Baltic InteGrid
Integrated Baltic Offshore Wind Electricity Grid Development

Supply Chain Analysis

Overview for the Baltic Sea Region

SUMMARY

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Within the scope of the project Baltic InteGrid, which works with a specific interdisciplinary and transnational perspective on the offshore wind energy (OWE) infrastructure sector in the Baltic Sea Region (BSR), a supply chain analysis was developed and presented in a paper that aims at equipping stakeholders with an overview on the current supply related to grid connection components. Furthermore, the paper presents forecasted supply capacities for 2020, 2025, and 2030 that shall contribute to identifying potential bottlenecks and, out of this, market potentials particularly for small and medium-sized enterprises (SME) related to component supply as well as to maintenance and service tasks. The focus of the investigation is on offshore wind transmission and, thus, on grid connection components. In addition, protection equipment related to OWE service and maintenance activities is taken into account.

In the first part of the analysis paper, the different components required for the construction of an OWE transmission system are identified as follows: export cables, offshore converters, substation foundations, protection equipment and offshore transformers. The supply chain analysis investigates related production processes as well as maintenance and services procedures related to these components. In the next step, the identified processes considered in the context of a typical construction timeline and the tasks every process step included. Here, it is stressed that the overall duration of the offshore transmission system installation process strongly – and even more than on other aspects - depends on the converters and transformers installation. For example, the installation can be significantly delayed in cases where components such as converters are not installed on time as this shifts the beginning of installation of the onshore converter as well as export cable to the start of offshore transformer installation.

The process analysis identifies basic studies as usual first step. These studies are mandatory prior to the construction of any offshore grid and are typically grounded in environmental surveys. Ornithological and mammal surveys investigate the offshore windfarm’s impact on birds and species in the water using survey vessels and aircrafts. The examination of the soil conditions is done by special geophysical survey vessels.

After the surveys are implemented and the construction process was started, the establishment of the grid connection is the next relevant process, aiming to allow the offshore wind infrastructure to transfer electricity to the onshore grid of the target country. Onshore subgrade and onshore converter as well as offshore subgrade and offshore converter are required here. The transmission system operator (TSO) is responsible for the grid connection, while the responsibility for the substation lays at the operator of the windfarm.

Here again, the process is heterogeneous and includes the provision and installation of different components. The first element considered here, is cable manufacturing and cable laying.
In an offshore wind farm, the connections (export cables) from the transformer stations to the converter stations or to the onshore grid are served by high voltage cables (AC or DC). AC cables have been the preferred export cable as the technology is

very mature and thus cost efficient. DC, however, is becoming more popular since the offshore farms are being built further away from the shore and the energy transmission loss of AC cable is much higher than those of DC cable technology.[1] The market for subsea cables is dominated by a few multinational corporations. Manufacturing subsea cables require highly specialized facilities. Especially the export cables are produced in extreme lengths to avoid too many joints. These long production lengths require special production lines called Vertical Continuous Vulcanization (VCV) lines and Catenary Continuous Vulcanization (CCV). With these production lines, a continuing vulcanization process is possible which helps to properly insulate the core of the subsea cables[2].

Cable laying can be done by two different technologies: either by post-lay burial (PLB) or by simultaneous lay and burial (SLB). With the PLB method, cables are first laid to the ground where a remotely operated vehicle (ROV) is used to bury it using water jets. When using the SLB method, a jet sledge pulls the export cable over the sea bed. The ground is trenched by a device at the front of the unit while the cable is put in place into the ditch from the back of the unit. In both variations, vessels must carry a significant spindle on which the cable is furled.

The foundation establishment process is the second process considered in the study related to the offshore grid connection establishment. It is stressed, that at the moment there are different kinds of foundations which are used for offshore wind farms. The most common types are monopiles, tripods and jackets. The choice of the foundation design depends on the water depth and the load they carry. As transformers and converters are characterized by extreme heavy load, jacket foundations are typically favoured. Vessels are needed to transport substructure components from the harbour to the location of the windfarm. There, a crane is used to lift the foundation into the correct position and install it into the ground. Depending on the fixation method, a drilling rig may also be needed.

In addition to cable installation and foundation construction, the installation of converter station is a significant part of the transmission establishment process. The electricity that is generated by offshore windfarms is converted from alternating current (AC) into high-voltage direct current (HVDC) by the converter station. Afterwards, the electricity is transmitted to a land-based converter station where it is converted back into an alternating current and then fed into the grid. As of today, seven converter stations have been built and two are under construction.
The offshore converters need a transportation vessel to transport it to its destination. Additional swimming crane is necessary to lift it up to the previously installed foundation. As indicated above, the installation process takes a comparatively long time and even longer for offshore converters (about 30 months)[3].

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[1] Manager Magazin," Deutschlands schwimmende Steckdose", http://www.manager-magazin.de/unternehmen/energie/general-electric-jagt-siemens-bei-offshoe-windkraft-a-1158523-3.html

[2] See http://new.abb.com/media as published on 8.8.2017

[3] See, for instance: Beschleunigungs- und Kostensenkungspotentiale bei HGÜ-Offshore-Netzanbindungen. Fichtner Study. Stuttgart 2016, p. 13 pp

At the transformer station, the power from the individual wind farms is collected and upscaled for further transmission. The installation process for the transformer is the same as for the offshore converter. Offshore transfomers are installed within 24 months while it takes 18 months for onshore transformers.

Out of the analysis of the installation procedures and related supply chain structures and processes, interviews with those companies were conducted, which can be currently considered as EU market leaders. Depending on what information were provided in the interviews and are publicly available, their profiles and portfolios were summarized (including information on business location and location of production site, key economic figures, OWE experience gained so far, competitive advantages and current market share) for presentation in a comparative overview aiming to show what market segments they cover, but also to identify and compare their projected capacities for the time frames 2020, 2025 and 2030.

The intention behind this data compilation was to determine market potentials specifically for SME, but also to identify currently observed market entrance barriers for the different components.

The **production of offshore cables** is very cost intensive and requires highly specialized manufacturing facilities. All the companies that produced inter-array and export cables for the European market in 2016 have been in business for many years and are often large and well established multinational corporations. New market entrants would face extremely high costs in building a manufacturing plant, hiring skilled workers, buying specialized cable laying vessels and developing the expertise for subsea cables. The cables must be extremely durable to face the underwater conditions. Subsea cables are produced in extreme lengths to avoid large amounts of joints; thus, the production process differs greatly from onshore cables. Only specialized manufacturing plants can perform the necessary production steps. Particularly the production of HDVC cables comes with a larger amount of risks than the production of HVAC cables. The HVDC technology is less established and potential setbacks - and with it a financial loss - would be more difficult to compensate for small and medium sized companies. An expertise in the field of onshore cables was considered as insufficient here, as the offshore cable sector has very specific requirements and is, thus, particularly technologically challenging. Still, an increasing demand for export cables was forecasted for the coming years. Interviews with major European cable suppliers suggested that manufacturers stand ready to adjust their production capacities so that no bottlenecks occur. Still, it was expressed that small and medium sized manufacturers are unlikely to enter the market as the interviewed consider larger companies, e.g. from Asia, as a more convincing option than smaller regional companies.

The research and development of **converters, transformers and protection equipment** is extremely cost intensive and many additional factors like employee training and education must be considered. Like the subsea cable market, the development and the manufacturing of the components requires specialized facilities and a large worldwide network of experts and know how. The market for converters is very new as only seven have been built as of today. The technology is extremely expensive. And the new technology has its risks that, for the most part, only large corporations can absorb.[4] [5] Offshore challenges such as extremely deep water, hostile weather conditions and lack of shore-side infrastructure further create entry barriers. The components must survive for many years in a highly punishable marine environment. Not only do market players deal with high cost pressures, but additionally the quality and durability of their products must be extremely high. [6]

The entry barriers for companies entering the market for **offshore substation foundations** are different to the entry barriers for the previously described products. The technology for foundations is less complex than for cables, converters and transformers, however some similar entry barriers still exist. New market entrants need to have a facility available where they can manufacture very large and very heavy products. Additionally, they need direct water access to transport their products since road transport would be nearly impossible due to the high costs. [7] Again, a market entry for small and medium sized companies would be difficult due to the high capital intensity. Larger companies might consider entering the market by creating a subsidiary and draw from expertise already existing in the field. An example is Steelwind Nordenham which is part of the Dillinger Group, an established steel producer. [8]

Maintenance and repair service is the combination of all technical and administrative measures including management measures during the lifetime of a unit to maintain safe and proper functioning. Especially in offshore projects the machines and equipment are facing extremely challenging environmental conditions. It is in the manufacturers' interest to have as little maintenance and repair work (especially in the early years of the project) because in an offshore environment it is more challenging and more expensive therefore having a greater impact on overall profitability. Services that many companies offer can include Asset/ Condition Monitoring, a process in which the machines/the technology is constantly monitored to detect wear or corrosion in a timely manner. It extends the service life and helps to avoid costly production losses. Other services can include end of service life solutions, here the manufacturer provides solutions for or takes over the de-commissioning process as well as the disassembly of the product.[9] It was stated clearly here, that most of the manufacturing companies offer maintenance and servicing solutions themselves, but that it happens quite often that these large companies hire subcontractors for some of the maintenance and service tasks and market potential for SME could derive from this. Addressing the large manufacturing companies would be the best approach here.

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[4] Manager Magazin, " Deutschlands schwimmende Steckdose", http://www.manager-magazin.de/unternehmen/energie/general-electric-jagt-siemens-bei-offshoe-windkraft-a-1158523-2.html

[5] Inwl, "Evaluation of active converters ".

[6] The High Wind Challenge, "Reducing weather downtime in offshore wind turbine installation", http://www.highwindchallenge.com/2016/06/13/reducing-weather-downtime-in-offshore-wind-turbine-installation/

[7] NWZ Online, " Nordenham: Steelwind-Ansiedlung versetzt Blexer in Hochstimmung", https://mobil.nwzonline.de/wesermarsch/wirtschaft/nordenham-steelwind-ansiedlung-versetzt-blexer-in-hochstimmung_a_1,0,583171070.html

[8] Steelwind Nordenham, "About us ", http://www.steelwind-nordenham.de/steelwind/unternehmen/wersindwir/index.shtml.en

[9] Wind-turbine.com," Condition Monitoring Systeme", https://wind-turbine.com/magazin/ratgeber/betriebsfuehrung/40196/condition-monitoring-systeme.html