Current status and development prospects of tidal energy utilization in China

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Abstract: With the increasingly serious environmental pollution and energy shortage in China, it is of great significance to develop clean and renewable energy such as tidal energy. This paper analyzes and introduces the principle and form of tidal power generation, and summarizes the current situation and future development prospects of tidal energy utilization in China.

1. Introduction

China has a vast coastline, and its tidal energy resources are very rich. The development and utilization of tidal energy resources is of great significance for improving and increasing energy supply, reducing environmental pollution, protecting ecosystems, and promoting sustainable economic development. It is an important choice for China's energy strategy in the 21st century. At the same time, China has entered the ranks of the world's largest energy producing and consuming countries. With the continuous economic growth and the continuous development of society, China's energy demand will continue to rise. To extraordinary effects.

Under the background of strong domestic policy support and the rapid development of foreign tidal energy utilization technologies, understanding the current status and future prospects of tidal development in China is a very necessary link to promote the research and development of tidal energy in China.

This article summarizes and evaluates the principle and form of tidal energy resources utilization, the current status of domestic development, and future development prospects. Finally, it summarizes and points out the significance of tidal energy utilization.

2. Overview of Tidal Energy

Tidal energy refers to the mechanical energy produced by seawater during its ebb and flow. Tidal energy intensity is related to the number and range of tide heads. In general, the tide with output value needs to have a head drop of more than 3m [1].

2.1 Principles of Tidal Power Generation

The use of tidal energy is mainly tidal power generation, and tidal power generation can be divided into two types: one is to use the kinetic energy of the tide to impact the rotation of the turbine when the tide rises and falls; Potential energy is used to generate electricity, that is, the water level height difference formed when the tide rises and falls to generate electricity. Using the first form to generate electricity is difficult and inefficient. Therefore, in tidal power generation, the second form is often used [2,3], that is, using tidal potential energy to generate electricity.

As a renewable resource, tidal energy has the characteristics of abundant reserves, low operating costs, and environmental protection without pollution. For countries and regions with large tidal energy reserves, investing in tidal power stations is also an effective solution to reduce energy scarcity and environmental pollution.

2.2 Types of tidal power stations

The tidal power station can be divided into three types according to the arrangement form: single-storage unidirectional, single-storage bidirectional and dual-storage unidirectional.

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(1) Single library and one-way type. At high tide, the gate of the reservoir is opened to allow the seawater to enter the reservoir for filling. At low tide, when the bay and the water inventory are at a certain water level difference, the gate is opened to allow the seawater to drain to the bay through the turbine motor.

(2) Single library bidirectional type. This type of tidal power station has two design schemes. One is to use a two-way hydro turbine unit with a forward and reverse generator; the second is to still use a one-way generator set, which uses two sets of one-way valves to independently control the rising and falling tides. 2 diversion pipes. At high and low tides, seawater can flow into and out of the turbine unit from the same direction to generate electricity.

(3) Double-bank one-way type. Construct two hydraulically connected reservoirs, one for high tide, one for high tide, and one for low tide. Install a hydro-generator between the two reservoirs to achieve continuous tidal power generation. At high tide, the high reservoir enters the water; at low tide, the low reservoir discharges water. Utilizing the water level difference between the two reservoirs, the water flow continuously flows from the high reservoir to the low reservoir, which makes the hydro-generator unit continuously rotate in one direction to generate electricity [4].

The advantages and disadvantages of the three types of tidal power stations are shown in Table 1 [5].

Table1 Comparison of different types of tidal power stations

Tidal power station type	Principles	Advantages	Disadvantages
Single library unidirectional	Generate water level difference by rising and falling tide	Simple principle and equipment, low investment	Low energy utilization and intermittent power generation
Single library bidirectional	Construction of two water diversion pipes for high tide and low tide, which are controlled independently	Increased power generation efficiency, power generation and power generation time	High requirements for site selection and equipment, complex structure and large investment
Double library unidirectional	Two reservoirs with high and low water levels, using the water level difference formed between the two reservoirs to continuously generate electricity	Achieve continuous power generation	High requirements for site selection, high investment cost, low working head and poor economy, and less practical applications

3. Current status of tidal energy utilization in China

China is a country with abundant tidal energy resources. According to data released by the Planning and Design Institute of the Ministry of Water Resources and Electric Power in December 1982, the theoretical reserves of tidal energy resources in China are 190 million kW [2,4] About 15%, the annual power generation available for development exceeds 80 billion kW / h.

The modern development of tidal power generation in China began in the late 1950s and has a history of nearly 60 years. According to its progress, it can be roughly divided into three periods in the late 1950s, 1970s, and 1980s to the present [6]:

The first stage: China's coastal provinces and cities first developed tidal energy resources in 1958. A number of smaller tidal power stations have been constructed in Shanghai, Shandong, Liaoning, Jiangsu, Fujian, and Guangdong. The statistics of the first large-scale tidal energy census in 1958 showed that at that time, 41 tidal power stations were built nationwide. These power stations were small in scale. The installed capacity of a single power station was mostly tens of kilowatts, and the total installed capacity was only 583kW. . Due to poor economic efficiency and other reasons, these power stations were quickly abandoned [7].

The second stage: In the early 1970s, the tide of constructing tidal power stations reappeared. In the past 10 years, a total of more than a dozen tidal power stations have been built. Jiangxia Tidal Power Station and Baishakou Tidal Power Station are the two largest power stations. Tidal power stations that still exist today are concentrated in this period or started construction. The completion of Jiangxia Tidal Power Station is the main result of this stage.

The third stage: After the 1980s, the construction and improvement of the tidal power stations that have been built have been started. At the same time, the tidal energy resources survey and the site selection of large-scale tidal power stations have been carried out. The second large-scale survey of tidal energy resources was from 1980 to 1983. In September 1991, among the tidal power station sites obtained by the second census, several key sites with good installed capacity in the megawatt class were designed and planned, and a lot of scientific research and technical work and large-scale tides were carried out. Design of power stations [7,8]. The third large-scale tidal energy survey was conducted in 1986. The fourth large-scale census is an important part of the 908 special task that has been implemented since 2004. During the census, the proposed dam site was explored on site, and the feasibility of constructing the power station was analyzed [9]. The research results show that there are a total of 171 dam sites with technology development capacity greater than 500 kW in China [10]. The total development capacity is approximately the annual development capacity (Table 2). The distribution of tidal energy resources in Zhejiang and Fujian provinces. The most numerous, the two provinces 'total developable installed capacity is 90.5% of the national developable capacity; the two provinces' total developable annual power generation is 90.7% of the national developable capacity.

Table2 China's tidal energy development site capacity table above 500kW

City	Number	Installed capacity /10^4kW	Proportion of the country%	Annual generation capacity/10^8kW · h	Proportion of the country/%
liaoning	24	52.63	2.3	14.48	2.3
Hebei	1	0.09	0.0038	0.02	0.0027
Shandong	13	17.99	0.79	3.60	0.58
Shanghai	1	70.91	3.1	19.50	3.1
Zhejiang	19	856.85	37.5	235.60	37.6
Fujian	64	1210.46	53	332.87	53.13
Guangdong	23	35.26	1.55	9.70	1.55
Guangxi	16	35.15	1.54	9.66	1.54
Hainan	10	3.57	0.16	0.98	0.16
All the country	171	2282.91	100.00	626.41	100.00

As the country with the most tidal power stations, China has built dozens of tidal power stations since 1958, mainly in the eastern coastal areas, such as Shandong, Fujian, Jiangsu, and Zhejiang provinces. Among them, Fujian Province and Zhejiang Province have the most construction, with 88 in Fujian and 73 in Zhejiang [11]. There are a total of 8 tidal power stations that are still in use so far (Table 3), with a total installed capacity of 6000 kW and power generation [12]

Table3 Main tidal power stations in china

Station name	Year of completion	Installed capacity / kW	Design head / m	Tidal difference / m	Units	Operation mode
Jiangxia, Zhejiang	1980	3200	3.0	5.1	5	Single library bidirectional
Shandong Baishakou	1978	960	1.2	2.4	6	Unidirectional power generation
Fujian Happy Ocean	1989	1280	3.02	4.5	4	Unidirectional power generation
Yuepu, Zhejiang	1971	1500	3.5	3.6	4	Unidirectional power generation
Haishan, Zhejiang	1975	150	3.39	4.9	2	Double library unidirectional
Shashan, Zhejiang	1961	40	—	5.1	—	Unidirectional power generation
Liuhe, Jiangsu	1976	150	1.25	2.1	2	Two-way power generation
Guangxi Guozishan	1977	40	2.0	2.5	1	Unidirectional power generation

Among the 8 tidal power stations still in use, Zhejiang has 3 and has the largest tidal energy power station in China-Zhejiang Jiangxia Tidal Power Station [11]. It has a total of 6 two-way cross-flow units and total installed capacity. With a capacity of 3,200 kW and an annual power generation

of 6 million kW · h, the scale is the third largest in the world, second only to the first-scale French Lance Tidal Power Station and the second-largest Canadian Finlay Bay Annapolis Tidal Power Station [2,16].

4. Development and utilization prospects of tidal energy in China

There are many harbors and islands along the coast of China. The continental coastline with a length of 16134.9km and the island coastline with a length of 11673.9km has a long and winding coastline and contains very rich tidal energy, at least 190 million kW. Among the reserves of tidal energy, the Yellow Sea accounts for 55 million kW, the Bohai Sea accounts for 30 million kW, the South China Sea accounts for 40 million kW, and the East China Sea accounts for 74 million kW. The tidal energy of the Qiantang River is above 7 million kW, and the Qiantang River tide with a tidal head height difference of up to 8.9m is theoretically equal to 50% of the Sanmenxia Hydropower Station [2].

It should be pointed out that the statistical results of the four tidal energy resource censuses in China are relatively conservative data collected under the technological conditions that were not advanced at the time, and in the statistical process of the previous census, the shallow sea and the The tidal energy resources of the coastal and tidal flats are included [6], so the actual amount of tidal energy resources in China is bound to be greater than these estimates, which also means that China's tidal energy resources may be far more than we imagine.

At present, the tidal power station has the development technical conditions and economic foundation that can be widely put into use. With the rapid development and continuous improvement of new science and technology, tidal energy has a very broad application prospect. In the future trend of energy utilization, tidal energy will inevitably occupy a place. Although the tidal power station has good construction prospects in China, as far as China's current stage is concerned, the development of the tidal power station has just begun to take off. [13] In the process of growth, there are still many problems that need to be solved and theoretical research is still needed , Innovation and breakthroughs in development technology and many other levels. The construction of a tidal power station has a long way to go, and it will not be an overnight success. China should further support and promote the construction of tidal power stations in terms of policies, further research and development of technological and theoretical results, while further improving the efficiency and scale of tidal power generation, reducing production costs, and promoting the construction of a complete tidal power industrialization system in China. And the development of integrated clustering in areas rich in tidal energy resources will radiate its benefits nationwide, which will inevitably have a huge impact on China's future energy industry.

5. Conclusion

As a developing country with very large energy production and consumption, China is currently in a state of severe pollution and insufficient energy resources. The sustainability and diversification of energy resources is a general trend. Promoting the development and application of renewable energy sources and the development of new energy sources are on the horizon. With the continuous economic growth and continuous social development, China's energy demand will continue to rise. The development and utilization of tidal energy can play an extraordinary role in alleviating energy scarcity and reducing environmental pollution. . China should vigorously promote the process of the tidal power generation industry, accelerate the development and innovation of technology, and make advance preparations for the future energy transition.

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