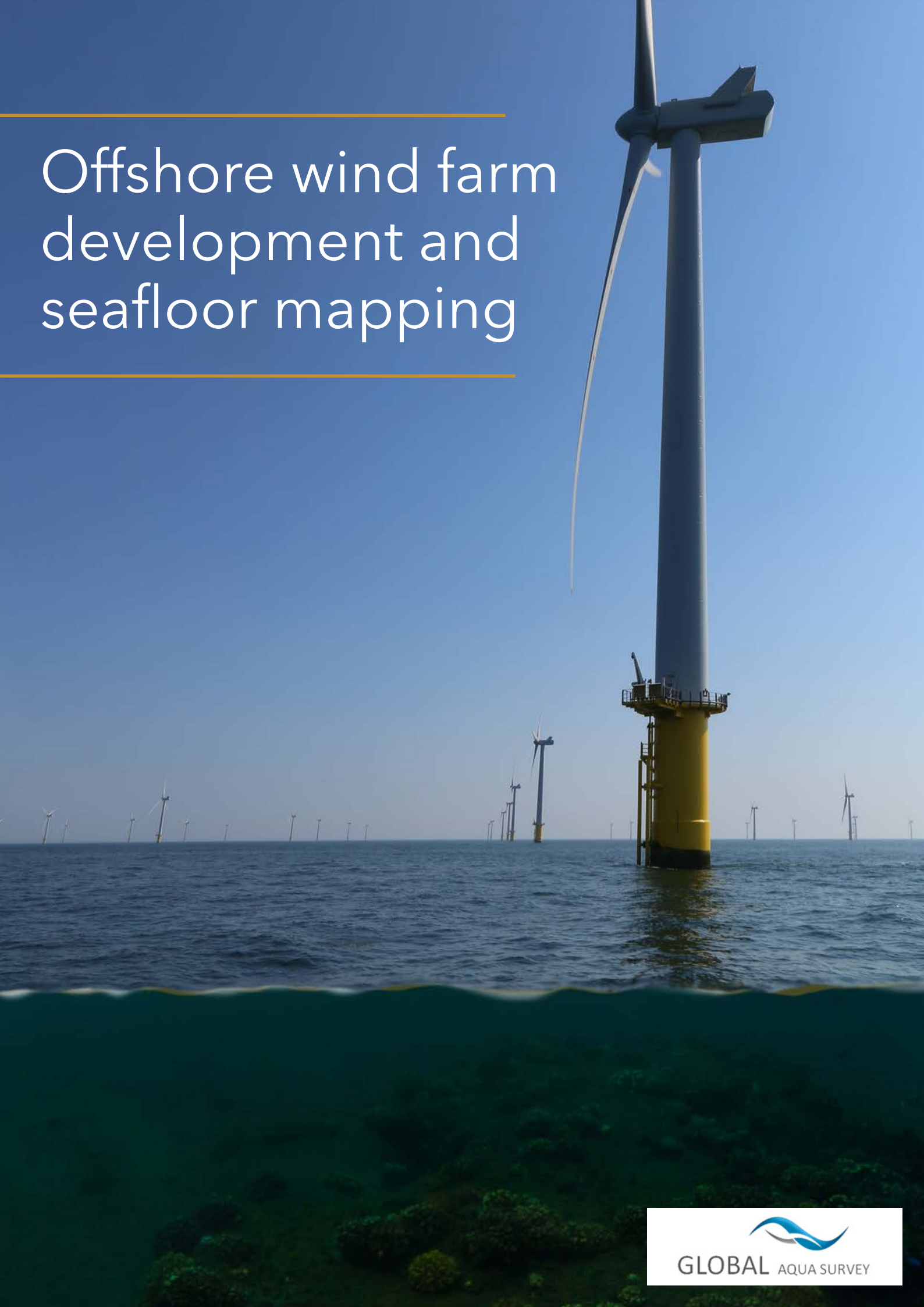
Offshore wind farm development and seafloor mapping



GLOBAL AQUA SURVEY

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In this probing piece of analysis, Global Aqua Survey share their expertise on offshore wind farm development and seafloor mapping

Wind power generation is a new energy source for environmental protection, developed by humans.

Offshore wind has evolved into the most efficient, green, energy for nearly a decade. This is due to the development of marine science and technology, also because of the more efficient wind conditions in the sea.

Another reason for the rapid development of skilled marine exploration is due to the available possibilities of offshore wind power, in addition to the refinement of modern maritime engineering technology. The techniques relative to this are divided into the following:

1. Environmental background survey of sea area

To collect background survey data, this has been carried out in addition to the basic parameters for the wind farm's turbine foundation design. This survey will also reduce the impact, in terms of an environmental assessment. The basic data is reported as the following:

A) Bathymetrical or morphological data

This data is collected using the 'multibeam beam echo sounder.' The echo sounder can provide very high-resolution and accurate terrain data at a water depth of less than 50m where the wind farm turbine foundation is located. The density of the data can be distributed across the seabed at intervals of each meter, which can then be used to produce very detailed underwater topographical maps. On these topographical maps, we can see the relief of the terrain, bottom marks, sand ripple or a series of sand waves and even the wreckage of the heavy ship that sank on the seafloor.

B) Sediment type and distribution data

On the vast seabed surface, we can use sonar systems, such as side-scan sonars to observe or analyse the sediment or seabed property. With the exception of determining the seabed is covered by muds, sands, gravels, rocks, biological or non-biological reef, we can also define the extent of where they are located in the ocean. Then, we can use a towed camera or remote underwater vehicle to understand the ecosystem of the seafloor to prevent improper engineering behaviour from unduly damaging the marine ecology.

C) Geological data

In order to investigate sediment property, such as its grain size and composition, as well as the substrate condition, the survey uses Sub-Bottom Profiler (SBP) and other types of sound sources to explore further. Firstly, in understanding the physical properties of layered sediments on the seafloor, we can use this data as a parameter to the construction noise propagation model to calculate the sound level of noise in the water caused by construction. This can prevent hearing damage to marine mammals, such as whales and dolphins. Secondly, by understanding the structural condition inside the seabed, we can also use this data to explore if there are mud volcanoes, methane gas, or active faults, to prevent construction damage from these risks.

D) Underwater topographic change data

The need for environmental protection and engineering construction, coupled with the

M/V Aquarius, Built in 2019, 62-foot survey vessel owned by Global Aqua Survey Limited. Equipped with multibeam echo sounders, subbottom profiler, USBL positioning system, A-Frame and 2000m cable winch.

increasing sophistication of modern bathymetric and positioning techniques, means that the following two types of data must be analysed;

1. Coastal change data: Taiwan's government wants to see if wind farm development behaviour within three nautical miles of the shore's territorial waters will affect shoreline changes in the future, using results from the construction block off of sand transportation under longshore and rip currents.

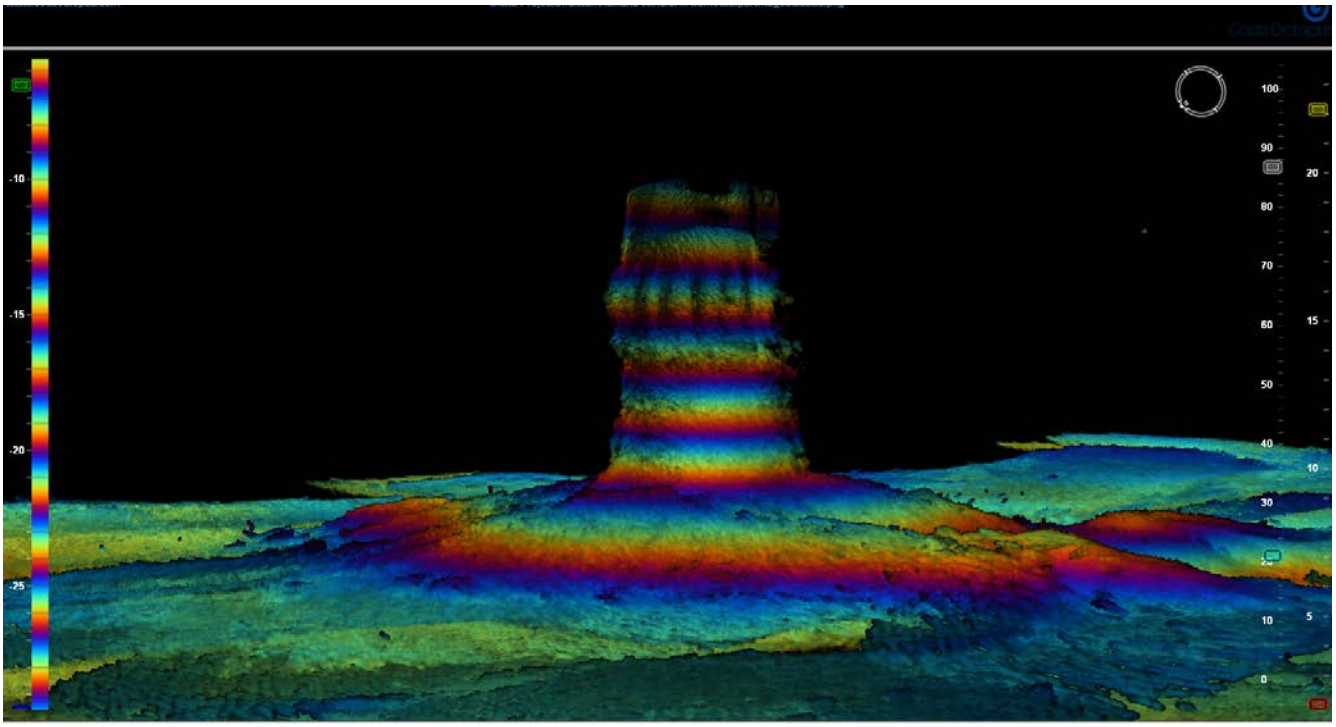
2. Sand waves' migration: There are very large undersea sand waves in the wind farm areas in Taiwan Strait or the offshore coastal line. These sand waves are more than 10m high and more than several hundred meters in length. Therefore, if we do not understand the patterns of these sand waves and the speed and direction of movement, the electric cables on the seabed would be exposed. This would be due to sand wave motions, which may lead to cables being detached or vulnerable to fishery activities.

Obtaining the above data requires the long-term collection of accurate bathymetric data and topographic measurements in intertidal zones. Since the wind power investment business will spend money for wind farm development, the outcome is increasingly important for academic research and to further plan the national coast protection strategy.

2. Underwater cultural heritage investigation

In order to protect underwater cultural heritage, the Taiwanese government should conduct a review of any underwater development behavior. Therefore, the method of heritage investigation operation should be decided by the professional team who will conduct the investigation and submit a report to be reviewed. These legacies include flooded ancient buildings, ancient shipwrecks and machines with some objects of cultural value.

The government has set strict norms in the way it investigates and forces the use of complete



3D underwater view using sonar data acquired by 3D multibeam imaging sounder the Coda Echoscope, it shows a wind turbine foundation that stands on 20m deep sea floor offshore of the Hsinchu coast, Taiwan

instruments, such as the multibeam echo sounder, side-scan sonar, marine magnetometers and sub-bottom profiler, for all area searching and exploration. The government also expects the survey team to use a camera or remote vehicle to document pictures of the targets for their records.

As a result, larger areas of offshore wind farm development, the government has data on underwater cultural assets that were not previously available. This data indicated what the unnatural man-made waste is on the seabed and the location submarine pipeline and cable, artificial reef distribution maps, etc. Such data is of great significance to the planning of national territory and protection of cultural heritage for the nation.

3. Preconstruction survey

The Engineering Consultant Company intends to determine sites to locate wind turbine foundations according to seabed conditions and substrate situation when the permission is granted by the Environmental Impact Assessment Committee. After then, the following tasks shall be adhered to:

A) Geotechnical Drilling:

This is a process of conducting soil samples or other physical properties at a presumed foundation site, where a wellbore is drilled below the seabed. There are two types of drilling; Seafloor Based Drilling (SBD) or Surface Drilling (SD), respectively. The SBD uses remotely operated seabed drilling system to get a soil sample and in-site test data, (such as cone resistance value, pore pressure and shear strength etc.). For example, Fugro's Seafloor Drills can obtain 73mm a coring sample in a variety of different materials to a depth up to 150m below the seabed, several thousand meters deep within the ocean.

For geotechnical drilling in Taiwan wind farms, the SD has been conducting. The SD needs to pull the pipe reaching to the sea bottom from a drilling vessel. Some of the project used drilling DP vessels (DP means a vessel positioned using dynamic positioning system to maintain at the same location during drilling) to operate but failed to obtain high-quality samples due to hard

materials (like a pebble layer) in the substrate at certain locations. Under this circumstance, A Jackup Drilling Ring or Jackup Platform was activated instead. It is a bottom founded drilling rig or floating platform which can stand on the seabed by its legs at water depth less than 60m.

By obtaining this geotechnical data of the substrate, we can see where the turbine foundation will go. The final decision for turbine construction will be made according to that.

B) Cable route survey:

This is cables coming out from wind turbines and spread throughout the seabed, then linked ashore. These cables will be covered by a sand layer and located in the area without disturbing the motion of sand waves. This is why the route survey will happen.

Along a designed cable route corridor, multibeam sounding and side-scan sonar investigation are the first set of data which shall be obtained, to make sure the cable can choose a route inside a survey corridor with the best knowledge. A high-resolution chirp profiler will be used to make sure the cable lies flat on the seabed with a soft underside so that the cable can be covered by soil.

Once the cable route is determined, the final stage is conducting the geotechnical survey at chosen locations along the route to validate results from the geophysical or sonar data. Two procedures can be followed:

1. Coring or vibracoring: It uses a steel pipe with its inside containing a plastic tube with a nominal diameter ranging from 2"~4". The head carries a weight that can freely fall into the soil on the seabed. However, when the soil is harder to pierce by weight, a power vibrated head is attached to allow coring through thicker coarse-grain sediment layer, obtaining a core sample up to 6m-10m in length.
2. Cone Penetration Test (CPT): An easier way than using the coring method to find out the sea bottom condition for cable laying is the CPT survey. This is used to determine the geotechnical engineering properties of soils and delineating soil stratigraphy. The instrument pushes a cone with its tip around 4cm in diameter into the soil layer at a controlled rate. During the penetration, it can record how much the sediments respond with different degree of resistance until the cone reaches a hard layer.

C) Unexploded Ordnance survey (UXO)

For maritime construction, such as offshore wind farm, penetration works on the seabed are needed, such as Jackup drilling, trenching along the cable route, or turbine foundation penetration. A desk study shall be done to make sure the work site is clean from the bombs during the War or in the area of military training grounds.

During World War II, the island of Taiwan was a Japanese military stronghold in the Western Pacific. Many of the Japanese forces participating in the Aerial Battle of Taiwan-Okinawa were based in Taiwan. Importantly, Japanese military bases and industrial centres throughout Taiwan were targets of heavy American bombing. Therefore, it is assumed that the smallest relevant UXO item is to be inspected in the many coastal areas where offshore wind farms are located. Theoretical studies indicate, for instance, a 250 lbs bomb with a ferromagnetic content of approximately 50 kg shall be offshore near Taoyuan City.

The UXO survey shall be done by means of deploying a ScanFish KATRIA ROTV (Remotely Operating Towed Vehicle) or a Geometrics TVG (Transverse Gradiometer), which is fitted with an array of G882 marine magnetometers. There is a relationship between the observed total Field Anomaly for a few common types of UXO. With

a magnetometer, it owns a detection limit of around 2-3nT for ferrous objects. For 155mm artillery shells, it is detectable with sensor to UXO distances of up to 4-5m; 100 lbs bombs with a sensor to object distance of up to 5-6m. When flight altitude of the ScanFish or single tow G882 is 4m, this corresponds to maximal burial depths of e.g. 1-2m for 100 lbs aerial bombs; this also corresponds to maximal burial depths of 4-6m for 500 lbs aerial bombs.

In order to detect UXO within maximal detection range below the seabed, the magnetometer array is fitted with an altimeter and depth sensor, which allows an active flight control of the ROTV or TVG with a limited flight altitude of 4m above the seabed. Spacing between navigation tracks will be kept to less than 7 ~ 8m, ensuring a high-resolution data coverage with a line spacing ~2m between individual magnetometer tracks. A fixed and limited distance between sensor and seafloor (for objects like UXO and archaeological remains) is of paramount interest to obtain a good quality magnetometer dataset. In such a situation, underwater positioning is also necessary to accurately position the sensor just above the seafloor.

Therefore, it is necessary to have enough seabed exploration technology to support the development of offshore wind power, but the investigation of such a sophisticated seabed in the territorial waters will be restricted by the law on the protection of Nation's secrets. In addition to restricting the operation of high-end sonar equipment in the national territorial waters, the law also limits the data from being taken out of the country.

As a Marine surveying company in leading in Taiwan area, Global Aqua Survey Ltd. (GAS) has been involved in a very large number of seabed mapping surveys in the course of offshore wind power development. Although, in the past, before the offshore wind farm project commenced, in addition to the academic community in Taiwan, there are no qualified survey vessels. GAS has been in the process of engaging with some European developers, in addition to learning how to improve the skill of measurement operations but also learn how to operate in a more safe, healthy environment by building its own survey vessel in this event.

To increase the size of the company acting as an internationally trusted survey company, GAS and many international survey companies signed MOUs (Memorandum of Understanding) for cooperation. Those include Gardline based in the UK, Neptune Marine Service based in Austria, Geolantic based in Malaysia. The development of the offshore wind farm has been subject to a lot of criticism throughout the pain in the period. However, this project has injected new life into Taiwan's marine survey community, which is to be expected.

Gwo-shyh Song
Associate Professor
National Taiwan University
Tel: +886 (0)930 053 046
Gwoshyh007@gmail.com & songs@ntu.edu.tw
www.oc.ntu.edu.tw/oceng/?page_id=24

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