Development of Ocean Energy Test Field in China

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Abstract:

The mission of the test field is to provide technical support to associates. The paper present the development of ocean Energy(OE) field in China and outline the new technologies and best practice, resources conditions, construction targets, generation device testing and standard system. The main purpose is to improve the level of China's ocean energy development.

The Chinese ocean energy test field, which was started in 2008, involved a development divided in three phases (the overall design, construction, demonstration). The methodology followed in the individual phases is described, and the standardization of testing wave and tidal current energy devices is introduced.

Key words: ocean energy, test field, testing, standardization

1. Introduction

China has long coastline and rich ocean energy resources. According to preliminary estimate, the theoretical potential of offshore Tidal range energy reached 192.86 GW, Wave energy reached 7.7 GW, Tidal Current energy reached 8.32 GW, especially Zhejiang and Fujian provinces. Ocean energy as a new type of green renewable energy, get the attention of the local government and society. Local governments have introduced various planning, policies and incentives to encourage the development of technology, alleviate the pressure of the environment, promote the development of ocean energy industry.

Status of MRE resources in China

	Types of MRE	**Theoretical potential/GW**	**Technical potential/GW**
1	Tidal range	192.86	22.30
2	Tidal current	8.32	1.66
3	Wave	7.70	1.52
4	OTEC	367.00	25.70
5	Salinity gradient	113.08	11.31
6	offshore wind	980.43	570.34
7	**Total**	**1669.39**	**633.36**

In order to accelerate the development of ocean energy utilization technologies and industrialization process, solve the device difficult to make the product industrialization, progress slowly, one after another around the world to build the ocean energy test field, to promote the ocean energy technologies. In 2008, China Government began to design and build ocean energy test field, basic is divided into several parts: environmental monitoring, power system testing, platform construction, device testing, standard study and so on.

2. Main framework

2.1 The regional layout

Ocean energy test field is a major technology research and development platform, it is a long time project. From 2009, we began to overall design and distribution, the test field divided into three stations: Northern National Ocean Energy Test Station(NNOETS) will be built in the coastal of Weihai of Shandong province, National Tidal Current Energy Test Station(NTCETS) will be built in the coastal of Zhoushan of Zhejiang province, and National Wave Energy Test Station(NWETS) will be built in the coastal of Zhuhai of Guangdong province.

Test station for MRE in China

The location of test station is in comprehensive consideration of the local natural environment conditions, resources conditions, traffic, employment, grid, economic feasibility, and after the argumentation of professional scientists. NNOETS is close to Beijing, have more ocean research institutions, and the resources is representative in the north China. NTCETS have much

channels, is the most abundant resources in China, the local economy developed, the transportation is convenient. NWETS is one of the most abundant wave energy in China, the position is superior, and the Marine economy planning has been listed in the local government.

Parameters of each Station

Weihai Ocean Energy Test Station	
Water Depth	（50-70） m
Mean Wave Height	1 m
Max Current Speed	1.2 m/s
Zhoushan Tidal Current Test Station	
Energy Density per Year	1.5 kW/m^2
Water Depth	（20-60） m
Max Test Capacity	3×1 MW
Zhuhai Wave Test Station	
Wave energy density	4 kW/m
Water Depth	30 m
Max Test Capacity	3×100 kW

2.2 Total Goal

The test field is to establish the oceanic general public testing platform. Main job is to investigate and analyze hydrological and meteorological parameters, and study the method of device testing and assessment, optimization efficiency of energy acquirement and power transmitting. To provide technology for the development of the national power generation device, prepare the way for industrialization.

Public Service Platform for MRE in China

Northern National Ocean Energy Test Station (NNOETS): located in northeast of Shandong province, was an early area of OE test site design. It is designed for testing and evaluation wave energy and tidal current energy generation device prototype in real sea condition. As a result of ocean energy technology, it is a test organization of power generation equipment and technology center.

National Tidal Current Energy Test Station (NTCETS): located in Zhoushan of Zhejiang province, is designed to testing and evaluation tidal current energy device, include optimizing, real sea testing, efficiency evaluation, environmental impact assessment, power transmission, grid connection and so on. Finally built a demonstration power station which has a public test berth, to accelerate the commercialization development in China. NTCETS design of three test berth, contains testing system and ocean observing system, could satisfied 300 kW, 600 kW and 1 MW tidal current generator unit.

National Wave Energy Test Station (NWETS): located in Zhuhai of Guangdong province, is designed to testing and evaluation wave energy device, like NTCETS, it can optimizing, real sea testing, efficiency evaluation, environmental impact assessment, power transmission, grid connection and so on. It can test the capacity more than 100 kW on wave energy device.

3 Build Ocean Energy Test Field

2008, NOTC started research and planning about ocean Energy Test Field. In 2010, with the support of national financial fund, we launched the engineering design work. After repeated arguments, until 2013, the location of NNOETS is confirmed, electric transmission and distribution, test platform and system have been carried out. At the same time, NTCETS and NWETS started, is expected after four years of time, China's first Ocean Energy Test Field will

open.

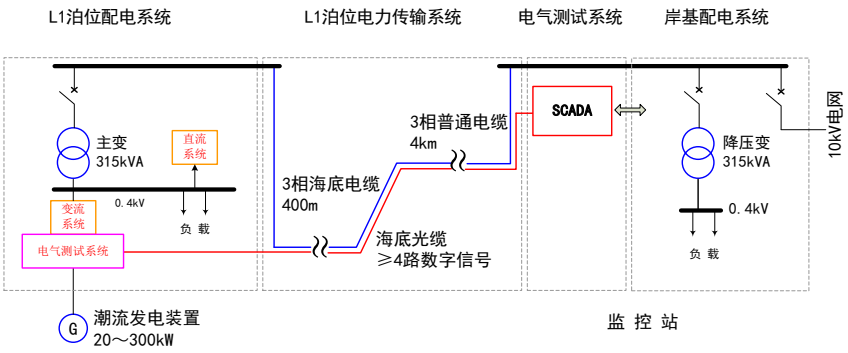
Building of NNOETS is divided into three parts in the first phase: power transmission system, tidal current testing platform and online environment observation system, include lift testing platform, electrical test system, berth power system, power transmission system, environment monitoring system.

3.1 Tidal Current Energy Testing Platform

Tidal Current Energy Testing Platform offshore distance is 300 meters, the depth of the water is 20 meters, including main structure and electrical generators output test system. It is supported by the main structure, the generation device installation platform, maintenance platform and lightning protection system. The installation platform installed on the seabed, carrying for elevating platform, the largest load is 250 t, can lift up and down through the water, maintenance platform reserved space for transmission and test system; The top of the platform will install lightning protection system and hoisting facilities, and the service life of the platform is not less than 25 years. Electrical test system can real-time testing power output electrical parameters, such as current, voltage, frequency, power, active/reactive power, power factor and harmonic, data transmission by the data collection and transmission system to the data management center.

3.2 Transmission system of the field

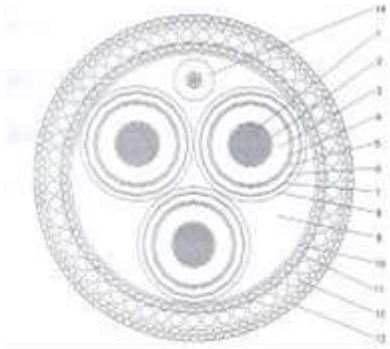
Transmission system consists of power distribution system, power transmission system and electrical test system, as a test platform it provide electricity generators and power management, research the design of distributed grid-connected power generation system and management methods. It is the main function of power distribution and transformer, current transformer and electrical testing, underwater cable laying and the environment impact assessment.



Transmission and distribution system design

The purpose of the transmission and distribution system is send electric energy to 35 kV electric substation (maximum power of 300 kW). Electricity needs by cross - straight - to pay after the transformation into a stable alternating current (ac), after isolation and transformation.

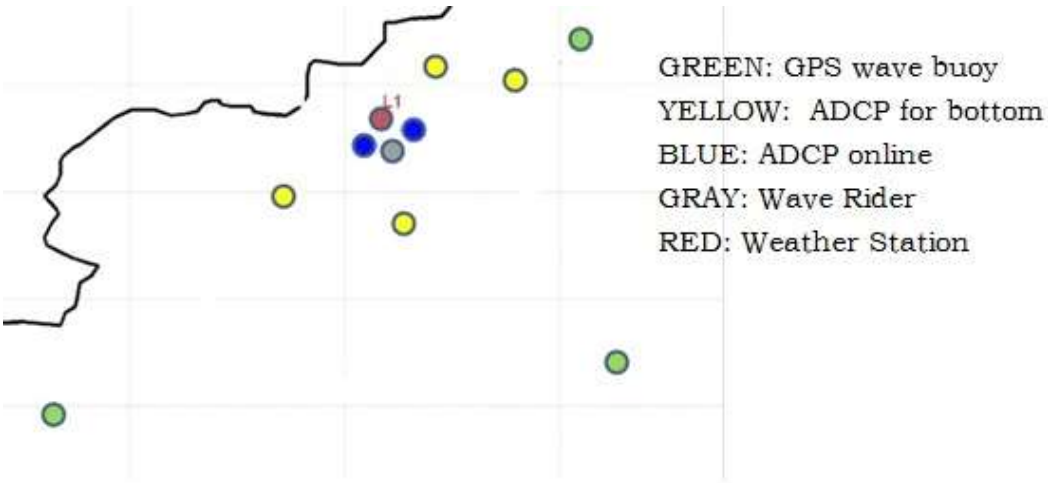
Power transmission is divided into underwater and water parts, underwater part using 3 x 120 mm^2 submarine power cable (submarine photoelectric composite cable). The underwater cable is 4 km long, and conductor cross-sectional area is 120 mm^2, the total diameter is 98.7 mm. 16 fiber cable laying used as data communications at the same time, the length of 4.0 km, and 16 core cable as data communications.



Cable cross section diagram

3.3 real-time observation system

Real-time observation system of the testing field within the scope of 5 kM^2 deploy 1 meteorological and hydrological observation system, and 1 waverider buoy, 2 bottom real-time observation system, 3 GPS wave buoy. The system measure wave, current, tide, water temperature, salinity, wind, temperature pressure and so on, and layout the most suitable testing plan for power generation device.



Deploy of real-time observation system

Real-time data transmit to the central data server, to storage, processing and analysis. You can analyze and query data, display the real-time curve, graphical wave and current data, such as

local access. FVCOM model is adopted to establish the 3D model, the use of SWAN model and the WSTF model for wave numerical simulation. At the same time, use component of curve display, parameter correlation, contour, vector visualization, GIS visualization, to design and development, become a powerful software system.

4 Device production design

Production design is really important for device from development to product, and is an important part of the testing field. After each power generation device through lab test, will be experience of marine environmental testing. After scaled model sea trial in testing station, evaluate and improve the prototype, until meet the requirements of the indicators, then a full-scale model prototype of demonstration experiment, and reach the phase of production. We put these experiences into power generation device standards, to guide the future work for a period of time of production design.

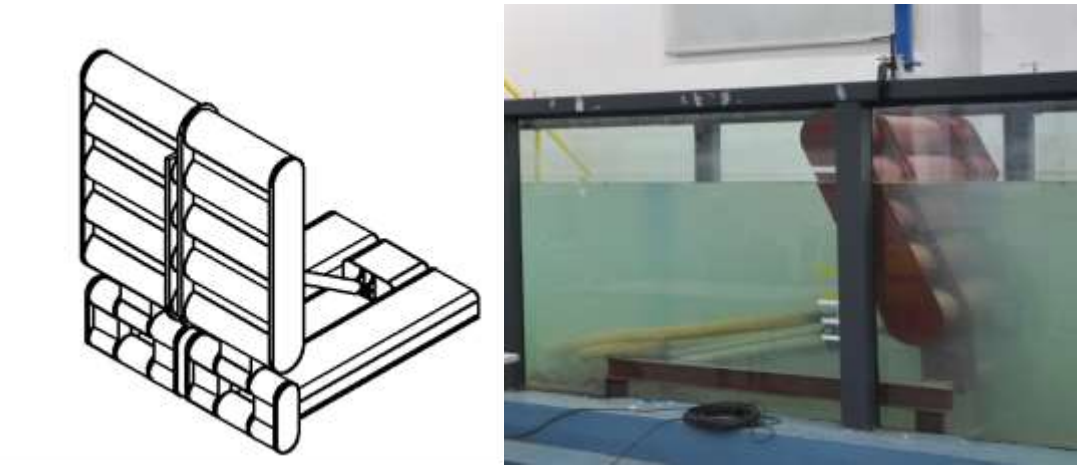
4.1 Lab Testing

(1) Out experiment tank is under construction, the length is 130 m long, wide is 18 m, deep is 6 m. It can simulate the sea wave, current and wind, and it has a removable test platform. The testing tank is scheduled to be completed in 2015. Testing tank can carry out power generation device lab tests, such as capture ability and static water resistance, energy conversion efficiency, the wave resistance, wind resistance, Multi-parameter coupling, provide evidence and assistance for generating set into the sea.The technical Parameters are as follows:

NOTC Testing Tank Parameters

Parameter	Range	Model Scale
Wave Height	（0.02～0.4）m	1:50
Wave Period	(0.5～5) s	
Wind Speed	(0～10) m/s	
Current Speed	(0～1.5) m/s	Full Scale

(2) Energy conversion efficiency testing tank is 25 m long, 1.6 m wide, 1.6 m high, the maximum working depth of 1.2 m, can provide simulated seawater environment test for physical model of power generation equipment. Scaled model is put in the tank, the wave and current device simulated seawater environment. At the same time, the tank is monitoring the environmental parameters (wave height, velocity), the mechanical measurement (spot pressure, total pressure), movement measurement (acceleration, displacement, rotation) and mechanical power (torque and rotational speed) measurement.



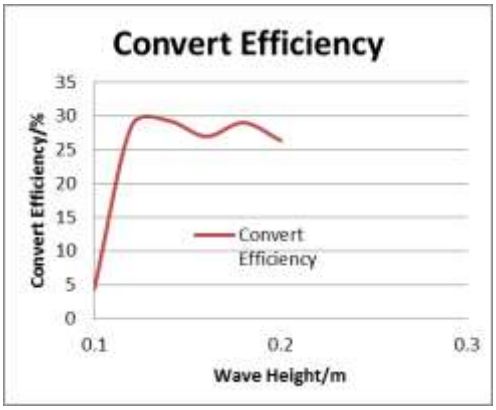
Testing the Model of Wave Energy Converter

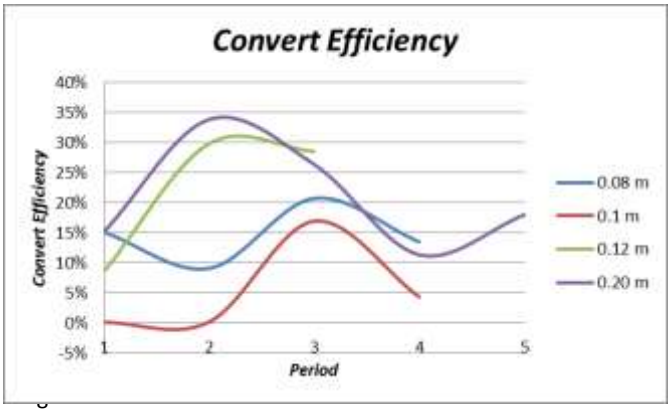
We use the NOTC gravity pendulum 1:5 scaled model for lab testing, set up different wave height and period. Then analyze conversion efficiency under various conditions, so as to determine the best transition conditions. Following is the result.

Result of NOTC gravity pendulum 1:5 scaled model testing

Wave Height	***Measure $H_{1/3}$***	***Convert Efficiency***	***Period***
m	*m*	*%*	*s*
0.10	0.1126	4.41	2.02
0.12	0.1383	28.56	2.02
0.14	0.1521	29.35	2.02
0.16	0.1778	27.02	2.02
0.18	0.1961	29.06	2.02
0.20	0.2132	26.41	2.02

As a result of the limitation of wave range test device, for the above test results are analyzed: At the same period, the wave height in a certain range to achieve the highest conversion efficiency; in condition of less wave height, period focused on the 2 s reach the highest conversion efficiency, wave height is bigger, the periodic increase to reach the highest conversion efficiency.





Convert Efficiency by different Wave Height and Period

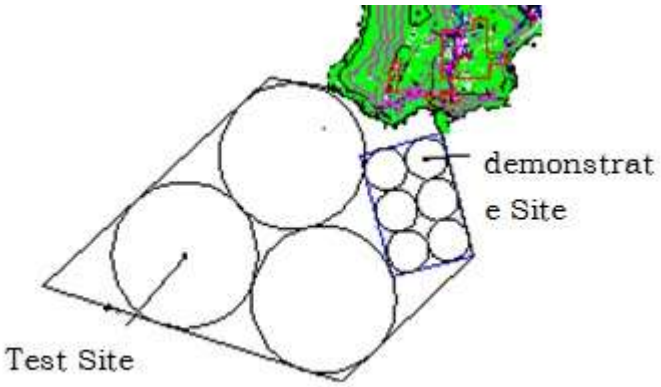
4.2 Real Sea Testing

The sea testing is put the power generation device into test sea area, proving ocean energy test site for testing.

(1) Generator for Marine environment test: Environmental data collection and analysis first, and then the numerical model simulate wave and tide, and spectrum analysis, ultimately can wave and tidal current distribution and power calculation;

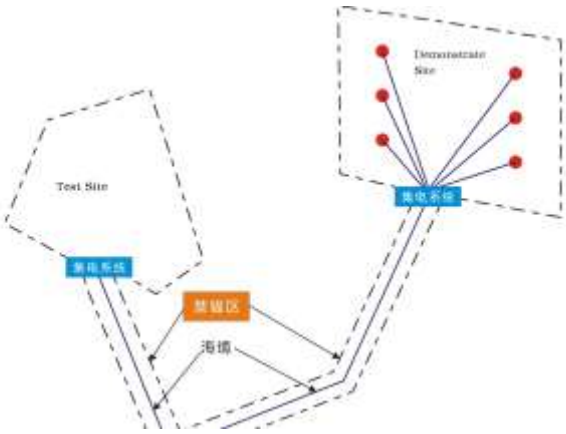
(2) Electric power test system is responsible for generating device of power quality, power quality detection, generator protection system.

Wave testing station: total area 0.4 m^2, 3 test berths for single 100 kW floating wave power devices. The berth offshore distance is 300 m, 350 m radius. After testing, the device access to the demonstrate site, demonstration operation have 6 berths, radius of 100 m.



Berth Position of Wave Test Station

Tidal Current testing station: Site is still in the design stage, it have 3 testing berths, one shallow-water berth (depth of 10 ~ 20 m), 2 for deep-water berths (20 ~ 50 m depth), a single berth meet capacity 1 MW floating type or stationary power unit test, single berth is greater than 0.4 m^2, offshore within 3 kM of distance.

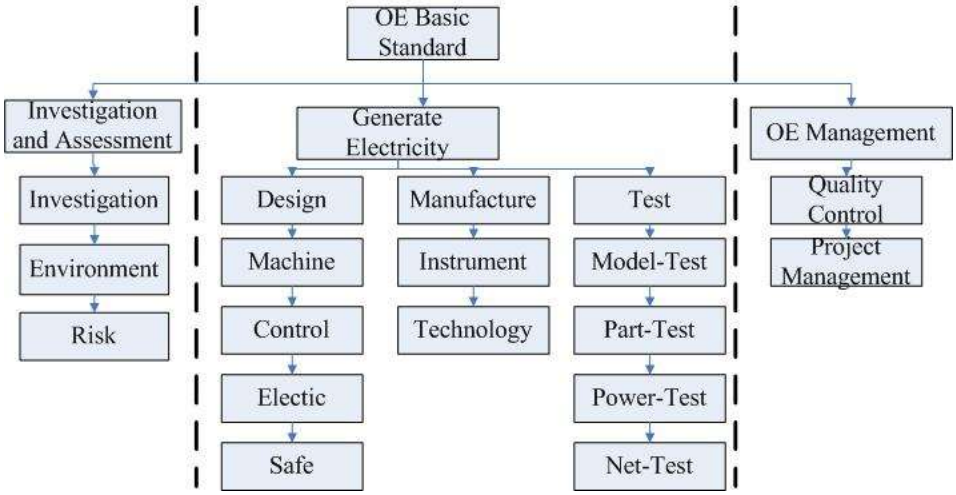


Berth Position of Current Test Station

(3) Integrate Assess System receive data from water area which is measured, compare and analyze the data from testing system and protection system, such as power quality, ultimately, evaluation the conversion efficiency of power system. The analysis of the data is included with time series analysis and statistics analysis.

5 Ocean Energy Standards

A common reference is important and necessary when comparing devices. At present, China's ocean energy research started late, standards is very little, from device research and development, to the indoor test, test to the sea. With the development of ocean energy technology, standard system will also gradually improve. In technology developed country, however, ocean energy standard is more, such as the IEA, EMEC, DNV.



Standard System of OE Development

In 2010, with the construction of testing field, we have built ocean energy standard system, the system will be the standard in the future. Till now, every part in the system: resource survey, resource statistics, map drawing method, quality control, the term has already begun the writing

of the standard, part of the standard has been released. In the next, standard like device testing, technology maturity, and device evaluation, will be start.

6 conclusion

This paper introduces the ocean energy resources, the targets of the testing field, production design and standard system in China, also introduces the framework, design concept and expected results of the testing field. China ocean energy research starts late, the technology is not mature, ocean energy testing field is also designed to promote the development of ocean energy technology, hope to be able to use the international advanced technology, improve China's ocean energy technology.

Many parts of testing field is still under construction, a lot of test can't carry out, so a lot of problems didn't appear. We will also continue to testing field research, like methods testing, standards testing, berth layout, data management, continuously improve standard system, promote the industrialization development of ocean energy technology in China.