeds demand, the supply chain of the market is broken. The status quo of wind power is to fill the gap created by the increasing abandonment of the use of fossil energy sources. The location and form of wind turbines are constantly changing in line with

technological innovations. However, it is worth discussing whether wind power will become the most dominant form of new energy generation.

2. Application of Wind Power

Making the switch to greener energy sources is crucial as the globe struggles to combat climate change and cut greenhouse gas emissions. Wind power offers an environmentally friendly solution that harnesses the natural power of wind to generate electricity without emitting harmful pollutants or greenhouse gases.

2.1. Improvement of Wind Power

The process of generating electricity from wind power involves several key components. At the heart of wind power generation are wind turbines. These large structures, often resembling tall, slender propellers, are strategically placed in areas with consistent and sufficient wind flow [4]. The blades of the turbine revolve when the wind blows, transforming the kinetic energy of the wind into mechanical energy. The mechanical energy from the rotating blades is then transferred to a generator housed within the turbine. A coil of wire within the generator rotates in a magnetic field while producing an electric current via electromagnetic induction. The majority of power grids used throughout the world use this alternating current (AC).

However, before the electricity generated by wind turbines can be integrated into the power grid, it needs to undergo some transformations [5]. First, the voltage of the electricity is increased through a transformer to reduce transmission losses over long distances. Next, the electricity is sent through power lines and substations to distribute it to homes, businesses, and industries that require electrical energy for their daily operations. Wind power's capacity to fill the gap left by the abandonment of fossil energy sources lies in its inherent scalability. As technology advances and economies of scale improve, the efficiency and capacity of wind power installations continue to grow. Larger turbines with higher capacity factors allow for more electricity to be generated from each installation, making wind power an increasingly viable and competitive energy source.

2.2. Contribution in Life

Moreover, wind power's complementarity with other renewable energy sources, like solar power and hydroelectricity, enhances its contribution to meeting the energy demands of modern societies. Wind patterns often align with periods of high electricity consumption, such as during hot summer days when air conditioning usage peaks. By combining wind power with solar power, which thrives during sunny hours, and hydroelectric power, which provides stable baseload energy, energy systems can achieve a more balanced and reliable energy supply.

Additionally, the decentralized nature of wind power is an advantage in filling the energy gap. Small-scale wind turbines can be installed on individual properties, providing localized energy generation and reducing dependence on centralized fossil fuel power plants [6]. This decentralization also improves grid resilience and minimizes the vulnerability to large-scale power outages caused by natural disasters or cyber-attacks.

3. Operation and Development of Wind Turbines

Wind power, as a low-cost as well as environmentally friendly way of generating electricity, derives its low cost from the wind generated by nature. Wind is a naturally occurring phenomenon on earth, which is converted into a form of energy by the natural occurrence of differences in air pressure. Such a green format fits well with the UN's expectations for sustainable energy. Wind power generation is similar to ordinary forms of electricity generation in that there is energy to drive a generator to turn.

3.1. Basic Mechanics of Wind Power

The entire wind power generation is divided into three main segments. The first is the main and necessary requirement is enough wind to turn the blades. The so-called wind current will carry enough kinetic energy when it passes through the nature, and the change of the air current through the rise and fall of the air pressure in the nature will provide the prerequisite of kinetic energy. The second process is accomplished by the huge turbine blades and rotors. The blades, which have been specially designed in the shape of huge streamlines, can be pushed normally, provided that they are driven by kinetic energy. Wind turbine blades are a crucial part of the entire body, which connects the rotor to the shaft. The shape of the blades is usually of the aerodynamic type, and based on the larger design of wind turbines, their blades are also long and thin. Therefore, the blades are usually constructed of strong, tough, lightweight composites or carbon fiber to be propelled by the wind. The captured wind energy is converted into kinetic energy by the shaft to turn the rotor, which in turn transfers the kinetic energy to a gearbox that converts the rotor speed to a speed suitable for the generator's operation, thus generating electrical energy. The final part is the power generated then flows through towers tens of meters high. This is the principle by which wind turbines generate electricity through the wind, but the advantages of this over ordinary methods of generating electricity have not yet been fully realized. The objective is to lower the cost of electricity from wind power so that it is more competitive with other energy sources [7].

3.2. History Evolution of Wind Power

Wind power is something that needs to be continually improved, and the main way that wind power is generated is by windmills. Early windmills date back to the 1880s in Denmark, one of the most sophisticated countries in wind power technology. Limited by size and resource poverty, Denmark, at the southernmost tip of the Scandinavian countries, needs a way to get more energy. So, windmills were used to grind grain even before the Industrial Revolution. As history progressed, World War II, the Cold War and the Suez Crisis escalated the energy crisis. Modern wind power can be described as an invention under the pressure of environmental politics. Danish energy politics and environmental politics became closely entwined in the 1990s as a result of the country's need to reduce its reliance on imported energy. Svend Auken, who served as minister of energy and the environment from 1993 to 2001, started the 'green' political movement in the field of energy politics [8]. The Danish government established its own national power system. Vindeby Havmøllepark the first offshore wind farm in the world was built at that time. Utilizing the kinetic energy of offshore winds for more efficient power generation, relocating space from land to sea, and obtaining more efficient power generation while saving land space is the choice of many energy-poor countries. Anti-nuclear during the same period was also one of the factors that contributed to the wind power development. The Organization for Information about Nuclear Power (OIA) and the Organization for Renewable Energy (OVE), two anti-nuclear NGOs, worked together with several researchers [9]. Within the last three decades, the share of wind power generation in major countries around the world and the overall global share have been on the rise, as shown in fig.1. Denmark's share of wind power is still today the highest in the world, with 55.03% according to the ratios in Fig. 1. But China, with a territory 2000 times larger than Denmark's, has a wind power share of only 9.06%. But this is not a negative, the vast territory provides plenty of space for future development.

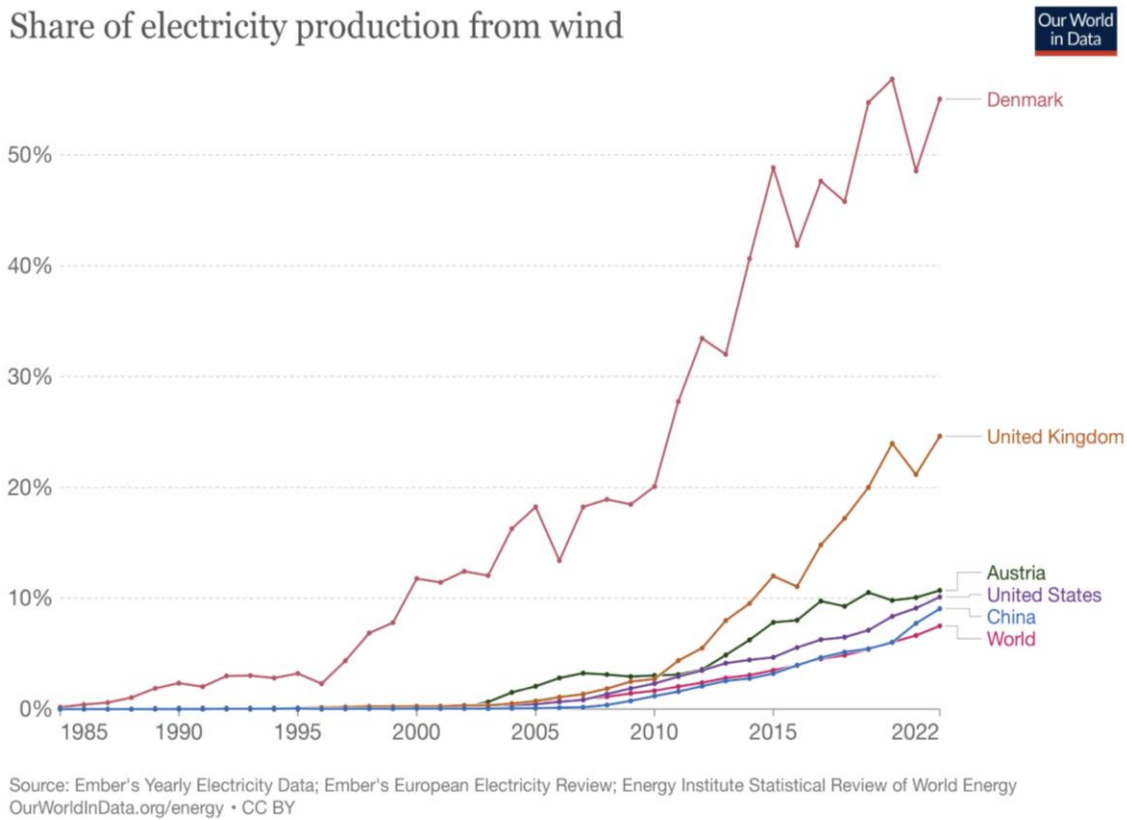


Figure 1. Share of wind power generation in Denmark, UK, Australia, US, China and the world as a whole from 1985 to 2022 [10]

4. Conclusion

Wind power has emerged as a transformative and indispensable contributor to the world of sustainable energy resources. Its benefits for mitigating climate change, reducing greenhouse gas emissions, and diversifying the energy mix cannot be overstated. By harnessing the natural force of wind to generate electricity, wind power offers a renewable and abundant source of energy that significantly decreases our dependence on fossil fuels. The rapid advancements in wind turbine technology and the growing investments in wind energy projects have led to substantial reductions in costs, making wind power increasingly competitive with conventional forms of energy. As a result, many countries around the globe are incorporating wind power into their energy strategies, fostering job creation, economic growth, and energy security in the process. However, it's important to acknowledge some challenges associated with wind power, such as intermittency and potential environmental impacts on wildlife and landscapes. These challenges can be mitigated through intelligent grid management, further technological innovation, and thoughtful site selection. In the broader context of sustainable development, wind power's trajectory is undoubtedly promising. It is obvious that wind power will continue to be a pillar of the sustainable energy landscape as we make the shift to cleaner energy sources. To maximize its benefits, policymakers, researchers, and industry leaders must collaborate to address its challenges, optimize its integration, and ensure that its growth aligns with long-term environmental and social objectives. By doing so, it secures a more sustainable and resilient energy future for generations to come.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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