Offshore Wind Logistics brief report 4

- Supply chain development in new offshore wind markets

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This *Offshore Wind Logistics brief report 4* is part of a series of brief industry-focused reports on the key conclusions from the global wind energy shipping and logistics PhD research project. The reports have been crafted by the Panticon team during the months of January through November 2019 in order to crystalize the main findings from the academic research project in a non-academic language and style which would support industry in implementing the key changes proposed as a result of the PhD research project. The report has been created primarily based on the PhD research project output, i.e. the PhD thesis and the academic publications produced by Thomas Poulsen during the PhD research project. Where necessary, additional data sources have been utilized as well in order to ensure that the findings are relevant and up-to-date (see Reference section).

The report contains forward-looking statements, which by their very nature, address matters that are, to different degrees, uncertain as they pertain to the future. These, or any other uncertainties, may cause the actual future results to be materially different than those expressed in the forward-looking statements as contained within this report. At Panticon we do not undertake to update our forward-looking statements, nor do we assume any liability for actions or dispositions made by firms, organizations, and/or individuals based on information contained in this report.

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This report has been sponsored by Den Danske Maritime Fond (grant 2018-144) as well as by Panticon.

ISBN 978-87-93809-13-0

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Report information: Report release version: 1.0

Release date: November, 2019

This report has been produced by:

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Table of contents

1. Introduction

This *Offshore Wind Logistics brief report 4* is the fourth in a series of eight short industry-focused reports.

The goal of the brief reports is to make the latest research in the market for logistics within the global offshore wind industry more accessible and usable for a wide range of constituencies on a global basis. The brief reports can be read consecutively or individually.

This *fourth brief report* in the series provides an overview of how the new offshore wind markets outside Europe have been preparing their local supply chains. This brief report also evaluates the supply chain readiness of these new offshore wind markets.

2. Supply chain development in new offshore markets outside Europe

Until the middle of this decade, the comparatively higher levelized cost of energy for offshore wind has contributed to holding back offshore wind development in countries outside Europe. In addition, the novelty and complexity of offshore wind development has been a barrier for adoption in new markets. Decreasing costs in Europe have, among other factors, encouraged other countries to embrace offshore wind, notably China. However, Europe still has the technological edge. Therefore, as new markets develop their local supply chains, they have reached out to the European offshore wind industry. Indeed, the new markets are keen to avoid mistakes encountered by the established offshore wind industry mainly to keep costs at European levels or lower.

Another factor encouraging more countries to embrace offshore wind is job creation. The offshore wind industry creates more jobs per megawatt compared to other conventional power generation technologies. Politicians, in their respective new offshore wind market countries, are keen to localize the supply chains and capture as much as possible of the developers total offshore wind farm life-cycle expenditure. Therefore, local content requirements are a key feature of offshore wind policy in new offshore wind markets.

At the same time, local companies from new offshore wind market countries in industries such as shipping and offshore oil & gas are seeking to diversify into the offshore wind industry. Some of these companies are already part of the European offshore wind supply chains and can be generally categorized in three groups: first, companies that have taken advantage of the comparatively lower production costs in their home countries to host production of vessels and selected wind turbine and balance of plant components for the European offshore wind industry; second, companies that have invested in the European offshore wind supply chain to access Europe's superior offshore wind expertise; and third, companies that have simply invested in European offshore wind to reap the returns of the lucrative offshore wind market.

Reconciling expertise transfer by localizing the supply chain in the new offshore wind markets has resulted in different forms of partnerships between local and established European companies from the offshore wind industry as well as the shipping and offshore oil & gas industries. Such partnerships

With this said, before a local supply chain can be established, an enabling offshore wind policy is crucial. Substantial offshore wind capacity installation targets that justify infrastructure investments should be in place. Supply chain development typically starts with ***port infrastructure*** development, followed by ***balance of plant*** elements, e.g. foundations, and finally ***wind turbine manufacture***. This reflects increasing complexity as well as decreasing plausibility. Naturally, all new offshore wind markets have several commercial ***ports***. However, these ports require upgrading or establishing new ports altogether to meet the unique demands of the offshore wind industry components and processes. In addition, the increase in wind turbine and component size calls for turbine assembly or foundation fabrication in port areas or close to ports. ***Balance of plant*** elements provide a more localized supply chain opportunity. For example, for foundations supply, monopiles have dominated the European and Chinese offshore wind markets. This is partly because of the relatively shallow waters, i.e., less than 50 meters depth. The new markets such as Japan, South Korea, and the USA West Coast, are characterized by deeper waters, requiring other foundation types such as jackets and floating. ***Wind turbine manufacture*** (nacelle assembly) requires a significant pipeline capacity. Only China, and to a lesser extent, South Korea and Japan, have local offshore wind turbine manufacture. The USA also has a local turbine manufacturer whose manufacturing locations are in Europe.

3. Supply chain readiness

Tables 1 through 4 below compare the supply chain readiness in Europe (EUR), China (CHN), as well as the most promising new offshore wind markets of India (IND), Japan (JPN), South Korea (KOR), Taiwan (TWN), and the USA (USA). The comparison has been done based on shipping and logistics and the listing of countries/regions has been done alphabetically. The basis of the comparison is the four life-cycle phases introduced in *Offshore Wind Logistics brief report 1*. A colour coding showing increasing supply chain readiness has been applied to the tables.

Figure 1: Legend for Tables 1 through 4

0	=	No local supply - no track record	
1	=	Emerging local supply or high potential synergies (or very limited track record)	
2	=	Existing local supply - not yet mature (limited track record)	
3	=	Existing local supply - mature (significant track record)	

3.1. Offshore wind farm life-cycle phase: Development & Consent

The *Development & Consent* life-cycle phase encompasses special geophysical, geotechnical, ornithological/mammal, and other survey vessels that enable different surveys to be carried out as part of the site planning efforts. The level of supply chain readiness per country or region for some parts of the Development & Consent life-cycle phase and some of their constituent parts are shown in Table 1.

Table 1: Development & Consent

		0	1	2	3
Consenting & development services	*Various development work and initial environmental impact assessments*	IND	KOR, TWN	JPN, USA	CHN, EUR
Environmental surveys	*Birdlife surveys*		IND, KOR, TWN	CHN, JPN, USA	EUR
	Sealife surveys	IND	KOR	JPN, TWN, USA	CHN, EUR
Site investigations	*LiDAR systems and Metocean buoys*		IND, TWN	CHN, JPN, KOR, USA	EUR
	Geological surveys	IND	TWN	CHN, JPN, KOR, USA	EUR
	Geophysical surveys, incl. boulder and unexploded ordinance removal	IND	TWN	CHN, JPN, KOR, USA	EUR
Engineering consultancy	*Layout design and engineering*	IND	JPN, KOR, USA	CHN	EUR
	Turbine, foundation type selection	IND		KOR, JPN, USA	CHN, EUR
	Installation methods	IND	JPN, KOR, USA	CHN	EUR
	Operational strategy	IND	JPN, KOR, USA	CHN	EUR
Other Development & Consent			IND	CHN, JPN, KOR, USA	EUR

Source: Panticon, based on Poulsen & Lema (2017)

3.2. Offshore wind farm life-cycle phase: Installation & Commissioning

The *Installation & Commissioning phase* has a distinctive inbound and a substantially different - but similarly very distinctive - outbound supply chain. It is the most extensive phase of the offshore wind farm life-cycle in terms of activities and components involved. Here, it is split into three sub-phases. The first two phases, *Wind Turbine & Wind Turbine Components Supply* and the Balance of Plant Components Supply, focus on respective supply of components. The third sub-phase, the *Wind Turbine*, *Wind Turbine Components*, and *Balance of Plant Components Installation* focuses on installation.

3.2.1 Sub-life-cycle phase: Wind Turbine and Wind Turbine Components Supply

This sub-life-cycle phase focuses on the Wind Turbine, its constituent components, as well as the components that support the wind turbine above the water. The level of supply chain readiness per country or region for some parts of this sub-life-cycle phase and some of their constituent parts are shown in Table 2a.

Table 2a: Installation & Commissioning - Wind Turbine & Wind Turbine Components Supply

		0	1	2	3
Wind turbine	*Nacelle assembly*	IND, TWN	JPN, USA	KOR	CHN, EUR
	Generators		TWN	IND, CHN, JPN, KOR, USA	EUR
	Gearboxes		KOR, TWN, USA	IND, CHN, JPN	EUR
	Power converters		TWN, USA	CHN, JPN, KOR	EUR
	Power transformers			JPN, KOR, TWN, USA	EUR
	Forgings		IND, USA	JPN, TWN	CHN, EUR, KOR
	Bearings		TWN, USA	CHN, JPN, KOR	EUR
	Nacelle covers		IND, USA	JPN, KOR, TWN	CHN, EUR
	Other wind turbine components		IND, TWN	JPN, KOR, USA	CHN, EUR
Rotor	*Blades*		JPN, KOR, TWN, USA	IND, CHN	EUR
	Castings (Hub)		IND, USA	JPN, TWN	CHN, EUR, KOR
	Epoxy resin			IND, JPN, KOR, USA	CHN, EUR, TWN
Towers	*Steel*			IND, JPN, TWN, USA	CHN, EUR, KOR
	Internals			IND, JPN, TWN, USA	CHN, EUR, KOR
	Other tower accessories			IND, JPN, TWN, USA	CHN, EUR, KOR

Source: Panticon, based on Poulsen & Lema (2017)

3.2.2. Sub-life-cycle phase: Balance of Plant Components Supply

This sub-life-cycle phase comprises all offshore wind farm components except the components that belong to the *Wind Turbine & Wind Turbine Components* in section 3.2.1 above. It also includes assets that transfer electric power from the offshore wind farm to the onshore sub-station. The level of supply chain readiness per country or region for some parts of this sub-life-cycle phase and some of their constituent parts are shown in Table 2b.

Table 2b: Installation & Commissioning - Balance of Plant Components Supply

			0	1	2	3
Onshore civil works	*Onshore substation*				IND, JPN, TWN, USA	CHN, EUR, KOR
	Onshore grid connection				IND, JPN, TWN, USA	CHN, EUR, KOR
Subsea cables	*Export cables*			IND, TWN, USA	CHN, JPN, KOR	EUR
	Array cables			IND, TWN, USA	JPN	CHN, EUR, KOR
	Cable protection			IND, TWN	JPN, KOR, USA	CHN, EUR
Offshore substation	*Electricals:*	*High voltage alternating current*		IND, TWN	CHN, KOR, USA	EUR, JPN
		High voltage direct current		IND, TWN	CHN, KOR, USA	EUR, JPN
	Topside/Structure:	*Manufacturer*		TWN	IND, JPN, USA	CHN, EUR, KOR
		Design		IND, TWN	CHN, JPN, USA	EUR, KOR
Offshore substation foundations	*Offshore substation Foundation:*	*Manufacturer*		IND, TWN	JPN, USA	CHN, EUR, KOR
		Primary steel		IND, TWN	JPN, USA	CHN, EUR, KOR
		Grouting		IND, TWN	JPN, USA	CHN, EUR, KOR
		Design		IND, JPN, TWN, USA	CHN, KOR	
	Offshore substation Transition piece:	*Primary steel*		TWN	IND, JPN, USA	CHN, EUR, KOR
		Secondary steel		TWN	IND, JPN, USA	CHN, EUR, KOR
Wind turbine foundations	*Monopiles:*	*Manufacturer*			IND, TWN, JPN, USA	CHN, EUR, KOR
		Grouting		IND, TWN, USA	JPN	CHN, EUR, KOR
		Design		IND, TWN, USA	CHN, JPN, KOR	
		Primary steel		IND, TWN	IND, JPN, USA	CHN, EUR, KOR
		Secondary steel		TWN	IND, JPN, USA	CHN, EUR, KOR
	Transition piece:	*Manufacturer*		TWN, USA	JPN	CHN, EUR, KOR
		Primary steel		IND, TWN	JPN, USA	CHN, EUR, KOR
		Secondary steel		IND, TWN	JPN, USA	CHN, EUR, KOR
	Jackets			IND, TWN	CHN, JPN, KOR, USA	EUR, KOR
	Suction bucket			IND, TWN	CHN, JPN, KOR, USA	EUR
	Gravity based			IND, TWN	CHN, JPN, KOR, USA	EUR
	Floating		CHN, IND, KOR, TWN, USA		JPN	EUR
Other Balance of plant components					JPN, KOR, TWN, USA	CHN, EUR

Source: Panticon, based on Poulsen & Lema (2017)

3.2.3. Sub-life-cycle phase: Wind Turbine, Wind Turbine Components, and Balance of Plant Components Installation

This sub-life-cycle phase involves installation of the major components in section 3.2.1 and 3.2.2 as well as supporting infrastructure such as ports. The level of supply chain readiness per country or region for some parts of this sub-life-cycle phase and some of their constituent parts are shown in Table 2c.

Table 2c: Installation & Commissioning - Wind Turbine, Wind Turbine Components, & Balance of Plant Components Supply

			0	1	2	3
Installation ports and logistics	*Infrastructure and diverse services*		IND	JPN, KOR, TWN, USA	CHN	EUR
	Installation/marshalling		IND	JPN, KOR, TWN, USA	CHN	EUR
Wind turbine and balance of plant installation	*Wind turbine:*	*Installation company*	IND, USA	TWN	JPN, KOR	CHN, EUR
		Vessels	IND, USA	JPN, KOR, TWN		CHN, EUR
	Wind turbine foundation:	*Installation company*	IND, USA	TWN	JPN, KOR	CHN, EUR
		Transition piece	IND, USA	TWN	JPN, KOR	CHN, EUR
	Offshore substation:	*Installation company*	IND	JPN, KOR, TWN, USA	CHN	EUR
		Vessels	IND	JPN, KOR, TWN, USA	CHN	EUR
		Foundation	IND	JPN, KOR, TWN, USA	CHN	EUR
		Transition piece	IND	JPN, KOR, TWN, USA	CHN	EUR
Subsea cables installation	*Export cables:*	*Installation company*	IND	JPN, KOR, TWN, USA	CHN	EUR
		Vessels	IND	JPN, KOR, TWN, USA	CHN	EUR
		Burial	IND	JPN, KOR, TWN, USA	CHN	EUR
	Array cables:	*Installation company*	IND	JPN, TWN, USA	CHN, KOR	EUR
		Vessels	IND	JPN, TWN, USA	CHN, KOR	EUR
		Burial	IND	JPN, TWN, USA	CHN, KOR	EUR
Installation equipment and support services	*Freight forwarders*		IND	JPN, KOR, TWN, USA	CHN	EUR
	Crewing and shore management personnel		IND	JPN, KOR, TWN, USA	CHN	EUR
	Transmission asset owners		IND	JPN, KOR, TWN	CHN, USA	EUR
Onshore works				IND	JPN, KOR, TWN, USA	CHN, EUR

Source: Panticon, based on Poulsen & Lema (2017)

3.3. Offshore wind farm life-cycle phase: Operations & Maintenance

The *Operations & Maintenance* phase has a *preventive* servicing supply chain which can be scheduled in advance as different parts and modules are expected to reach the end of their durability. The other two types of *Operation & Maintenance*, *unscheduled* and *breakdown* or *contingent*, are not planned in advance. All *Operations & Maintenance* supply chains endure for the entire duration of the offshore wind farm operational phase which can be 20–25 years or longer. The level of supply chain readiness per country or region for some parts of the *Operations & Maintenance* life-cycle phase and some of their constituent parts are shown in Table 3.

Table 3: Operation & Maintenance

		0	1	2	3
Operation & Maintenance supply chains	*Preventive/predictive services*	IND	JPN, KOR, TWN, USA	CHN	EUR
	Unscheduled services	IND	JPN, KOR, TWN, USA	CHN	EUR
	Breakdown (contingency) response	IND	JPN, KOR, TWN, USA	CHN	EUR
Service vessels and related equipment	*Crew transfer vessels*	IND	JPN, KOR, TWN	CHN, USA	EUR
	Special operation vessels	IND	JPN, KOR, TWN, USA	CHN	EUR
Operation & Maintenance ports		IND	TWN, USA	CHN	EUR

Source: Panticon, based on Poulsen & Lema (2017)

3.4. Offshore wind farm life-cycle phase: Decommissioning

The *Decommissioning* phase involves the taking down of the offshore wind farm infrastructure at the end of the offshore wind farm life-cycle. The level of supply chain readiness per country or region for some parts of the *Decommissioning* life-cycle phase and some of their constituent parts are shown in Table 4.

Table 4: Decommissioning

	0	1	2	3
Decommissioning ports and logistics	IND, KOR, TWN, USA	CHN, JPN		EUR
Wind turbine decommissioning	IND, KOR, TWN, USA	CHN, JPN		EUR
Balance of plant decommissioning	IND, KOR, TWN, USA	CHN, JPN		EUR
Site restoration	JPN, KOR, TWN, USA	CHN		EUR
Project management	IND, KOR, TWN, USA	CHN, JPN		EUR

Source: Panticon, based on Poulsen & Lema (2017)

Because the offshore wind industry is young, only four offshore wind farms have so far been decommissioned – two in Sweden, one in Denmark, and the latest one in the UK in April 2019. Therefore, it could be argued that Europe's readiness score under this section should be lower. However, in the context of the global offshore wind farm decommissioning, as well as the competences of the leading European marine contractors, Europe is leader, and is therefore given a higher score.

4. Conclusion

New offshore wind markets cannot avoid relying on European expertise if they are to establish their markets and industries. This creates business opportunities for European companies across the offshore wind farm life-cycle phases. If the offshore wind capacity installation targets in these new markets are significant, experienced European offshore wind industry suppliers are willing to localize production. This will determine the speed at which local supply chains will be established in that new offshore wind market. In contrast to the offshore wind development in Northern Europe and the expected expansion into other parts of Europe, the European suppliers need an additional set of capabilities to adapt to the new markets outside of Europe. Such adaptation will include business culture and offshore wind farm site characteristics, such as the weather and sea conditions. European offshore wind suppliers with a global presence in other industries are well placed to leverage their knowledge of different business environments in the new offshore wind markets.

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About Thomas Poulsen

Mr. Poulsen is a seasoned professional who has specialized in crafting strategy coupled with generating both tactical organic and strategic M&A driven growth for companies and organizations, mainly based on his experience in the shipping, transport, logistics, offshore wind, and supply chain industry. During his 30+ years in the business, Mr. Poulsen has lived in 8 countries namely his native Denmark, Indonesia (Jakarta), People's Republic of China (Shanghai), Singapore, Hong Kong (before hand-over to PRC), USA (New Jersey, California, and Florida), UK (London), and the United Arab Emirates (Dubai).

Abstract about Thomas Poulsen's PhD: Logistics in Offshore Wind

The PhD thesis is about offshore wind and focuses on logistics, broadly defined. As such, the research pertains to the offshore wind supply chain from the perspective of transportation and logistics tasks on land, through ports, at sea, and in the air. In addition, the research has dealt with logistics costs seen in relation to levelized cost of energy throughout the entire lifespan of an offshore wind farm project. The research has also dealt with the globalization of the offshore wind market, using China as the main example.

The results of the research have shown that logistics makes up a significant cost item within offshore wind. The results also revealed that it is important to organize logistics in an effective manner within those firms and organizations participating in the offshore wind industry. The eight academic articles which have been published as part of the PhD research project have been framed in the context of strategic management as well as the mergers & acquisition efforts forming part of the offshore wind industry as the market consolidation intensifies.

The research has been conducted in close collaboration with a series of leading offshore wind organizations and companies. The research was funded by Aalborg University and the Danish Maritime Foundation (Den Danske Maritime Fond) through grant number 2012-097.

What we do at Panticon

At Panticon, we are particularly strong in the Offshore Wind and Logistics sectors within our three core disciplines of **Strategic Management Advisory**, **Mergers & Acquisitions**, and **Market Intelligence**. We are mainly focusing on the business side to improve our clients' performance, create value in the long-term, and to create sustainable competitive advantages.

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