

Fluid Mechanics Use in Renewable Energy and the Effect on Economy

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Abstract. Fluid mechanics is a core theoretical basis for renewable energy power generation systems, especially wind energy and water energy. By applying the Bernoulli effect and related fluid dynamic principles, engineers can optimize blade profiles, flow channel structures, turbulence control and operation stability, so as to improve power generation efficiency and reduce engineering and operation costs. Wind power generation has the advantages of low environmental impact and flexible layout, but its stability is limited by wind resources. Hydropower features high stability and controllability, but its construction may affect aquatic ecology. Fluid mechanics provides technical support for flow rate calculation, structural design and ecological protection. Reasonable application of fluid mechanics can promote the economy, stability and sustainability of renewable energy, reduce greenhouse gas emissions, lower reliance on fossil fuels, and boost industrial benefits and market investment confidence. This paper analyzes the mechanism, economic benefits, environmental impacts and engineering optimization paths of wind and hydropower from the perspective of fluid mechanics, and clarifies the key role of fluid mechanics in the development of new energy.

Keywords: Fluid mechanics, renewable energy, wind power, hydropower, bernoulli effect

1. Introduction

Fluid mechanics is a critical branch of mechanics that studies the laws of motion, equilibrium and interaction of fluids, and constitutes an indispensable theoretical support for renewable energy utilization systems. With the global promotion of low-carbon development and the increasing demand for electricity, wind energy and water energy have become the most widely used and rapidly developed renewable energy sources due to their cleanness [1], sustainability and rich reserves. The conversion efficiency, operation stability, engineering cost and ecological impact of wind and hydropower systems are all directly restricted by fluid dynamic characteristics. Therefore, the application of fluid mechanics theories such as the Bernoulli effect, turbulence calculation and flow control plays a decisive role in structural design, performance optimization and benefit improvement of power generation devices. This paper focuses on the application of fluid mechanics in wind power and hydropower systems, discusses the mechanism of energy conversion, economic profitability, environmental impacts and engineering optimization strategies, and reveals how fluid mechanics promotes the efficient, stable and low-cost development of renewable energy, so as to

provide theoretical and practical reference for related engineering design and investment decision-making.

2. New energy and fluid mechanics fundamentals

New energy helps reduce fossil fuel combustion and pollutant emissions, thereby improving environmental quality and alleviating ecological problems such as global warming and acid rain. Wind power generation drives generators through blade rotation driven by flowing air to convert wind energy into electric energy, which can effectively replace thermal power and reduce greenhouse gas emissions [2]. With the continuous growth of population and the expansion of industrial and commercial buildings, the global demand for electricity is rising rapidly. The efficient development of renewable energy has become an inevitable trend to meet power demand and achieve green development.

In fluid systems, the Bernoulli effect indicates that the pressure of a fluid decreases with the increase of flow velocity, and increases with the decrease of flow velocity. The pressure difference formed on both sides of the wind turbine blade pushes the blade to rotate, realizing energy conversion. Based on this principle, engineers optimize the airfoil structure and torsion angle of blades to enhance lift and improve power generation efficiency [3]. Stable airflow is conducive to stable output, while excessive turbulence will reduce efficiency and even damage equipment. Fluid mechanics provides a theoretical basis for calculating turbulence intensity and optimizing blade shape to weaken adverse effects and maintain stable operation.

Because wind turbines have a relatively small footprint and do not require the participation of more fossil fuels, the cost of power generation has been significantly reduced. Moreover, more industries will continue to manufacture wind turbines [4]. The development trend of this industry will become more stable, and the economy will also function accordingly. This will greatly promote the improvement of economic trade, and it will not interfere with the construction in other regions.

3. Hydropower generation and fluid mechanics application

Let's talk about water energy. Water energy is used for power generation through the use of water turbines. The water turbine is the core component of the hydroelectric power system. When water flows down from a higher place, it possesses significant potential energy and kinetic energy. These energies drive the rotation of the turbine blades, converting the water's energy into mechanical energy [5]. Subsequently, the water turbine drives the generator to operate, ultimately converting the mechanical energy into electrical energy. Additionally, there are guide vanes. The guide vanes can be opened or closed, opened wider, allowing more water to flow and rotate faster, and closed narrower, causing the water to rotate more slowly. The Bernoulli effect is also utilized here. By changing the shape of the flow channel, in cases where it is necessary, the water speed can be increased, allowing more electrical energy to be generated. Thus, the desired amount of power is obtained, and more electricity can be obtained in a short period of time. And although the amount of electricity increases.

However, the cost of its operation is relatively lower compared to wind energy. The factors to consider for wind energy include any location; without wind, there is no electricity. Water energy is basically controllable, while wind energy has many unstable factors [6]. Turbulence formation can cause the wind speed to become abnormal. However, water energy, when built on a dam, as long as the dam is not dry, it will not experience power shortage due to lack of energy, and thus will not fail to generate electricity. Therefore, it is more stable. If building a base station requires a lot of funds,

then wind energy is not the first choice because the instability of wind power generation is stronger than that of any other form. If a base station is built at a high cost, it may not be profitable because the wind speed cannot be artificially determined. Moreover, experts need to be invited to test the wind speed, which is also a considerable expense. Although the dam for water energy also requires certain testing, and the funds are not less than those for wind energy, the construction of the dam project is very large, and sometimes it may affect the natural environment. However, if it is built, it will no longer be a situation where it depends on nature for survival, and the waterway is controllable, which does not affect the production efficiency of electricity generation. If considered from a more commercial perspective, I think water energy is more stable and will give investors more peace of mind and stability, and the money will not be wasted. However, if considering the environmental aspect, I suggest favoring wind energy. Although water energy has stable power generation, it will affect the protection of habitats. For example, changing the environment of the river, the formation of the dam [7]. cannot be done without water left at a higher position for power generation, and this project requires blocking the river, which will cause the flow of animals in the forest to be blocked, the surrounding plants to stop growing due to the new changes, and may lead to severe damage to the ecological environment of fish [8].

This requires the application of fluid mechanics knowledge. The greater the water flow, the greater the impact force. If fish living in water do not control the water flow speed [9], it will cause them to be forced to move and even injure their bodies, resulting in them getting injured and contracting diseases. Handing this over to fluid mechanics experts can assure us of this. The flow speed of the dam can be calculated using the fluid mechanics flow rate formula, and then the biologist can estimate the probability of fish survival at what flow rate and adjust the operating speed of the turbine blades to reduce the injuries of the fish. As long as these two points are sufficient to support it, then the fish will not be affected, the fishing by the fishermen will not be affected, and the fishery ecology will be protected. Although building a turbine requires a lot of funds, once these reasons are considered and repaired, the turbine can operate at a low cost and be a natural resource, running for a long time. During this period, excluding maintenance, there is no need to worry about problems. As long as the turbine does not break, with such a speed of power generation, the profit of the power plant will gradually emerge. From this perspective, the instability of wind energy means that the investment is not as large as that of a dam. However, every day's wind speed or if there is no wind for several consecutive days, the equipment station needs to be repaired. This power generation method may cause certain economic cost losses. In contrast, the success rate of hydropower generation is higher. Although fluid mechanics can help adjust the blade structure to obtain more stable wind speeds, without wind, this would be a huge loss. Like solar energy, it is a gamble. And unlike water, wind varies in speed in different regions. But wind turbines cannot be arranged in several different places. If they are all in one place, if there is no wind for a whole day, then the wind turbine will not rotate. In the long run, it is not a loss either. Therefore, if wind turbines need to operate smoothly, they can be distributed across different places to control the existence of wind speed. With one more place, there will be more electricity supply. Thus, the loss on that day will not be too much. This wind power generation also requires cooperation and communication with meteorologists because wind speed needs to be predicted and observed through satellite conditions. The wind power plant needs to hold weekly meetings to discuss changes in wind speed and consider power generation efficiency. If a place always has low wind speed, the construction project there can be stopped and a new place can be considered for investigation. After on-site investigation, a decision can be made. In this way, the funds can be effectively controlled and there is no need to worry about power loss and instability.

4. Comparative analysis and engineering suggestions

Wind energy has environmental-friendly characteristics, but it is highly dependent and entirely depends on wind resources. Diversified layout and meteorological prediction can reduce risks and improve stability. Hydropower is stable and efficient, but its construction has a significant impact on the environment.

Fluid mechanics provides technical solutions for the performance optimization and ecological protection of these two energy sources [10].

Apart from wind energy and hydropower, fluid mechanics is also widely applied in marine energy systems such as tides, ocean currents, and waves, converting marine kinetic energy into electricity. Marine energy utilizes the kinetic energy generated by the movement of tides, ocean currents, and waves in seawater, converting it into electricity through fluid mechanics principles. This not only has environmental benefits but also saves financial costs [11]. Compared with other mechanical or fuel-based power generation methods, it can obtain the same amount of electricity with less investment. This enables funds to be allocated to more needed areas. For example, if there is an urgent need for funds in new drug research, then investment in the power generation sector can be reduced, and it can be redirected to the medical field. This is also a reasonable use of funds. By investing different amounts of funds in the development of the same power system, the environment can be improved and confidence in products can be enhanced. The quality of the manufactured products can reach a higher level, and their stability will also be higher. If the environment is protected, certain diseases will not reappear, and medical resources will not be wasted on other aspects but can be concentrated on treating cancer or incurable diseases [12].

5. Conclusion

The fundamental principles of fluid mechanics play a significant role in the application of new energy sources and help investors identify and solve difficulties. Once the difficulties are resolved, it can enhance the credibility of investors on a certain basis, facilitate the smooth development of the market economy, and increase product production. If the quality is improved, investors will be more persuasive in maintaining their investment projects, and the industrial chain will also gain profits. The supply of electricity will also bring profits to investors. After reaching an agreement, both parties will engage in long-term cooperation. Electricity is indispensable, and it is used in many places, such as factories, household lights, printers in business buildings, and various types of electronic products. If a certain profit is achieved, more investors will be attracted, the supply of electricity will be stabilized, and the same electricity charges will be collected, which is also a benefit from natural resources. This will improve the impact on the environment because excessive greenhouse gas emissions lead to glacier melting and global warming. The use of fossil fuels for power generation is gradually fading from human sight. This method not only protects the environment but also saves some unnecessary and non-essential expenses, such as the need for human or machine excavation of fossil fuels, which will eventually be exhausted, and the shortage of human resources. In today's society, there are more professional elites in the workplace, but a lack of labor force from workers. The cost of human resources will be very expensive. Moreover, machines need to be manufactured for excavation, which is very costly for enterprises. The existence of new energy sources is also a new trend, promoting economic growth and more frequent economic exchanges. Fluid mechanics has also laid a certain foundation for this, eliminating unnecessary factors from the beginning and achieving a higher success rate, giving investors

confidence and making market transactions more successful and active. The realization of both new energy sources cannot be separated from the knowledge of fluid mechanics.

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