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The offshore wind market deployment: forecasts for 2020, 2030 and impacts on the European supply chain development

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Abstract

Almost 4 GW of offshore wind power capacity will be installed in European waters at the end of 2011. The impressive growth of the sector during the last decades continues and by 2020, EWEA expects 40 GW of offshore wind capacity to be installed across Europe and 150 GW by 2030. However, the growth of the offshore wind sector will not happen without a strong supply chain underpinning its development. This paper presents the latest developments of the offshore wind power market and the objectives the supply chain needs to meet to assist the growth of the industry.

Keywords: Offshore wind energy; supply chain; wind turbines; substructures, electrical infrastructure, ports, vessels

1. Introduction

Offshore wind power, representing 10% of total annual wind energy installations in 2010, is becoming a major player in the European electricity mix. 148 TWh of electricity will be produced in 2020, meeting over 4% of the EU's total demand. By 2030, offshore wind will produce 562 TWh, covering 14% of the EU's electricity demand. Deployment of the offshore wind industry in European waters has started, both in terms of installed capacity and in terms of the necessary onshore infrastructure. A strong supply chain is needed to support the development of all the different sectors involved in feeding the European grid with electricity from offshore wind power. Moreover, this emerging industry provides significant

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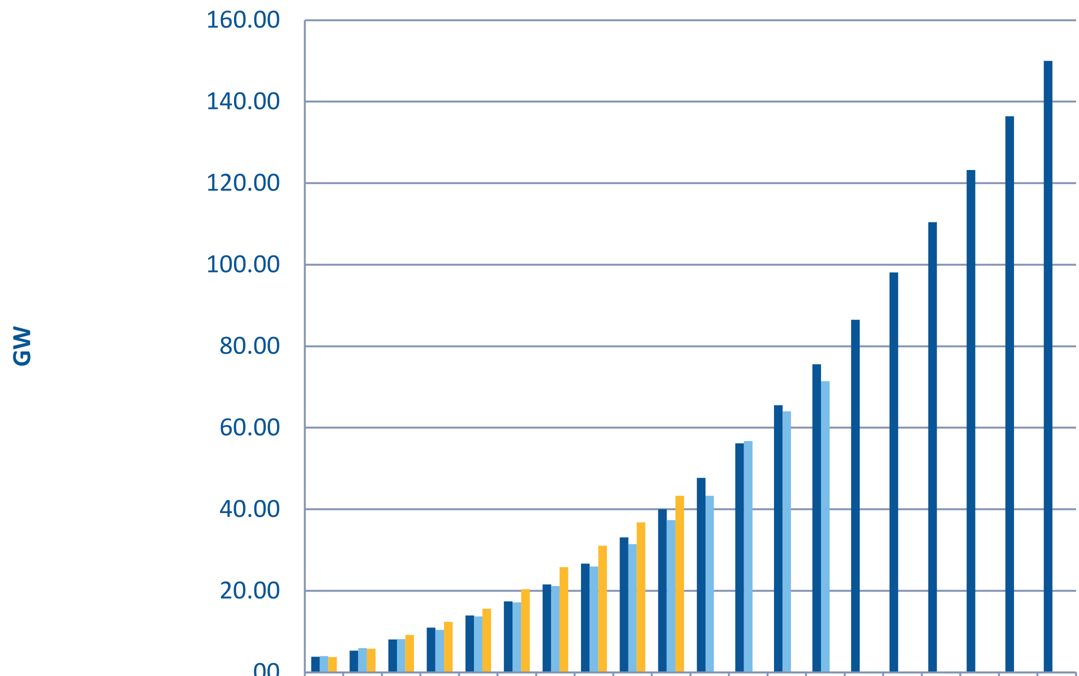
opportunities for growth and job creation in numerous fields. The analysis focuses on current and future trends in the supply chain which will allow a healthy growth of the offshore wind industry.

1.1. Offshore wind market: historical and current view

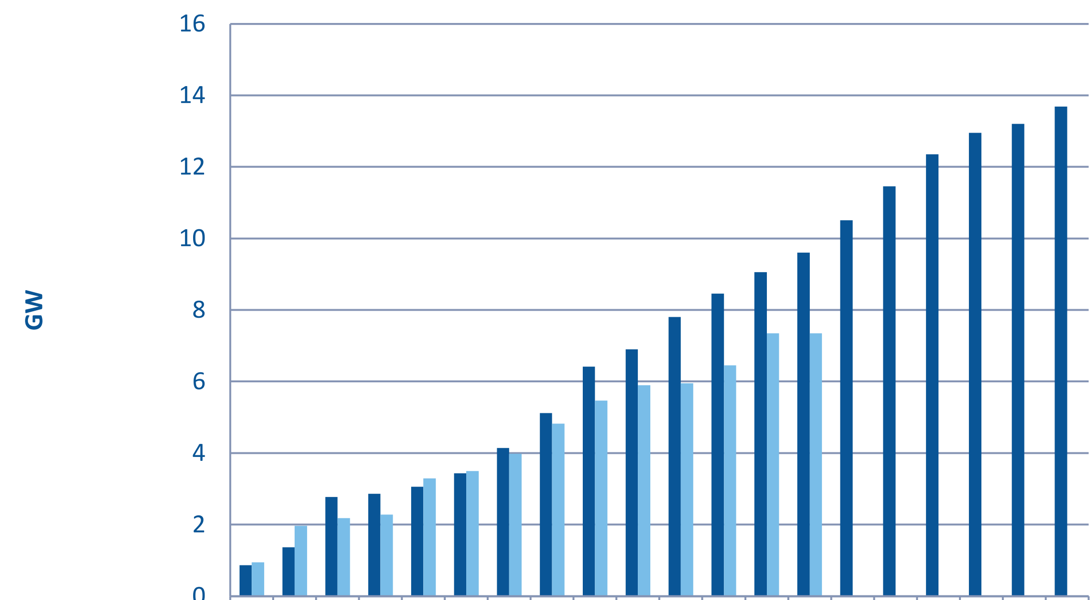
In 1991, the first 4.95 MW of offshore wind power were installed 2.5 km off the Danish coast, in Vindeby. Twenty years later, at the end of 2010 offshore wind capacity reached 2,946 MW in Europe, spread across 45 wind farms in nine countries. Since the beginning of the decade, the share of new offshore capacity in total new wind capacity additions has been increasing.

Annual installed capacity in 2011 was 866 MW. Cumulative offshore capacity has increased to 3,813 MW. Figures 1.1 and 1.2 show EWEA's forecast for cumulative and annual installed capacity compared with other scenarios [1], [3], [4].



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EWEA	3.813	5.314	8.082	10.94	13.99	17.42	21.56	26.68	33.10	40.00	47.70	56.20	65.50	75.60	86.50	98.10	110.4	123.2	136.4	150.0
Emerging Energy Research	3.982	5.945	8.125	10.40	13.69	17.19	21.18	26.00	31.47	37.37	43.32	56.72	64.07	71.42						
National Renewable Energy Action Plans	3.724	5.829	9.146	12.35	15.60	20.42	25.82	31.10	36.79	43.32										

Fig. 1.1. Cumulative offshore wind power capacity installations 2011 – 2030



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EWEA	.866	1.370	2.768	2.859	3.054	3.434	4.145	5.116	6.420	6.902	7.807	8.457	9.057	9.607	10.507	11.458	12.350	12.950	13.200	13.690
Emerging Energy Research	.945	1.963	2.180	2.280	3.290	3.500	3.985	4.820	5.470	5.900	5.950	6.450	7.350	7.350						

Fig. 1.2. Annual offshore wind power capacity installations 2011 – 2030

Figures 1.1 and 1.2 demonstrate that EWEA targets are in line with other market analysts [3] as well as the EU Member States' own forecasts detailed in their National Renewable Energy Action Plans (NREAPs) [4]. This shows that the vision of a strong offshore industry is common and drives development throughout Europe.

1.2. Trends in offshore development – moving bigger, further and deeper

As the technology develops the experience gained allows projects to increase in size, pushes them further from shore and into deeper waters. Figure 1.3 (a) shows the distance from shore and average water depth of the online, under construction and consented projects. Figure 1.3 (b) shows this for planned offshore wind farms.

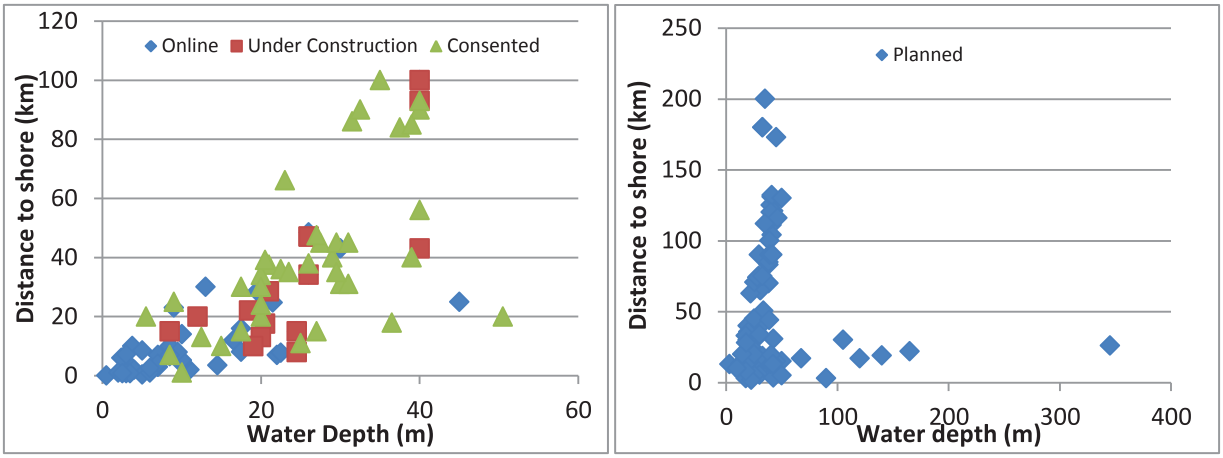


Fig. 1.3. (a) online, under construction and consented (excluding Hywind); (b) planned offshore wind projects in EU

As shown in figure 1.3 (a) and (b), there is a clear trend for new projects to move to deeper waters and further from shore. A strong supply chain is needed to accommodate all the relevant and necessary developments for offshore wind energy to develop.

The following analysis presents current and future trends in the main components of the supply chain: wind turbine manufacturing, substructure manufacturing, electrical equipment suppliers, marine contractors and port operators.

2. Offshore wind supply chain

The offshore wind supply chain is evolving rapidly. This is particularly due to ambitious national programmes and financial incentives that limit risk and, thus, attract investors to the sector.

An important step before analysing each component of the supply chain is to identify the way in which all of its different components work together in the contracting environment. Historically, during the first years of offshore wind development (2000-2004), the common practice was to use “Engineering – Procure – Construct – Install” (EPCI) contracts. The turbine manufacturers, together with marine contractors, formed a joint venture and worked out the whole development of the project. Later, during the 2004-2010 period, a general switch to multi-contracting was observed as the main players considered certain project risks to be beyond their core competencies. This resulted in complex and numerous construction contracts, involving many contractors. Since last year, the industry has, again, entered a new phase, where larger contracts are being signed, trying to minimise the number of contractors and facilitate overall project management. The current trend could be to revert to a full EPCI contract environment, described mainly as joint ventures between the plant contractors and the turbine manufacturers, who take responsibility for a broader scope of work.

2.1. Wind turbines

The offshore wind industry is new compared to onshore wind energy. Deployment of offshore wind started taking off over the last ten years, increasing its share in new annual wind capacity from 0.1% in 2000 to 9.6% in 2010.

The main component of a wind power project is the wind turbine. The recent rate of development in offshore wind has driven the industry towards manufacturing specific offshore wind turbines in dedicated facilities. Nevertheless, this 'decoupling' from the onshore wind sector is not evident for all the subcomponents due to their common uses both in on- and offshore turbines. Overall, the main trends show that established manufacturers prefer vertical integration as a solution to design and produce wind turbines. For new entrants, partnerships with component manufacturers are a key first step into the offshore industry.

Table 2.1 summarises current market status of the main subcomponents of an offshore wind turbine, in terms of barriers to entry, logistical issues (transport, manufacturing facilities, etc.), and vertical integration possibilities.

Table 2.1. Current picture of the sub-component market in offshore wind power

Wind turbine components	Barriers to entry	Logistical issues	Integration possibility
Towers	Low	Medium	Low
Blades	High	Medium	Medium
Drive train	Medium	Low	Low
Castings and forgings	Medium	Low	Low

The offshore wind industry is ready to face challenges in the manufacturing of wind turbines and this is demonstrated by the growing list of companies developing wind turbine designs to be used in European waters. In [1] a selection of announcements for new offshore wind turbines is listed. According to [1] 52 new wind turbine models from 39 different companies are expected to serve the offshore wind power industry globally. Amongst these companies, 49% is originates in Europe (figure 2.1).

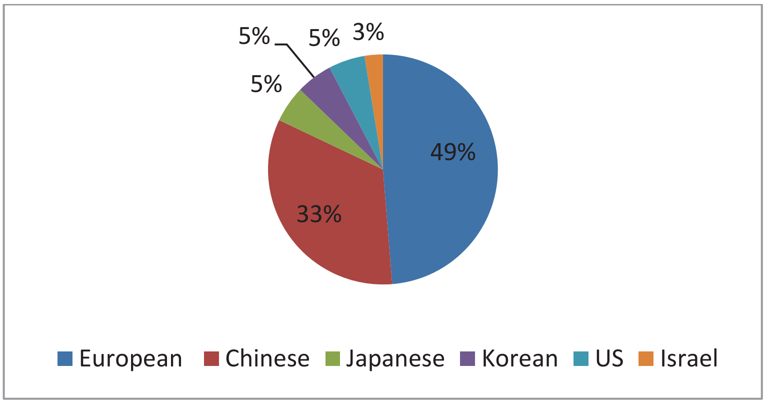


Fig. 2.1. Origin of companies announcing new offshore wind turbine models

The rest is dominated by Chinese companies (33%) followed by Japanese, Korean and US companies with 5% each and Israel entering the offshore wind power industry with a 3% share. Not all of these wind turbines are expected to finally be launched, reasonably assuming some natural cancellation. According to [1], even in the most pessimistic scenarios, the supply of wind turbines is expected to meet demand, creating a healthy and competitive environment.

On the technical side, based on announced concepts and new models that have reached market recently, several key trends are shaping offshore wind turbines:

- increased rated capacity and rotor diameter;
- slight move from geared to direct drive or hybrid systems;
- move from partial to full conversion.

Overall, the wind turbine supply for the offshore sector is heading towards a lower energy cost with improved reliability and energy capture. Decoupling from the onshore wind industry is a symptom of an established industrial sector, already generating substantial power.

2.2. Substructures

Representing around 20% of the capital cost of offshore wind power, substructures are a significant part of a wind farm project. Different types of substructures include monopiles, gravity based structures, space frame (tripods, tripile and jacket) structures, floating and other (battered piles, suction buckets). The choice of the right type depends on the specific project and is a multi–variable concern, taking into account cost, water depth, seabed conditions, turbine characteristics and technical/commercial risk factors [1].

Currently, monopiles dominate the European market, as the majority of offshore wind farms operate in water depths below 25 meters. The other projects use gravity base foundations and a smaller share use jackets.

According to [1] substructure manufacturing has low entry barriers and can be carried in locations close to offshore wind areas. Therefore, significant industrial deployment can be expected in numerous countries and regions independently of whether there is local turbine manufacturing.

As highlighted above, offshore projects' move further from shore and in deeper waters highlights the need for improved or new substructure types and specifications. Floating concepts have already been studied for the deployment of future projects in waters over 50 meters in depth. Three types of floating foundation exist today: the spar, the tensioned leg platform and the floating jacket. The following table presents a selection of developments in floating concepts in Europe.

Table 2.2. Selection of developments on the floating concepts in Europe

Company	Project name	Floating turbine	Floating platform / substructure only	Wind and Wave combined	Turbine capacity	Deployment date	Region
Statoil	Hywind	X			2.3 MW	2009	Norway
Sway	Karmoy	X			5MW	2013	Norway
Technip	Vertiwind	X				2013	France
Nass and wind	Winflo		X		2.5MW	2012	France
Catalonia institute for Energy research	ZÈFIR Floating Med Wind Plant		X		8X4MW		Spain
EU project	HiPRwind		X			2016	Europe

Gamesa	Azimut	X			15MW	2020	Spain
Principle Power	Windfloat		X		2MW	2011	Portugal
Hexicon	Hexicon platform			X	54MW		Sweden
Ideol	Floating foundation		X				France
Nautica Windpower	Advanced Floating Turbine	X			n/a	2015	US
EU project	Deepwind	X			n/a	2015	Europe

Looking forward, monopiles will continue to be the solution of choice as long as their technical characteristics are appropriate for the project. In shallower waters, gravity base foundations are likely to continue being used. Moving further and deeper will push for the use of jacket foundations as well as the utilisation of floating structures as long as challenges such as cost and electrical infrastructure design are overcome.

2.3. Electrical infrastructure

One of the main differences between offshore and onshore is the need to transport electricity from the sea to the shore. Currently, the development of offshore wind power further from shore and in deeper waters drives the industry towards the use of substations, capable of minimising the amount of cables used to connect onshore. Using multiple medium voltage cables up to 35 kV is considered economically less attractive than using less and smaller high voltage (12 – 150 kV) cables when the distance is of a few kilometres.

The inter–array cables used are typically in the range of 33 kV. Specific submarine cable technology has to be used to install the sub-sea cables. The relevant products and suppliers already exist. Trends moving towards a higher voltage level of 45kV or even 66kV can already be observed, but the suppliers of this technology are currently limited.

For the export cables, High – Voltage – Direct – Current (HVDC) cables are expected to be used widely in the future. The cost effectiveness of this solution is improved when the projects are above 500 MW and the distance is around 100 km from shore [1].

However, independently of the level of voltage, the installation of subsea cables requires specialised vessels, installation techniques and tools. The supply and availability of these has to be looked into in order to avoid delays in the installation phase.

The challenge in the electrical infrastructure section of the offshore wind industry relates to the availability of suppliers in higher voltage levels with the expected installed capacity. As reported in [1] a shortage of supply could become possible after 2015. Taking into consideration that lead time to produce new subsea cable capacity is around three to four years, significant investment decisions have to be taken rapidly in order to avoid future bottlenecks.

Following the potential operation in higher voltage levels, new switchgears are required, but this is not considered a problem as long as the volume of demand justifies the investment.

Cost reduction is always the main driver for future development. Components such as cable laying vessels, substations and HVDC cables are likely to result in cost reduction following economies of scale and technological improvements.

Nevertheless, regulatory issues and constraints should be resolved in a sustainable manner to allow deployment at the described scale to take place. Some of these issues include: clear procedures on market operations when offshore farms are connected to more than one market, optimised interconnection of multiple farms as well as availability of cable laying routes and permits for network reinforcement.

2.4. Ports and vessels

Developing offshore wind energy in European waters creates the need for appropriate vessels to carry out different operations at sea during the various phases of a project: site development, construction, operation and decommissioning.

Site development vessels are required for a variety of activities including environmental impact assessment studies, cable laying and geotechnical and geophysical surveys. The major part of dedicated vessels used by the offshore sector falls in the site construction vessel category. There, the installation of substructures and turbines are the main operations and many technical specifications have to be met by the vessels in order to carry out the work. Different options for site construction vessels are: jack – up vessels, leg stabilised crane vessels, dynamic positioning (DP2) heavy lift cargo vessels, semi – submersible heavy lift vessels, shearleg cranebarge as well as floating dumb barge with crane.

According to [1], the balance of supply and demand for vessels seems good up to 2015. Potentially, bottlenecks could arise when new capacity installations ramp up after 2015. The offshore wind power industry is expected to use both specialised vessels and vessels ‘diverted’ from the oil and gas sector as long as the latter are available on time.

The deployment of the offshore wind sector drives the developments in ports which will serve as the last onshore point before moving to sea. European ports see opportunities to offer their services to the wind sector as other traditional industries decrease their activities.

Currently the ports are either manufacturing or mobilisation ports [1]. Manufacturing ports accommodate significant part of the assembly of the wind turbine whereas mobilisation ports serve as a hub between the supply of components and the final destination: the wind farm. Several factors are to be considered when choosing what operations to carry out in a port, the most important being the cost benefit analysis and the location. In order for the ports to be suitable for offshore wind, requirements have to be met, mainly related to the vessels expected to operate within the port and the size of equipment transported through the port.

Future trends in the use and operation of ports show that cluster-building of offshore wind manufacturing can be realised in ports located close to each other. Financial support could be significantly used to develop the necessary onshore infrastructure for the offshore wind energy to become a mainstream technology in the near future.

3. Conclusions

The offshore wind power industry is taking off, moving with larger projects into deeper waters and further from the shore. The needs of this new industrial sector are to be met with the development of a strong supply chain, covering all the aspects related to wind power. Lessons learned from onshore wind as well as from other marine industrial sectors bring the necessary experience for a sustainable and feasible growth of the offshore wind power sector.

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