

# Analysis of the Development of Ocean Energy Industry in China

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**Abstract:** The global ocean energy resource is abundant. The ocean energy is a kind of emerging renewable energy. Climate change is the focus for international society. For the independence and the safety of energy, many countries take renewable energy into consideration. The emerging ocean energy industry is an important choice for marine economy recovery. The ocean energy resource is rich in China. Fostering ocean energy industry in China is very important for implementation of Carbon Peak and Carbon Neutral strategy, diversifying the energy structure and developing marine economy. In the critical period of ocean energy industrialization in China, it's necessary to summarize the status of ocean energy technology and industry and to analyze the developing trend and application scenarios.

**Keywords:** ocean energy; technology; industry; trend; application scenarios.

## 1. Introduction

Ocean energy refers to renewable natural energy that is attached to the seawater, mainly including tidal current energy, wave energy, tidal energy, temperature difference energy, and salinity gradient energy. Ocean energy in a broad sense also includes offshore wind energy, offshore solar energy, and underwater geothermal energy, also known as offshore energy in Europe. The forms of ocean energy development and utilization include direct power generation, seawater desalination, and seawater cooling source application. This paper mainly studies the development and utilization of tidal current energy, wave energy, tidal energy, temperature difference energy, and salinity gradient energy.

## 2. The Significance of Ocean Energy Development and Utilization

The ocean occupies 71% of the Earth's surface and, as a treasure trove of resources, is the largest area on Earth that has not yet been fully developed and utilized. The global ocean energy resources are abundant. According to the "World Energy Assessment-Energy Resources" released by the United Nations in 2010, the global potential for the development of ocean energy resources is estimated to be as high as 235 billion kW[1]. The development and utilization of ocean energy has significant potential role in reducing carbon emissions. In recent years, with frequent international and regional conflicts, energy independence and energy security have been highly valued by many countries. The United States, the United Kingdom, the European Union, and others attach great importance to the development and utilization of ocean energy. They have released ambitious medium- and long-term goals for the development of ocean energy, aiming to build it into the next offshore wind power industry.

The development potential of China's ocean energy is enormous. China attaches great importance to the development and utilization of ocean energy. The 14th Five Year Plan for National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through the Year 2035 have made a strategic deployment to "promote the large-scale utilization of ocean energy". The report of the 20th National Congress of the Communist Party of China pointed out that "we need actively and steadily promote carbon peak and carbon neutrality, deepen the energy revolution, and accelerate the planning and construction of a new energy system", guiding the direction for the development of China's ocean energy industry.

### **3. Analysis of the Development of International Ocean Energy Industry**

From an international perspective, addressing climate change has become a hot topic of concern for the international community. Frequent regional conflicts have triggered multiple countries to re-examine energy independence and security, highlighting the pressure on regional economic recovery. The ocean energy industry has ushered in important development opportunities.

#### **3.1 The United Kingdom and the United States Strengthen Target Guidance and Seize the First-mover Advantage in the International Ocean Energy Market**

From a global perspective, a study by the International Renewable Energy Agency (IRENA) in 2020 predicted that the total installed capacity of global ocean energy will exceed 10 million kW by 2030, which means that the global ocean energy market will exceed 300 billion yuan by 2030[2]. To seize the first-mover advantage in the 100-billion-level international ocean energy market, countries such as the United Kingdom and the United States continue to increase their research and development investment and policy support in the generally immature ocean energy technology, so as to accelerate the industrialization process of ocean energy.

Countries such as the United Kingdom and the United States have abundant ocean energy resources. Taking the United States as an example, the 2021 Opportunities for Ocean Energy Development and Utilization in the United States released by the US Department of Energy shows that the exploitable amount of ocean energy resources in the entire US waters can reach up to 6,400 TWh/year, which can meet 1.6 times the electricity demand of the United States in 2019[3]. To develop and utilize this enormous potential ocean energy resources, the United States has set medium- and long-term goals for ocean energy development, that is, achieving an installed capacity of 500MW by 2030 and 1 GW by 2035[4]. To accelerate the low-cost and large-scale development of ocean energy technology, the United States has repeatedly amended relevant laws in recent years. The annual investment in ocean energy research, development and demonstration funds has been internationally leading for many years.

The European Union proposed the Offshore Renewable Energy Strategy in 2020, setting the goal of achieving an installed capacity of over 1 GW of ocean energy by 2030 and over 40 GW by 2050[5], and committed to making ocean energy the next offshore wind power industry. For this purpose, the EU continues to maintain its investment in research, development and demonstration funds for ocean renewable energy, investing over 800 million euros of public funds in the past decade and financing nearly 3 billion euros of private funds into the development and utilization of ocean energy.

#### **3.2 Strengthening Public Funding Investment and Policy Guidance to Accelerate the Industrialization Process of Ocean Energy Technology**

To accelerate the industrialization of ocean energy technology and make it a practical option for coastal countries to adjust their energy structure, countries such as the United Kingdom and the United States have widely adopted measures such as strengthening financial investment, formulating incentive policies, and consolidating the foundation of public services.

In 2019, the United States amended the Energy Independence and Security Act (2007), establishing a coordination mechanism led by the Department of Energy, the Department of the Interior, the Department of Commerce, and the Federal Energy Management Commission, raising the annual budget limit for ocean energy for the Department of Energy's Water Power Technologies Office to 160 million US dollars, and proposing a new National Ocean Energy Center to support the expansion of research and testing activities at the existing National Ocean Energy Center. In 2021, the United States Congress passed the Infrastructure Investment and Employment Act, agreeing to provide an additional 110 million US dollars in the WPTO's annual budget to support the construction of ocean energy infrastructure. From the perspective of financial support, WPTO's support for ocean energy technology research, development and demonstration has been increasing

year by year. Starting from 2020, the annual fiscal budget has increased to over 100 million US dollars. From the project participants, it can be seen that nearly 40% of the funds was allocated to enterprises, 36% was allocated to institutions such as the National Laboratory of the Ministry of Energy, and over 20% was allocated to universities[6].

The scale of development and utilization of tidal current energy in the United Kingdom has taken the lead in the world. Reviewing the development history of ocean energy industry in the United Kingdom, especially the development of tidal current energy in the past decade, the electricity price incentive policy has played a crucial role. In 2015, the United Kingdom's renewable energy policy began implementing the Contract for Difference (CfD) fixed electricity price system. In 2022, with the support of the fourth round of CfD policy, over 40 MW tidal current energy power stations in the United Kingdom received electricity price policy support of approximately 1.4 yuan/kWh. In 2023, with the support of the fifth round of CfD policies, a total of 53 MW tidal current energy power stations received electricity price policy support of approximately 2 yuan/kWh[7]. These tidal power stations will be completed and put into operation by the end of 2028 at the latest. At that time, the United Kingdom will further consolidate its leading position in global tidal current energy.

### **3.3 Accelerating the Pace of Large-scale Utilization of Tidal Current Energy, with a Hot Topic in Its Integrative Development with other Ocean Industries**

According to IRENA statistics, as of the end of 2020, the total installed capacity of global ocean power stations was 535 MW, mainly tidal power stations. The development and utilization of tidal current energy and wave energy have made rapid progress. In addition, a total of 31 countries worldwide are conducting research, development and demonstration of ocean energy[8].

Tidal energy technology has the ability to be commercialized, but the traditional dam-type tidal energy development restricts the large-scale development of tidal energy due to its occupation of coastal resources and adverse effects on the nearshore ecological environment. In recent years, significant progress has been made in the industrialization of international tidal current energy technology, and multiple stable operation demonstration power stations have been built worldwide, with a maximum single unit power of 1.5 MW. As of the end of 2022, the installed capacity of tidal current energy units in operation accounted for more than 70% of the world, and the grid-connected power generation accounted for more than 80% of the world[9]. The first phase of the "MeyGen" tidal current energy demonstration power station in the United Kingdom, which was completed and connected to the grid in 2016, installed a total of four tidal current energy units with a total installed capacity of 6 MW.

To expand the application scenarios of ocean energy and enhance the scale of ocean energy utilization, the international community has explored the integrative development of ocean energy with hydrogen production, refrigeration, seawater desalination, power supply for aquaculture equipment, and power supply for ocean monitoring equipment in recent years. For example, the European Marine Energy Centre (EMEC) in the United Kingdom has established a subsidiary to carry out tidal power generation for hydrogen production.

## **4. Analysis of the Current Situation of China's Ocean Energy Industry**

China has relatively abundant ocean energy resources, and significant progress has been made in the industrialization of ocean energy technology. Accelerating the planning of ocean energy development and utilization, and promoting the development of the ocean energy industry are of great significance for advancing the implementation of the dual carbon strategy, maintaining the diversification of energy structure, and developing the marine economy to build a strong marine country.

#### **4.1 The Development of Emerging Ocean Energy Industry Has Great Potential**

The survey and evaluation results of ocean energy resources showed that the technically exploitable amount of offshore ocean energy resources and deep sea temperature difference energy resources in China exceeds 70GW, with huge potential for development and utilization. China's ocean energy has the ability to develop into an important renewable energy, which can provide support for enhancing national energy security and promoting sustained growth of the marine economy.

The global ocean energy market has broad prospects. In the medium to long term, the international ocean energy industry will achieve leapfrog development of billions and trillions. The scale of China's ocean energy industry is expected to reach billions and grow into an important emerging marine industry. The ocean energy industry is characterized by long industrial chain and strong driving force, which can become a new growth point for China's marine economy.

#### **4.2 Current Development Status of Ocean Energy Technology in China**

Since 2012, driven by the ocean energy projects of the Ministry of Natural Resources and the Ministry of Finance, China's ocean energy power generation technology has made rapid progress, generally reaching the international advanced level, and the industrialization and commercialization process has accelerated.

The independently developed MW-level tidal current energy power generation unit "Fenjin" maintains the world's first continuous grid-connected operation time, and the independently developed 500 kW and 1 MW wave energy power generation technology is internationally leading in the field of remote island power supply. The independently developed 20 kW floating ocean temperature difference energy unit was successfully tested in the South China Sea in August 2023. The semi-submersible wave energy aquaculture platform "Penghu" and the wave energy power supply units for sea observation "Hailing" and "Haixing" have achieved over 3 years of sea demonstration operation, and the demonstration of tidal current energy hydrogen production and seawater desalination has been completed.

A batch of ocean energy demonstration projects have achieved significant results, laying a solid foundation for the large-scale utilization of ocean energy in China. As of the end of 2022, the total installed capacity of China's ocean energy power stations exceeded 10 MW, ranking fourth in the world. In the past decade, the newly installed capacity accounted for 30% of the world. The Jiangxia Tidal Experimental Power Station has cumulatively reduced carbon dioxide emissions by over 200,000 tons, and the world's first tidal photovoltaic complementary power station built in 2022 has an annual grid-connected power generation of over 100 million kWh. Multiple tidal current energy demonstration projects, such as Xiushan Island in Zhejiang, Jieruoshan Island, and Huludao Island, are operating steadily. Multiple wave energy demonstration projects, such as Wanshan Island in Guangdong and Yongxing Island in Hainan, are currently undergoing sea trials.

#### **4.3 Development of Ocean Energy Industry in China**

Considering the resource conditions, sea use conditions and technical foundation, China's tidal current energy and wave energy have a good industrialization foundation, and the temperature difference energy has a good development prospect. Large enterprises represented by China Southern Power Grid, China Three Gorges Corporation, China National Offshore Oil Corporation, and China Guodian Longyuan Power Group Corporation have entered the marine renewable energy industry chain, providing strong industrial foundation support for the development of China's ocean energy industrialization.

The standard system for ocean energy utilization in China has been further improved. As of the end of 2022, a total of 22 national standards and 11 industry standards have been implemented.

## **5. Analysis and Outlook on the Development of China's Ocean Energy Industry**

### **5.1 Problems in the Development of Ocean Energy**

Lack of independent innovation capability in key technologies of ocean energy. Compared with the requirements of large-scale and industrial development, there is still significant room for improvement in the long-term reliability of China's offshore energy technology. The forms of development and utilization of existing ocean energy technology are diverse, and the progress of industrialization technology such as standardization and equipping is relatively slow. The manufacturing cost of power generation devices is relatively high, and the effective power generation hours are limited. The economic viability of ocean energy development and utilization projects is not yet strong.

Insufficient policy incentives such as feed-in tariff. The ocean energy feed-in tariff policy urgently needs to expand its support scope and intensity. Currently, only the Zhejiang Jiangxia Tidal Experimental Power Station and the Xiushan Island Tidal Current Energy Demonstration Project have received (temporary) feed-in tariff policy support. Lack of policies such as tax incentives for ocean energy sales revenue and subsidies for power station operation and maintenance.

The investment of financial funds in the development and utilization of ocean energy urgently needs to be strengthened. The key technologies, device demonstrations, and equipment finalization required for the large-scale utilization of ocean energy are difficult with significant investment, and the sustained support and guidance of financial funds are urgently needed. Affected by multiple factors, the scale of funds supported by the central government for ocean energy has significantly decreased in recent years, making it difficult to meet the needs of technological iteration, upgrading, and industrial development of ocean energy.

### **5.2 New Requirements for the Development of Ocean Energy in the New Era**

In 2022, General Secretary Xi Jinping, when presiding over the 36th collective learning session of the Political Bureau of the Communist Party of China Central Committee on striving to achieve carbon peak and carbon neutrality goals, pointed out the need to accelerate the development of large-scale and effective new energy sources such as ocean energy. According to the vision of fundamental improvement of the ecological environment and basic realization of the goal of building a beautiful China by 2035, the development of the ocean energy industry is an objective requirement for China's ecological civilization construction. The ocean energy industry is a typical green and low-carbon industry, which can also effectively solve the energy and electricity needs of coastal areas, especially remote islands.

The 14th Five-Year Plan for the Development of Renewable Energy, Opinions on Improving the System, Mechanism and Policy Measures for Green and Low Carbon Energy Transformation, and Implementation Plan for Promoting High-quality Development of New Energy in the New Era also deployed ocean energy related work. The "14th Five-Year Plan" for the Protection and Utilization of Natural Resources and the "14th Five-Year Plan" for the Development of Marine Economy listed the Zhejiang Zhoushan 100 MW-level Tidal Current Energy Scale Demonstration Project as a special column and major project.

### **5.3 Suggestions for Accelerating the Development of China's Ocean Energy Industry**

Firstly, establishing a long-term funding support mechanism for the ocean energy industry. We will strengthen financial support for ocean energy projects, guide central enterprises and development and policy financial institutions to support the large-scale utilization of ocean energy, fully leverage the cornerstone and guiding role of central fiscal funds, and focus on subsidies for ocean energy demonstration projects, testing and standard public services. We will establish diversified investment mechanisms in finance, insurance, venture capital, and financing to further diversify development and utilization risks.

Secondly, increasing efforts to support the demonstration and application of key core technologies in ocean energy. It is recommended to include key core technologies such as advanced control of units, MW-level equipment manufacturing, and unit array operation involved in the large-scale utilization of ocean energy in the national key research and development plan for support, support the demonstration application of key core technologies around the construction of ocean energy demonstration projects.

Thirdly, formulating incentive policies for the large-scale utilization of ocean energy. We will research and formulate incentive policies for ocean energy feed-in tariff, encourage local governments to formulate and implement engineering construction subsidies, tax incentives, and other policies for the large-scale utilization of ocean energy. We will also strengthen the management of natural resources and control of land use in the field of offshore energy supply, scientifically plan potential development areas for ocean energy.

Fourthly, strengthening the construction of public service capabilities in the ocean energy industry. We will continuously support the construction and operation of ocean energy testing site, support research and development units to use relevant indoor and outdoor testing infrastructure for free, and support the iteration and upgrading of ocean energy technology. We will support enterprises to take the lead in formulating relevant standards for the design and offshore construction of offshore power generation devices.

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