

Marine renewable energy policy in China and recommendations for improving implementation

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Abstract. Renewable energy is the effective solution for the harmonious coexistence of human and environment as well as for the sustainable development. Marine renewable energy as one of the renewable energies, potentially offer fewer environmental risks and thus community acceptance than other renewable energy developments. Government support is the key and initial power for developing marine renewable energy. To promote the development and utilization of marine renewable energy, the Chinese government has established the special funding plan for marine renewable energy, and released "the 13th Five-years Plan (2016-2020) for marine renewable energy". This paper describes the mechanisms established by the marine renewable Energy policy in China, and provides a comparative analysis of the Chinese marine renewable energy policy framework. We provides some policy recommendations for future development of marine renewable energy in China.

1. Introduction

Marine renewable energy, refer to the energy contained in the ocean physical process such as wave, current and tide with the sea water, and temperature difference between the surface layer and the deep sea water. China has abundant marine renewable energy resources. The development of marine renewable energy according to the local conditions can effectively solve the lack of power and fresh water generation in islands, marine equipment operation, pelagic ocean development etc, which has strategic significance for the maintenance of national marine rights and interests, protection of the marine ecological environment, and expansion of the development space. From 2010, China has increased the financial support for the development and utilization of marine renewable energy, e.g. the Ministry of Finance (MOF) and the State Oceanic Administration (SOA) jointly set up the Special Funding Program for Marine Renewable Energy (SFPME) to promote the rapid improvement of marine renewable energy technologies in China. It's essential to plan the development layout and main tasks in the medium and long term for the industrialization of China's marine renewable energy.

2. Background

With the attention of the government to the development and utilization of marine renewable energy, the State Council and relevant ministries propose to support the development of marine renewable energy in the form of a number of laws, regulations and planning. The financial funding increases the support for marine renewable energy through special funding programs as well as R&D programs. In the strong support of government, the overall level of marine renewable energy in China has been improved significantly. Whereas, compared to the international level, there are still some deficiencies, for example, the theoretical research on marine renewable energy is relatively weak, the key



technologies such as device reliability and efficiency are relatively low, the construction of public service platform is too slow.

2.1. Marine renewable energy resources

One of the important backgrounds to develop Chinese Marine renewable energy development strategy and roadmap is that China has rich marine resources including wave energy, tidal current energy, tidal range energy, Ocean Thermal Energy Conversion (OTEC) and salinity energy etc. The developable marine energy resources in offshore area reach to 66 GW approximately, accounting for nearly 15.1% of the total Chinese installed capacity of renewable energy power generation (436 GW) in 2014 (Table 1) [1].

Table 1. MRE resources in China.

	Tidal Current Energy	Wave Energy	Tidal Range Energy	OTEC	Salinity Gradient Energy
Extractable Potential Power	~1.7 GW ¹	~4.4 GW ¹	~22.8 GW ¹	~25.7 GW ¹	~11.3 GW ¹
Total Extractable Potential Power	~66 GW				
Chinese RE Installed Capacity (2014)	436 GW ²				
Chinese Installed Capacity (2014)	1360 GW ²				

1. Data from SOA (2014)

2. Data from National Energy Administration (NEA) (2014)

2.2. Technical foundations and challenge

The technology of tidal range energy utilization in China has reached the international advanced level, have made great progress in the technical R&D of tidal current energy and wave energy etc and the application of small-sized demonstration projects (Figure 1), the basic experimental research is under development for the ocean thermal energy conversion technology, but the development and utilization of salinity gradient energy is still in its infancy (Table 2) [2].

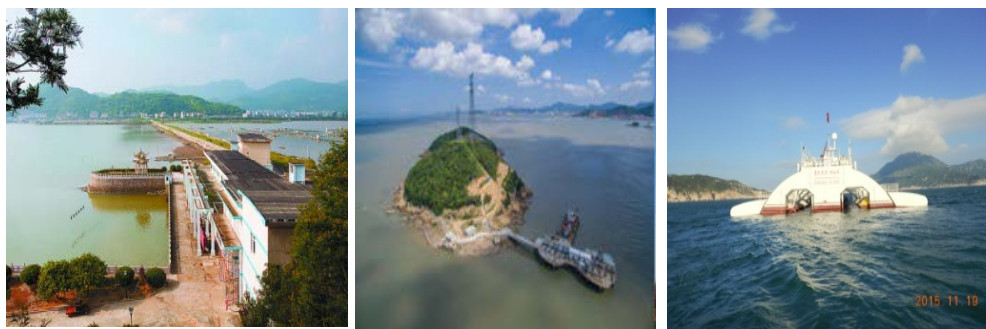


Figure 1. Jiangxia Tidal Power Station, LHD turbine and Wanshan wave converter.

Table 2. Summary of MRE project in China^[4]

Name of project/technology	Place	Project Status	Type of resources	Installed capacity/kW	Remarks
Jiangxia Tidal Power Plant	Jiangxia, Zhejiang Province	operational	tidal range	4 100	
LHD Tidal Current Energy Demonstration Project	Zhoushan, Zhejiang Province	operational	tidal current	1 000	The total installed capacity is 3 400 kW.
Zhairuoshan Tidal Energy Power Demonstration Station	Zhairuoshan Island, Zhejiang Province	operational	tidal current	180	A 120 kW tidal current turbine and a 60 kW tidal current turbine
Daishan Tidal Current Technology Demonstration Station	Zhoushan, Zhejiang Province	installed	tidal current	600	2×300 kW tidal current turbine
Zhaitang Island Hybrid Power Station	Zhaitang Island, Shandong Province	installed	tidal current	300	The demonstration project has been concluded.
Shengshan Island Isolated Hybrid Power Demonstration Station	Shengshan Island, Zhejiang Province	operational	wave	525	300 kW wave energy converters, 150 kW wind turbines, 50 kW bio-energy devices and 25 kW solar thermal cells
GIEC Wanshan Island Isolated Hybrid Power Demonstration Station	Wanshan Island, Guangdong Province	installed	wave	700	300 kW wave energy device, 100 kW wind turbines and 300 kW solar panels

More and more Chinese enterprises, universities, scientific research institutions begin to enter the field of Marine renewable energy. With Marine renewable energy technology R&D, demonstration application and accumulation of marine engineering experience, it promotes the exchanges and cooperation among the enterprises, universities and colleges, and research institutions. Based on the knowledge and experience of related industries, it is helpful to accelerate the maturity of Chinese Marine renewable energy technology and industry, for the purpose of developing and utilizing the rich marine resources earlier, as well as seizing the international marine energy market.

3. Status of marine renewable energy policy

The National Development and Reform Commission (NDRC), SOA, NEA and coastal local governments have issued and implemented a number of relevant plans referring to the marine renewable energy. During the past “12th Five-year Plan” period, more than one billion Yuan has been invested to develop the marine renewable energy in the form of SFPMRE and other R&D programs in China.

3.1. The financial support for marine renewable energy has been enhanced

In the “12th Five-year Plan” period, the National High-tech Research and Development Plan (863 Plan), National Science and Technology Research Program, and National Natural Science Foundation have provided sustainable supports for the R&D of marine renewable energy. Especially, MOF and SOA jointly set up the SFPMRE in May 2010 to support the the development of marine renewable energy from 5 aspects, including marine renewable energy independent power system demonstration, marine renewable energy grid-connected power system demonstration, marine renewable energy industrial demonstration, marine renewable energy technology R&D, marine renewable energy standards and service system. As of September 2017, more than 100 marine renewable energy projects

have been supported by SFPMPRE, funding about \$160 million totally, which fully played a guiding role of central government finance in the aspects of support for national industrial structure adjustment, cultivation of strategic emerging industries, safeguard of national energy security and exploration of energy structure adjustment etc. In general, the SFPMPRE has been promoting the significant improvement of marine renewable energy technologies in China [3].

3.2. Several plan referring to marine renewable energy have been formulated

Table 3. MRE plan in China.

The 13 th Five-Year National Key Development Plan	
●	Four sub-sectors would be set up in the energy sector, including the renewable energy and hydrogen energy sub-sector.
●	Eight technical directions would be set up in the renewable energy and hydrogen energy sub-sector, including Marine renewable energy and its comprehensive utilization.
●	Two priority tasks would be set up in the Marine renewable energy direction, including Marine renewable energy theoretical research, and Marine renewable energy key technologies.
The Marine Renewable Energy Development Outline (2013-2016)	
●	The breakthrough of key technologies
●	The improvement of TRLs
●	To promote the construction of Marine renewable energy demonstration projects
●	To improve the industry service system, establish and perfect the related standard
●	To implement the survey, selection of Marine renewable energy resources in South China Sea

In 2006, the “Renewable Energy Law” (amendment issued in 2010) was promulgated to determine the system of guaranteeing the purchasing of electricity fully generated using renewable energy resources including marine energy, which has strongly improve the development of renewable energy industry in China. Such plan as the “National 11th Five-year Plan for the Development of National Marine Affairs”, “National 11th Five-year Plan for the Development of Ocean Science and Technology” and “Outline of National Plan for the Development of Maine Industry through Science and Technology (2008-2015)”, have put forward to support the development of marine renewable energy. In the “12th Five-year Plan” period, dozens of plan referring to marine renewable energy have been issued by central and local governments in China. Among which, the “Outline of Marine Renewable Energy Development (2013-2016)” issued the by SOA in 2013 has proposed five key tasks and regional layout of marine renewable energy before 2016, which has played an important role in guiding the implementation of SFPMPRE and promoting the marine renewable energy technologies and industrial development in China (Table 3) [4].

4. Comparative analysis of marine renewable energy policy

The international marine renewable energy policies are mainly reflected in the middle and long term planning with obvious objectives, the diversification of financial support, the sound standardized test system, strong targeted industrial incentive policy and so on. Compared to the international marine renewable energy policies, there are still some problems for marine renewable energy policies in China.

4.1. The objectives of medium and long term planning are not clear enough

Up to now, the partial development objectives of marine renewable energy were proposed only in the “12th Five-Year Plan for Renewable Energy Development” and the “Middle and Long-term Planning for the Renewable Energy”, such as, “to build marine renewable energy power stations with total capacity of 50 MW to 2015” and “to build tidal power plant with capacity of 100 MW to 2020”; the “Outline of Marine Renewable Energy Development (2013-2016)” issued by SOA proposes the key tasks and regional layout. Meanwhile, the other plans involving in marine renewable energy do not

mention the relevant goals of marine renewable energy technology or industrial development. Internationally, many countries have made the clear long-term goals. In the UK, the plan determined in 2010 issued the implementation route of large-scale application of marine renewable energy before 2030. It also proposes the goal of marine renewable energy with the capacity of 1,000-2,000 MW to 2020. The lack of long-term plan goals and development path for marine renewable energy are unable to attract the enterprises to enter the sector, which cannot keep the stable development of marine renewable energy institutions and teams, and it will create a negative impact on the sustainable development of marine renewable energy technologies and industry in China.

4.2. It is not integrated for the investment fund mechanism

The investment fund for marine renewable energy was mainly supported by government in China, including the national science and technology programs and SFPMRE. During the “12th Five-Year Plan” period, nearly \$20 million has been invested by the Ministry of Science and Technology (MOST) and National Natural Science Foundation of China (NSFC) to support the theoretical and technological research on marine renewable energy. More than \$150 million Yuan has been invested by SFPMRE, focusing on the technical demonstration and industrialization of marine renewable energy, attracting some investment from enterprises. China has invested a lot of money for the technical demonstration, but less support for the theoretical research which restricts the development of marine renewable energy technologies and result in the insufficient innovation.

4.3. The supporting policies need to be further perfect

At present, the technology level of marine renewable energy in China is still in the R&D stage for the key technology and needs the support and encouragement from the supporting policies. Some countries attach great importance to the policy support for marine renewable energy, including the implementation of financial subsidies and differentiated electricity prices as well as quota system for renewable energy generation. for example, the obligation system and CfD (contract for difference) system of renewable energy implemented in UK. These supporting policies have effectively stimulated the power enterprises to invest the renewable energy. However, at present, the supporting policies in China are still imperfect. It is still not clear in the aspects of financial subsidies, grid power price and preferential use of the sea areas[5].

5. Policy suggestions for marine renewable energy future in China

5.1. Providing the long-term development goal for marine renewable energy

Carry out the research on the development roadmap of marine renewable energy in China, make clear the goal and main work in each phase, set up marine renewable energy industry incentive policy system.

5.2. Establishing an efficient coordination mechanism

The communication and coordination among different departments should be strengthened, and a coordination mechanism under the lead of the National Ocean Commission and the National Energy Commission should be established to formulate and implement the marine policies. According the development status of marine renewable energy, the feed-in tariff system should be reseeded, to promote marine renewable energy local manufacturing and drive marine renewable energy development[6].

5.3. Building a financial support and social investment mechanism

China's marine renewable energy technology is still in the stage of technological breakthroughs and demonstration applications, the national financial support would continue and the social investment would also be important [7]. Firstly, the SFPMRE would continue to implement and play the leading role of the national special funds in promoting technological innovation, enhance public service

capabilities, strengthen demonstration and application, and gradually realize the transformation from project financing and subsidies to electricity price subsidies and equipment reward mechanism[8].

6. Conclusions

The SFPMRE and 12th Five-year Plan marked a new stage for marine renewable energy development in China. The last 5 years have witnessed a rapid growth of marine renewable electricity capacity, which demonstrates China's commitment to renewable energy development and the positive impact of the plan. However, some facts prevent us from being optimistic about China's marine renewable energy future. This paper illustrates the necessity of developing marine renewable energy policy system in China. Future research should look into the long-term plan and supporting mechanism for marine renewable energy. These efforts can help China to achieve a diverse, large-scale renewable portfolio that can scale up electricity from safe, clean and reliable renewable energy sources.

Acknowledgment

The financial support by the World Bank's "China Renewable Energy Scale-development Project" (CRESP II)

The financial support by National Ocean Technology Center under the project 91700414 is gratefully acknowledged.

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