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Assessing the level of integration in the offshore wind industry value chain

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Summary

The offshore wind industry (OWI) has experienced an explosive growth within the course of a decade and because of this rapid expansion, the industry has not had the opportunity to integrate well and become more efficient. The aim of this paper is to contribute to the understanding of the integration level of the offshore wind industry value chain. The work relies on a review of international peer-reviewed journals. The empirical basis of the paper is based on interviews with key players in the industry. The scope of this study covers the wind turbine generator, foundations, subsea cables, offshore substation, installation vessels and the wind farm developer. The preliminary findings are that the different industrial sectors participating in the OWI are not aware of the maturity level of the sector. The fact that some developers are disintegrating the already integrated supply of some components highlights the importance of being aware of the industry's maturity level to take appropriate decisions. On the other hand the strategic alliances taking part in various sectors of the OWI show that some of the players know that they have to join and share the expenses of much needed R&D for the benefit of the whole industry. This work is a first step to map the state of integration of the OWI. It is intended that the results will help managers in the different industries to be aware of the challenges that need to be tackled in order to make the OWI more competitive and become more integrated in the future.

Keywords

Offshore wind industry, Collaboration level, Supply chain integration

1. Introduction

Wind turbine generators (WTG), commonly known as "wind mills", are devices used to convert the kinetic energy of the wind into electrical power. Most of the WTGs are installed in land (onshore wind power), but there is an increasing share of them built at the sea (offshore wind power) (EWEA, 2014). Although, these wind farms are more expensive and difficult to construct, they provide a higher yield of energy due to stronger and more constant wind flows in the sea.

Electric power obtained by conventional means, such as gas or coal-powered plants, has a lower cost (0.7 €/kWh) compared to the one produced by offshore wind turbines (0.9 €/kWh) (EWEA, 2010). Today the offshore wind industry (OWI) evolves thanks to the subsidies provided by the countries where this power sector is present, but most of those economic subventions are set to expire within the next five to ten years.

The OWI has experienced an explosive growth within the course of a decade. It passed from installing 4 MW of new capacity in year 2000 to 1,029 MW in year 2010 (EWEA, 2011). Because of this rapid expansion, the industry has not had the opportunity to integrate well and become more efficient. Today, the OWI can be characterised as being immature in terms of less integration, transparency and collaboration in the value chain compared to other mature energy industries. This means that there exists high economical potential for cost improvements in researching supply chain innovations that can improve the offshore-wind business model.

Differently from other energy sectors that had the chance to mature in the course of many decades, the OWI was born in an already competitive energy market where it faces well-integrated and mature industries. The expiration of governmental subsidies means that the OWI has a specific deadline to become a competitive source of energy or to risk being swallowed by the energy market.

An offshore wind farm (OWF) is a complex energy plant consisting of four main components (Figure 1): the WTGs (I) with their respective offshore foundations (II), subsea cables (III) connecting those WTGs to an offshore transformer substation (IV) and an export cable bringing the energy to the land. Each one of those components is produced, installed and

commissioned by a wide array of industries characterised by having different integration levels, backgrounds and which also have major participation in industries unrelated to the OWI. In addition to the already mentioned components, the wind farm developer (V) and the installation vessel (VI) play vital roles in the development of an OWF.

The European Union has set a target of obtaining 20% of the energy from renewable sources by 2020 (EC, 2009). If the OWI wants to be part of them it has to reduce more than 25% of its costs within the next years and any initiative to do that requires the participation of most of the main players in the industry.

A high level of maturity in any given industry is related to a high level of integration of the players involved in it (Lockamy III et al., 2004). For the case of the OWI it would be represented by a high level of information sharing among the actors, a high level of standardisation of components, good attitudes towards collaboration, supply chain performance management and capacity and inventory management mechanisms.

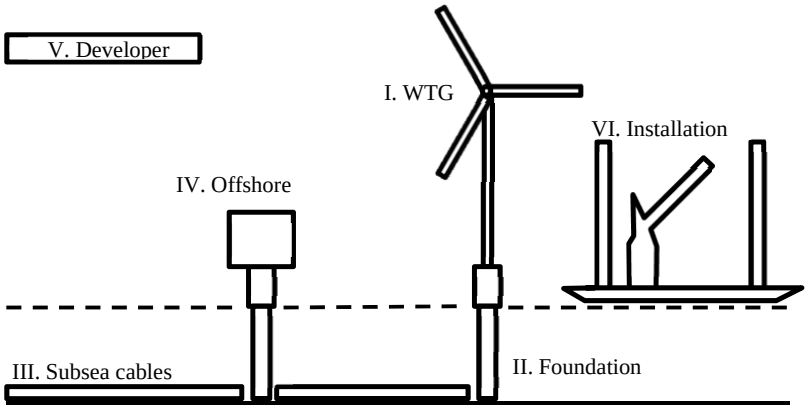

Figure 1. Schematic representation of the offshore wind industry

This research suggests that in order to become a competitive industry, the offshore wind sector has to speed up its maturity process in a short period of time. Existing literature does not provide a comprehensive map of the offshore wind industry integration from the perspective of the supply chain; therefore a first step is to draw a map of the current level of integration of the OWI value chain.

The relevance of this research lies in the fact that the survival of the offshore wind power sector depends on reducing the cost of energy to make it competitive with other power sources. The originality of the study is that it is the first empirical work mapping the current state of integration of the offshore wind industry and the challenges faced by the involved actors. The scope covers the sectors of the industry pictured in Figure 1.

The research questions of this work are: What collaboration mechanisms are established across the OWI supply chain? What is the current level of integration between the actors of the OWI? What is the scope of the integration? What actions could be implemented in order to reach a higher level of integration that allows it to reduce the cost of energy?

After this introduction follows a theoretical frame of reference, which is followed by the methodology section. Hereafter follows the preliminary findings and a discussion of those findings. The paper closes by a conclusion.

2. Theoretical frame of reference

The leap made by the wind industry when venturing into offshore sites created a new specialized market where links between previous unrelated entities were created. It has been argued that this kind of movements bring challenges to integrate industries that are used to work in different ways (Malerba et al., 1996). The OWI is comprised of six different industries that collaborate and coordinate to build wind parks at the sea: 1) Developers, which are mostly energy utilities with a background in onshore energy production; 2) WTG manufacturers, experienced in producing and installing onshore wind turbines; 3) Foundation suppliers, with a background in servicing the oil and gas industry; 4) Subsea cable providers, which work in the electrical cable industry; 5) Offshore substation manufacturers, experienced in onshore power systems; and 6) Installation vessels, which are ship owners and transportation suppliers. The OWI could be a good example of how companies strategically extend their activities outside their existing boundaries to form networks with other companies in order to align their capabilities to compete in other markets (Lockamy III et al., 2004).

As industries evolve, the organisational structure of the firms and its boundaries change and lateral and vertical integration are characteristic features in this process (Malerba et al., 1996). The integration of supply chains derives into a better use of valuable resources (Lambert et al., 2000). It also creates value for the firms, their suppliers, customers and shareholders and the cost and efficiency is positively influenced by the level of integration between the actors of a value chain (Bagchi et al., 2005; Frohlich et al., 2001).

Supply chain integration among European firms is starting to become of strategic importance for the survival of many industries (Bagchi et al., 2005). A work from Andersen and Drejer (2009) suggested that developing products through collaboration of different teams in the wind industry increases the communication and results in new solutions to improve team performance. The integration process is not absent of drawbacks, previous experiences of the actors in other networks shape their perceptions and specific role in the new one, which also shapes the framework of action in the new network (Anderson et al., 1998). It has been highlighted the importance of knowing the maturity level of an industry, so that the executives leading the firms can take proper decisions according to the current stage of development and not based on a misperceived one (Abernathy et al., 1988; McGahan, 2000).

A model proposed by Lockamy and McCormack (2004) identifies five levels of supply chain maturity. In this model, unstructured and ill-defined practices characterise the first level of maturity. The middle stages are characterised by a process in which individual firms start venturing in cooperation with other firms, vendors and customers. This process precedes an integration phase in which companies take cooperation to a process level. The last stage of supply chain maturity consists of a multi-firm competitive environment, where close collaboration between legal entities allows the transfer of information and responsibility without legal ownership. Trust and mutual dependency are vital in keeping each member of a multi-firm network close together.

Companies have been reportedly to either naturally or purposely integrate with other entities of a supply chain (Lambert et al., 2000). Integration initiatives among supply chains are long-term journeys and require considerable managerial efforts and understanding (Fawcett et al., 2002, Vallet-Bellmunt et al., 2013). Managers play a keen role in adopting a supply chain integration approach within companies by strengthening linkages with customers and suppliers, additionally, by seconding positive attitudes towards collaboration by actions (Hernández-Espallardo et al., 2010, Vallet-Bellmunt et al., 2013, Van der Vaart et al., 2008).

Although supply chain understanding helps companies to increase competitiveness compared to others having a poor understanding of it, it is not common that firms map their supply chains in order to take proper decisions based on relevant facts (Fawcett et al., 2002). A clear view of the environment where a company is participating is of vital importance for its leaders to adapt their organisational structure and to be prepared to face new challenges (McGahan, 2000). Integration of supply chains requires being aware of the relationships to be reinforced, processes to be linked and the level of integration required in each link (Lambert et al., 2000). Companies that have mapped their supply chains are able to analyse their core competences, value propositions and the suitability of future supply chain relationships (Fawcett et al., 2002).

What are the characteristics of an integrated supply chain? Vallet-Bellmunt et al. found in 2013 that it is widely agreed that integration is mostly defined in terms of interaction and collaboration, both at internal and at external level. Trust has been identified as a relevant variable that has a favourable effect in the integration among supply chain partners and which is maintained by means of mutual information exchange, cooperation in finding solutions to common problems and the sharing of knowledge (Cousins et al, 2006). Supply chain integration is also characterised by open, transparent and a constant flow of information (Lambert et al., 2000). Collaboration among players of a supply chain means not only to share information openly, but also to make efforts in establishing integration mechanisms that enhance collaboration, coordination with its suppliers and customers (Fawcett et al., 2002). Additionally, as the customer is the focus of an integrated supply chain, the accurate and timely exchange of information regarding demand and production capacity to respond to fluctuations in customer's demand is another important dimension in an integrated supply chain (Lambert et al., 2000).

From this, it can be concluded that an explorative study of the level of integration in an industry should include trust, mutual exchange of knowledge, cooperation in finding solutions to common issues and information sharing regarding demand and production capacity. Based on this, a semi-structured questionnaire was built including explorative questions for the following dimensions: 1) Information sharing; 2) Collaboration level; 3) Demand management; 4) Capacity planning; and 5) Inventory management.

The relevance of this work from a theoretical perspective is that it helps to fill the gap of studies in which supply chain integration is applied to a nascent offshore wind energy industry. Research previously done in industries with similar characteristics (complex procurement projects involving many industries) has been focused in military, civil works and offshore oil and gas (Ahola et al., 2008; Caldwell et al., 2009; Caniëls et al., 2012; Olsen et al., 2005; Yeo et al., 2002).

3. Methodology

3.1 Sampling criteria

The empirical foundation of this paper is based on qualitative interviews with six players in the OWI, each one representing a sector defined in the scope of this work. The interviewed companies were chosen as a convenience sample. The authors of this paper have contacts from at least one company representing each sector of the OWI. The persons were contacted and asked for their willingness to participate in the project or to mention one person in the company that could participate. They represent one OWF developer and five tier-1 companies in the OWI value chain. All companies are actively participating in the development of off-

shore wind parks and are based in Northern Europe. The companies were informed about the overall purpose of the research.

3.2 Data collection

This research is based on interviews. Interviews may be structured, semi-structured, or unstructured depending on the type of study conducted and the purpose of the interview (Blumberg et al., 2008). Interviews in this study are semi-structured and designed to uncover the integration level in the industry by analysing the dimensions outlined in Section 2. The interview guide was sent in advance so the interviewee had the opportunity to reflect on the topics. This approach was chosen to give interviewees the opportunity to provide a richer description of the topics and hereby to get a more holistic view on them. However, with one interview per company only one view is captured. Nevertheless, with more companies in the value chain interviewed on the same topic this limitation is believed to be less biased. Another limitation is that only larger players are interviewed. Interviewing smaller players in the value chain may reveal other views on the topics. However, as this study is explorative in nature, this is a deliberate choice of the authors.

As research regarding the level of integration of the OWI is scarce, an explorative and inductive research strategy was selected for this project. All the participants were asked for their permission to record the interview and all of them agreed to do so. Anonymity was granted to all participants. Interviews were transcribed and sent back to the respondents for their approval. When necessary, follow-up interviews were carried out in order to correct misleading information or to complete topics that were not addressed during the first encounter.

3.3 Data processing

The transcribed interviews were analysed and coded into the dimensions of integration described in Section 2. Based on the transcriptions, Section 4 describes the findings categorised in the defined five dimensions of integration. Each one of the interviews was analysed and the correspondent comments were categorised in one of the dimensions of supply chain integration. The results of this analysis were returned to the respondents for validation.

3.4 Judgment criteria

The research presented in this work is exploratory in nature and is has the objective of providing new knowledge on the field of offshore wind supply chain integration. As this is the first attempt to apply supply chain integration theory to the OWI, there is no extant theory against which the results of this research could be compared with.

4. Preliminary findings

This section summarises the results of the interviews, which are grouped into the five dimensions of industry integration. Additionally, Table 1 presents the key points of each one of the interviews.

1) *Information sharing***:** During the development of offshore wind projects the share of information is neither open nor transparent. The developer of the wind farm has taken the responsibility of collecting and coordinating the information in the projects avoiding the direct interaction between the industry actors. That system slows the flow of information and there are abundant cases of information lost in the way. It is a common perception that WTG manufacturers hide most of the information to their suppliers with the objective of

avoiding it to go into better products for the competitors. Most of the individual projects happening in the construction of offshore wind farms are managed by the developer. There is a good exchange of information among strategic partners, such as is the case of the interviewed developer with the WTG manufacturer and the installation vessel company. Some of the players pointed out to the high levels of information sharing in other industries where they are also present.

2) *Collaboration level*: There is a high level of collaboration between the utilities developing offshore wind farms. Also, joint projects and shared R&D activities are carried out by several of the different offshore foundation suppliers. The cross-industry collaboration is very scarce, e.g. there is no joint research between WTG and foundation manufacturers or between offshore-substation providers and the suppliers of the structure that will support it in the sea. There is an open exchange of communication between teams responsible of the management of ongoing projects. Strategic alliances are being formed among tier-1 suppliers and developers to compete against other networks formed in the OWI. Some developers are disintegrating already integrated processes in order to increase competition in the tendering process. Subsea cable suppliers are part of a multi-industry forum in which they meet together with universities and clients to agree on standards and the solution of common problems in the electrical industry.
3) *Demand management:* Framework agreements settled among the interviewed developer and WTG supplier provide certainty to the supply of equipment and helps to keep a pipeline of constant projects. There is no need of a strict demand management for offshore wind farm tier-1 manufacturers as there are few projects being developed each year and the demand of components/services is known with enough time to be prepared for it.
4) *Capacity planning:* For the case of the interviewed WTG provider, the building of new manufacturing capacity is affected by the political uncertainty derived from the change in subsidies provided by governments where offshore wind is present. Most of the players in the OWI are also actively participating in other industries. This allows them to reallocate there their manufacturing capacity due to the fluctuation of the demand in the OWI.
5) *Inventory management:* The OWI projects are planned with more than three years of lead time. For the suppliers of the wind farm components it is clear when their products will need to be delivered. In case of delays the wind farm developer notifies in advance so the suppliers can plan their production capacity and inventories accordingly.

5. Discussion

The interviews carried out to the different players in the OWI reveal that the integration of the industry is taking place among some of them with the objective of forging strategic alliances to secure the supply of equipment for future projects. The most notable case is the setup of framework agreements and joint R&D projects between one of the wind farm developers, a foundation supplier and a WTG manufacturer, which has derived into benefits to the companies and improved team performance, as similarly reported by Andersen et al. in 2009.

Other actors in the industry are planning to setup similar joint ventures to offer competitive options. These findings are in line with Lambert et al. who in 2000 reported that companies naturally integrate with other players in a supply chain and Lockamy's (2004) observations of formations of networks with other companies in order to align their capabilities to compete with other networks in an industry.

Dimension	Developer	Substation	Foundation	Subsea Cable	Inst. Vessel	WTG
Information sharing	The developer shares information with its strategic partners, with whom it has framework agreements. The flow of information during the development of an OWF is controlled by the developer	Good exchange of information with other actors except with the WTG manufacturers, which are very secretive with the data. Some OWF developers exert a tight control of the information exchanged among suppliers when developing an OWF.	Some OWF developers exert a tight control of the information exchanged among suppliers when developing an OWF and this leads to inefficiencies in the process. There is a lot of secrecy from the WTG manufacturers.	Constant exchange of knowledge with universities, developers and other cable manufacturers via a common forum for the electric industry. OWF Developers decide how to manage the exchange of information among players. There is a good communication with a platform-structure provider.	The sharing of information is limited to the one needed to fulfil the work to be done during the installation of WTGs and foundations. The company installs WTGs from different manufacturers and handles the information confidentially by means of non-disclosure agreements.	Good sharing of information with a developer, with whom there exists a high level of trust earned through multiple successful interactions. High level of information sharing with installation vessel developers to share the information of coming WTG technologies.
Collaboration level	There is a high level of collaboration with other utilities in the sector of offshore wind power. This is used to carry out R&D activities for the benefit of the OWI. High level of collaboration with a WTG and a foundation manufacturers.	There is still plenty of space to do collaboration in the OWI. Some alliances might be formed among companies to compete against other networks in the OWI. The company has analysed a possible joint venture with a WTG manufacturer.to be able to compete with other alliances being formed in the OWI. The company has a close cooperation with some foundation providers.	There is a good collaboration level among foundation manufacturers. OWF developers are disintegrating many processes that are already integrated in order to increase competition in the tendering process.	Good collaboration level with subsea cable installers and OWF developers. Good integration with two subsea cable layers	The company has a high level of integration with a developer, a WTG manufacturer and a subsea cable layering company by means of ownership. The company has installed turbines from all of the offshore WTG manufacturers. The company does not share learnings, competitive information or development of new ships with competitors.	High level of collaboration with an OWF developer. It has difficulties to reach high levels of collaboration with other developers, mainly because of political uncertainty in the development of new markets. Development of new collaborative relationships requires investment of resources.
Demand management	Framework agreements for the long-term supply of WTGs and foundations help to provide certainty to the developer and to the suppliers of those systems.	N.A.	N.A.	They know at least one year in advance about the demand of their products. They produce cable for many different industries.	Currently, there is a high demand of their installation services and most of the projects are synchronised to start one after the other.	Demand of the WTGs is forecasted 2-3 years in advance.
Capacity planning	Framework agreements help to keep a constant pipeline of projects to make the most of the installed capacity.	Long lead time for the manufacture of the substation. In case of delays in the requested delivering time at the harbour, the OWF developer will notify in advance.	N.A.	They base their capacity planning according to the cable demand from many industries. There is enough demand to keep full production at their manufacturing facilities.	For the moment there is enough work. The capacity is planned according to all the projects in the pipeline. If market goes down they can go to do work in other markets.	Difficult to plan more than five years in advance when deciding on new manufacturing facilities. This problem is mainly due to political uncertainty in the countries where offshore wind power is present.
Inventory management	N.A.	Components inside the substation are standard electric devices that do not require a long lead time. Therefore no special inventory is required.	N.A.	No inventory, they manufacture by demand. If the client requests a later delivery of a cable, the company stores it to avoid delaying the production of other orders.	N.A.	N.A.

Table 1. Key points of the interviews

Some influential developers are trying to disintegrate several of the already integrated sectors with the aim of increasing the competition among suppliers. One example of this is that instead of subcontracting a single firm to design, manufacture and install the offshore foundations, the entire process is divided for three different companies to work on it. This situation reveals that the different industrial sectors participating in the construction of offshore wind farms are not aware of the maturity level of the OWI. The fact that some developers are disintegrating the already integrated supply of some components highlights the importance of being aware of the industry's maturity level to take appropriate decisions (McGahan, 2000; Abernathy et al., 1988). On the other hand the strategic alliances taking part in various sectors of the industry show that some of the players know that they have to join and share the expenses of much needed R&D for the benefit of the whole industry.

Information sharing was found as one of the most challenging obstacles to be overcome. Specially, WTG manufacturers should learn from the experience of other industries where an increase in the exchange of information has led those industries to improve their overall performance. It was found that the management of WTG manufacturers are willing to integrate, but it is at employee level where it does not happen, which is in line with previous findings related to the rhetoric and the reality of supply chain integration (Fawcett et al., 2002).

It is evident that the developer of offshore wind farms has a crucial role in the integration of this industry. The developer is the one who has the role of central collector of information and the one who coordinates most of the individual projects that form the construction of an OWF. The way in which the information flows in the projects is directly affected by the developer and it has been found that the current way of exchanging data is inefficient.

It was also observed that the demand management, capacity planning and inventory management dimensions were not applicable to many of the interviewed companies. Contrary to other industries where high volumes of products are manufactured, stored and sold, the main players in the OWI are aware well in advance, in some cases with many years, about the demand of their products.

6. Conclusions

Among the various actions that could be implemented to speed up the integration of the OWI are to allow the direct contact and exchange of information among the actors participating in the construction of an OWF. For that, a central documentation system as the one used in civil works involving different industries (highlighted by one interviewee), could be implemented. Further research should focus on finding the usefulness of such system in other industries and how could it be implemented in the OWI. Additionally, more support has to be given to initiatives of joint R&D projects between the different sectors in the OWI. This approach has been found to be an innovation enhancer and improve team performance in the wind industry (Andersen et al., 2009).

Further studies should evaluate the exclusion of demand management, capacity planning and inventory management from its scope of research as these dimensions do not seem to have a high impact in the interaction of OEMs of a supply chain like the one in the OWI.

This work is a first step to map the state of integration of the offshore wind industry. It is intended that the results will help managers in the different industries to be aware of the challenges that need to be tackled in order to make the OWI more competitive and become more integrated in the future.

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