

World-leading

Offshore Wind

Power. Here!

Catch the *Wind* of Fukushima!

Huge offshore floating wind turbines located off the coast of Hirono Town and Naraha Town in Fukushima Prefecture started operation in November 2013.

Various innovative technologies combined with people's passion are working together to create a "symbol of reconstruction."

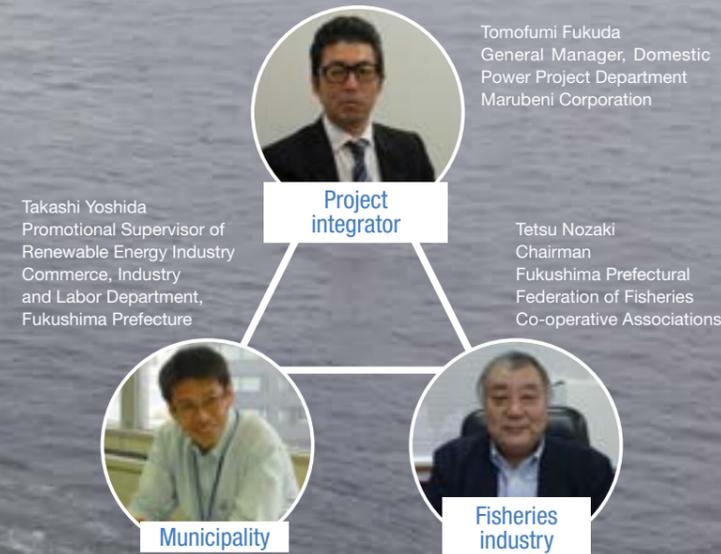
The Japanese archipelago is surrounded by ocean. In order to exert the potential of such abundant resources, there are active movements towards the establishment of offshore wind power generation throughout the country. Among them, a project is ongoing offshore of Hirono Town and Naraha Town, Fukushima Prefecture, namely, the Fukushima Floating Offshore Wind Farm Demonstration Project. In waters about 20km offshore of the coastal area, Fukushima Mirai (Future), which is a floating wind power generating facility with a height of over 100m, and Fukushima Kizuna (Bonds), which is a floating offshore substation equipped with transformer facilities, are now in operation. The most outstanding characteristic of the facility is that they float like ships, as the term "floating" shows, unlike wind farms fixed on the seabed with a substructure. "The world's first demonstration and research project will start in Fukushima:

upon hearing this I was moved to take on the challenge." This is a quotation from Mr. Tomofumi Fukuda of Marubeni Corporation, who presides over the Fukushima Offshore Wind Farm Consortium. The consortium consists of ten of Japan's leading companies in the areas of wind turbines, floating structures and power transmission lines, together with the University of Tokyo. Innovative technology and knowledge are gathered toward the goal to "Make Fukushima the frontier of renewable energy." Not only the development of the floating offshore substation, but connecting the floating wind turbine and substation with a power cable is also a method that cannot be seen in any other project.

Aiming for "coexistence" and exploring the development path

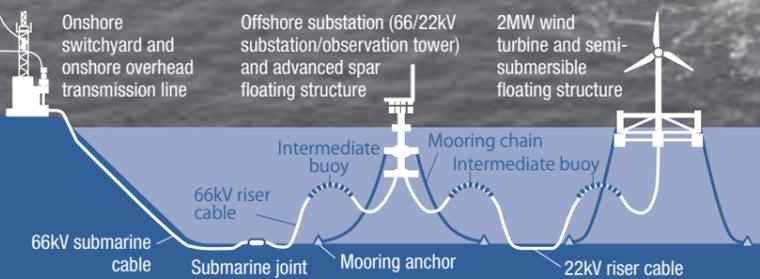
People in Fukushima are also intently watching the development of the new

possibilities of wind power generation. "I expect that it will become a major source of energy in the future," says Mr. Takashi Yoshida, who is the Promotional Supervisor of the Renewable Energy Industry, Commerce, Industry and Labor Department at Fukushima Prefectural Government. "Promotion of the introduction of renewable energy is an important measure of the prefecture. We would also like to exert our utmost efforts to make it truly conducive to the reconstruction of the region, such as promoting industrial clusters and job creation related to wind power generation." And there is another important theme we must not forget. That is "coexistence with the fisheries industry." Mr. Tetsu Nozaki, the Chairman of the Fukushima Prefectural Federation of Fisheries Co-operative Associations says, "People in the fisheries industry also fully recognize the importance of this project. Local industry also has high hopes for the project, and I would like to see the establishment of world-leading efficient and stable renewable energy." On the other hand, there are also problems. What kind of impact the wind power generation facility will have on fishing areas is still unknown. "A system to ensure smooth communication between us and the consortium is being established, such as the foundation of a co-operative committee of fisheries. We would like to seek a way to make mutual development through collaboration, by gathering our ideas."



- CLICK!
- Fukushima Offshore Wind Farm Consortium
 - Marubeni Corporation
 - Fukushima Prefecture renewable energy
 - Fukushima Prefectural Federation of Fisheries Co-operative Associations

Two floating structures are steadily accumulating data!



Fukushima Mirai, the 2MW wind turbine and floating structure, and Fukushima Kizuna, the offshore substation, in waters 20km offshore and where the depth is about 120m.

The Making of the Floating Wind Turbine.

Almost everything was an unprecedented experiment. In addition, nature provides sudden and frequent changes. What kind of problems did the project members face, and how did they get to the point of starting the operation of the two floating structures? We would like to go over the record of their efforts up to now.



The wind turbine was towed all the way from Tokyo Bay to Fukushima by ship.

The moment the long-standing tension among project members slightly relaxed came in October 2013, 19 months after the consortium kicked into gear in March 2012.

"At any rate, everything was so difficult." Mr. Tetsuji Shiroeda of Shimizu Corporation talks openly about what was on his mind, looking back at the project so far.

Toward the Forefront of the Wind Power Industry with a Project that Leads the World

Then, let us review the way the Fukushima Floating Offshore Wind Farm Demonstration Project has been working up to now. First, following the Great East Japan Earthquake in 2011, on December 1, 2011 Fukushima Prefecture submitted the Prioritized Request on the Reconstruction of Fukushima Prefecture to the Local Office of the Headquarters for the Reconstruction from the Great East Japan Earthquake. The request included an initiative for reconstruction using the Fukushima Floating Offshore Wind Farm Demonstration Project as a

stepping stone to further develop the strong points of Fukushima Prefecture, which had previously been making efforts towards the spread of renewable energy.

Responding to the request, on December 22, the national government publicly solicited the company to whom the project is entrusted. Marubeni Corporation, with strong record in offshore wind power generation business abroad, assumed the role as project integrator, with the participation of members such as Shimizu Corporation, Mitsubishi Corporation, Mitsubishi Heavy Industries, Ltd., Japan Marine United Corporation, Mitsui Engineering & Shipbuilding Co., Ltd., Nippon Steel & Sumitomo Metal Corporation, Hitachi, Ltd., Furukawa Electric Co., Ltd., Mizuho Information & Research Institute, Inc., and with the University of Tokyo serving as the technical advisor.

Compared to Europe and other countries, Japan is still largely behind in the area of wind power generation. In addition, because the availability of adequate land sites on the plains

of Japan is diminishing, expectations toward offshore wind power generation are increasing. Particularly, floating structures are at the stage where demonstration and research has started recently in countries such as Norway and Portugal. In all cases, only one offshore wind power generation facility is floating on the water. The Fukushima Floating Offshore Wind Farm Demonstration Project is the first project in the world where two facilities (including a substation) are being floated. Thus, it also offers an occasion for Japan to make a big leap forward and become the world's leader in this area.

Struggling with the Huge Structure both Under and On the Sea!

However, what awaited the members was a series of works to open up a new horizon on an unexplored frontier. In addition to the fact that "everything was so difficult," as mentioned in the beginning, "in fact, seas near Japan tend to have steep waves and swift currents, on top of the frequent arrival

of typhoons. The conditions are severe considering the situation around the world. Since we decided to venture into a floating type project facing such conditions, professionals in the wind power generation sector abroad were surprised, saying 'are you serious?'" explains Mr. Shiroeda.

Against such a background, Japan does not have much experience in offshore construction, even though it is a maritime nation.

This project started with ocean-based research by Shimizu Corporation to consider the planning layout of the floating structures. "Where should we lay out the transmission cable? We studied the geological distribution of the seabed and other factors, and by making adjustments with local people with the help of Marubeni Corporation, selected an appropriate site." In November 2011, a test to pull the anchor and chain set at the actual site was conducted. After all project members felt the positive response that "it should work at this site," the project took a major step forward from the design of the wind power generation facility to its construction.

A joint venture formed with Nippon Steel & Sumikin Engineering Co.,



Mooring of the floating structure of the wind turbine: the work was implemented both on and under the sea while adjusting the angles carefully. The mooring chains weigh as much as 330 tons per chain.



Ltd. was in charge of the towing and mooring the floating wind turbine from Tokyo Bay, and the laying and burying of the submarine cable. Although it is necessary to set an anchor and chain for mooring the floating structure, the wind turbine rises 100m from the sea surface. It is not easy to affix a structure of such size to the seabed. "The chain designed is a huge one, with a diameter of 132mm. We repeatedly had discussions with Mitsui Engineering & Shipbuilding, the company that designed the chain, to consider a secure construction technique. The construction work to moor the floating structure in waters 120m deep with this chain, the largest in Japan, is unprecedented."

In Order to Make the Facility Truly Acceptable to the People

What Mr. Fukuda from Marubeni was prioritizing in this project was "speediness." "I thought that it was important to complete the actual facility at the earliest possible moment and to let people see it turning." However, nature is unpredictable. There were many unexpected incidents, such as the successive occurrence of heavy typhoons this summer.

"Once the work starts, you basically spend the whole period at sea. One worker spent nearly a whole month without returning onshore. It is a cardinal rule that one must do what can be done at that time, by closely watching the weather at the site," says



A cable to connect floating structures that move one another, which was developed by Furukawa Electric Co., Ltd. and VISCAS Corporation, was laid through the joint venture. New achievements were made one after another, such as succeeding in the difficult work of drawing in the cable to the bottom of the floating structure.

Mr. Shiroeda.

Conquering such difficulties, the first period of the construction work, which was until the end of FY2013, was completed. Mr. Shiroeda says, "We reached this point with various kinds of cooperation, such as people in the fisheries industry joining in and providing patrol ships. We believe that it is necessary to securely implement demonstration research, and utilizing the results in subsequent cases will make this facility something that is truly acceptable to the people."

CLICK! Shimizu Corporation



Mr. Tetsuji Shiroeda was engaged in the project as the director of Shimizu/Nippon Steel & Sumikin Engineering Special Construction, a joint venture by Shimizu Corporation and Nippon Steel & Sumikin Engineering Co., Ltd.



Offshore substation

2MW wind turbine and semi-submersible floating structure

How Do the Facilities Resist Severe Conditions?

During the first period of the demonstration research, the world's first 66kV floating offshore substation was constructed by Hitachi, Ltd. The substation differs largely from conventional onshore substations. The facility must maintain its insulating capacity and operability even when the floating structure sways. Remote operation and monitoring for unattended operation will also be necessary. Further, because the substation serves an important role of supplying power to critical facilities for ensuring safety, including lights to avoid maritime collision accidents, high reliability and an emergency backup system in case the facility has a breakdown are necessary. The quality will be ensured from various points of view, by also checking the state of aging degradation through regular demonstration checkups.

CLICK! ● Hitachi, Ltd. Electricity Distribution System

The Wind Turbine Itself is Designed for Offshore Use as Well

The 2MW wind turbine by Hitachi, Ltd., which is a supplier of downwind type wind turbines, was improved for the project. In addition to the design to increase the strength of the tower, devices such as a gear box and hydraulic unit were also designed to work on the oscillating floating structure. Further, because the supporting structure is floating, and not fixed like onshore or seabed-affixed facilities, movement caused by the turning of the turbine itself must also be restrained.

CLICK! ● Hitachi, Ltd. Wind Power Generation System

Protecting the Wind Turbine from Motion and the Elements!

A compact semi-submersible floating structure requires design and analysis capabilities to estimate the behavior of the facility in marine environments, and to minimize the inclination and oscillation caused by waves, winds and currents. Deep consideration was made based on the technology developed by Mitsui Engineering & Shipbuilding Co., Ltd., through the designing and construction of offshore oil and gas floating structures. In order to verify the validity of the design methodology, various sensors were installed on the floating structure and the wind turbine, and monitoring will continue for two and a half years. This is expected to provide valuable data and knowledge.

CLICK! ● Mitsui Engineering & Shipbuilding Co., Ltd. Social infrastructure

Harnessing Expertise !

Technology Leading the Way to a New Era of Power Generation

The project will enter the main stage from FY2014, which will be an important step towards the realization of a large-sized offshore floating wind farm in the future, such as the addition of a 7MW wind turbine, which is one of the largest in the world. Know-how and knowledge are pouring in from experts in various fields in order to overcome technical challenges one by one.



The World's Trend is Offshore Wind Power: Japan is Striding Forward!

Large growth of the wind power generation market is continuously expected worldwide in the future. Japanese companies also have a favorable opportunity for exploring new businesses.

Competition to develop the offshore wind power generation market is heating up globally. Wind turbines are put into practical use mainly in European countries such as the UK and Denmark. For example, the introduction amount for a single year used to be about 50,000 kW in 2001, but increased rapidly to about 890,000 kW by 2011. Under such a trend, Japanese companies are also stepping forward. Mitsubishi Heavy Industries, Ltd., Japan's leading company in the construction of wind turbines, made an agreement with Vestas Wind Systems A/S (Denmark), a world-leading wind power generator manufacturer, on the establishment of a joint corporation. "In order to survive global competition, it is important to utilize power from outside, in addition to the company's

original technology development, also from the perspective of cost and efficiency. It is essential to find a company that can serve as a strong partner over an extensive scope of needs, including sales, manufacturing and service. What we consider as a top priority is to supply an economically reasonable and reliable wind turbine that can contribute in the spread of offshore wind power generation to the market. The recent partnership is a part of efforts to realize such a goal." (Mitsubishi Heavy Industries, Ltd.) Developing the wind power generation technology made in Japan into an important industry in the world; the challenge has already started.

↓ The current mainstream offshore wind power generation technology is based on types that are attached to the seabed. While the construction of large-sized wind farms is being planned in Europe, the U.S. is also setting a goal of introducing 54GW by 2030. Wind power generation is attracting attention more and more in various different places.

CLICK! ● Mitsubishi Heavy Industries, Ltd. Wind power generation plant

Transition of the introduction amount of offshore wind power generation throughout the world

