

Research of Tidal Energy and Tidal Power Generation Technology

Zhang Xudong¹, Hui Ze²

^{1,2}Construction Bureau, University of Shanghai for Science and Technology, Shanghai, China

Corresponding Author: Hui Ze

Abstract

The new energy resources are an important means to support China to achieve the strategic goal of "carbon peaking and carbon neutralization". The research and development of tidal power generation is an indispensable part of new energy resources. In this paper, the current status of research work on tidal power is summarized. Also, the research and development situation of tidal power generation in China is introduced. It shows that the technical driving force behind the tidal power development in China is unsatisfactory and the policy support is insufficient. Thus, it is necessary to promote the international cooperation to achieve technical breakthroughs. And the government should provide more favorable policy environment. With the progress of science and technology, tidal power generation will develop rapidly.

Keywords: *The new energy resources; tidal power; tidal power generation*

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I. INTRODUCTION

In the global energy structure, fossil energy occupies the absolute mainstream. Before the industrial revolution, the main source of energy for human beings was natural wood. In 1840, coal accounted for more than 5% of the world's energy consumption for the first time, and this proportion reached 50% in 1900. Later, oil and natural gas were gradually widely used and became the mainstream fossil energy like coal. Over the past three decades, global energy consumption has basically maintained a trend of increasing year by year, but the proportion of fossil energy in human energy structure has remained basically stable. At present, fossil energy accounts for about 85% of global energy consumption; hydropower accounts for about 7% of energy consumption; nuclear energy ranks third, accounting for about 4.5%; solar energy, wind energy, tidal energy, geothermal energy, modern bio Matter, energy, etc. add up to about 3.5%. We must be soberly aware that the new energy that has attracted much attention is pitifully small in the global energy structure, and there is still a long way to go before becoming a "mainstream energy". As the pollution on a global scale becomes more and more serious, the disadvantages of traditional energy sources become more and more prominent. Finding alternative energy sources has become an important theme for the future of human development.

The earth we live on is a planet with blue oceans. The ocean is an important future for human development. The energy provided by the ocean is an important option for our future energy. Among them, the energy carried by ocean tides is a sustainable and environmentally friendly endless energy. Therefore, from the perspectives of new energy, alternative energy and the future of human development, we should attach great importance to the development and application of tidal energy. Most of the energy used in China's power generation is non-renewable fossil energy. With the introduction of the concept of carbon neutrality, seeking renewable and clean energy to reduce dependence on fossil fuels has become one of the hot topics in China, while green and high-quality tidal energy has attracted worldwide attention. China is rich in tidal energy resources, the theoretical reserve is about 1.1×10^8 kW, and the exploitable one is about 0.2179×10^8 kW [1]. At present, tidal energy is mainly used for power generation, which converts the energy of the regular fluctuations in seawater into electrical energy. The construction of tidal power stations and the development and utilization of tidal energy are undoubtedly a solution to alleviate environmental problems.

II. THE PRINCIPLE OF TIDAL POWER GENERATION

Under the gravitational force of the moon and the sun, the seawater will rise and fall periodically, which is the tide phenomenon. Tidal energy refers to the potential energy and kinetic energy of tidal fluctuations. It is an inexhaustible renewable energy with huge reserves. The main use of tidal energy is power generation. The principle of tidal power generation is similar to that of hydropower. Generally, a dam with a gap is built to separate the estuary or bay near the sea from the open sea to form a natural reservoir. When the tide rises, the water level in the reservoir is lower than the seawater level, and a large amount of seawater will enter

the reservoir through the gap. The kinetic energy and potential energy in the seawater can be converted into the mechanical energy of the water turbine, which drives the water turbine to rotate and the generator set to generate electricity; When the tide ebbs, the water level in the reservoir will be higher than the seawater level, and when the seawater is injected into the sea from the reservoir, it will drive the turbine to rotate in the opposite direction [2]. Therefore, the fluctuation of seawater makes the generator set generate electricity continuously, and there is a certain difference between tidal power generation and hydropower generation, mainly because the water level difference in hydropower generation is relatively large, while the water level difference in tidal power generation is small, so the water turbine in tidal power station The group is a unit suitable for small water level difference and large flow.

2.1 Advantages of tidal power generation

Tidal energy is a clean and renewable energy. The tide rises and falls every day, and the energy is continuous. This characteristic makes it inexhaustible and inexhaustible. Using tidal energy to generate electricity can not only make up for the problem of energy shortage, but also can develop into an important supplementary energy source for people's production and life in coastal areas and national defense construction. Since tidal power stations are generally built in places with low population density by the sea, there are no complex problems such as submerged farmland and population migration, and they can vigorously develop enterprises such as marine chemical industry and aquaculture, which will effectively alleviate the problems of more people and less land and scarce farmland by the sea. problems and promote local economic development. Tidal power stations do not need to build high dams, and the water level in the reservoir will not be too high. Therefore, even if disasters such as earthquakes cause the dam to be damaged, it will not cause serious disasters to the downstream cities and the safety of people's lives and properties.

Tidal energy is a relatively stable and reliable energy source, which is rarely affected by natural factors such as climate and hydrology. Due to the existence of tidal phenomena, seawater fluctuates periodically. Compared with ordinary hydropower, there are no wet or dry seasons, so the energy supply is relatively stable. The use of tidal energy for power generation does not require other fuel and transportation costs. It is an economical energy source, but compared with traditional thermal power plants, the construction investment is large. Therefore, tidal energy power generation is the same as river hydropower stations, with large primary investment and low power generation costs. specialty. In the long run, tidal power generation has good social and economic benefits, and can effectively reduce dependence on conventional energy.

2.2 Disadvantages of tidal power generation

The tidal range and water head of seawater often change within a day, and the tidal range can even differ by 2 times within a month. Therefore, in the absence of special adjustment measures, the time to ensure output is short, the annual utilization hours of the installed capacity are low, and the power generated by the generator set is unstable and the power quality is poor.

Tidal power stations are generally built in harbors and seaports. Compared with ordinary hydropower stations, the water depth dam is longer, the construction is more difficult, and the foundation treatment and anti-silting problems are more difficult to solve. Therefore, the construction cost is higher and the investment is larger. Since the tidal power station is a form of power generation with low water head and large flow, it needs to use larger turbines, consume a lot of steel, and have complex structures. Moreover, due to long-term immersion in seawater, it is necessary to pay attention to the corrosion hazards of seawater to these buildings.

III. RESEARCH STATUS OF TIDAL ENERGY AT HOME AND ABROAD

3.1 Current status of foreign research

EI in the United States, there are more than 9,620 documents with the title or keyword of " tidal energy ", which lasted from 1969 to 2023, and new documents were included every year. There were only 7 documents included in 1969, such as Charlie et al. [3-4], Charlie's article directly discussed the application and development of tidal energy. Since 1970, the number of documents included has increased year by year, especially since the beginning of this century, more than 200 articles are included every year, and nearly 400 articles in some years. As recently as 2022, Auguste Christelle et al. published an article in "Renewable Energy " [5], which studied the simulation of the impact of tidal energy converters on the dynamics of sediment in the Tasmanian Strait. It can be seen that the research on tidal energy abroad has lasted for more than half a century, and an atmosphere of tidal energy research has been formed.

From the perspective of specific practice, the UK is currently a relatively advanced country in tidal energy technology research. Countries rich in marine resources such as the United States, France, Norway, and Ireland have a relatively high level of tidal energy utilization technology. Its academic research is also relatively complete, and the research angles are different. Most of them focus on the professional technology of tidal energy development, the significance of tidal energy development to the environment, and the safety of tidal

energy development. For example, Rourke FO et al [6]. It is believed that in order to improve the application and development of tidal energy, the key is to improve and improve tidal turbine technology, but this technology has not matured; at the same time, due to the influence of installation, maintenance, power transmission, load conditions and environment, the tidal turbine R & D and application are also very slow. Some scholars also start with the feasibility analysis of tidal energy development and analyze the advantages and disadvantages of tidal energy power generation. For example, Denny E [7] compared the cost of coal power generation and tidal power generation from an economic point of view, and believed that tidal power generation is uneconomical. Musial W [8] looked at it from the perspective of clean energy, and believed that marine energy resources are global, and no single energy source can independently achieve energy conservation and emission reduction. Clean energy should be developed at the same time in order to achieve future emission reduction goals.

When specifically discussing the development and application of tidal energy in different countries, scholars from some countries conducted multi-angle discussions. For example, when Grabbe M [9] and others discussed the development and application of tidal energy in Norway, they believed that tidal power generation in Norway is superior in geographical location and ocean conditions. In the future, Norway may become a major exporter of electricity; The bays and islands make the tidal energy flow in Norway huge; due to the geographical lag of tides and tidal phases, the intermittent nature of tidal energy itself is also alleviated, which is conducive to the reasonable distribution of tidal energy load time. Haas KA [10] believes that the United States has extensive potential for tidal energy development, and a US tidal current energy database and tidal energy geographic information system tool should be constructed to promote the research and development of tidal energy conversion technology.

To sum up, it can be seen that the research on tidal energy in foreign countries has a long duration, covers a wide range of fields, and the technology is relatively mature.

3.2 Domestic Research Status

My country's research on tidal power generation is mainly concentrated in the eastern coastal provinces of Fujian, Zhejiang, Jiangsu, Shanghai, and Shandong. Basically, there are few researches on the tidal energy in the Bohai Rim region in terms of technology development, development prospects, resource utilization, etc. of tidal energy. Rong Xiaohong [11] believes that through the analysis of China's energy status, although tidal power generation has certain shortcomings, it will be one of the most potential power generation methods in the future; one of the factors restricting tidal power in China is the cost of power generation. question. Zhang Fahua [12] believes that the main impact on tidal power generation in China is the cost of electricity prices, and the purpose of reducing power generation costs can be achieved through comprehensive development, mainly including the development of transportation, breeding, and tourism in the surrounding area. Zhang Yong et al [13] believed that China's tidal energy development potential is huge, but the development speed is relatively slow, and that the development of China's tidal energy should be accelerated from a policy perspective. Shi Hongyuan et al [14] believed that the feasibility of tidal energy development was discussed from the aspects of China's geographical advantages, resource advantages, and technological advantages. Liu Yefeng et al. [15] studied the technology of using tidal energy instead of electric-driven water pumps to generate electricity, and then using solar energy and tidal energy for distillation, which greatly reduced the cost of the system, mainly for tidal energy power generation. Wang Yong et al [16] studied the influence of incoming flow velocity on the working efficiency of tidal energy power generation blades, and determined the incoming flow velocity suitable for the power generation equipment through a series of studies. Through simulation, the optimal flow rate was determined.

Generally speaking, although domestic and foreign tidal energy research angles are different and technology breakthroughs have been made, there is still a big gap between my country and foreign countries, especially in the research of tidal energy power generation technology, which is still in its infancy.

IV. BOTTLENECKS IN THE DEVELOPMENT OF TIDAL POWER GENERATION IN CHINA

At present, the development of my country's tidal power plants is still in its infancy. Although my country is advocating the use of new energy for power generation, overall, my country's tidal power generation technologies, policies, and motivations are insufficient. The construction of tidal power stations in my country is a long-term task that cannot be accomplished overnight.

(1) Geographical location is limited. Most tidal energy power stations use dam-building power stations, which have high and strict requirements for the site selection of power stations. There are not many stations in coastal areas that can build power stations. In provinces or regions rich in tidal energy such as the Bohai Sea, there are not many sites that are truly suitable for the construction of tidal power stations, which objectively limits the construction of tidal power stations in China.

(2) The technology development is immature. For tidal power generation technology, whether it is dam-building power generation technology or tidal energy flow power generation technology, China is not

mature enough. Compared with some European countries, there is a big gap in some core technologies and advanced equipment, which leads to The construction and operation costs of power stations are very high, which seriously restricts the further development of tidal power generation technology in China.

(3) The cost of power generation is relatively high. The cost of tidal power generation is higher than that of coal and oil power generation. For example, the Jiangxia tidal power station not only has a high initial construction cost, but also during operation, due to the discontinuity and volatility of tidal power generation, the utilization rate of the generating units is not high, and the output power varies greatly. These two aspects have resulted in the cost of tidal power generation being higher than that of thermal power generation. In addition, tidal power generation equipment is soaked in seawater for a long time, causing some aquatic organisms to adhere to the surface, or rust caused by soaking, which needs to be cleaned every few years. The work is more complicated, troublesome, and requires manpower and material resources. More financial resources, which also lead to increased cost of power generation.

(4) Destroying the ecological environment and affecting the hydrodynamics of the bay. The long-term construction of hydropower stations on the coast has destroyed its original marine ecosystem, making it impossible for marine life along the coast to survive. In severe cases, it will cause instability of the marine ecosystem and change the original flow of seawater. Every country currently has such problems. The development planning and demonstration of power stations in countries such as the United Kingdom, France, and Canada have lasted for decades.

(5) The raw materials of the subsea equipment are poor. Mechanical equipment that has been operating underwater for a long time has been corroded by seawater for a long time, and will rust and adhere to marine organisms on the surface. It must be cleaned regularly, which will increase operating costs. It is understood that in the late 1950s, China built more than 40 small tidal power stations or power stations along the southeast coast. Due to the lack of scientific research and formal survey and design, improper site selection, poor equipment, seawater corrosion and other problems, most power stations were abandoned after a period of operation [17].

(6) The support from the government is not strong. Due to the relatively large occupied area and reclamation area of the construction of tidal power stations, if it conflicts with other construction projects such as ports and docks, the government will choose to build other projects, mainly because the income of tidal power stations is lower than other projects.

V. A BREAKTHROUGH TO PROMOTE THE CONSTRUCTION OF TIDAL POWER GENERATION IN CHINA

To further promote the economic benefits, ecological benefits and social benefits of tidal power generation in my country, we need to make breakthroughs in the following aspects.

(1) Technical aspect. Promote domestic and foreign cooperation and achieve technological breakthroughs. Although the development technology of China's tidal power station has been developed, it is quite different from the core development technology of foreign countries. China must first vigorously develop the development technology of tidal power station. At present, most of our country adopts dam-building, single-double storage and other forms. These forms not only have certain adverse effects on the ecological environment, but also use these forms to generate electricity. The cost is relatively high. However, the development and operation technologies of tidal power stations in the United States, the United Kingdom, Norway and other countries are mature and complete, and they have initially achieved a double harvest of ecological and economic benefits. Britain is currently the most advanced country in tidal power generation technology in the world. According to reports, in 2014, the UK built the world's largest lagoon tidal power station in Swansea Bay, with an annual power generation capacity of 420 kWh and a design service life of 120 years [18]. This can not only solve the problem of electricity consumption in the UK, but also develop sailing and other sports, tourism, leisure and entertainment projects, achieving a win-win situation of economic, ecological and social benefits. my country needs to vigorously promote international cooperation, carry out multi-faceted cooperation with European countries, the United States and other countries, fully learn from and absorb their advanced experience and advanced technology, and apply them to the construction and operation of tidal power generation in our country. Fortunately, in early June 2015, a company in our country became the first Chinese company to build a British tidal power station. It is also the UK's first infrastructure development project that draws in part on the expertise of a Chinese company. This provides an opportunity for the two countries to carry out project cooperation in the future, and for China to achieve breakthroughs in tidal power generation technology [19]. In terms of professional technology, it is necessary to make breakthroughs in some key technologies and core technologies. For example, to invent or update anti-corrosion underwater tidal power station raw materials, use some raw materials or anti-corrosion films that are compatible with marine plants or marine organisms, which can not only save regular cleaning work, but also save manpower and material resources. Reduce the cost of power generation, but also reduce the impact on marine life.

(2) Policies. The government should formulate special support policies to further optimize the policy environment. my country has used tidal energy to generate electricity for a long time, but the national policy support is not strong, and there is a big gap compared with the support of western countries, resulting in high cost of tidal energy power generation in my country, and low economic and social benefits. Therefore, for the construction and operation of tidal power stations in China, the government should provide corresponding support and preferential policies before, during and after project development. Before the development of the project, priority policies are mainly given on the site selection, feasibility, technical operation, and introduction of hardware facilities for tidal power stations. A dedicated team of experts will be assigned to conduct on-the-spot investigation and measurement of the site selection, and provide necessary technical guidance. For the introduction of hardware facilities and the introduction of foreign experience and technology, the state needs to provide some economic subsidies or tax exemption policies. The country should introduce some protective policies, and provide necessary priority guarantee for the construction of tidal power stations in some places suitable for the construction of tidal power stations [20]. In terms of electricity fee management, the state needs to give some preferential subsidies to the application of tidal energy power, so that the electricity price of tidal energy power generation is consistent with the electricity price of other forms of power generation. In short, the construction prospects of my country's tidal energy power stations are very good, but in terms of national conditions, there are still many problems to be overcome, and breakthroughs in theoretical research and technical patents are still needed. Through further policy advancement, further technical and theoretical research, and improvement of the efficiency and scale of tidal power generation in the eastern coastal areas, it will form a tidal industrial industry in the eastern coastal areas and carry out cluster development, so that the eastern coastal areas will be Nationwide produces a wide-ranging benefit.

VI. EPILOGUE

With the development of China's economy, insufficient power supply has become an important factor restricting the development of China's national economy. In some coastal areas, there are few fossil energy reserves and large energy demand. Therefore, China should vigorously develop tidal power generation with the characteristics of renewable, clean, and huge reserves, so as to reduce dependence on fossil energy and effectively alleviate environmental pollution problems. At present, due to the competition of cheap electricity charges from conventional power stations, although there are not many tidal power stations that have reached commercialization, under the background of building a powerful ocean country, increasing investment in science and technology and accelerating technological development will eventually lead to widespread application of tidal power generation. In short, tidal power generation has a brighter prospect.

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