Analysis and Research of China’s Marine Renewable Energy Standards

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Abstract. China has already had relatively mature marine renewable energy utilization, among which tidal current energy power generation has achieved grid connection, and wave energy power generation has been commercialized. However, in spite of progress in the marine renewable energy utilization, China’s marine renewable energy standard system still needs improvement as there is still no marine energy standards for some subsystems, which can’t provide effective support for the innovation of marine renewable energy and the development of the industry. This paper explains the status quo of marine renewable energy standards both at home and abroad, analyzes China’s current problems in the development of marine energy standards, and offers recommendations for future development.

Keywords: marine renewable energy, standards, standard system.

1. Preface

The standard is defined as a consistent rule of repetitive things and concepts [1]. With the establishment of the special fund of marine energy in China, the marine energy development and utilization has developed rapidly with the fund support, and achieved the initial transition from “capable of power generation” to “stable power generation”, and some marine energy power generation technology has reached the international advanced level. However, compared with other marine technologies, marine energy development and utilization has many disadvantages such as high investment, great risk, and slow investment return. This also affects the development of marine energy to some extent, especially in terms of marine energy standards. At present, insufficient testing standards for marine energy power generation devices, and lack of standards for synthetical evaluation on performance and operating safeguard, which seriously hinder the development of marine energy technology, and fail to support the expansion of the marine energy industry[2].

2. Status quo of marine energy standards both at home and abroad

2.1 Status quo of overseas marine energy standards

The major overseas organizations that manage and publish marine energy standards include International Electrotechnical Commission (IEC), the European Marine Energy Center Ltd (EMEC). In addition, the European Committee for Standardization (CEN)/the European Committee for Electrotechnical Standardization (CENELEC) have released two international standardized profiles as well.

(1) International Electrotechnical Commission (IEC)

International Electro technical Commission (IEC) is a non-governmental international organization that formulates and publishes national electricity and electronics standards. It was established in London, England in 1906. In 2007, International Electrotechnical Commission/ Technical Committee for Marine Energy-Wave, Tidal and Other Water Current conversion equipments (IEC/TC114) was established. At present, Mr Danny Peacock (UK) serves as the Secretary, and Mr Jonathan Colby (United States, with a term expired in October 2022), the Chair. IEC/TC114 hosts a plenary meeting every year. Currently, it has 14 member states and China is one of them. Till now, IEC/TC114 has published 16 technical specifications on marine energy. Specifically, they can be divided into the following 4 categories:

Basic standards;
Resource assessment of marine energy;
Design, development, test and evaluation of marine energy devices;
Technology evaluation of marine energy devices.
(2) European Marine Energy Center (EMEC)
The European Marine Energy Center Ltd. (EMEC) was established in 2003. As the world’s most well-known testing and certification authority for marine energy power generation devices, EMEC has released a total of 12 guidelines and standards on resource assessment, prototype testing, performance evaluation, and industry development in 2009 [3]. Specifically, they can be divided into the following three categories:
Resource evaluation and project planning of marine energy;
Design, development, and test and evaluation of marine energy devices;
Quality assurance for marine energy devices.
(3) The European Committee for Standardization/the European Committee for Electrotechnical Standardization (CEN/CENELEC)
In 2021, CEN/CENELEC released two international standardized profiles including CWA 50271:2021 Recommendations for a Modular and Cross-Cutting Power Take-off for Wave Energy Direct Drive Linear Solutions, and CWA 50272:2021 Methodology, Procedures and Equipment Required for the Laboratory Testing of a Modular and Crosscutting Power Take-Off for Wave Energy Converters, which mainly addressed the laboratory testing of wave energy converter models.
Through the analysis of IEC and EMEC standards, it can be seen that overseas marine energy standards mainly focus on the design, development and evaluation of marine energy power generation devices, and great importance is attached to technology R&D of marine energy power generation devices, followed by emphasis on standards in areas such as resource assessment of marine energy and underlying common of marine energy, covering the entire chain of the marine energy standard industry.

2.2 Status quo of domestic marine energy standards
Domestically, organizations that manage the standards of marine energy development and utilization mainly include Sea Area Use and Marine Energy Exploitation (SAC/TC283/SC1), and National Technical Committee 546 on Marine Energy Converters of Standardization Administration of China (SAC/TC546).

(1) Sea Area Use and Marine Energy Exploitation (SAC/TC283/SC1)
In 2005, Standardization Administration of China approved the establishment of National Technical Committee 283 on Ocean of Standardization Administration of China (SAC/TC283) [4]. Within this Committee, the Secretariat of Sea Area Use and Marine Energy Exploitation is affiliated to National Ocean Technology Center, and is fully responsible for the centralized management by specialized departments of standards on marine energy exploitation.

(2) National Technical Committee 546 on Marine Energy Converters of Standardization Administration of China (SAC/TC546)
In 2014, National Energy Administration approved the establishment of National Technical Committee 546 on Marine Energy Converters of Standardization Administration of China (SAC/TC546), which is responsible for formulating and amending national standards for marine energy converters (including power generation by wave, tidal and other water current energy, excluding tidal range energy converter with dams), while assuming similar responsibilities of International Electrotechnical Commission/ Technical Commission for Marine Energy-Wave, Tidal and Other Water Current Converters (IEC/TC114).

(3) Standard system for exploitation and utilization of marine energy
In 2015, the former State Oceanic Administration issued HY/T 181-2015 Standard system for exploitation and utilization of marine energy, which proposed that marine energy standards be divided into 4 categories including “underlying common”, “marine energy resource survey and
evaluation, and site selection survey and evaluation”, “development, testing and evaluation of marine energy power generation devices”, and “construction of marine energy power plants”. Therefore, in accordance with the classification method of Standard system for exploitation and utilization of marine energy, the marine energy standards that have been released in China are divided as follows:

Underlying common—6 standards including Marine Energy Terminology, Marine Energy-Wave, Tidal, and Other Water Current Converters: Terminology and so on;

Marine energy resource survey and evaluation, and site selection survey and evaluation—15 standards including Quality Control Requirements for Marine Energy Surveys, Guidelines for the Survey and Assessment of Marine Renewable Energy Resources, etc.;


To sum up, as marine energy development and utilization in China came into being relatively late, current marine energy standards mainly focus on the front end of the marine energy industry such as “underlying common” and “marine energy resource evaluation” in terms of technical content. As for other areas such as power generation devices testing and evaluation and power plant construction, though in 2021 two marine energy standards Power performance assessment of electricity producing wave energy converters and Specifications for sea area use acceptance of reclamation projects surveys were released, such standard coverage is still not enough to support the development of the marine energy industry. There is still a lack of comprehensive utilization of standardization for the energy industry including off-grid/grid-connected power generation, industry protection, marine energy + seawater desalination, marine energy + mariculture, marine energy + ocean observation and so on.

3. Comparative analysis of China’s marine energy development and utilization standards and overseas counterparts

3.1 Difference in the top-level design of the standard system

China’s marine energy development and utilization standards are formulated mainly based on HY/T 181-2015 Standard system for exploitation and utilization of marine energy. The technical content of such standards covers four areas including underlying common, marine energy resource survey and evaluation and site selection survey and evaluation, development, testing and evaluation of marine energy power generation devices, and construction of marine energy power plants, which basically cover the whole process of the marine energy industry. On the other hand, although no standard system documents or announcements on marine energy development and utilization were released for overseas marine energy standards, it has been recommended in the Business Plan released by IEC/TC114 in 2018 that standards should be formulated as a priority in the next 3~5 years in 10 areas including: (1) technical appraisal plan, (2) guidelines and procedures for cable laying, (3) submarine cable/cable network and connector performance/reliability design guidelines, (4) design guidelines for connecting marine energy systems and distribution-level grids, including small/zone projects, (5) guidelines for installation (deployment) and retrieval processes, (6) array performance, (7) operation and maintenance specifications, (8) commissioning and decommissioning procedures, (9) data acquisition and communication, (10) measurement methods, including measuring physical parameters of equipment. Through comparative analysis, it can be known that the top-level design of the domestic marine energy standard system is mainly oriented to the industry, aiming to promote the overall development of the industry, whereas the top-level
design of overseas marine energy standard system is mainly oriented to technology, aiming to promote technology iteration.

3.2 Different focuses in the technical content of standards

The total number of domestic marine energy standards exceeds that of overseas marine energy standards. However, through analysis of the technical indicators of our country’s marine energy standards, it can be known that the technical content mentioned by about 70% of China’s marine energy standards such as Quality control requirement of ocean energy investigation, General technical specifications for instruments and equipments for ocean energy survey, and Ocean energy terminology—Part 1: General, focuses on working conditions of testing instruments, accuracy of indicators or description of basic terminologies. On the other hand, the technical content mentioned by 60% overseas marine energy standards such as Measurement of Mechanical Loads, Power performance assessment of electricity producing wave energy converters and Power performance assessment of tidal current energy converters are about testing instruments, testing procedures, data analysis, uncertainty assessment and so on, which can provide accurate guidance for the development, testing and evaluation of marine energy power generation devices. In particular, in the standard verification process, overseas marine energy standards will list the experimental verification procedures and data in the form of appendices so as to enable marine energy technicians to refer to and use such standards.

3.3 Different leading organizations in authorizing standard

The administrative bodies of marine energy standards of China are mainly Sea Area Use and Marine Energy Exploitation (SAC/TC283/SC1), and National Technical Committee 546 on Marine Energy Converters of Standardization Administration of China (SAC/TC546). More than 70% of standards released by this administrative body are formulated by National Ocean Technology Center of Ministry of Natural Resources. In addition, Ocean University of China, National Center of Ocean Standards and Metrology of Ministry of Natural Resources, Hohai University and other institutions have also formulated some marine energy standards. Looking at the leading organizations in the formulation of marine energy standards, it can be seen that currently our nation’s marine energy standards are primarily developed by scientific research institutes and institutions of higher learning, and the majority of such standards are about research and development results or evaluation methods, and there is a lack of marine energy industry standards on device research and development, materials technology, testing and evaluation, operation and maintenance, and so on. Moreover, few enterprises have participated in the formulation of such standards. In the formulation of IEC standards, the leading organizations are mainly enterprises. For instance, the European Marine Energy Center (EMEC), as a company that tests marine energy power generation devices, has released 12 marine energy standards as its priority, based on which it actively participates in the Working Group of IEC standards. Till now, 6 standards formulated under the leadership of EMEC, including Assessment of Performance of Tidal Energy Conversion Systems, Assessment of Performance of Wave Energy Conversion Systems, Assessment of Wave Energy Resource, Assessment of Tidal Energy Resource, Guidelines for Design Basis of Marine Energy Conversion Systems, and Tank Testing of Wave Energy Conversion Systems, have been submitted as the proposed work plan of IEC/TC 114, and part of the standards have been published through IEC/TC 114. 4.

4. Existing problems of China’s marine energy standards

At present, China has a total of 30 marine energy standards. Both the technical content and the number of such standards are far insufficient to sustain the development of the marine energy industry. Compared with the standards in areas of hydropower, wind power and photovoltaic power, the marine energy standard system still needs optimization and improvement. In particular, for the
key links at the development and growth stage of the marine energy industry, there are still no standards and methods for the testing and evaluation of marine energy power generation devices. Therefore, it is impossible to effectively and comprehensively evaluate the technical performance, reliability, and economical efficiency of current marine energy power generation devices. As a result, both manufacturers and administrative bodies of marine energy power generation devices lack scientific and credible data to provide decision-making support for research result transformation and policy formulation of marine energy power generation devices, which seriously prevents the development and expansion of the marine energy industry. The major problems in our current marine energy standards are as follows:

4.1 The marine energy development and utilization standard system needs continuous optimization and adjustment.

The current marine energy standard system HY/T 181-2015 Standard system for exploitation and utilization of marine energy has provided guidance for the formulation and revision of marine energy standards at the early stage of marine energy development and utilization [5]. However, with the ongoing progress of marine energy development and utilization technology, especially the continuous advancement of the industrialization of marine energy development and utilization, Standard system for exploitation and utilization of marine energy needs optimization and improvement in terms of framework structure and standard details. For instance, in terms of framework structure, for the three categories stipulated in HY/T 181 including “marine energy resource survey and evaluation and site selection survey and evaluation”, “development, testing and evaluation of marine energy power generation devices”, and “the construction of marine energy power plant”, more information should be added so as to give a comprehensive description of the status quo of the marine energy industry of China.

4.2 More efforts should be made to promote the internationalization of marine energy standards.

The Thirteenth Five-Year Plan for the Development of Marine Renewable Energy pointed out “supporting the internationalization of the marine energy technology” and the strategic requirement of “serving the Belt and Road Initiative”. In terms of the internationalization of marine energy standards, currently no domestic marine energy standard has been transformed into an international one. The reason is that the marine energy standards published in China mainly focus on two areas: basic terminology and resource assessment, which overlaps with the marine energy standards that have been released abroad to some extent in terms of technical content. Therefore, China lacks significant technical advantages in applying for international standard projects. In addition, due to the international situation, it is difficult to secure affirmative votes from the majority of member states. As for serving the Belt and Road Initiative, though China has achieved certain results in marine energy cooperation with countries along the Belt and Road, international cooperation on marine energy standards has not yet been carried out, hence providing insufficient support for the Belt and Road Initiative [6].

4.3 Incentive policies for the formulation and amendment of domestic marine energy standards need to be strengthened.

For marine energy which is a new strategic industry, it is necessary to provide certain incentive policies at its initial development stage so as to drive the development of marine energy standardization. For the manufacturing of marine energy devices, China has rolled out the Assessment and Evaluation Method for the First Major Technical Equipment in the Energy Field to reduce taxes and provide insurance. However, there are few national incentive policies for marine energy standard formulation. Most of the incentive policies for standard formulation and amendment are confined to the standard formulation and amendment organizations themselves only, and such organizations may vary in terms of the priority given to such incentive policies, which
may to some extent hinders the promotion and expansion of the formulation and revision of marine energy standards. Meanwhile, through the analysis of the technical content of China’s current marine energy standards, it can be found that the technical content of our current marine energy standards primarily focuses on the front end of the marine energy industry, which still needs great improvement in comparison to that of current international marine energy standards. The National Ocean Technology Center is the primary institution responsible for formulating marine energy standards, according to a review of the key players in this field. Just a few other marine energy organizations have contributed to this effort. Moreover, it is relatively single for technical force of standard development.

5. Suggestions for the development of China’s marine energy standards

5.1 Continue to optimize the framework of the marine energy development and utilization standard system

To drive progress of the marine energy development and utilization and accelerate the industrialization of marine energy, it is necessary to continue to optimize the framework of the marine energy development and utilization standard system. It is recommended that at the next stage, efforts should be made to drive formulation and amendment of marine energy standards on testing and evaluation of power generation devices, site selection and survey and construction of marine energy power plants, off-grid/grid-connected power generation, energy storage and hydrogen production of power generation devices, and safety protection and guarantee, explore standards and specifications for various new utilization models such as “Marine Energy +”, accelerate standard development for the array and large-scale application of generator piston of marine energy, and provide stronger support for “strengthening efforts in the finalization and application of devices of tidal current energy, wave energy and other energies, and vigorously promoting large-scale utilization” as stipulated by General Office of the State Council.

5.2 Intensify efforts in “introducing” marine energy standards

At present, International Electrotechnical Commission (IEC) is the major international organization that formulates and publishes standards on marine energy development and utilization. In 2009, EMEC released 12 guidelines and standards on resource assessment, prototype testing, performance evaluation, and industry development. In 2014, National Ocean Technology Center completed the translation and proofreading of all EMEC standards. The International Electrotechnical Commission (IEC) had published 16 technical specifications on marine energy by November 2021. For such standards, China has introduced some of them including terminology, evaluation and qualitative description of tidal current energy resources, evaluation and qualitative description of wave energy resources, and marine energy system design requirements. Among them, National Ocean Technology Center of Ministry of Natural Resources has introduced “IEC/TS 62600-1 Marine Energy - Wave, Tidal and Other Water Current Converters: Terminology and transformed it into national standard GB/T 37551-2019 Marine Energy-Terminology of wave, tidal and other water current converters and implemented in January 2020. In terms of the contents of standard technology, in 2020 IEC released IEC 62600-3:2020, which specifies full-scale structural testing requirements for the subsystems or components of marine energy power generation devices, especially for the rotor blades of power generation devices, and the description and evaluation of testing results. However, there are no such marine energy standards in China. As a result, in the process of following up the development of overseas marine energy standards, it is necessary to comprehensively study the key differences between overseas marine energy standards and domestic ones in terms of technical content, and speed up the introduction of international standards so as to fill in the gaps in relevant professional fields in China.
5.3 Actively support domestic marine energy standards to “go abroad”

At present, the three internationally recognized standardization organizations are ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), and ITU (International Telecommunication Union). Among them, only ISO and IEC are involved in formulating marine energy standards or similar standards. At present, the technical content of our country’s marine energy standards primarily focuses on the front end of the marine energy industry, which still needs great improvement in comparison to that of current international marine energy standards [7]. The National Ocean Technology Center is the primary institution responsible for formulating marine energy standards, according to a review of the key players in this field. Just a few other marine energy organizations have contributed to this effort. Moreover, it is relatively single for technical force of standard development. Therefore, in order to achieve the internationalization goal for marine energy standards, it is suggested that marine energy standards should be researched and developed on a larger scale, the collaboration and coordination mechanism of the Marine Energy Standardization Technical Committee should be explored, and priorities should be given to scientific research in international standards on marine energy device testing and maintenance, so as to achieve the zero breakthrough in the internationalization of marine energy standards, and actively support domestic marine energy standards to “go abroad”.

5.4 Optimize the incentive mechanism for the formulation and amendment of domestic marine energy development and utilization standards

To boost the morale of marine energy practitioners in formulating and amending standards, it is recommended that administrative authorities should roll out incentive policies for the formulation and amendment of marine energy standards at the national or industry level [8], establish a special fund for marine energy standardization to reward the work in formulating and amending industry standards and group standards of marine energy so as to increase the supply of available marine energy standards, and build an marine energy standard verification platform so as to provide marine energy organizations with verification support for their testing capability and technical content of their standards, and shorten the formulation and revision cycle of marine energy standards by building a non-profit, open and shared testing resource platform.

References


