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An overview of Taiwan's offshore wind turbine and components testing and certification capacity and current situation

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Abstract

Due to the high manufacturing and maintenance costs, the quality of the turbine is an important factor in wind farm operations. Offshore wind farms have been in operation for years in Europe, and wind turbine supply chains and the testing and certification mechanisms have formed. As the manufacturing of offshore wind turbine components has become a globally competitive business, the testing and certification of turbines and their components have become a key factor in turbine quality. Testing and certification is also an important quality control mechanism for turbine manufacturers in their supply chain management. The rapid development of Taiwan's offshore wind power industry has created a need for better quality control. This paper will give an overview of testing and certification mechanisms for offshore wind turbines and components, and the overview of Taiwan's offshore wind policy current situation, giving recommendations for Taiwan in building its own testing and certification capacity.

Keywords: offshore wind power, testing, certification, directions for allocating installed capacity of offshore wind potential zones

1. Introduction

Offshore wind power has emerged as an important option for developing new renewable power sources as the onshore wind market became saturated. More than 20 years after the first offshore wind farms were developed and began operations in the 1990s. Many European countries have established mature models for controlling risk and ensuring continuous operations. Testing and certification is one part of these models. The main source of revenue for offshore wind farms is selling electric power, so ensuring stable long-term generation is an important priority. Offshore wind turbines are an important power-generating asset for any wind farm, and the costs of manufacturing and maintaining the turbines are high. Quality control for wind turbines must start early in the planning process in order to lower the risks of future breakdowns. European wind farm operators must ensure that their turbines go through quality audit procedures, including type testing and type certification, in order to obtain project financing and insurance and to comply with domestic laws [1]. Wind turbine manufacturers also ensure that their components are certified as part of their supply chain management. Taiwan's policymakers are planning 12 offshore wind development projects to be completed between 2020 and 2025, with a total installed capacity of 5.5GW. With some turbine component manufacturers planning new plants in Taiwan, demand for quality control services is expected to rise.

2. An Overview of Testing and Certification for Offshore Wind Turbines

Testing and certification are activities that fall under the umbrella of conformity assessment

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procedures. According to the ISO/IEC 17000 Conformity Assessment, the related activity includes testing, inspection, certification and accreditation, and conforming subject is different between these activities (Table 1). The ISO/IEC 17000 standard defined testing as the “determination of one or more characteristics of an object of conformity assessment, according to a procedure” and certification as the issuing of a statement by a third party, based on a review, that an object’s process or characteristics conform with specified laws or standards [2]. As the offshore wind turbine can be categorized as industrial product, important test items for whole turbines include power generation performance and adaptability to offshore environments. The certification of wind turbine includes the auditing of design, environmental, and power generation parameters, and the inspection of manufacturing plants [3][4]. Various characteristics of the turbine under assessment are strictly reviewed, with a final statement issued certifying that the turbine conforms by the specified requirements. Additionally, all wind turbine models are considered distinct from one another. Retesting or additional testing, and the issuing of an updated certification statement are required, once any part of a turbine’s design is changed [5].

Table 1. Identification of testing, certification, inspection and accreditation

Activities	Objective	Identification
testing	product, procedure or services	determination of one or more characteristics of an object of conformity assessment, according to a procedure
certification	product, procedure or services	third-party attestation related to products, processes, systems or persons
inspection	product, procedure or services	examination of a product design, product, process or installation and determination of its conformity with specific requirements or, on the basis of professional judgement, with general requirements
accreditation	conformity assessment service institute (e.g. certification institute and laboratory)	third party attestation related to a conformity assessment body conveying a formal demonstration of its competence to carry out specific conformity assessment tasks

Source: [2].

In Taiwan, there has a potential demand of testing and certification for wind turbine components, because of the offshore wind power policy recently. In terms of building Taiwan’s testing and certification capacity, most components that require adherence to European standards can be tested and certified by international providers. For localizing testing and certification, Taiwan’s history of exports adhering to US or Japanese standards can be leveraged to build capacity for testing and certification services. Domestic organizations with the potential to develop offshore wind-related testing and certification capacities include the Metal Industries Research and Development Centre (MIRDC), the Taiwan Electric Research and Testing Centre (TERTEC), the Taiwan Electronics Testing Centre (ETC), and the CR Classification Centre (CR). The aforementioned organizations are currently building up the software and hardware infrastructure as well as training technical personnel for offshore wind power testing and certification activities. They are also signing technical cooperation and mutual recognition agreements with international testing and certification organization.

As mentioned above, Taiwan’s testing and certification demand is result from the policy. While the offshore wind industry in Taiwan is now on development, the trend of related policy followed the market and has a strong impact on Taiwan’s offshore wind industry. The following article is going to introduce the current state of Taiwan’s offshore wind policy and industry.

3. The Current State of Taiwan’s Offshore Wind Policy and Industry

Taiwan has rich potential for offshore wind power generation. To promote the development of this industry, the Executive Yuan approved the “Thousand Wind Turbines Program” in 2012, and the Ministry of Economic Affairs (MOEA) began the “Four-Year Plan of Promotion for Wind Power” in 2016. The government aims to complete the development of 520 MW of installed capacity in shallow offshore wind farms by 2020, and to reach the goal of 3GW of installed capacity in offshore wind by

2025. As for completed projects, the preparatory office for the Formosa I Wind Power Company has completed the construction of two 4MW offshore wind turbines in its Formosa I pilot wind farm, in accordance with the MOEA's Regulations for "Offshore Wind Power Demonstration Incentive Program" in 2012. This pilot project is an important milestone for Taiwan's offshore wind power development [6].

Taiwan is now actively pursuing the development of high-potential offshore wind power sites. The Bureau of Energy (BOE) announced "Directions of Zone Application for Planning (ZAP)" in 2015. By analyzing the water depth, wind speed, and the regulation limited of each zone, ZAP selected 36 high-potential sites for wind farm application, while the non-potential sites still can be applied as long as the application abided by several regulations additionally. In February 2018, 18 high-potential sites and 2 non-high-potential sites have passed environmental impact assessments (EIA). In March 2018, developers submitted grid connection capacity application for the 18 sites. The government announced the selection results on April 30, 2018, and seven developers, including both domestic and international companies, were awarded a total of 3,836 MW of grid connection capacity, to be completed between 2020 and 2025 [7]. Furthermore, there are 4 cases of project won the tender of ZAP phase for auction period, with total capacity 1,664MW in June 2018. In Conclusion, in the ZAP's schedule, totally 5,500MW (5.5GW) capacities will be built during 2020 to 2025 [8].

In consideration of policy requirements and O&M supply chains, projects that were awarded grid connections between 2021 and 2025 must make local procurement commitments for certain offshore wind turbine components, as specified in the Industrial Development Bureau's (IDB) "Offshore Wind Energy Industry Policy" [9]. The "Offshore Wind Energy Industry Policy" is expected to drive the development of local procurement markets for certain components, creating a market demand for certification. The authors of this paper have undertaken a preliminary study of Taiwan's domestic industry. The following is a brief overview and future recommendations regarding the current state of Taiwan's domestic components industry and domestic testing services and the localization of requirements.

3.1. An overview of related industry action plans

To ensure that power generated by offshore wind farms can be fed into Taiwan Power Company's (TPC) grid system and to build the localized supply chain, the BOE and IDB issued the "Directions for Allocating Installed Capacity of Offshore Wind Potential Zones" and the "Offshore Wind Energy Industry Policy" respectively. The documents require that developers who were awarded grid connections between 2021 and 2025 must make local procurement commitments for certain offshore wind turbine components. The projects' grid connection rules and mandatory commitments are as Table 2.

Table 2. Schedule and rules for selection and tendering period of offshore wind potential sites installed capacity application.

Period	**Selection Period**		**Auction Period**
Year	2020	2021-2025	2025
Rules	● Planned Capacity: 0.5GW ● Selection Criteria: construction and grid connection before 2020	● Planned Capacity: 3GW ● Selection Criteria: local content of industrial production, technical ability, environmental protection and financial ability	● Planned Capacity: 2GW ● Auction Criteria: price
Scoring Criteria	● Technical capabilities (60%): Divided into construction (25%), engineering design (20%), operation and maintenance planning (15%). ● Financial capabilities (40%): Divided into financial soundness (30%), associations with domestic financial institutions (10%).		● The project with the lowest tender price could win the bidding

Notes:

1. Developers have to make a localization commitment to get the power plant set up permit. If the developer cannot meet its commitments, the government will reduce its FiT or expropriate its 3% guarantee money. Furthermore, if the developer doesn't improve significantly in three months, it will lose its qualification for wind farm development.
2. The developers who get the grid connection before 2022 should make a localization commitment in 2018.

3. The localization commitment should refer to the IDB "Offshore Wind Energy Industry Policy", and the further information is in Table 3.

Source: [10].

Table 2 shows that a total of 5.5 GW of TPC grid connection capacities can be allocated between 2020 and 2025. A further breakdown of the timeline shows that 0.5 GW is allocated to projects that can be completed by 2020, which are not required to make local procurement commitments. 3 GW are allocated to projects to be completed and connected between 2021 and 2025. The developers for these projects must submit related industry action plans on their local procurement of construction services and components. Projects to be connected after 2025 will be awarded grid capacity through an auction process. Project developers have now begun planning their procurement strategies and investigating supply chains, so that they will be eligible for connection to the TPC grid. The award process for the bid took into account the comprehensiveness, feasibility, and appropriateness of the site plan, as well as the supporting evidence given.

The IDB also conducted a survey of domestic manufacturers on their willingness to produce turbine components. The IDB's Industry Plan includes development plans for the offshore wind turbine components industry between 2021 and 2025. Projects awarded grid connections in 2021 and 2022 must submit their related industry action plans, supporting documents, and a letter of opinion from the IDB by December 31, 2018. Projects awarded grid connections in 2024 and 2025 should submit the three documents by December 31, 2018. The detailed list of projects which were required to submit the plans, and the components specified for local procurement, are as Table 3 below.

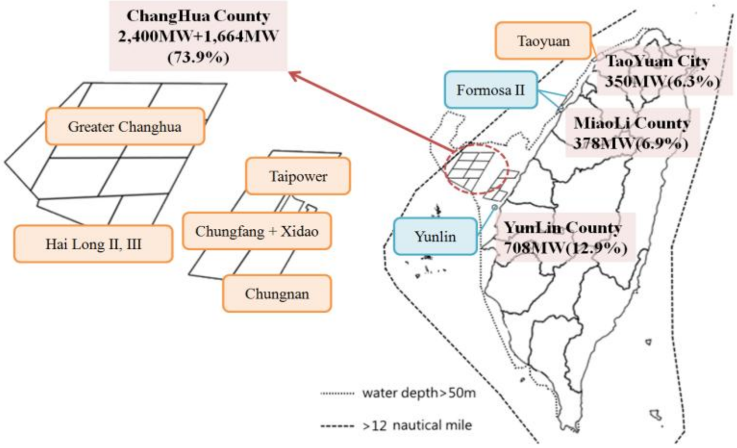
Table 3. 2021 to 2025 grid-connected plan and IDB localization requirements

Grid Connection Period	**2021-2022 Pre-stage**	**2023 Phase 1**	**2024-2025 Phase 2**
Localization Requirements: Components	• Tower • Foundation • Onshore electric equipment (transformer, switchgear, distribution panel)	• Pre-stage items • Wind Turbine Components: Rotor Nacelle Assembly, Transformer, Distribution panel, Uninterruptible Power Supply, Spinner, Cable, Rotor Hub, Bolts • Submarine High Voltage Cable	• Pre-stage items • Phase 1 items • Wind Turbine Components: Gearbox, Generator, Power Converters, Rotor Blade &Epoxy Resin, Nacelle Cover, Nacelle Bed Frame/Plate
Localization Requirements: Marine Engineering	Marine Engineering planning, design, construction, supervision and manufacturing: • Construction and supervision of investigation, cable laying, exploration, etc. Ship and machine tool planning design and safety management. • Ship Building：Provide the construction ship industry supply chain for new ships or ship restoration (including the ships for investigation, support, seabed preparation, transportation and cable laying.)	Marine Engineering planning, design, construction, supervision and manufacturing: • Construction and supervision of tower, foundation, etc. Ship and machine planning design and safety management. • Ship Building：Provide the construction ship industry supply chain for new ships or ship restoration (including the ships for transportation)	Marine Engineering planning, design, construction, supervision, and manufacturing ： Construction and supervision of wind turbines and others. Ship and machine tool planning design and safety management.
Wind farm	• Taoyuan、Yunlin (wpd) • Greater Changhua South East 、 Greater Changhua South West (Ørsted) • Chungfang (CIP)100MW	Chungfang(CIP)452MW	• Chungnan (CSC) • Xidao (CIP) • Taipower (TPC) • Hai Long II (NPI & Yushan & Mitsui)
Total Grid-connected Capacity	1,698MW	452MW	948MW

Source: [7] [11].

3.2. An overview of developing project and the recent problem

After the selection and auction process of "Directions for Allocating Installed Capacity of Offshore Wind Potential Zones", the programming capacity 5.5GW has been completely allocated. Most of the capacity centralized in ChangHua County, the southeast part of Taiwan. The other capacities separated in TaoYuan City, MiaoLi County and YunLin County, about 26.1% of total capacity (Fig. 1).



Sources:[7] [8] [12]

Fig. 1. Taiwan's local capacity and offshore wind project distribution in ZAP phase

In addition, the total capacity belongs to 10 different developers, and the committed grid connection year separated from 2021 to 2025 (Table 4). By observing the capacity allocation, we can find that most of the project has to construct in different years, and most of the grid-connected capacity will be built in 2021(1,698MW), 2024(948MW) and 2025(1,664MW).

From the above, it can be seen that local component procurement will come from the related industry action plans in the short term. However, much remains unclear about these action plans for both developers and domestic manufacturers. Related industry action plans will be reviewed by a group formed by the IDB. However, the review criteria (such as what constitutes local procurement and what evidence for local procurement is necessary, and other restrictions) remain unclear. Before specific details become available, developers can only keep their options open regarding their procurement strategies, making procurement decisions only after the concrete implementation details are announced. This has indirectly created a lack of clarity regarding the domestic market and the testing and certification market, as the specific testing and certification needs remain unidentified. It can be foreseen that, once the details become available, there will be a significant effect on Taiwan's offshore wind power industry and testing and certification needs.

Table 4. Allocated projects and the developers in Taiwan ZAP phase

Developer	**Project**		**Type**	**Committed grid connection year**	**Capacity Allocation (MW)**	**Notes**
wpd	Yunlin		Selection	2020	360	No local content requirement
				2021	348	-
	Taoyuan			2021	350	
Swancor & Macquarie	Formosa II		Selection	2021	378	No local content requirement
Ørsted	Greater Changhua	South East	Selection	2021	605.2	-
		South West			294.8	-
		South West(2)	Auction	2025	337.1	Tender price: NTD$2.5480/kwh
		North West			582.9	Tender price: NTD$2.5481/kwh

CIP	Chungfang	Selection	2021	100	-
	Chungfang(2)		2023	452	
	Xidao		2024	48	
NPI & Yusan & Mitsui	Hai Long II	Selection	2024	300	-
	Hai Long II(2)	Auction	2025	232	Tender price: NTD$2.2245/kwh
	Hai Long III	Auction	2025	512	Tender price: NTD$2.5025/kwh
CSC & CIP	Chungnan	Selection	2024	300	-
TPC	Taipower	Selection	2024	300	-

Sources: [12] [13]

4. Conclusion and Future Study

As stated above, testing and certification requirements for turbines and components are an important part of quality management during procurement. For components, international standards are only the first step in entering manufacturer supply chains. Local requirements are considered as the minimum acceptable standard for the region, so offshore wind developers usually use local requirements to judge whether a vendor is an appropriate choice for the locality. Taiwan needs to formulate its own local requirement of standards, but these standards should be professionally approved and consider the following issues:

- Applicability: Whether the requirements are truly appropriate for the local environment.
- Market acceptance: Whether the requirements will be accepted by domestic manufacturers, turbine manufacturers, and project developers.
- Compatibility with international standards: Judging by the current trends for offshore wind, offshore wind turbines and components will become an internationally competitive market. Local requirements therefore need a certain degree of compatibility with international standards to help expand the market for domestic manufacturers.

For the future study, the Taiwan's testing and certification demand and the related standard have the research potential. We expected that the policy change or policy update will change Taiwan's domestic offshore wind testing and certification market. Furthermore, due to the special climate and geological condition, the localized testing and certification standard have the potential requirement [14]. For the foreign developers, the localized standard is the least acceptable criterion for the products or the wind farm design. It can be expected that the demand for the standards about special climate condition (e.g. typhoon, seismic) will increase during the 2020 to 2025.

Throughout development of the international offshore wind, companies have aimed to ensure that the quality of turbines and components fit the demands of the environment, and that turbines will be able to operate for 20 years. To that end, the testing and certification of offshore wind turbines and components has become an industry norm. From the grid connection awarding criteria set out by the BOE and IDB for prospective offshore wind developers, it can be foreseen that the need for offshore wind component testing and certification will grow in Taiwan. Domestic component suppliers are still reluctant to jump in on the offshore wind market, but with supporting measures such as lower rents for land or other subsidies, companies can be incentivized to start work on testing and certification equipment. This will lower costs for testing centers in Taiwan as they purchase equipment. As clearer details emerge on the related industry action plans, the market will also develop further. The establishment of local requirements will also encourage international offshore wind turbine system companies to use local testing and certification providers when they enter the Taiwan market. This will also be an opportunity to train professionals to build future project O&M capacity. Put simply, testing and certification not only provides a guide to industrial upgrading, it can be a guide to procurement for companies and help facilitate the development of the industry. It is hoped that the government, testing and certification centers, and the industry will all work together to drive forward the development of Taiwan's offshore wind industry and increase green energy use.

Conflict of Interest

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Author Contributions

Author Wan-Hua Liao, Hsiao-Chi Lin and Ting-Hao Kuo contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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References

[1] Wu CC, Chen LK, Chiu SY, Feng TW. A study of foundation design standard and localization of geotechnical parameters for offshore wind farm. In: *Proc. of the 37th Ocean Engineering Conference in Taiwan*; 2015: 709-714.

[2] International Organization for Standardization (ISO). *ISO/IEC 17000:2004 Conformity Assessment-Vocabulary and General Principles*. 1st ed. London: ISO; 2004.

[3] International Electrotechnical Commission (IEC). *IEC 61400-22:2010 Wind Turbines - Part 22: Conformity Testing and Certification*. 1st ed. London: IEC; 2010.

[4] CR Classification Society. *Rules for the Certification of Offshore Wind Farms 2016*. 1st ed. Taipei: CR Classification Society; 2016.

[5] Twidell J, Gaudiosi G. *Offshore Wind Power(Taiwanese Chinese).* 1st ed. Taipei: Multi-science Publishing/SHY MAU; 2010.

[6] Lu SD, Ho WC, Lu WH, Hu CK, Chen ML, Lien YS. A research on the potential energy of offshore wind power and preferable offshore blocks in Taiwan. Presented at: 2015 The 36th Symposium on Electrical Power Engineering.

[7] Offshorewind.biz . (April 2018). Taiwan selects eleven offshore wind projects. [Online]. Available: https://www.offshorewind.biz/2018/04/30/taiwan-selects-eleven-offshore-wind-projects/

[8] Offshorewind.biz . (June 2018). Taiwan awards further 1,664MW of offshore wind capacity. [Online]. Available: https://www.offshorewind.biz/2018/06/22/taiwan-awards-further-1664mw-of-offshore-wind-capacity/

[9] Industrial Development Bureau (IDB). (January 2018). The Approach of the Offshore Wind Energy Screening Mechanism: The Industry Association Execution Plan. [Online]. Available: https://www.moeaidb.gov.tw/external/ctlr?lang=1&PRO=news.rwdNewsView&id=23720

[10] Bureau of Energy (BOE). (January 2018). Directions for Allocating Installed Capacity of Offshore Wind Potential Zones. [Online]. Available: https://www.moeaboe.gov.tw/ECW/populace/news/Board.aspx?kind=3&menu_id=57&news_id=14936

[11] Industrial Development Bureau (IDB). (January 2018). Offshore Wind Energy Industry Policy. [Online]. Available: https://www.moeaidb.gov.tw/ctlr?PRO=policy.rwdPolicyView&id=5614

[12] Bureau of Energy (BOE). (April 2018). 7 developers (10 Projects) awarded the Allocated Project Qualification, with Cimmitted Construction Capacity 738 MW in 2020, 3,098 MW during 2021-2025. [Online]. Available: https://www.moeaboe.gov.tw/ECW/populace/news/News.aspx?kind=1&menu_id=41&news_id=15003

[13] Bureau of Energy (BOE). (June 2018). 2 developers (4 Projects) tendered the Auction Porject Qualification, with Committed Construction Capacity 1,664 MW in 2025. [Online]. Available: https://www.moeaboe.gov.tw/ECW/populace/news/News.aspx?kind=1&menu_id=41&news_id=15061

[14] Hsu TW, Leu TS, Kuo YS, Hsiao SC, Chai JF, Shyu WS, Miau JJ, Jue CD. Behavior and responses of offshore wind turbine foundations under extreme environmental loading conditions (I). Department of Hydraulic and Ocean Engineering, NCKU, 2013.