Planning on Establishment of Sea Test-Bed for Tidal Current Energy Converters in Jindo, Korea

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***Abstract*— Tidal current power is the nearest technology for the commercialization of marine energy. In particular, southwestern sea of Korea is the optimal candidate site for the development of tidal current energy. In addition, Uldolmok and Jang-Juk straits have abundant tidal current energy resources. This paper aims to introduce the plan for the establishment of 4.5MW sea test bed titled K-TEC for tidal current energy converters in Jind located at southwestern sea of Korea.**

***Keywords*—tidal current power, marine energy, Uldolmok, Jang-Juk, sea test-bed, tidal current energy converters**

I. INTRODUCTION

Lately, all countries of the world confronted the global warming and climate change due to increased greenhouse gas emissions. So, there are being a lot of interest and investment in the development of marine energy. Among marine energy technologies, tidal current energy is the closest technology to the commercialization([1]).

Southwestern sea of Korea has the optimal candidate sites for the development of tidal current energy([2]). There are strong velocities above 2m/s between islands. Especially, Uldolmok and Jang-Juk straits have abundant tidal current energy resources.

Meanwhile, KIOST(Korea Institute of Ocean Science & Technology) has been researching about tidal current energy since 2001. And KIOST constructed Uldolmok tidal current power plant having 1MW installed capacity at Uldolmok, Jindo, Korea. Fig. 1 is a photo of Uldolmok tidal current power plant.

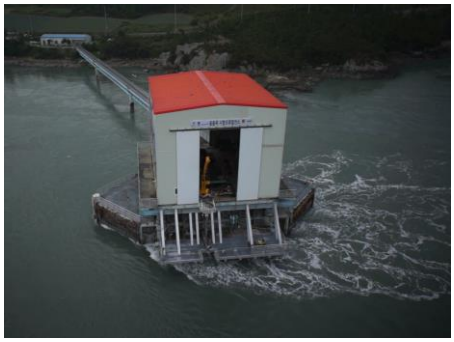

Fig. 1 A photo of Uldolmok tidal current power plant

MOF(Ministry of Oceans and Fisheries) which is a Korea government agency had established “2030 ocean energy development plan” in December, 2017. In this policy, development plan of 1.5GW ocean energy infrastructure had been built. Also, this plan includes sea test bed for ocean energy converters, commercialization technology for tidal current power generation and tidal current energy farm etc.

Meanwhile, establishment of sea test bed for TEC(tidal current energy converters) is important for improving tidal current power technology along with the development of high-performance tidal current turbines. Because of this, advanced countries, such as UK and Canada, etc., are operating the sea test bed([3]).

Thus, this paper aims to introduce the planning for the establishment of 4.5MW sea test bed titled K-TEC for tidal current energy converters(TEC) a Jind coast located in southwestern sea of Korea. The main contents of TEC sea test bed are to construct sea test-bed for performance evaluation of tidal current power generation system and facilities. This project will construct the sea test bed for 4.5MW tidal current energy converters equipped with grid-connected system and test facilities for performance evaluation of tidal current power generation components(blade, drive train, etc.)

II. MARINE ENERGY POLICY IN KOREA

The Korean government has been changing the national energy paradigm for power supply to safety, clean and diverse energy resource supply. In particular, Japan's Fukushima nuclear accident ('11.3), Gyeongju earthquake ('16.9) and Pohang earthquake ('17.11) have raised public concerns over safety and environmental energy security.

The energy conversion roadmap ('17.10), which was announced by the Korean government, provides national energy policy changes, including phased reductions of nuclear power plants, expansion of renewable energy and promotion of regional industry. MOTIE(Ministry of Trade, Industry and Energy) has announced “3020 planning for development of new and renewable energy” in 2017([4]). This objective is to supply renewable energy to 20% of total energy by 2030. In addition, starting with non-nuclear power, this policy shows the direction for the development of eco-friendly, safety, efficient energy. It has set a goal to increase the size of new

renewable energy facilities to about 76 GWs by 2030. Fig. 2 shows 3020 planning for development of new and renewable energy.

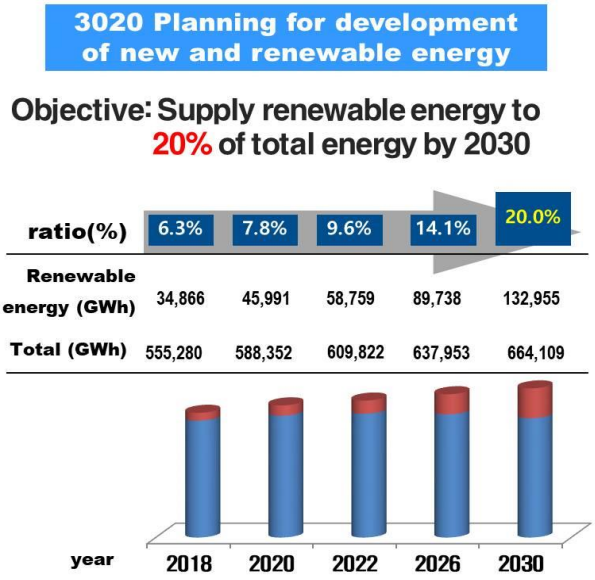

Fig. 2. 3020 planning for development of new and renewable energy

Meanwhile, MOF(2017) has announced "the 2030 long term planning and strategy for the development of ocean energy". This objective is to construct a total of 1.5GW ocean energy infrastructure by 2030([5]). Fig. 3 shows the 2030 planning for development of tidal current energy announced by MOF.

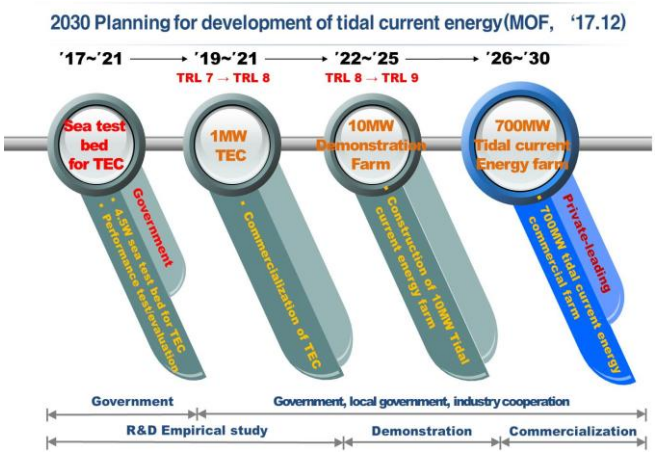

Fig. 3. 2030 planning for development of tidal current energy by MOF

This policy strategy is divided into four stages. The first strategy is the expansion of R&D in ocean energy and establishment of test bed. The second strategy is to construct the large ocean energy farm. A third strategy is to enter the global market and expanding domestic supply. And last strategy is the Establishment of ocean energy certification system and strength of policy support.

Fig. 4. 2030 planning for development of ocean energy

III. K-TEC SEA TEST BED

K-TEC project aims to construct sea test bed for performance test/evaluation of tidal current converters at Jindo coast located in the southwestern sea of Korea. It is divided into three parts(offshore test site, onshore test field and KOLAS testing laboratory accreditation).

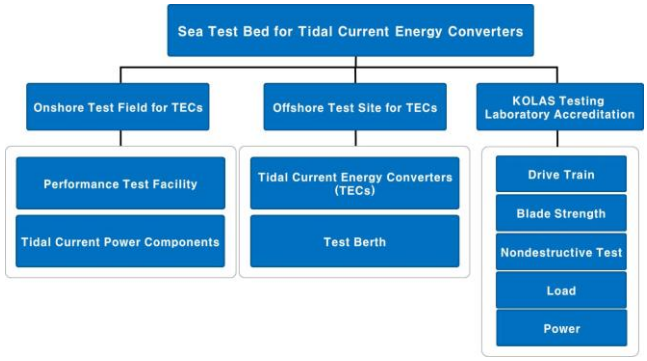

Fig. 5. The 3 tasks diagram of project

The main content of this project is the construction of sea test bed for 4.5MW tidal current converters with the grid connection system. Sea test bed is defined as general term of onshore and offshore test sites where performance test and evaluation of TEC is possible.

A. Offshore test site for TEC

Offshore test site is where submarine cables are connected to enable testing of load and power performance. It consists of

four 1MW test berths and a 0.5MW test berth. Four 1MW test berths will be constructed at Jang-Juk strait and 0.5MW test berth will be constructed at Uldolmok strait. Only submarine cables will be provided at offshore test site and developers have to install the TEC themselves. Jang-Juk strait has more advantages for construction of large-scale tidal current energy farm. Because there are deeper water depth and wider width than the other sites. Fig. 5 shows the location map of sea test bed candidate sites.

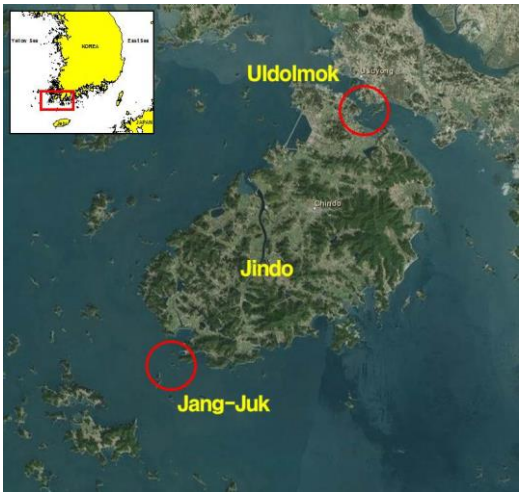

Fig. 5. Location map of sea test bed sites

Meanwhile, we carried out the static field survey using ADCP at 5 locations for 1 month to analysis characteristics of tidal currents. Two instruments had been installed according to the direction of flow at Uldolmok and three instruments had been installed across Jang-Juk strait as shown in Fig. 6.

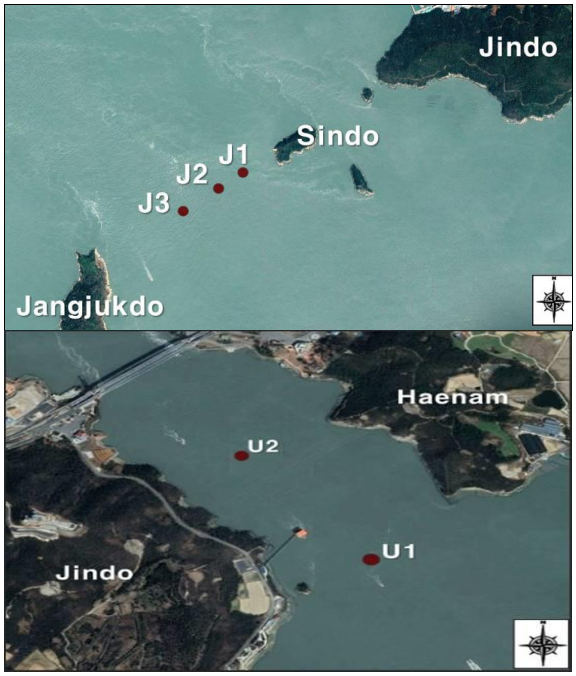

Fig. 6. Survey points at Jang-Juk(top) and Uldolmok(bottom)

The survey results are summarized in Table 1. As a result, water depths of Uldolmok ranged from 20 to 32m below datum level. And the peak tidal current speed rises to over 4 m/s in the ebb tide. The tidal range is up to 4.5m in the spring tides and about 2.5m in the neap tides.

Meanwhile, the peak tidal current speeds of Jang-Juk ranged from 3.34 to 4.22 m/s in the flood tides. And water depths were about 21 to 35 m below datum levels. As a result, all locations were possible to install above 1 MW tidal energy converters.

TABLE 1
CHARACTERISTICS OF TIDAL CURRENT VELOCITY AND DIRECTION

Location		U1	U2	J1	J2	J3
All	Mean (m/s)	1.36	2.00	1.79	1.87	1.50
Flood	Mean velocity (m/s)	1.52	1.69	1.90	1.95	1.51
	Mean direction(°)	299	324	299	304	317
	Maximum velocity (m/s)	2.90	3.26	4.09	4.22	3.34
	Maximum direction (°)	293	321	299	308	324
Ebb	Mean velocity (m/s)	1.22	2.34	1.67	1.79	1.49
	Mean direction(°)	118	151	158	156	154
	Maximum velocity (m/s)	2.52	4.05	3.21	3.57	2.90
	Maximum direction (°)	125	150	156	196	150
Water depth(m)		31.97	20.25	24.24	21.50	34.64

As sea test bed aims to evaluate the power performance, a concept of grid connection had been designed such as Fig. 7.

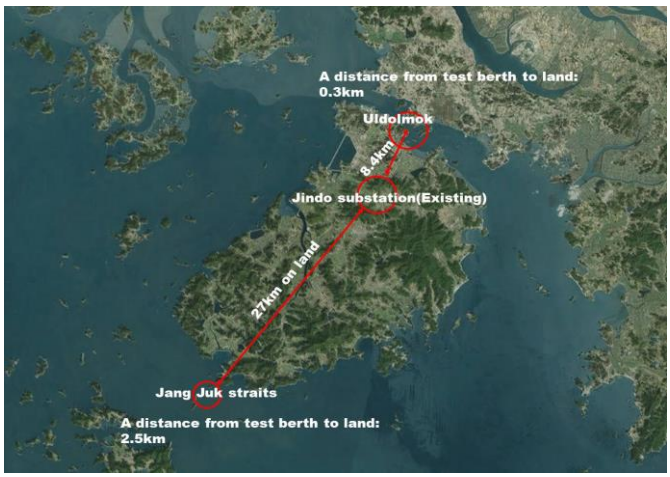

Fig. 7. A concept of grid connection

In case of Jang-Juk strait, a distance from test berth to land was about 2.5 km and a distance to substation was about 27km. Each test berth is connected by submarine cable to an onshore substation. Onshore substation will be installed in close proximity to the landing point of the submarine cables and it can be applied to both Uldolmok and Jang-Juk. In particular, dry-mate connectors will be used to connect between a device and submarine cables. Connection method to substations is currently under consideration and consultation with relevant agencies is under way.

B. Onshore test field for TEC facility

Onshore test field is defined as test filed equipped with performance test facilities for components. And there will be installed the testing facilities for blade strength, drive train and non-destructive test. In addition, K-TEC will be accredited by KOLAS in accordance with the national standards(drive train, blade strength, non-destructive test, load and power performance). A design of the onshore test field is currently under way.

Moreover, KIOST have to establish the infrastructure on technology standardization and try to promote tidal current power industry through this project.

IV. CONCLUSIONS

In this paper, we presented the planning for establishment of sea test bed for tidal current energy converters in Jindo, Korea. This project will establish the sea test bed for a total of 4.5MW tidal current energy converters and test facilities for performance evaluation of tidal current power generation components. The test sites will be located at Jang-Juk and Uldolmok strait, Jindo, Korea.

Meanwhile, marine conditions in both areas are as follows. Uldolmok have around 20~30 m of water depth. The peak tidal flow rises to over 4m/s in the shallow area, reducing towards 2.9m/s at the deepest point. The tidal range is up to 4.5m in the spring tides and around 2.5m in the neap tides. The Jang-Juk strait has tides that peak in the speed range 3.2 to 4.1 m/s on the flood tide and 2.9 to 3.2 m/s on the ebb. The tidal speed reduces moving west from Sindo Island where the water depth increases to 40m.

K-TEC should support the establishment of government policies, and contribute to regional economy activation. Finally, K-TEC would contribute to boost the industrial innovation for the development of tidal current energy.

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