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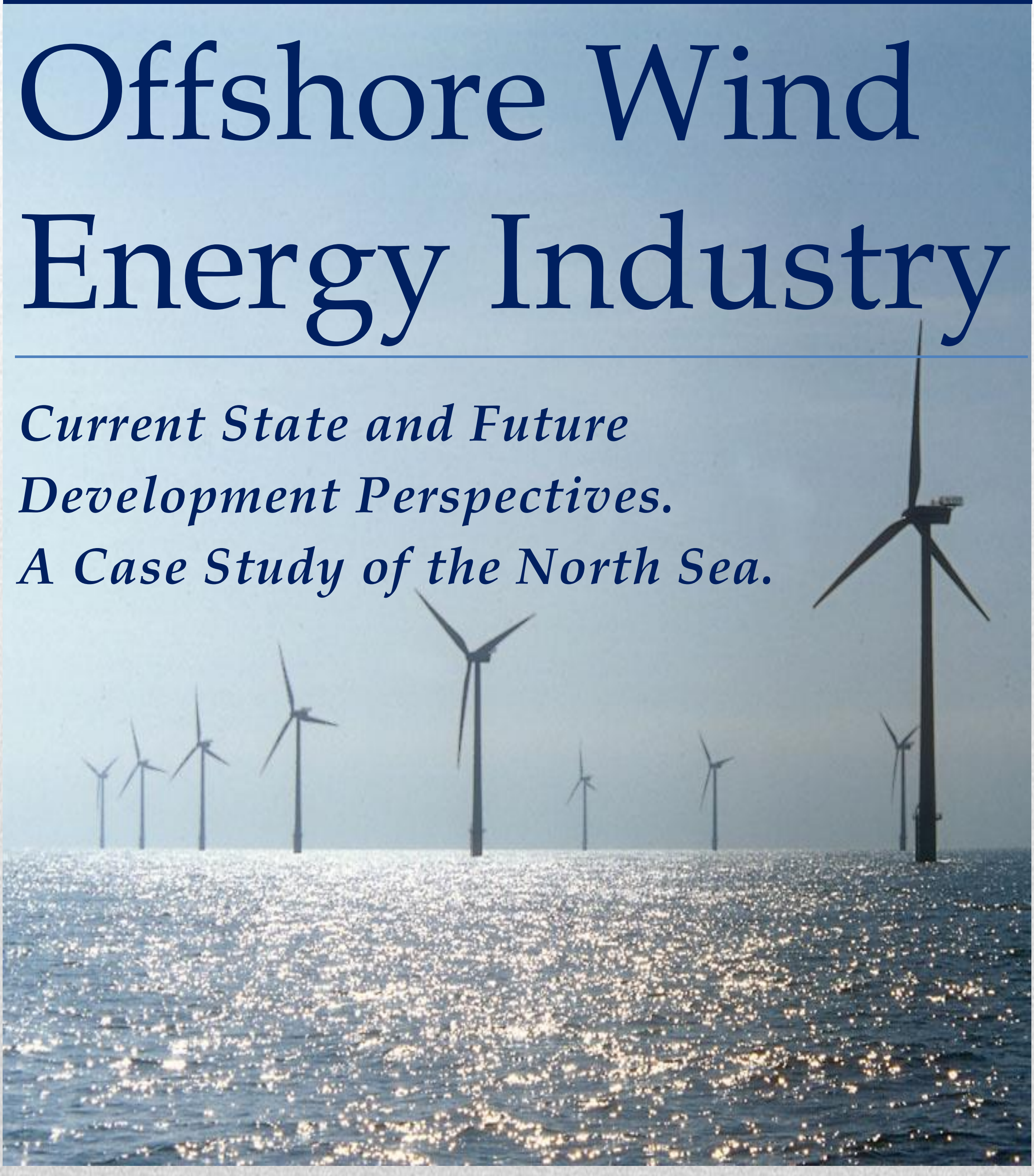
Offshore Wind Energy Industry

Current State and Future Development Perspectives. A Case Study of the North Sea.



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With gratitude, Anna Znachko

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Executive summary

The following research has been aimed to evaluate the current competitive position of offshore wind energy industry in the North Sea region compared to other energy suppliers on the European electricity market. In relation to that, existing business environment and competitive rivalry surrounding the industry has been properly analysed and evaluated, consequently indicating few significant factors possessing the most influence on the industry's performance, growth potential and further development. Accordingly allocating those factors in a two-dimensional framework allowed assessing the future development and deployment potential of the industry in the North Sea region in the upcoming years.

In order to learn about the industry, understand the operation principles of technology applied, and determine the factors shaping future growth and development pattern of the industry in a chosen region, exploratory/qualitative research design has been applied in the following study. Accord to chosen research design, the research has been built on data gathered upon own direct observations and conversations with the field experts, and in-detail analyses of various consulting reports, policy statements, planning documents, journals, magazines, and other materials available online and in print.

Through comprehensive and thorough analysis of the industry's business environment and its competitive position on the European electricity market it has been concluded that the industry currently possesses certain competitive advantages, and is strongly preferred by the market and political powers. However, being uncertain in support from the politicians and public in the near future, as well as speed and path of further development of offshore wind technology, different scenarios for future growth and development of the industry in the North Sea are presumed. Assuming the industry to continuously invest into R&D and expand existing technology potential aiming for higher profits and decrease in involved cost level, inclines the "Great Growth" scenario in the short-term and "Market Rival" scenario in the long-term perspective in terms of future competitive pattern for the offshore wind energy industry. As for active industry players, it is presumed for Siemens and its followers to consolidate their current business position, leaving Siemens the dominant player in the industry due to the first-mover advantage.

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Glossary

AC/DC	alternating current (AC) and direct current (DC) differ by the direction in which the electrons flow. In DC the electrons flow steadily in a single direction or forward, while in AC electrons keep switching directions, sometimes going forwards and then going backwards.
Baseload power	energy source that supplies the amount of power required to meet minimum demands based on reasonable expectations of customer requirements.
Carbon fibre	possess properties of high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance, low thermal expansion.
Commercialisation	process of introducing a new product or production method into the market.
De facto	from Latin means concerning fact in practice, but not necessarily bound by law.
Eco-industry	are activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes technologies, products and services that reduce environmental risk and minimize pollution and resources. The sectors fall into two general categories, pollution management and resource management.
Eco-innovation	innovation in products and services which includes a benefit for the environment.
Excitation power	the power created in the process of generating a magnetic field by means of an electric current.
Gearbox	increases the slow speed of the main shaft to a speed suitable to the generator. Thus, the speed of the rotor, which is typically well below 100 rpm, is increased up to the 1200-1800 rpm range required by the generator to produce grid-quality electricity.
Green marketing	marketing of products that are presumed to be environmentally safe. Incorporates a broad range of activities, including product modification, changes to the

production process, packaging changes, as well as modifying advertising.

Horizontal axis turbine	a wind turbine that has its main rotor shaft and electrical generator installed at the top of a tower. The turbine is designed to be pointed into the wind.
Hub	connects the blades to the main shaft. Hydraulic, mechanical or electrical equipment to drive the pitch setting of blades or emergency aerodynamic brakes are often mounted in the hub.
HVAC	has the flow of electric charge periodically reversing its direction. This type of cabling is usually more economically attractive for offshore wind developers.
Levelised cost of energy	an economic assessment of the cost of the energy-generating systems including all the costs over the lifetime of the project comparing the combination of capital cost, initial investment, operations and maintenance, fuel costs, performance. Applied by both utility-scale and distributed generation renewable energy technologies in calculating the price at which electricity must be generated from a specific source to break even over the project's lifetime.
Lignite	brown coal used exclusively as a fuel for steam-electric power generation.
Nacelle	the box-like structure located behind the rotor blades. Contains the gearbox, the generator, and various control and monitoring equipment.
Natural monopoly	defined in economics as an industry where the fixed cost of the capital goods is so high, that it is not profitable for a second firm to enter and compete. Natural monopoly tends to be the case for industries, such as public utilities.
Net electricity generation	the total amount of electricity generated by power plants after deducting the amount of electricity consumed by power plants for their own use (in plant auxiliaries and in other transformers).
Permanent magnets	magnets that are capable of creating its own persistent magnetic field.

Pitched regulation	an active control system that can vary the pitch angle (turn the blade around its own axis) of the turbine blades to decrease the rotation produced by the blades in a fixed-speed turbine and to decrease the rotational speed in variable-speed turbines. Employed for high wind speeds only allowing having a constant power output above the rated wind speed.
Prevailing winds	winds that blow predominantly from a single general direction over a particular point on the Earth's surface.
Quantum blade technology	is a unique design and manufacturing process of turbine blades applied by Siemens to offer superior performance in a wide range of wind speeds. The given technology consists of IntegralBlade® one-piece moulding for maximum strength, optimised aerodynamics for medium to high wind conditions, increased length for higher energy yield, blade root designed for minimized root leakage and increased lift.
Ramp-up time	describes the period between product development and maximum capacity utilization, characterized by product and process experimentation and improvements.
Revolutions per minute	a measure of the frequency of a rotation. It annotates the number of full rotations completed in one minute around a fixed axis.
Rotor	includes the blades and hub. The rotor can rotate either at near-fixed speed, or at variable speed, depending on the design concept. With fixed-speed operation, the rotational speed is typically 20-25 rpm for a 700 kW wind turbine, though this is dependent on design criteria. Larger turbines with longer blades have slower rotations, while small turbines with short blades rotate more quickly. For a three-bladed turbine, optimum power output is typically achieved when the ratio of blade tip speed to wind speed is approximately four to one.
Semiconductors	can be modified by controlled addition of impurities or by the application of electrical fields or light, therefore useful for energy conversion.
Slip rings	is an electromechanical device that allows the transmission of power and electrical signals from a stationary to a rotating structure. Used in any electromechanical system that

required unrestrained, intermittent or continuous rotation while transmitting power.

Stall regulation — the system that relies on the aerodynamic design of the blades to control the aerodynamic rotation or the rotational speed of the turbine in high wind speeds. The following system is not able to keep a constant power output in high winds.

Transformer — the low voltage electricity output from the generator is stepped up to grid level through the transformer. From the transformer, a high voltage cable or overhead line feeds into the main grid.

Upwind wind turbine — type of turbine that has the wind meet first the rotor than the tower, have a higher efficiency than downwind machines, since there is no aerodynamic interference with the tower. Need a tail vane or a yaw system to catch the wind. Are intrinsically self-aligning and have the possibility to use a flexible rotor to withstand strong winds.

List of Abbreviations

€	Euro currency
AC/DC	Alternating current / direct current
Approx.	Approximately
Bn	Billion
CCS	Carbon capture and storage
CEO	Chief Executive Officer
CO_2	Carbon dioxide
COM	Commission of the European Communities
CTO	Chief Technology Officer
DDT	Direct Drive technology
EC	European Commission
ESI	Electricity supply industry
Etc.	Et cetera
EU	European Union
Eurofound	European Foundation for the Improvement of Living and Working Conditions
Eurostat	European Commission Statistics
EWEA	European Wind Energy Association
Ex.	For example
GDP	Gross domestic product
GW	Gigawatt (energy unit)
HVAC	High voltage alternating current
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IPP	Independent Power Producer

LCOE	Levelised Cost of Energy
MW	Megawatt (energy unit)
NGO	Non-Governmental Organisation
O&M	Operations & Maintenance
OECD	Organization for Economic Co-operation and Development
OWE	Offshore wind energy
OWT	Offshore wind technology
POWER group	Pushing Offshore Wind Energy Regions
POWER programme	Partners Offering a Water Energy Revolution
R&D	Research & Development
Ref.	Refer
RES	Renewable energy sources
RPM	Revolutions per minute

1. Introduction

1.1 Background and research topic

European offshore wind power market has boosted over the past decade, and heated discussions over offshore wind potential in the North Sea have not left the European Commission open floor discussion since the beginning of this decade (EC, 2008). Expecting the industry to create vast employment opportunities and meet 14% of total EU electricity demand in 2030 through installation of offshore wind capacity up to 150 GW, European companies showed excessive interest in benefitting from this major development. Various manufacturers, constructors and service providers for the offshore wind energy industry pushed for continuous support from the governments in order to ensure a smooth deployment surpassing the challenges (Arapogianni, 2012). Offshore wind gradually developing towards maturity has been claimed to already generate regional economic growth and jobs, moreover contribute into reaching the EU 2020 CO_2 reduction targets (Wiersma, Grassin, Crockford, Winkel, Ritzen, & Folkerts, 2011). Being highly supported by new European energy policy and various environmental regulations, subsidized by the governments and endorsed by the public offshore wind energy industry seem to hold a prosperous future.

Yet, currently available offshore wind capacity accounts for less than 1% of total electricity production in Europe[1], having European electricity market heavily dependent on nuclear power and import of fossil fuels. Moreover, according to the World Energy Outlook, with Asian markets experiencing substantial increase in electricity demand Europe is threatened to face a 13% cut back on its fossil fuel imports from Russia by 2035. Being in quite vulnerable position in relation to electricity supply forces Europe to exploit and invest into all possible alternatives, not necessarily favoring development of offshore wind energy among the other renewable energy sources. Having the industry substantially supported by subsidies from the governments and experience difficulties in financing new projects offshore, questions ability of offshore wind to compete on the European electricity market with other players as independent sector, as well as raises concerns over the future development and deployment of offshore wind in the North Sea.

[1] http://en.wikipedia.org/wiki/Renewable_energy

1.2 Research objectives and research question

Taking into consideration the rising global energy demand, intensions of EU to improve security of its electricity supply, the potential of offshore wind technology and profitability concerns about the offshore wind energy industry, the purpose and objectives of the current thesis are as follows:

1) learn about the European electricity market development and understand its current state and driving forces,
2) examine the operation principles of the offshore wind technology and study the key trends towards offshore wind energy industry,
3) understand the business environment surrounding the offshore wind energy industry and different significant factors influencing the industry's further development and deployment in the North Sea,
4) evaluate the intensity of competition on the electricity market and assess the ability of the industry to compete against significant market players independently,
5) determine the key success factors essential for efficiency improvement and realisation of profit and industry growth, as well as the key challenges affecting operation within the industry.

The above proposed objectives of the study consequently lead to the following research questions:

Q1: With increasing electricity consumption and demand for security of electricity supply, determine how competitive at the moment is the offshore wind energy industry deployed in the North Sea in comparison to other energy suppliers on the European electricity market?

Q2: Based on surrounding business environment and current competitive position of the industry, assess how the future development and deployment of offshore wind in the North Sea may come about?

2. Methodology

2.1 Literature review

Since the first offshore wind farm installation in Denmark in 1991 a lot of research and analyses have been done on the potential of wind turbines in deep waters of the sea, and prospect of offshore wind generating substantial energy to contribute to existing electricity mix. Reviewing the critical points of current knowledge contributed to the study on offshore wind power, various issues and concerns have been observed and discussed by field experts, NGOs, independent consultants, and scholars. The core of discussions was mainly focused on the challenges and opportunities of the industry, future potential, investment and project financing, new technology development and deployment, targeted markets, and many more, inquiring whether the offshore wind industry has a future whatsoever. Several independent consultants with expertise and knowledge on global power and utilities have gathered few in-depth analyses on the concerns of the offshore wind energy (OWE) industry, findings and recap of which were prepared in a number of reports. According to availability of the following reports and other articles published on the subject of offshore wind, this topic became a debating point some four-five years ago, when the industry has shown some dynamic growth. By reviewing the following reports and articles offers an availability to understand the current trends in OWE industry development pointing towards the near future.

The European Wind Energy Association (EWEA) vigorously promoting use of wind power in Europe has annually reported on the European offshore wind industry key trends and statistics since 2009. The reports have mainly contained information on the future energy policy deployment, technology and further research on its potential, cost and investment issues in comparison to conventional electricity production costs, transnational offshore grid integration prospects and other challenges. EWEA is primarily focused on promoting the aggressive EU's objectives to reduce greenhouse gas emissions and ensure security of energy supply through banning carbon emissions from new power plants installed after 2015, claiming it the most effective way of ensuring a carbon free power sector by 2050. In general EWEA concludes that European market is well placed to lead the world in offshore wind technology (OWT) due to its highest interest in offshore wind. According to EWEA, due to lack of political support OWT has not been yet developed to its full potential, and therefore new policy framework is required since the industry and governments are claimed to be the main actors capable of improving the development and potential of this technology. In its reports EWEA divided industry challenges into five categories of issues relating to 1) policy regulations and framework, 2) market, 3) research and technological development, 4) grid integration, connection, network and power market design, and finally 5) environmental requirements and planning practices. Through in-depth analysis and evaluation of those challenges it is possible to determine the current competitive position of OWE industry, its strengths and opportunities. EWEA has also admitted Siemens as a leading market player in wind turbine manufacturing supplying the offshore market with up to 80% of manufactured components in 2011; and DONG Energy as a leading market player in the offshore wind farm development. All in all, EWEA has determined the primary market for offshore wind operations, some major players worth analysing and evaluating, major challenges potentially influencing competitive position of the industry in electricity market, current state of technology and its potential, the importance of business environment affecting the industry through political power, environmental regulations, social influence, and technological innovations (EWEA, 2007; EWEA, 2011b; EWEA, 2012).

A "Renewable Energy: An International Journal" has focused its interest on the subject publishing articles on attitudes towards offshore wind power development and assessment on value of offshore wind resources since 2008. Several articles have been focused on explaining the reasons for OWT growth by bringing attention to climate agenda and raw material scarcity, and outlining the advantages of the following technology by comparing the OWE to other renewable sources and conventional power. Some articles have touched upon the forces influencing shift from onshore to offshore wind farms, such as social and political power and land scarcity; and highlighted the challenges in design, development, manufacturing, installation, and maintenance and operation. One of the articles discussed the lack of common framework on data collection that could possibly help understanding not only the real behaviour of offshore wind turbines in the marine environment, but also possible effects on the reliability and maintainability of these turbines. Nevertheless, main focus was directed to the current status of wind technology for offshore installation, potential for OWE, prospects in the North Sea in the near future, existing plans, and promising new solutions. Recommendations of the scholars have been given regarding the focus on research and development (R&D) to explore the use of alternative materials and bring OWE closer to competitiveness, and emphasis on the scaling and learning effects due to global growth of technology to reach reduction in wind power construction costs (Hameed, Vatn, & Heggst, 2011; Breton, & Moe, 2009; Esteban, Diez, Lopez, & Negro, 2011; van der Zwaan, Rivera-Tinoco, Lensink, & van den Oosterkamp, 2012).

PwC report discussing the OWE industry capability of turning wind power potential into actual performance is mainly focused on answering the question of whether this industry will be able to bring the costs down allowing wind power compete in the energy mix with little or no subsidy. The report is based on a number of surveys gathered from some main industry players' views regarding the expectations from offshore wind power, and is prepared as a general guidance on matters of interest in the following subject. Since the OWE industry is furthest advanced in Europe, the survey was focused on opinions from European respondents, such as developers, contractors, original equipment manufacturers, utility companies, government bodies and financial institutions. All in all, the report sums up opinions on various risks and challenges of the industry reviewing the potential of OWE to successfully operate as an independent industrial sector (PwC, 2011).

KPMG has recently offered a number of reports on offshore wind in Europe regarding investment opportunities, tax exempts and other initiatives. KPMG has brought attention to existing gap between customers' demand for electricity and its actual production, asking for an introduction of a strong energy efficiency action plan including smart management systems to manage and reduce this breach. The main issues discussed at the KPMG Global Power and Utilities Conference in Paris in September 2011 brought attention to structural problems, currently insufficient competitiveness and intermittence in wind power production, reliance on political decisions and environmental policies. It has also highlighted the lack of binding global framework, lack of involvement into smart-energy systems, lack of transparency and stability in legislation. KPMG has also outlined that the current OWT possesses high construction risk and is claimed to be less proven in comparison to other renewable generation technologies. This makes the OWT quite immature in the eyes of lenders, and therefore strongly influences future growth prospects for the industry (KPMG, 2011).

KPMG has also prepared a 2010 Market Report on Offshore Wind in Europe, since awareness for offshore wind is experiencing a steady growth and the industry itself is increasingly perceived established. The core of report provides comprehensive analysis and guidance on the current state and trends of the German offshore wind market and addresses the most significant obstacles to implementing projects. In the analysis of the market in the following report it has been revealed that many offshore wind projects fail to reach the significant goals necessary to obtain investors approval of financial close, thus increasing further delays to the expansion of the projects. The report data is based on a number of individual interviews and a market survey conducted in cooperation with the German Offshore Wind Energy Foundation, Stiftung Offshore Windenergie, and the participation of numerous offshore wind developers and banks. All in all, the findings of the following analysis expose as potential obstacles to the development of offshore wind in Germany, as opportunities for building an alternative framework for the industry’s future growth (KPMG, 2010).

To sum up, the future of OWE industry is in concern of many market players due to high expectations for the industry’s future growth. Currently insufficient competitiveness and intermittence in wind power production, reliance on political decisions, environmental policies and social power questions the industry’s ability to successfully operate as an independent industrial sector. Previous studies have been closely focused on the European market and on the prospects for OWE industry in the North Sea in particular due to assured success in that area. Comparing the OWE to other renewable sources and conventional power, and evaluating the current status and trends of technology and its potential led to discussions and analyses on what will it take for the industry to allow wind power compete in the energy mix within little or no subsidy. Therefore, previously carried out research and analyses by actors involved in the given industry strongly supports the objectives determined for the following thesis.

2.2 Research methods

2.2.1 Research philosophy and research design

The aim of the current report is to study, gain the insight and analyse in-detail the OWE industry deployment and development in the North Sea and to provide industry outlook. Moreover, the following study is not designed to come up with definite decisions and/or solutions, on the opposite understand the ongoing situation within the industry and draw hypothesis about the future. Therefore, the following study is based on exploratory/qualitative research design, as to explore the factors influencing and interacting with the industry's further development (Brown, & Suter, 2012). The systematic investigation of relationship among different factors, further classified according to theoretical framework under PESTEL analysis and Porter's Five Forces model, will determine the effect of one factor on another, further resulting in creation of certain mechanism (further in the report known as two-dimensional framework applied to explain different alternative scenarios for the industry) to supplement the understanding of reality (in the report perceived as future outlook of the OWE industry) (Brown et al., 2012). In the following report the researcher is becoming familiar and acquiring insight into the specifics of the industry in order to formulate a precise problem, therefore relying mainly on empirical data, thoroughly reviewing and analysing available literature in terms of various consulting reports, public authority's reports, project planning documents, and data, as well as examining case studies (Brown et al., 2012). The choice and discussion of the literature, as well as application of qualitative research methods indicates chosen research design.

As for research approach, collecting and analysing the empirical data, subsequently developing a theory as a result of my data analysis indicates application of inductive research approach in the given study (Saunders, Lewis, & Thornhill, 2009). Personal attendance at the Offshore Energy Exhibition & Conference 2012 allowed gaining specific observation of the industry issues, as well as permitting to note a certain pattern development of the OWE industry in the North Sea. Relying on premises drawn from thorough analysis and evaluation of collected data leaves a degree of uncertainty regarding the future development of the industry in the chosen geographical region, thus specifying the following research approach. As follows, inductive approach is usually linked with interpretivist philosophy, which is normally seeking to understand specific context through perceived knowledge and focusing the research on the concrete understanding and interpretation (Saunders et al., 2009). In chosen study personally generated knowledge occurs through evaluation and analysis of numerous consulting reports based on socially constructed and subjective interpretations. According to interpretivist perspective, the researcher enters the field with prior insight about the industry aiming to understand the complexity and unpredictable nature of perceived reality (Carson, Gilmore, Perry, & Gronhaug, 2001). In chosen study the researcher is striving to understand complexity of various factors significantly influencing the future of the industry and unpredictability in terms of alternative scenario for the future industry development in chosen geographical region. Therefore, the following report should be seen as evaluation of applied technology and an industry that is rapidly growing and changing.

2.2.2 Research structure

The structure of the following thesis, demonstrated below in Figure 1, indicates that the thesis begins with introduction of research topic and its background, consequently leading towards research objectives and research questions, found under Chapter 1.2. The foundation of the consequent research questions has been based on the in-depth study of the literature described in Chapter 2.1. The structure of chosen literature and nature of research questions have subsequently led to particular research methods and application of certain theoretical frameworks thoroughly described in Chapter 2.2 and Chapter 2.3. Then, the introduction part of the thesis ends with description of project scope and theoretical delimitations, found under Chapter 2.4.

The second part of the thesis begins with the study of European electricity supply industry. Describing the history of European electricity market liberalisation and development helps understand the position regarding competition on the market and players involved. Subsequently, the current electricity market state is described followed by description of market trends and driving forces leading toward further analysis of chosen research topic. The second part is in-detail described in Chapter 3.

The third part of the thesis is most significant as it holds the main arguments of chosen research topic. The analysis of the following part is built on application of two theoretical models – PESTEL analysis and Porter's Five Forces model, – beginning with description of chosen industry's operation principles, followed by description of key trends towards the industry. The thorough analysis of the industry in specific region (the North Sea) follows in Chapter 4.3, structured according to PESTEL analysis. Subsequently, analysis and study of competition on the European electricity market determining position of North Sea offshore wind follows in Chapter 4.4, structured according to Porter's Five Forces model. Finally, the whole part ends with application of a case study describing best practice in offshore wind turbine manufacturing. The case study helps determining key success factors required for successful performance and profit growth, as well as key challenges present within the chosen sector. The case study is found under Chapter 4.5.

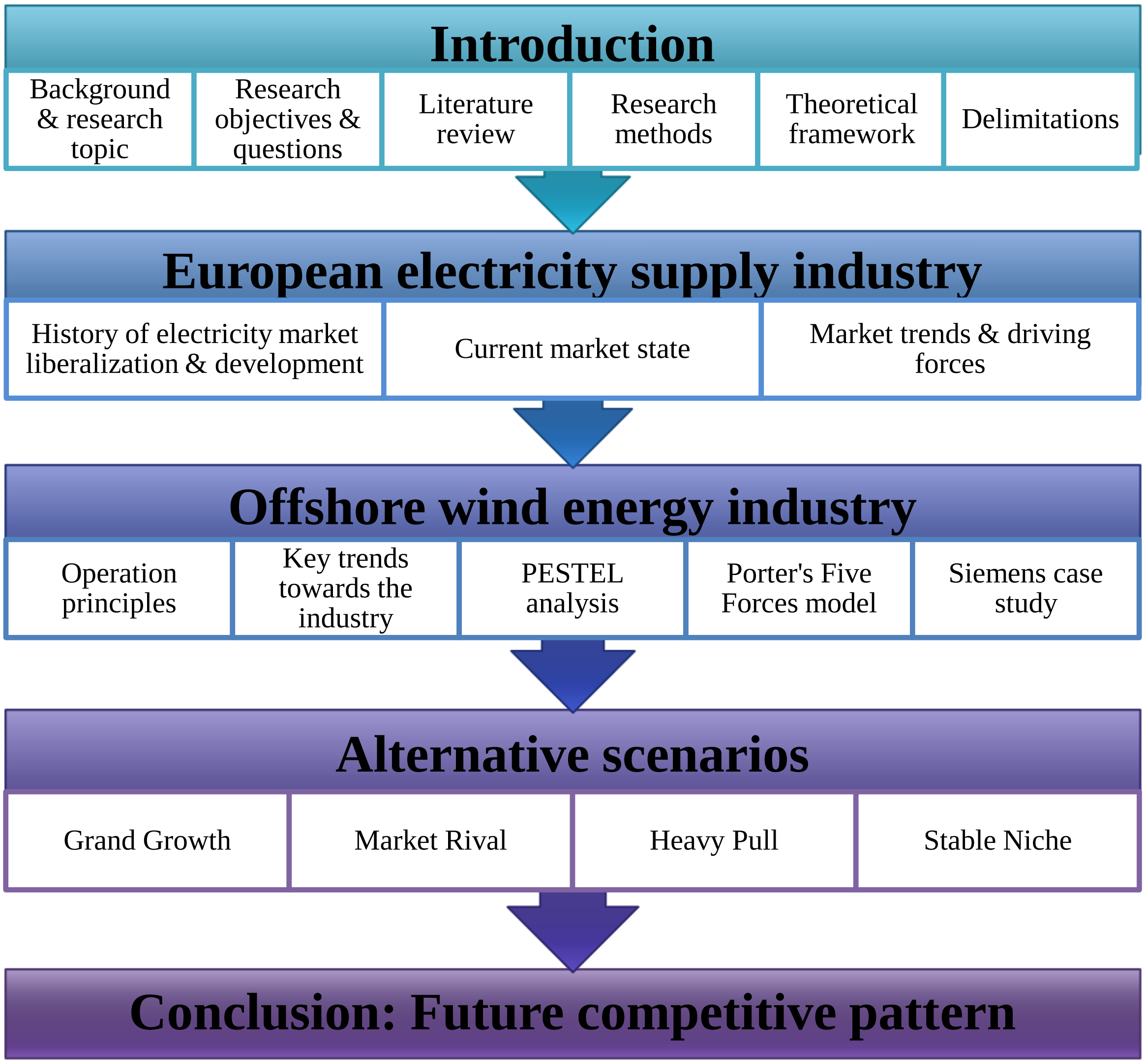

Figure 1: Thesis structure

Source: Own creation

The final part of the thesis presents alternative scenarios describing industry's potential development in the North Sea, found under Chapter 4.6. The chapter holds description of two dimensions most significantly affecting further development of the industry. Combination of those dimensions forms four alternative scenarios, characterisation of which is depicted in Figure 9 and shortly, but accurately described in Chapter 4.6.3, Chapter 4.6.4, Chapter 4.6.5, and Chapter 4.6.6. All in all, the following research ends with the chapter concluding on future competitive patterns within the industry.

2.2.3 Research data

In order to reach the defined objectives, the following research has been conducted with application of both primary and secondary data. Under primary data collection own direct observations and conversations with the field experts at the Offshore Energy Exhibition & Conference 2012 in Amsterdam have been used. Application of primary data in the following research is meant to assure reliability and validity of data and information gathered from secondary sources concerning the research topic. In terms of secondary data applied, both qualitative and quantitative data has been used. Under quantitative data various international electronic sources such as EWEA and International Energy Agency (IEA) have been used, as well as government sources and statistics available at OECD and European Commission (EC) have been applied. On the qualitative data level, various policy statements, planning documents, consulting reports and other official documents have been used. Books, journals, magazines, as well as e-journals have been applied in terms of secondary data. Last but not least, a case study regarding the best practice example in wind turbine manufacturing for offshore installations, as well as Siemens observation records have been applied in terms of secondary data source. Overall, in terms of secondary data sources plenty of data and information on the chosen research topic has been available on the internet and electronic sources.

2.3 Theoretical framework

Assessment of the current business environment for OWE industry and evaluation of competition for offshore wind in the electricity market localised in the North Sea leads to application of the two relevant models – PESTEL analysis and Porter's Five Forces – in the report. Through application of the following models it is possible to shape the bigger picture of the environment in which the industry is currently operating, and understand the influence of external environment establishing the position, potential and direction for the offshore wind. Application of the following theoretical frameworks will assist in evaluating and understanding the basic forces collectively describing the state of competition in the given industry. Finally, through evaluation of the competition intensity for offshore wind in the electricity market it will be possible to assess the ability of the offshore wind to compete on the electricity market as an independent player and the opportunity for active players in the industry to experience superior profitability.

The business environment of electricity markets strongly influences the industry's operational efficiency on given market mainly through intervention of new policies and changes in existing legislation proposed by the governments. Social awareness, public opinion and power focused on environmental concern are capable of setting barriers for the industry to operate and compete for a leading position. Competition on the electricity market driven by utility companies following their own specific electricity purchasing criteria from one side, and turbine and generator parts manufacturers from the other, gets quite influenced by substitution from innovative technologies. Therefore, assembling the structure of the current report thorough application of the following two models will explain the present competitive ability of the offshore wind industry on the European electricity market (Mohammed Abdullah, 2009).

The model displayed below (Figure 2) reveals external influence of the outer circle – PESTEL analysis – on the business environment of the OWE industry, and demonstrates in the inner circle – Porter’s Five Forces – interaction of basic elements determining intensity of competition within the OWE industry.

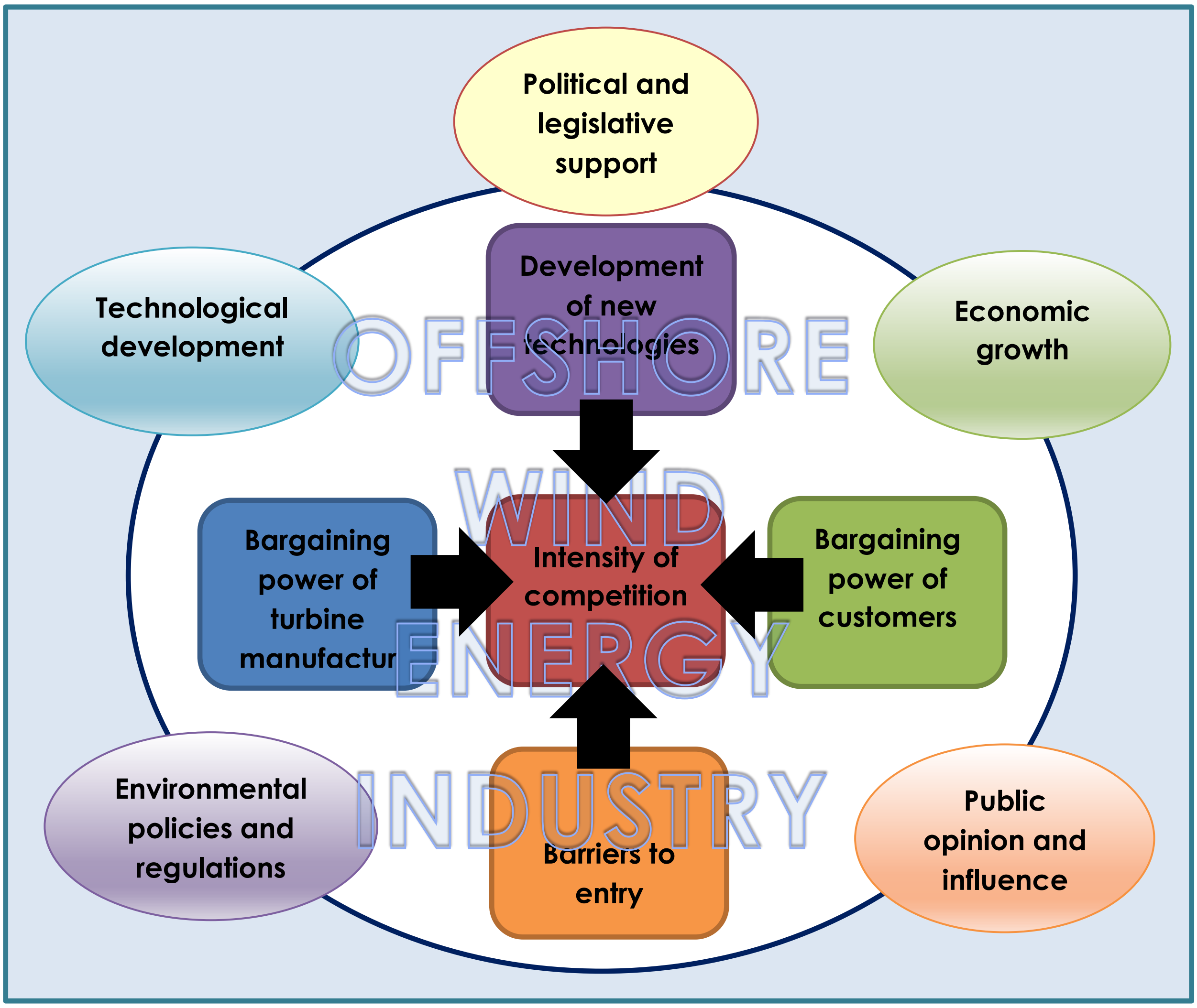

Figure 2: Theoretical framework

Source: Own composition

2.3.1 PESTEL analysis

Current business environment formed around particular industry is quite crucial as for existing as for new players. Different macro-environmental factors may influence the way companies do business in the given industry, and even more every industry tends to be affected unevenly by each of those factors. Through application of such strategic tool as PESTEL analysis the most influencing factors on the development and current state of the offshore wind industry will be pointed out. This analysis will also help understanding market movement towards growth or decline, and its potential and direction for operations.

According to the model, business environment of the OWE industry is currently influenced by all Political, Economic, Social, Technological, Environmental, and Legislative factors, more by some and less by the others (Mohammed Abdullah, 2009). At the moment government intervention and support of the current sector is quite sufficient and intense. New political decisions and implementation of novel regulations assist the industry through certain subsidies, tax exemptions, and allowances. It is noticeable that governments possess strong interest in the offshore wind power and thus, any political and legislative changes strongly impact development and movement of the industry. As for technological developments affecting electricity sector offshore wind industry has been overprotected against innovative expansions from other market players by the governments and its power. However, will there be a novelty more attractive to the political view OWE industry may lose its current support. Speaking about the environmental impact offshore wind is believed to have certain effect on marine wildlife through existence of some noise and vibration undersea. A number of projects has been set up to closely study and monitor these effects. On the other hand, concern for greenhouse gas emissions and reduction in global warming has already resulted in implementation of various environmental policies and regulations establishing taxation on CO_2 emissions, referring to all renewable energy sources as environmentally friendly. Steadily increasing energy demand triggered a search for new alternatives. Therefore, from an economic angle offshore wind is believed to be capable of meeting energy demands in the near future, thus energy generated by offshore wind turbines is believed vital for sustaining economic growth. The major obstacle created by the state of economy is credit accessibility for new offshore wind projects. Finally, public opinion and its influence have been lately taken into significant consideration. For the given industry society is believed to be a key to influence actions of some states and operations of various players on the market. Supporting offshore wind to move into deeper waters may trigger political intentions to assist the industry financially and legally. All in all, through application of the following framework in terms of evaluation of business environment will help determine competitive edge of OWE industry in relation to industries operating with conventional energy sources.

2.3.2 Porter's Five Forces model

As will be further described in delimitations, research of the following thesis is focused on analysis of the industry first and foremost and not any firm in particular. Under this condition it is meaningful to analyse the industry through Porter's Five Forces framework commonly used for industry analysis. The model identifies and analyses five competitive forces that are shaping every industry, and helps determine an industry's weaknesses and strengths (Mohammed Abdullah, 2009). In order to determine the competitive rivalry of given industry, competitive position of OWE industry on the European electricity market is to be analysed. Competitive position of the industry in relation to other conventional and renewable sources of energy will be described. Consequently, the ability of the OWE industry to compete against significant market players independently will be determined, thus shaping the attractiveness of the offshore wind market in chosen area.

According to Porter's model, the core of any competition that a business might face is the industry competition, to be exact the inter-rivalry known within the industry. Competitive rivalry of the offshore wind is dependent on other businesses that are already supplying similar product and services on the market (Mohammed Abdullah, 2009). Therefore, all players operating in the electricity market create competition for offshore wind, which in given case are oil-, gas-, and coal-based power plants, as well as nuclear, solar, tidal, and onshore wind power. This traditional area of competition is a key for the analysis of competition, assessing which will explain the current competitive position of the OWE industry. Consistent with Porter, in order to do a thorough overview of the competitive environment several other essential factors are to be understood. One factor Porter looks at is a technical threat clarifying that somebody might develop a substitute product providing similar outcome satisfaction for the customer, however slightly in a different way (Mohammed Abdullah, 2009). In terms of substitute product within a given industry the new forms of innovative technologies appearing on the electricity market might threaten current position of offshore wind. However, besides threats from new technologies different opportunities can be considered for OWE industry, creating higher value and potential. Referring to the next factor, bargaining power of buyers in certain cases can put industry under massive pressure (Mohammed Abdullah, 2009). In circumstance when a limited number of buyers is present on the market with extensive amount of supply, buyers will have the power to influence the industry. Therefore in given case utility companies, other industries, and even individuals purchasing electricity are quite significant for evaluation of competitive environment surrounding the industry. And in order to evaluate the buyers' power various decision-making criteria influencing the electricity purchase should be discussed. Moreover, the level of competition within the industry is affected by the amount of bargaining power that suppliers possess. Providers of wind turbine components, labour, and other services can be very powerful having few substitutes of inputs on the offshore wind market. OWE industry relying upon certain elements of supply in terms of materials, services, and know-how technology, can be highly dependent on offshore wind turbine manufacturers. In that case it is worth evaluating individual suppliers of offshore wind turbine technology. Finally, with increasing interest in the OWE industry new entrants may be expected to go into the market as from conventional energy suppliers' side, as from other alternative energy suppliers' side. Evaluating how easy it is for other businesses to become part of the industry, offer similar services, and start manufacturing of significant components will determine the level of ease for creating competition for already existing players in offshore wind market (Mohammed Abdullah, 2009). All in all, through application of the following framework the current state of OWE industry in terms of competition will determine attractiveness of offshore wind market.

2.4 Delimitations

2.4.1 Scope of the project

The core of the following analysis will be limited to the OWE industry deployed in the region of the North Sea generating electricity for European market. The present state of the industry will be analysed, as well as surrounding business environment and factors granting or denying competitive edge of offshore wind against other electricity generators on the European electricity market. The report will also propose assumptions regarding further development and deployment of offshore wind in the North Sea in terms of several alternative scenarios. Therefore, aiming to analyse the development of the industry on its own no particular company has been chosen to be evaluated in terms of individual opportunities on the OWE market, since the analysis is focused around the industry and not any independent business affiliate. Hence, no specific suggestions for a strong business model are going to be made in the report addressed to any company.

Moreover, Siemens case study will be applied in the following project with the purpose of analysing and determining the key success factors essential for exploiting the potential of the offshore power market. Applying the best practise in offshore wind turbine manufacturing will not only indicate the key success factors realizing efficiency and potential profit opportunities, but key challenges affecting operation and performance within this sector. Still, the report will not be built to favour the market position Siemens is currently occupying, and hence no strategic suggestions for Siemens in particular are going to be made.

2.4.2 Theoretical limitations

The following model – Porter's Diamond of National Advantage – has been considered to be included into the project to explain the successful and pioneering initiative in development of OWE industry on the European market. However, appliance of this model would be inappropriate to explain the development of entire industry for several reasons.

Normally, this model could be used in two cases: when analysing particular company's capability to function in a national market, and when analysing a national markets potential to stand the rivalry in an international market (Smit, 2010). In the following project none of the cases is applicable. First of all, the analyses will not include any particular firm and its strategic choices to expand into a new market, and therefore Porter's Diamond of National Advantage cannot be used as a comparative analysis tool. Second of all, choosing only one European market as example for analysis will not explain the competitive position of the OWE industry altogether on the international level. Instead, North Sea as the most active industry operations area due to highest number of offshore wind turbines installation will be chosen to be observed in terms of targeted market area. In that case chosen market will consist of various players with different advantages and abilities, a mixture of factor conditions, and involvement of numerous related and supporting industries. Moreover, according to Porter's Diamond of National Advantage, nature of domestic demand is presumed to be capable of explaining the appearance of innovative products on the market providing its suppliers with competitive advantage (Smit, 2010). In order to explain the emergence of offshore wind technology electricity demand has to be considered on a much broader scale than domestic or local. Therefore, Porter's Diamond is not suitable for the following research as a tool to attain earlier set objectives.

3. European electricity supply industry

In the past 40 years electricity supply industry (ESI) has experienced various changes and innovations. The history of oil crisis in the early 70s has clearly pointed out to direct dependence on oil in energy supply and forced many countries reconsidering their energy reforms, as well as energy consumption to ensure the security of energy supply. Apart from that, previously state-owned ESIs began transformation into a collection of a privately-owned generation, transmission and distribution utilities. This process has been driven not only by economic considerations and technology of the industry, but also political motivation (O'Mahony, & Vecchi, 2001). And in order to avoid repetition of the 70s turmoil, many European countries set their focus on complete or at least partial independence from the fossil fuels in the upcoming future.

ESI in Europe in the past two decades has been heavily focused on introduction of renewable energy technologies into its current electricity grid. This has been primarily done with a purpose of diversifying existing mix of energy generation sources, and thus reducing the risk of future electricity price spikes (Szarka, 2007). Currently many European countries heavily rely on fossil fuels, having coal produce around half of electricity generation, and gas being a second main source of electricity production. According to IEA and EC, EU energy import dependence currently stands at about 50%, continuing to grow at a steady rate, expecting to reach 70% in the next 20 years (Eurofound, 2008). Among the reasons are conditions of market economy that are pushing many consumers to prefer options with less overall costs normally offered by conventional sources of energy to other environmentally friendly sources, such as wind energy.[2]

3.1 Market liberalisation and development

In general European ESI is considered a *natural monopoly* due to complete ownership of the whole infrastructure from generating stations to transmission and distribution infrastructure. The industry is also heavily regulated by the governments, often with price controls. However, depending on the nature and state of reforms of the electricity market the electric companies are allowed to be involved in some regulation processes without having to own the entire infrastructure, and the end-users of electricity – selecting

[2] http://en.wikipedia.org/wiki/Electricity_market

preferable source of electricity supply.[3] The cost for infrastructure in the electricity market is very high, and thus creating actual competition on the market through duplicating the facilities, such as installing parallel sets of electric wires to every home and business, is often inefficient.[4] Therefore, transmission and distribution processes of electricity supply are normally regulated by monopoly functions, however not necessarily owned by the same actors operating as independent players (Szarka, 2007).

Talking about modifications on the European electricity market the restructuring process started in the late 90s, also known as the market liberalisation, primarily initiated to improve the reliability and security supply, and most significantly – create one common electricity market (COM, 1999). Yet, the goal has not been reached and currently several sub-markets exist in this area separated by partly insufficient transmission capacity and differences in access conditions to the grid. The low number of competitors, great market entry barriers and high incentives for mutual agreement prevent the creation of a joint competitive European electricity market (Haas, Redl, & Auer, 2008). In order to introduce effective and sustainable competition on the electricity market new reforms took place and many countries have opened up their electricity markets to all users, including households. Therefore, by increasing competition the main target for European market has been to make the functions of the electricity sector more efficient, reduce costs and improve quality, and additionally guarantee the free choice for consumers, the reason why generation and selling of electricity supply are currently run under competition (Haas et al., 2008).

The pressure on governments to improve electricity system reliability with the following reforms has been induced by substantial electricity supply disruptions in Europe during 2003, which clearly demonstrated the fundamental importance of transmission networks for the efficient and secure operation of electricity markets. Thus, the following ESI reforms introduced not only the empowerment of consumer choices, but also initiated separation of transmission activities and an obligation to provide non-discriminatory third-party access to the transmission and distribution networks (OECD/IEA, 2005). By looking at the demand side, the recent transformations allowed the end-users freely choose their supplier and negotiate their contracts. On the supply side, companies generating electricity

[3] http://en.wikipedia.org/wiki/Electric_power_industry
[4] http://www.linfo.org/natural_monopoly.html

gained opportunity of selling their electricity to any other market player, thereby creating retail competition on the electricity market (OECD/IEA, 2005). However, any developments on the European electricity market became significantly influenced by the EU energy and climate policy, which strongly affects the way electricity is generated and used today (Viljainen, Makkonen, Annala, & Kuleshov, 2011).

3.2 Current market state

Demand for and consumption of generated electricity strongly depends on economic activity and growth. As countries increase their level of economic development and living standards their appetite for electricity increases with the growth of GDP.[5] Likewise, lower level of economic activity decreases consumption of electricity, what has been observed among European markets in 2009 (as demonstrated in Figure 10 in Appendices), reflecting the impact of the financial and economic crisis.[6]

European markets have also experienced several changes among its electricity generation sources. Among the reasons is the problem of energy gaps frequently occurring at the power *transformers* and cables. Overall energy losses between the power plant and end users, which are recently recorded to be ranging about 8% to 15%, request efficiency improvements in the transmission and distribution systems (IEC, 2007). And thus, it leads to diversifications in the electricity supply mix deeper exploring options within the renewable energy sector. For instance, Lithuanian market has encountered reduction of 62.2% in electricity generation in 2010 being attributed to the closure of Lithuanian's last nuclear reactor. While Estonian market felt increase in its *net electricity generation* by 48.8% in 2010, partially due to stronger focus on electricity generation from renewable energy sources (RES), incl. wind energy (Eurostat, 2012). Furthermore, as previously mentioned Europe is strongly dependent on combustion fuels, and according to Eurostat, in 2011 54.6% of net electricity generation in the EU came from power stations operating on natural gas, coal and oil. Speaking of nuclear power plants, they have covered 27.6% of total net electricity generation. As for RES, the highest share of net electricity in 2011 was generated by hydropower plants (10.7%), followed by wind turbines (5.6%) and solar power (0.3%) (Eurostat, 2012).

[5] http://en.wikipedia.org/wiki/Economic_growth
[6] http://en.wikipedia.org/wiki/Economic_growth

Diversification of the electricity mix allows improving stability of electricity supply, which is today threatened by continuous growth of world electricity demand and some other significant environmental factors. According to the IEA's World Energy Outlook 2012, world electricity demand is projected to double between 2000 and 2030, growing at an annual rate of 2.4% (as demonstrated in Figure 11 in Appendices), which is much faster comparing to total energy consumption. This means electricity production has to increase gradually in order to meet the electricity demands in the near future simultaneously cutting down CO_2 emissions (Eurofound, 2008). Moreover, according to statistical records in EC database on electricity prices, it can be clearly seen that over the period between 2005 and 2012 prices on electricity have progressively gone up experiencing only two periods, when price growth slowed down in 2007 and slightly declined in 2009 (as demonstrated in Figure 12 in Appendices). In order to moderate electricity prices in the future and provide stable supply of electricity, governments set greater focus on alternative energy sources and are gradually increasing share of electricity generated from RES (OECD/IEA, 2012).

3.3 Electricity pricing models

At present the biggest issue within the electricity sector is economical storing of electricity, which is not yet possible to achieve with large quantities. Therefore, due to volatile consumption and uneven balance between supply and demand of power, the price of electricity is determined in the day-ahead markets (also known as the spot market), which is a short-term pricing model, to balance the generation and consumption during the delivery hours of the following day (Viljainen et al., 2011). The following pricing model in principle operates on an auction system similar to a stock exchange by matching offers from generation sources to bids from consumers at each node to develop a classic supply and demand equilibrium price, usually on an hourly interval (Viljainen et al., 2011). According to the bidding rules, market closes at noon for deliveries from midnight and 24 hours ahead. In case of submission of insufficient number of bids, the price is increased. And likewise, if too many bids are submitted – the price will decline. As for the offer price, it normally includes the generation cost as well as the transmission cost along with any profit (Viljainen et al., 2011).

Another type of electricity sales is run by bilateral contracts, which are representing a long-term pricing model. Normally bilateral contracts are directly negotiated between a buyer (an electricity wholesaler or retailer) and generator with weekly, monthly, or annual duration. This pricing model provides stability to both seller and purchaser in terms of quantity and price, as it indicates specified time periods under set prices. And in comparison to the day-ahead and real-time markets the following contracts are not subject to price fluctuations (Viljainen et al., 2011).

Some markets (or electricity generators) allow time-based pricing of produced electric power. More commonly dynamic pricing is applied having the electricity price vary between times of low and high electricity network demand. The following pricing model offers its customers constantly shifting prices, having the price signal provided by generator on an advanced or forward basis. The provided price signal usually reflects the utility's cost of generating and/or purchasing electricity.[7] This pricing model proposes real time and peak pricing models to its customers. As for the real-time pricing model, electricity prices are adjusted on an hour-to-hour basis, reflecting various conditions (ex. environmental), supply of electric power, and demand for electricity. Peak pricing in turn is implemented on a day-to-day basis, to address peak demand conditions specific to that day.[8] However, dynamic pricing is commonly available for commercial and industrial customers, currently excluding the same options for residential customers.

Another common time-based pricing models utilized by generators on market based electricity markets is known as time-of-use pricing. In the following pricing model the electricity charges are applied according to specific time periods when the electricity is being consumed. Normally this pricing model is appropriate when smart meters are in use, making it possible to base electricity bills on the exact times of electricity consumption. Therefore, under time-of-use pricing electricity charges vary for certain periods of the day, having time of use rates classified under specific time blocks known as on peak, mid peak and off peak. Prices paid for used electricity during these time periods are pre-established and known to consumer in advance, which allows them to vary their consumption in response to such prices.[9] And according to the time blocks, the higher time of use rates are charged during on peak times (when demand for electricity is high), less during mid-peak

[7] http://en.wikipedia.org/wiki/Electricity_pricing
[8] http://energy.about.com/od/billing/g/Dynamic-Pricing-Of-Electricity.htm
[9] http://en.wikipedia.org/wiki/Dynamic_pricing#Electricity_Industry

(when demand for electricity is moderate) and the cheapest – off peak (when demand for electricity is the lowest).[10]

3.4 Market trends and driving forces

The European electricity industry is evolving accordingly to a number of important driving forces, both external and internal. Various developments on economic, social, environmental and technological level directly impact upon organizational structure, growth level and energy demand from individual countries (EURELECTRIC, 2009). Those forces influence decision-making process and finally shape the development of European electricity market.

Among the biggest market drivers of the energy sector is continuous development of new technologies, which strongly affect not only the technical, but also economic potential of decision-making options. As example, recent focus on development of low-carbon electricity generation technologies, which are encouraging reduction of CO2 emissions, forced utility companies to start implementing the following technology by having the government officials limit CO_2 emissions allowance and increase price on it (OECD, 2012). Speaking about economic potential, technological breakthroughs of energy efficient technologies potentially impact the manufacturing capacity of goods or lower the costs of energy, thus significantly affecting the demand of energy and creating opportunities for consumers. Another significant driving factor of the electricity industry is improvement of energy security, which due to conventional energy resource scarcity, growing electricity demand and expected rising fossil fuels import dependency consequently leads to switch on alternative energy sectors. Thus, improving the energy mix with implementation of RES provides greater diversity of supply (OECD, 2012).

Moreover, mitigation of climate change and other environmental impacts is a force most significantly influencing the energy sector. Recent supplement to EU climate and energy policy includes objectives of ensuring the competitiveness of European economies and the availability of affordable energy through promotion of low-carbon and RES (Ruska, & Similä, 2011). Therefore, recent trends on the electricity market have shown the big move towards generation of electricity from renewable and sustainable energy sources in order to

[10] http://housewares.about.com/od/glossary/g/Time-Of-Use-Electricity-Rates-Tou.htm

create carbon-neutral environment in European countries. Furthermore, reviewing energy accidents for the past two decades it is noticeable that concern over nuclear power plants safety forces government representatives to shift away from the current power source. Thus, one of the major changes in the OECD situation in 2011 was the 9.2% cut in electricity production from nuclear energy. The occurrence of an underwater earthquake followed by the tsunami in Japan and the resulting accident at the Fukushima nuclear power plant in 2011 forced Japan to decrease its nuclear electricity production by 65%. Following the Japanese action Germany cut electricity generation from its nuclear power plants by 23%, what finally lead to the total full-OECD energy demand reduction by 1.9% in 2011 (OECD/IEA, 2012).

The electricity pricing trend is dependent on many other factors and varies from country to country. The price for electricity on the spot market is not only dependent on the factors influencing supply side, but demand side as well. In fact, on the supply side the price of generated power strongly depends on the type and market price of the fuel used for electricity generation, and the prices for CO_2 allowance. Fossil fuel based electricity generation is directly dependent on the future price projections for coal, oil, and gas. Under current trends and policies of the EU energy system, current trend on economic development including recent economic downturns, and taking into consideration the high volatile energy import price environment of recent years, the world fossil fuel prices are expected to grow over time, as demonstrated in Figure 3. Although, every time a new fossil fuels deposit discovery is made, it adds up to existing deposits, increasing its source supply, thus directly reducing retail price. Over a long-term period if no deposit discoveries are made, the available supply of source decreases, consequently demanding higher retail prices. Thus, in order to avoid power blackouts and electricity price spikes in the future EU has strongly concentrated its power policy on involvement of bigger share of RES into the energy mix.

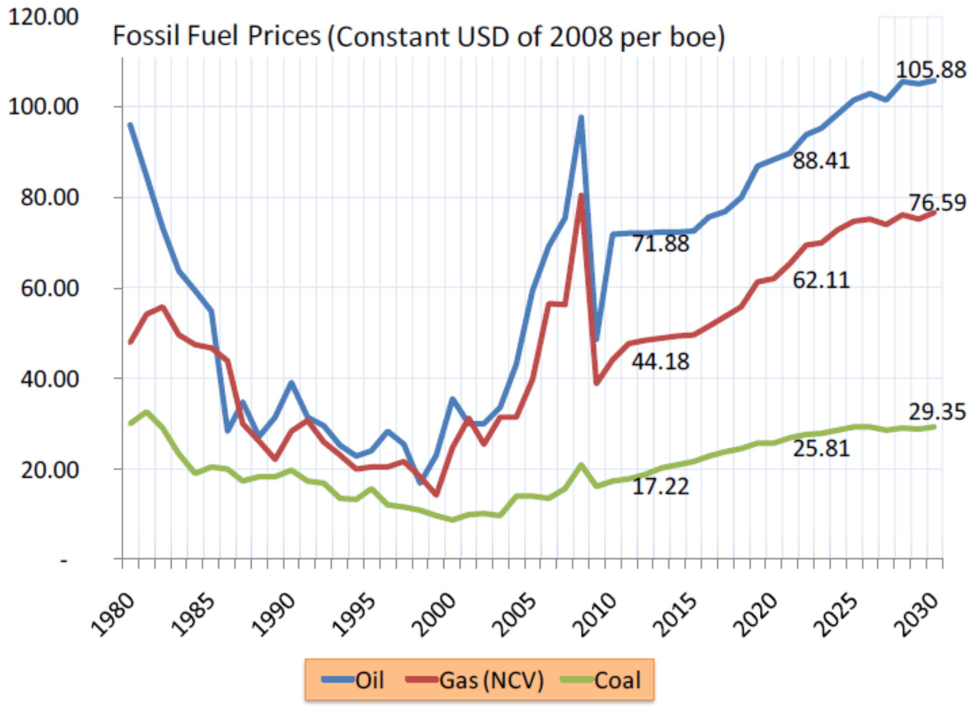

Figure 3: World fossil fuel prices

Source: EC, 2010

Other crucial factors, such as capacities of power plants, their current technical condition, planned repairs or accidental outages, condition of transmitting power lines and substations also directly affect the price formation from supply side.[11] Electricity price likewise depends on the amount of government subsidies, government and industry regulations, and even more local weather patterns, which greatly impact on operation of renewable energy generators.[12] Wind turbines and hydroelectric stations are primarily dependent on the wind and weather conditions. As for the demand side, such weather conditions as low/high temperatures and high cloud coverage will directly influence consumer behaviour to consume more electricity.[13] Under conditions of electrically-based heating of the households consumers will tend to consume more electricity during colder seasons of the year. Likewise, during the summer months usage of air conditioners, fans and other cooling systems will increase the electricity consumption. Overall, determination of the

[11] http://www.rwe.com/web/cms/en/403722/rwe/press-news/specials/energy-trading/how-the-electricity-price-is-determined/
[12] http://en.wikipedia.org/wiki/Electricity_pricing
[13] http://www.rwe.com/web/cms/en/403722/rwe/press-news/specials/energy-trading/how-the-electricity-price-is-determined/

electricity price in the future will be impacted by various other driving forces and electricity market trends (as demonstrated in Figure 13 in Appendices).

Another significant force putting pressure on the energy sector is an ongoing global debate on climate change and environmental issues. EC enforcement requirements to cut CO_2 emissions already resulted in increased focus on extending the share of RES as a proportion of total energy production (Eurofound, 2008). Besides, Europe's ESI is challenged not only by growing energy demand, projected to rise by at least 2% a year in the next two decades, but simultaneously meeting the requirements for CO_2 emissions (IEA, 2006). Implementing more RES into the European energy sector will require participation from new financial players to update the energy infrastructure (IEA, 2006; EC, 2006).

Nevertheless, related to renewable energy technologies developments and implementations, such as extension of the energy infrastructure, could also cause a serious gap of skills and personnel in the sector demanding more changes and modifications in the energy sector (Eurofound, 2008).

4. Offshore wind energy industry

Growing concerns over energy and climate dilemma, rising dependence on increasingly costly fuel imports, increasing threat of supply disruptions, diminishing natural energy resources and various other factors promoted modifications towards existing Energy Policy. EC recommended including higher percentage of electrical energy generated from renewable power sources, specifically wind power sources (EWEA, 2009b). Using natural energy source and being particularly usable in the temperate zones, where most of the industrialised countries are, made this technology very attractive for implementation on the European market. Evaluating successful growth of onshore wind capacity EWEA predicts the offshore market for wind turbines to follow the pattern. It is also forecasted for offshore wind industry to have higher growth potential comparing to onshore market for wind turbines taking into concern increasing difficulties to locate new sites for onshore wind farms, especially very large ones (ABB, 2011).

4.1 Operation principle of the offshore wind technology

Electricity generation from wind power happens on transformation of kinetic energy contained in the moving air into mechanical energy. The energy is captured by the *horizontal axis turbine* blades, which work like an airplane wings. These blades are attached to the *hub* either in a fixed/angular position, known as *stall regulation*, or on bearings, known as *pitched regulation*. Current wind turbines have three blades fixed to an *upwind wind turbine* type. Blowing air passes over the angled blades resulting in a turning force. The shape of the blade causes the air pressure to be uneven, higher on one side of the blade and lower on the other, what makes the blade spin around the centre of the turbine. To help the turbine capture the most energy a little weather vane (wind vane) is installed on the top of the turbine, which through connection to a computer keeps the turbine turning into the wind. The blades are attached to a shaft, which is further connected to the generator. The shaft rotates at quite low speed of approx. 18 *RPM*, which is not fast enough to generate electricity by itself. Therefore, the *rotor* shaft spins a series of gears connected to small gear on high speed shaft, what increases the rotation to about 1800 RPM. The *gearbox* increases the rotational speed, enabling the generator to produce a lot of electricity (U.S. Department of Energy, 2011). However, newly implemented technologies, such as direct drive technology (DDT), allow replacing the gearbox with permanent magnet systems, thus improving reliability of the turbine.

Speaking of turbine types, horizontal axis turbine with upstream three-bladed rotor became the most suitable typology in the industry covering about 99% of all wind turbines installed on the electricity market. Consequently this type of wind turbine has found a remarkable development, characterized by a quick in size and power, as well as by a wide spread (ABB, 2011). Larger turbines can capture wind energy more efficiently, therefore taller turbines are capable of reaching stronger winds. However, the ground nature and any surrounding obstacles, such as buildings, trees, rocks, etc. significantly influence the height of wind speed curve (ABB, 2011). Thus, the height of wind speed curve is determined to be higher in completely open spaces, one of the reasons why installation of wind turbines relocated offshore. To this point available technologies allow installing wind turbines offshore founded into the seabed with water depth up to 30-40m. For deeper depths the floating wind turbine models are suggested, however this technology is still being tested. Technical lifetime for wind turbine is considered to reach 30 years under continuous operation (ABB, 2011). In reality, variety of power plants are usually dismantled after 20 years of full operation for onshore wind turbines and after 25 years for offshore wind turbines due to progressive decrease in the energy production and aging of wind turbine components (EWEA, 2009c). However, once the turbine is dismantled some of its components get recycled and turbine itself gets replaced with a new one.

4.2 Key trends towards offshore wind energy industry

EWEA claims that Europe's offshore wind potential is enormous due to the strong *prevailing winds* and shallow waters of the North Sea. On average, the North Sea has a depth of 94m and in the south it is only 25-35m[14], which is a perfect match for currently utilized offshore wind turbine technologies. Thus, 80% of the total capacity installed in European waters in 2012 was located in the North Sea (EWEA, 2013). Moreover, frequency and regularity of wind out at sea can be up to 40% higher than on land. Under this condition offshore wind farms are more productive in comparison to onshore farms of the same capacity. The OWE industry was able to supply the required technology,

[14] http://simple.wikipedia.org/wiki/North_Sea

materials and construction capacity necessary, yet the technology behind offshore wind turbines has not been developed to its full potential.[15]

According to the study commissioned by the EC in 2009, offshore wind industry has great economic benefits and impact on all sectors of the economy in the EU Member States. Speaking of economic effect, in 2010 EWEA reported the offshore wind power market worth €2.6 billion, comparing it to the European onshore market worth €10 billion. EWEA also expects the offshore wind sector to reach comparable economic size to the onshore wind sector by 2020, thus showing strong potential in reaching recently set EU renewable target aiming for 20% of energy to be generated from renewable sources (Wiersma et al., 2011). According to EC, current European energy power plants are ageing and at some point there will be a need to replace them with new electricity capacity taking into account expected increase in demand. Clearly recognising that offshore wind power will be the key to Europe's energy future EWEA encourages exploiting abundant OWE resources, and thus targets reaching 40 GW of offshore wind power capacity in the EU by 2020 (EWEA, 2009b).

4.3 Offshore wind energy industry in the North Sea

The North Sea is of significant importance for development of OWE industry. Birth of the industry itself took place in the North Sea with installation of the first offshore wind farm in the 90s, as already mentioned, and afterwards installations of Horns Rev 1 – the first large-scale offshore wind farm in the world completed in 2002.[16] Generally the North Sea is a hotspot for past and ongoing developments in offshore activities, considered by many an attractive sea basin for large scale deployment of OWE. Moreover, the North Sea basin is surrounded by densely populated and highly industrialised countries, and thus is one of the busiest in the world (Veum, Cameron, Huertas Hernando, & Korpås, 2011).

According to the Pushing Offshore Wind Energy Regions (POWER) network and matchmaker for the OWE industry, the North Sea region is currently a world leading offshore wind market, both in installed and planned capacity and capability. Over 90% of the globally installed OWE capacity is located in Europe, leaving the remaining 10% of share to China and Japan. To be exact 80% of total offshore wind power capacity installed

[15] http://www.zefirteststation.com/en/offshore-wind-energy
[16] http://en.wikipedia.org/wiki/North_Sea

in European waters is located in the North Sea, with most of the key companies of the sector operating in that region (EWEA, 2013). Currently North Sea basin has an OWE capacity of 3 GW, and therefore, major growth of the OWE industry is expected to take place in that area (Wiersma et al., 2011). This sea basin is strongly believed to be in position of keeping its leadership in OWE deployment (Veum et at., 2011). According to EC, up to 12% of electricity generated from renewable sources in 2020 is expected to come from offshore installation in the North Sea in particular. The POWER group also indicates that the offshore wind located in the North Sea has potential to become a significant energy source for Europe, and currently offers huge innovative potential (POWER, 2007). Moreover, availability of specially adapted ports and harbours is critical for supplying the offshore wind market. Therefore, existence of 27 facilities capable of performing pre-assembly activities onshore, adapting to the specific needs of the sector and suitable for the installation of substructures, being located in the North Sea support the condition for this area to be the leading region for OWE industry (EWEA, 2009b).

Several other external factors are strongly influencing further development and growth potential of the OWE industry in the North Sea basin. Political interest and support for the given industry, as well as technological developments and innovations within the offshore industry are seriously shaping the development path towards industry's maturity. Economic growth within the North Sea region, specifically within the surrounding countries, public opinion and influence, and nevertheless, environmental policies and regulations on nature and marine environment strongly affect the business environment surrounding the industry, which according to theoretical frameworks can be described and analysed under PESTEL analysis.

4.3.1 Political and legislative support for offshore wind

Political drive towards ensuring good availability and security of energy supply, efficient utilisation of resources and support for EU's competitiveness, sustainable development of European cities and regions, and especially support for the climate policy targets, recently lead to significant promotion of RES (Viljainen et al., 2011). Under short-term EU energy targets to have at least 21% of electricity generated from renewable energies, it is believed offshore wind can make a significant contribution to all three objective of the new EU energy policy (COM, 2008). Especially already possessing a proven track record onshore, OWE industry is considered to possess an enormous potential (EWEA, 2009b). As for Member States, aiming for reduction of greenhouse gas emissions, ensuring security of energy supply and improving EU competitiveness, many have already incorporated the EU energy targets into their national strategies and implemented various support mechanisms for the promotion of offshore wind projects (KPMG, 2010).

Policies and legal frameworks towards deployment of OWE industry in the North Sea basin have progressed well over the last decade. Quite significant attainment for offshore wind took place in 2005, when European Parliament recognised the exceptional importance of renewable energies in a "Resolution on the share of renewable energy in the EU" underlining the impressive development of wind energy and observing remarkably huge offshore wind potential in the North Sea (De Corte, 2008). In 2007 the third legislative package "*An Energy Policy for Europe*" has been introduced by EC proposing separation of production and supply from transmission networks, facilitating cross-border trade in energy, proposing more effective national regulations and greater market transparency on network operation and supply, and finally proposing to increase solidarity among the EU countries. The following legislative package has been launched in order to ensure all European citizens benefiting from a truly competitive energy market in terms of consumer choice, fairer prices, cleaner energy, and better security. Further actions taken by the EC in 2010 consisted of adopted set of actions proposed by the "*Energy 2020 – A strategy for competitive, sustainable and secure energy*", which defined the energy priorities for the period 2011-2020. In order to achieve the objectives of EU energy policy a *Strategic Energy Technology Plan* (SET-plan) has been initiated to accelerate the development and market take-up of low-carbon technologies, and several *Electricity Directives* implemented supporting the policy goals. The following legislation laid down rules for the international market in electricity, contributed to opening of electricity markets for customers and separation between transmission and production activities (Ruska et al., 2011).

Moreover, governments are strongly supporting the industry in terms of granting permits for technology installation into the North Sea basin and specifying the sites for OWT installation. Defining the installation site of the wind farm is a time consuming process normally taking up to 5 years for various wind projects. Therefore, national governments of Member States are becoming increasingly involved in the site selection for OWE projects through detailed screening exercises. The following usually consisting of wind speed, water depth and soil conditions evaluations, thus assuring minimal impact on the environment (Wiersma et al., 2011).

At the moment OWE industry is claimed to be strongly supported by the government subsidies, what creates the risk of political interference to be always present in the market (Eurofound, 2008). However, in order to facilitate the industry moving towards maturity political power and leadership can play a significant role. Increasing a price on emission allowance will partially reduce the support needed for renewable energy. By imposing higher price on CO_2 emissions, governments will most likely direct investments towards low-emission production forms, what will consequently contribute to falling costs of renewable electricity production (Viljainen et al., 2011). As for the market support mechanisms, various investment support measures and operational support initiatives have been provided towards the industry promoting its development and further integration. Certain capital grants and purchase price reductions have been introduced. Various price subsidies (such as feed-in tariffs), green certificates, tender schemes for the construction of new generation capacity, guaranteed access for turbine installation, tax exemptions or reductions on energy production, and quota obligations have been implemented to support the industry. Speaking of feed-in tariffs introduced in most of the Member States, this policy is formed to offer extra investment security and guarantee long-term stability to producers. As for green certificates, those oblige the suppliers to deliver a portion of their electricity from RES, and actually finance the additional cost of producing green electricity (De Corte, 2008).

Even though governments have strongly supported the development of OWE industry, a clear lack of coherence in the current ambitions and support provided for OWE deployments has been noticeable (Veum et al., 2011). Legal framework for offshore wind is not fully clarified and until now is only country specific, and lack of synergy prevents the industry from exploiting its full potential. Decisive policies and clear procedures have boosted the growth of the offshore wind sector only in some countries. Thus, in order to facilitate dynamic trade across borders and efficient sharing of reserves, unified regulation and unified system operation are to be pursued (OECD/IEA, 2007). In 2005 the

Copenhagen Strategy on offshore wind power development only urged the European Council and Commission to initiate a real European policy for offshore wind power in order to further develop grid access, infrastructure and system integration (Danish Energy Authority, 2005). Currently, a significant amount of delays is caused by slow licensing and inefficient approval procedures. Therefore, it is essential to rebalance competing interests in favour of new electricity system infrastructure and offer cleaner and more efficient approval procedures (OECD/IEA, 2007). Finally, in order to secure future financing of offshore wind projects it is significant for the Member States to facilitate capital investments required for the projects in terms of low interest loans or preferential loans with financial interest subsidy. Currently competition for funds is claimed to be quite excessive normally letting the available finances flow towards the countries with the most stable policy environment and favourable return-risk ratios (Wiersma et al., 2011).

4.3.2 Technological development

Speaking of technological developments within offshore wind, the initial technology and system design applied for wind turbines offshore has been adapted from onshore-based versions and deployed in shallow waters. Speaking of types of wind turbine by power generation applied offshore, several manufacturers have developed turbines ranging from 3 MW to 6 MW in capacity, and are presently aiming for 10 MW. Currently available OWT is gradually evolving towards larger-scale offshore system that can be deployed in a range of water depths across a wider range of geographical areas (EWEA, 2009b). Accessible technologies positioned offshore allow installing wind turbines into seabed with an average water depth of 25 m and at the distance of 30 km from shore. As technology evolves and experience is gained, the OWE industry will move into deeper waters and further from the shore. The proof for that is announcement of several new projects planned and consented to move up to 200 km from shore and in water depth of up to 215 m (EWEA, 2013). Overall, the wind industry throughout its development has been characterized by its strong focus on R&D, and recognized in business as technological race internally between manufacturers.

Locating wind turbine technology offshore eliminated restrictions for the physical size of the farm and the height of the wind turbines. As already mentioned, over the last two decades offshore wind turbines have gradually increased in size reasoned by a steady reduction in the cost of generation and overall improvement in access to wind resources with height. In 2012 alone, offshore wind farms increased by 36% in terms of total project capacity compared to 2011 (EWEA, 2013). As for offshore wind turbine design, turbines are built to cope with the marine climate having its surfaces corrosion protected and provided with special filters preventing sea particles entering the ventilation and lubrication systems. Furthermore, turbines located in areas with ice are designed to protect the construction against loads of ice (Clausen, Bjerregaard, Madsen, Morthorst, & Sørensen, 2004).

With development and growth of the OWE sector increases necessity to boost the development of vessels, ports and harbours along the installation region. Even though offshore wind turbines inherited many design characteristics from onshore wind energy, a number of challenges posed by marine environment asks for further R&D. Due to challenges in access of turbines installed offshore at the time of harsh climate conditions alternative solutions for offshore intervention have been looked into, such as helicopter based access, large accommodation vessels moored at sea, or permanent island structures constructed closer to wind park locations (Veum et al., 2011). Speaking of recent developments of vessels, during 2012 several new generation installation vessels were delivered in Europe specifically designed to be operating in deeper waters up to 75 m and in higher waves. These vessels were designed to carry a larger number of foundations and turbines, equipped with stronger cranes capable of lifting and installing wind farm components with enhanced precision (EWEA, 2013). Applying featuring innovative technologies in development of installation vessels allowed increasing work efficiency of installation vessels offshore.

In OWE industry certain standardisation has already taken place driven by the high capital expenditures early on in the projects. Standardisation methods have been suggested in practices, technology and processes in order to increase productivity of assets and labour. Standards within OWE industry are still considered voluntary, however certain *de facto* rules and regulations require turbine manufacturers to meet the basis for certification, without which no wind turbine is ever granted allowance for manufacturing, installation, or finance. Therefore, certain wind turbine standards have been developed to cover design of rotor blades, gearboxes, foundations and turbines themselves. Today a number of national, European and international organisations are involved into standards development for OWE industry after it has been agreed upon that international standards drive innovation and successful implementation of R&D (Geertzen, 2013). Regional cooperation among several European countries recognising opportunities for offshore wind in the North Sea encouraged offshore grid configuration and development, discussing standardisation of future regional offshore grid design applicable in transmission systems (EWEA, 2013). Currently standardisation is seen as a mechanism capable of improving the productivity scale of the industry, easing and accelerating turbine installation process and promoting operations and maintenance (O&M) risk reduction. However, standardisation of the entire OWE supply chain has to be considered in order to enhance the ability of the industry as a whole to gain experience through lessons learned and introduce safer work processes (The Crown Estate, 2012). So far there is no standard for offshore substation and cable connections, which is vital for lowering the costs of the entire project.

The support of the EU is increasing towards the OWT strongly believing OWE to be a key power generation technology for the renewable energy future. So far wind turbines positioned offshore are still considered as immature technology leaving enormous potential for innovation and development. Currently available heavy offshore foundations, long *HVAC* export cables, offshore transformer stations and installation vessels, which occur to be essential components of the sector, are likewise claimed to be at the initial stage of innovation and development (Wiersma et al., 2011). It is clear that the supply chain efficiency and cost reduction can be achieved not only through emphasis on new technologies, new construction methods and a high level of R&D, but also through a focus on economies of scale and standardisation. Therefore, OWE industry requires stronger commitment and investment from a wider range of players and business.

4.3.3 Economic growth

Electricity liberalisation that led to transition of European electricity market from natural monopoly to a market economy not only encouraged competition in the internal market, but also created opportunities for energy resources diversification and increased renewable energy *commercialisation*.[17] As already mentioned in Chapter 3.1 “Market liberalisation and development”, by increasing competition of European electricity market governments

[17] http://en.wikipedia.org/wiki/European_Union

created feasibility for electricity sector to become more efficient, cost-effective in achieving environmental goals, and capable of responding to any future energy crisis by diversifying its energy supply. Electricity market liberalisation enabled households and enterprises of some countries freely choose their suppliers, thus increasing flexibility and competition, and subsequently promoting economic efficiency. Liberalisation process has then triggered a directive on the promotion of electricity produced from RES (Trevino, 2008). Certificates granted for electricity generated from RES both created extra choice and provided additional opportunities of exploiting and seriously considering new market perspectives for green cross-border electricity generation (The Danish Government, 2002).

Due to fuel price volatility and insecure electricity supply, EU is seriously focused on increasing the share of RES on the electricity market. As already spoken of, the EU’s new climate-energy legislative package made it mandatory to increase the share of renewable energies in overall community energy consumption. Wind energy expanded quite fast being recognised as proven source of clean and affordable energy, thus making it feasible for the governments to notice economically competitive potential especially in the OWE potential. Therefore, not only concerns for increasing prices of fossil fuels, but also ability to realize economic potential of alternative energy sources drives European decision makers towards supporting such promising sectors. Economic potential of the OWE industry has a quite significant role in Europe’s economy contributing to its GDP, particularly in the current economic climate. The development of a new industrial sector in Europe is considered an innovative motor for the regional and local development, creating jobs and facilitating growth of other economic sectors. In 2010 the wind energy industry including both onshore and offshore contributed € 32.4bn to the EU’s economy. According to the global drivers of energy sector, economic growth and structure of the Member States have direct influence on energy demand. Currently wind energy sector as a whole is capable of meeting 3.7% of EU’s electricity demand, making wind technology the second largest contributor to economic activity and employment in the area of power plant manufacturing (EWEA, 2008). It has also been noticed that the wind industry sector has become a major industrial exporter, thus in 2010 reaching € 8.8bn in the value of exports (EWEA, 2008).

Offshore grid infrastructure is within significance for further development and deployment of the OWE technology. Realising an enormous potential of the North Sea different Member States engaged in development of an inter-governmental initiative known as The North Seas Countries' Offshore Grid Initiative. Such program has been launched in order to offer a framework for regional cooperation to find common solutions in questions of current and possible future grid infrastructure developments in the North Sea (EWEA, 2010). However, currently available offshore electricity infrastructure in the North Sea is not yet suitable for a large scale deployment of offshore wind. Grid integration, comprising onshore connection and offshore interconnections are key barriers for successful large scale offshore wind deployment. Due to differences in the markets mechanisms in the European countries the full technical potential of offshore wind development is not feasible at the moment. Therefore, EU plays a key role in facilitating the establishment of appropriate grid infrastructure through the application of various programs, such as e.g. EU-funded European Energy Plan for Recovery initiated in 2009 (Wiersma et al., 2011). Overall, realizing the potential of OWE in the North Sea government officials are focused on developing various mechanism to endorse further development of the partner regions and the North Sea region as a whole, which is strongly dependent on transnational cooperation through exchange of specific experience, lessons learned from other OWE projects, best and good practice transfer, common transnational activities, economic support, supply chain and skills development.[18]

4.3.4 Public opinion and influence

Nowadays public support is quite critical for the successful operation of many projects, the reason why many developers within an offshore wind sector make significant effort to highlight the benefits of their projects publically. Application of public information centres, access to information on the websites, availability of newsletters and press conferences have assisted to project a positive image towards the growing OWE sector. Generally, same themes are reflected in the media mostly drawing attention towards the sector's ability to improve energy security, increase employment and economic development, indicating capability of the industry to power households and other industries with reduced greenhouse gas emissions, and contribute towards national and EU

[18] http://www.offshore-power.net/information.asp?Page=7&menu=1&type=menu&print=print

commitments (Wiersma et al., 2011). Therefore, application of social networks and public engagement assisted in changing public perceptions of offshore wind farms and technology by granting society familiarity and knowledge towards the industry. Consequently, the social acceptance of wind power entailed general positive attitude towards the wind energy technology (EWEA, 2009a).

Moreover, public concern for ecology and health is believed to be shaping attitude towards all renewable technologies exploited today. Frequent attitude surveys, known as Eurobarometer Standard Survey and carried out twice a year over the past 30 years, have shown that society generally has a strongly positive overall attitude towards renewable energies and wind energy in particular (89%), especially when compared to nuclear or fossil fuels (EWEA, 2008). Currently in operation coal and natural gas plants are declared to be causing significant air and water pollution, which is subsequently linked to breathing problems, neurological damages, heart attacks, and cancer among individuals. Appliance of RES instead of fossil fuels has been found to reduce premature mortality and lost workdays. In addition, OWT essentially installed in sea does not pollute drinking water systems or compete with agriculture, while both coal mining and natural gas drilling pose significant pollution of water resources.[19] As for visual and noise impacts normally listed among public concerns over operating wind energy turbines, those are known to be minor due to installation of technology on a greater distance from the coastline and far away from human populations (EWEA, 2009a).

Recently customers themselves gained power to freely choose the preferable source of electricity in their household, since available technologies afford to offer prompt electricity meters and services that help customers to understand and control their electricity usage. This allows customers to be aware of full benefits from correct timing of electricity consumption and deploy its potential. Possessing the ability to control costs of and actual consumption of electricity empowers end-users to build the attitude towards the industry, influence its development trends, and draw political attention (Viljainen et al., 2011). As for career attributes, OWE industry is claimed to be offering opportunities for economic growth and job creation specifically in the North Sea countries (Wiersma et al., 2011). According to future forecasts, the OWE sector alone is estimated to employ over 460,000

[19] http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/public-benefits-of-renewable.html

people in 2020, likewise creating development opportunities for various European companies. Besides, OWE sector slowly emerging as an independent market segment and strongly promoting green/sustainable business became well-recognized as an *eco-industry*, giving minimal negative impact on the global and local environment, community, society and economy. Applying the concept of eco-industry towards OWE allows creation of positive image and improvement of public attitude towards the industry. All in all, public support towards OWE industry is quite affirmative and is growing on a continuous basis. Currently European society is capable of significantly contributing to overall levels of OWE deployment. Proof to that recent appearance of online crowdfunding platforms, which created additional mechanisms for broader participation and support for industry, thus allowing anyone to invest and benefit from the returns.[20]

4.3.5 Environmental policies and regulations

As previously mentioned, growing global concern for environment and climate change is a significant drive towards expansion of offshore wind industry in terms of a clean source of electricity with no emissions of greenhouse gases or local air pollution (COM, 2008). A clean and healthy environment is today considered vital for maintaining wealth and high quality of life, thus actions taken at the end of 90's considering EU energy policy have been related to increase electric power supply with promotion of RES. Starting from 2008 EU emphasis changed towards implementation of regulations covering the compulsory use of green technologies in all key energy sectors (Broņka, & Zvirbule-Bērziņa, 2012). Overall, European energy policy has been modified towards delivering sustainable, competitive and secure energy within the EU power industry. Since OWE industry is considered sustainable and among the most promising energy systems for reducing environmental problems at both global and local levels, it is highly supported and prioritised by the governments.

EU governments imposed environmental taxes in order to reduce negative impacts on the environment, primarily generating environmental tax revenues from petrol and diesel operating industries. Likewise new policies have been focused on cutting subsidies to conventional energy sources, such as coal-based electricity generators, and allocating those into RES. Moreover, implementation of new environmental policies triggered drive for

[20] http://en.wikipedia.org/wiki/Renewable_energy

innovation, concretely known as *eco-innovation*, thus encouraging European companies to innovate in resources they use (EC, 2011). Nevertheless, various concepts and methods have been developed and introduced for estimation of environmental impacts by various electricity generators.

As for OWE industry in particular, in order to understand and evaluate the environmental impacts of the different phases of wind plant installations, life-cycle assessment concept has been introduced. This concept has shown that the largest environmental impacts are found in manufacturing and disposal phases of an offshore wind farm life-cycle. It also concluded that the energy consumed in the whole chain of wind plants is recovered in several average operational months, and comparing to competing electricity generation technologies allows obtaining quite significant emissions reductions. Thus, allowing comparing OWE with other electricity generating technologies highlights the environmental advantages of the industry (EWEA, 2009a).

Nevertheless, environmental impacts of the applied technology at existing offshore wind farms are closely monitored for impacts on local biodiversity and habitats. The existing EU legislation on nature and environmental assessments highly protects sensitive nature areas, and therefore grants permission for wind farm operation only when certain conditions have been met. Potential locations for offshore wind farms are to be granted approval and permits in order to avoid substantial adverse environmental impacts. Currently there have been several sites in the North Sea granted permission to install offshore wind farms, which definitely eases planning and permitting process of future offshore wind projects. In order to support the permitting process EC has planned to establish a European Marine Observation and Data network to facilitate access to data that can underpin environmental impact assessments. This initiative is still under development process (COM, 2008). All in all, newly implemented environmental policies and regulations support development and future deployment of OWE industry in the North Sea. Majority of adopted legislations referred to environment and climate concerns strongly affect electricity generators operating on conventional energy sources, thus creating barriers and challenges for those players. In term of competition this accompanies OWE industry being exempted from certain regulations, which may definitely complicate conditions of running business-as-usual for conventional energy generators.

4.4 North Sea offshore wind competitive position in the electricity market

When analysing competition within offshore wind industry it is possible to distinguish between two types of rivalry – external and internal. All electricity market participants are chosen by its customers according to price of offered electricity, type of power sources the electricity is generated from, and several other criteria. Therefore, OWE industry willing to compete for some share of electricity market is facing external competition created by conventional energy suppliers, such as fossil fuels (coal, oil, natural gas) and nuclear power, and other renewable energy suppliers, such as solar, wave and tidal power, biomass, and onshore wind energy. As for industry participants those create internal competition within offshore market for wind turbines. Capable of offering different technologies, services and operations turbine manufacturers compete for the projects available on the offshore wind market. Internal competition within the offshore wind industry will most certainly depend on competitive position of turbine manufacturers and their bargaining power.

4.4.1 Intensity of competition

Power sector reforms of the past two decades and the introduction of competition clearly changed the structure of ESI. This consequently created as wholesale as retail competition on the majority of European markets, with electricity generators and marketers competing to sell power directly to wholesale or retail customers, either through bilateral contracts or a power pool. Thus, competition amongst generators tends to move towards rivalry based exclusively on price, in which OWE is currently incapable of readily competing (Redlinger, Andersen, & Morthorst, 2002). Moreover, with gradual market liberalisation, the process of which has been in-detail described in Chapter 3.1 “Market liberalisation and development”, EU governments began to fear for direct foreign competition to take place in the European energy market in the near future. In case foreign state-controlled energy companies, such as ex. Gazprom, enter the EU energy market through acquisitions, they will most likely gain a leading position in the liberalised EU energy market. In order to avoid such monopolistic predominance of direct foreign competitors on the EU market the EC issued directives on making it impossible for non-EU companies to own majority stakes in gas pipelines or electricity transmission and distribution grids. Under the newly-proposed directives this will only be possible if foreign countries signed an agreement giving EU companies access to their energy markets (Eurofound, 2008). However, that is not the primary concern for the OWE industry having EC support liberalisation process of European electricity market and enhance competition among suppliers. Major interest for OWE industry is development and competitive position of its nearest competitors – offshore oil and gas industry, as well as onshore wind power.

Offshore oil and gas industry

Currently offshore oil and gas industry creates major concern for the OWE industry both heavily competing for similar resources on the offshore market. Offshore oil and gas industry is way ahead in experience operating offshore, thus creating enough examples for the OWE industry to learn from. Under condition that fossil fuel energy prices keep gradually increasing, electricity demand continues growing, and electricity supply remains in constraints, the offshore oil and gas industry is likely to outbid the OWE industry (Edwards, 2011). In terms of resources, offshore oil and gas industry is competing with offshore wind for areas licensed for projects implementations, such as wind farms installation for offshore wind and drilling platforms installation for offshore oil and gas. Moreover, in the near future OWE industry may have to significantly compete for offshore equipment and expertise of skilled employees with offshore oil and gas industry. Speaking of gas sector alone, it is highly important in electricity generation and currently accounts for about 20% of the total EU electricity production (Eurofound, 2008). Today natural gas is the second largest primary energy source in EU, considered less carbon intensive in comparison to coal and oil and known to release fewer particles into the atmosphere. Therefore, gas market is projected to grow rapidly in the coming years due to growing demand for cleaner energy sources (Eurofound, 2008). Heavily depending on gas imports have previously threatened EU gas supply, notably illustrating the risk of such great dependency by the so-called “pipeline war” between Russia and the Ukraine in 2008-2009 (Eurofound, 2008). Additionally, offshore oil and gas industry has several advantages over wind industry in terms of storage and support. Offshore oil and gas industry does not rely on subsidies as much as the OWE industry does, thus the industry of oil and gas is more prepared to pay higher prices for goods and services. As for capabilities to store oil and gas, it gives the industry availability of providing the energy when demanded by the market, whereas OWE industry directly relying on the weather conditions.

Onshore wind industry

Speaking of onshore wind industry, it is the closest competitor to OWE industry in terms of nearly identical technology applied in the energy sector. OWT is more complex in relation to installation and O&M. It is also more costly and therefore requires higher investments compared to wind technology applied onshore. However, offshore wind turbines have advantage of capturing stronger wind, more stable at sea than land, which consequently results in higher production per unit installed (COM, 2008). Wind turbines installed offshore also allow installation of bigger turbines with higher capacity as previously described in Chapter 4.3.2 “Technological development” under analysis of overall business environment for OWE industry. Moreover, having high population densities in most European countries creates boundaries for location of new sites for onshore wind farms, especially larger ones, thus preventing the industry to benefit from scale economies. As far as the North Sea concerned, extra costs and difficulties of offshore installation are manageable due to shallow waters of the North Sea region (Lynn, 2011). Speaking of competition for similar resources among two industries, the biggest challenge will result in competition for key technical stuff with competent skills, which will greatly increase with growth of both industries. As for advantages of offshore wind industry over onshore wind industry, it can generally provide power for a higher percentage of time and be combined with some form of energy storage, thus reducing intermittence and gaining greater market value. Still in order to combine offshore wind with other sources of energy a large scale multinational grid has to be build and operated (Edwards, 2011). Overall, operating within wind sector with nearly identical technology both industries have to compete for analogous resources in order to enhance its further development, deployment and profit potential.

Other renewables

As for other renewable technologies based on solar, wave and tidal energy, biomass (and other bio energies), geothermal, and hydro energy, OWT is considered the most mature (Roland Berger Strategy Consultants, 2013). However, those industries offering clean technologies for energy generation threaten the OWE industry to entice their customers and attract higher share of overall available investments. In case offshore wind becomes incapable of competing on price level with other environmentally friendly technologies, it will have to produce power more efficiently and seek for additional subsidies to remain competitive (Edwards, 2011). For instance, solar power is considered relatively young industry, yet quite attractive and growing. In comparison with OWE farms, solar power projects have similar lifespan of about 25 years, and having the solar panels reduce in costs by 75% over the past three years makes solar power industry more attractive for investors (Kaminker, & Stewart, 2012). Evaluating the financing of renewable energies involving pension funds over the period between 2004 and 2011, it has been noticed that each industry (solar power and offshore wind) received 30% investment share from overall financing to support its further development (Kaminker et al., 2012). As for evolving wave and tidal technologies, developers of POWER programme have recently announced its new technology designed for shallow sea basin. A dam-like structure of 30 to 60 km in length with a large series of turbines built perpendicular to the shore can create significant competition for offshore wind. Taking the dimension specifics of the following technology forces other marine users, such as OWE industry, as well as offshore oil and gas industry, to compete for physical space in the sea. However, according to POWER programme, dam-like structure technology is not threatening OWE industry in the North Sea basin having non investors interested in installation of a 50 km long structure in European waters.[21] Even so, OWE industry is forced to compete with other renewable technologies for financing, customers, marine space, qualified personnel and other resources.

Coal sector and nuclear power

According to Figure 4 located below, primary amount of electricity in EU is generated from coal and nuclear power plants. Nuclear energy is considered clean source of electricity generation since it does not release any air pollutants. Considered as one of the least costly alternatives among non-carbon energy sources, nuclear power is capable of contributing into stabilising the emission of greenhouse gases in the longer term (OECD, 2000). Several Member States heavily rely on nuclear energy being the leading electric power source in Europe. Over the years nuclear power has been effectively used in terms of risk mitigation of fossil fuel supply disruption and increasing prices. In order to secure power supply governments have been subsidising nuclear power industry, occasionally illegally (Usman, 2008). Therefore, political support is quite substantial for any industry operating within the energy sector.

[21] POWER programme presentation at the Offshore Energy conference and exhibition 2012

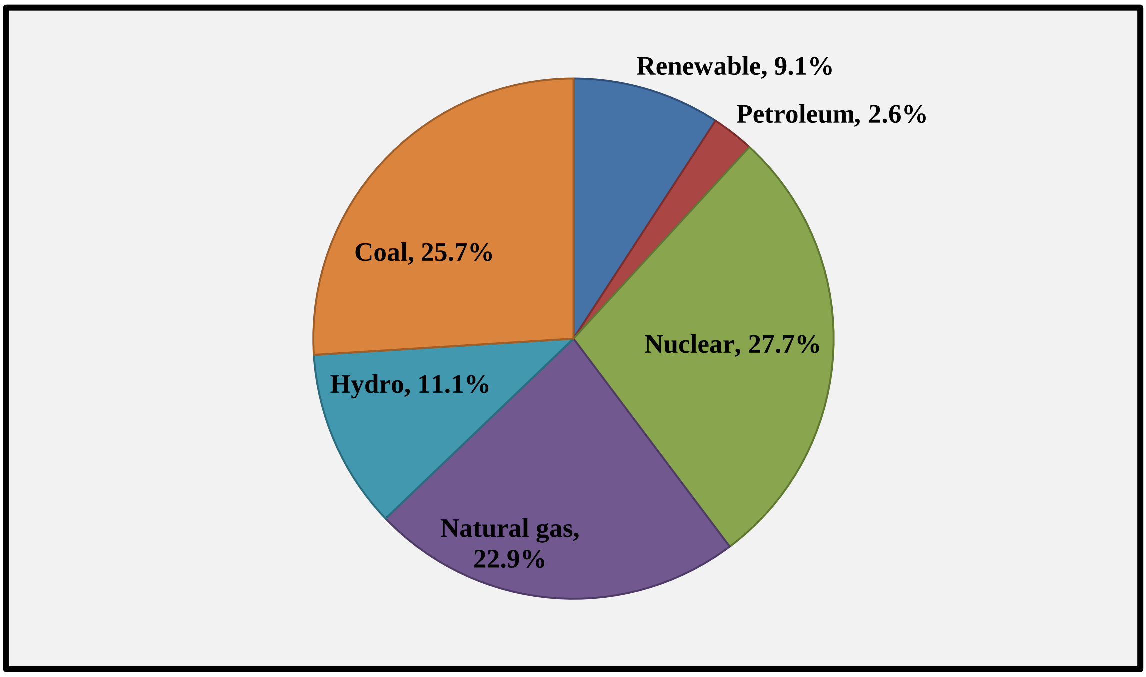

Figure 4: Electricity production by source in EU, 2011

Source: Own composition from Index Mundi

In terms of technological developments it is claimed that new nuclear reactors are designed to prevent the meltdown in times of power plant's operation, thus ensuring safety. Quite significant advantage of nuclear power remains in its efficiency and reliability of electricity generation, having nuclear energy produce large amounts of electricity from small amounts of fuel and suitable for providing a base load, present at all times.[22] However, the future of nuclear power industry is quite unclear. Following the Fukushima nuclear disaster of 2011, as previously mentioned in Chapter 3.4 "Market trends and driving forces", many Member States shut down its active reactors and banned construction of new ones. Many European countries agreed to follow the path of non-nuclear electricity generation and use, looking for alternatives to nuclear power plants in order to avoid direct dependency on imports of fossil fuels.[23] Under these circumstances OWE industry has a great potential in offering its technology on the European electricity market having its electricity generated from clean energy source, offering expertise and quality of provided technology, and possessing necessary resources for reliable operation within the North Sea region.

[22] http://howtopowertheworld.com/advantages-of-nuclear-power.shtml
[23] http://en.wikipedia.org/wiki/Nuclear_power_phase-out

As for coal-based electricity generation Europe significantly relies on international markets for its coal supply, having around 65% of hard coal and 95% of *lignite* used in electricity generation (Nigel Yaxley Ltd, 2011). The amount of electricity generated from coal has been increasing over the past couple of years in several European countries, having European utilities prefer coal over gas due to price differences. It is claimed coal price determined by global market was relatively low compared with the price of gas in Europe in the period between August 2011 and August 2012, therefore resulting in higher coal purchases compared to gas (The Economist, 2013). Moreover, after closing down several nuclear power plants some governments initiated construction of new coal-fired plants in order to rebalance the electricity supply, requiring those plants to meet certain environmental demands. Under the following terms, development of new clean coal technologies for carbon capture and storage (CCS) purposes, consequently assisting coal in becoming a low-carbon source, created potential for CO_2 emissions reduction and promising future for coal-based power plants (EURACOAL, 2013). It is indicated that all the elements of CCS technology have been separately proven, and currently operational CCS projects store around 32 million tonnes of CO_2 worldwide.[24] Having Europe heavily rely on coal power for electricity generation and further development and successful deployment of CCS technologies directly threatens the OWE industry in terms of competition for government subsidies and potential financial investments.

All in all, intensity of competition on the European electricity market between existing players is quite fierce having the industries compete for similar resources, equipment, expertise, skilled personnel, investments and financing, customers, physical space, and much more. However, with intense political and legislative support for offshore wind, as in-detail described in Chapter 4.3.1, as well as public support and implementation of various environmental policies and regulations discussed in Chapters 4.3.4 and 4.3.5, the intensity of competitive rivalry remains quite moderate leaving the OWE industry very attractive for doing business in.

4.4.2 Development of new technologies

Energy market is currently experiencing transition to new renewable technologies, what is drastically changing the sector. Today OWE industry constitutes significant part of

[24] http://www.worldcoal.org/coal-the-environment/carbon-capture-storage/ccs-technologies/

portfolio for majority of utility companies (Wind Energy, 2012). Most significantly the sector is characterized by relatively high technological level in both production and distribution, therefore any developments of new technologies are vital for energy sector (Eurofound, 2008). OWE industry itself is driven by innovative technologies alone, and there is a chance of technological breakthroughs boosting offshore wind power development (PwC, 2011). Likewise breakthroughs in other renewable technologies threaten to overtake the offshore wind sector (PwC, 2011). And thus, various innovative developments within the electricity sector can become both an advantage and a threat to OWE industry.

Many European governments are convinced technological breakthroughs within electricity sector will support the development of offshore wind in the years to come, therefore political support for OWT remains firm, as already mentioned and properly described in Chapter 4.3.1 “Political and legislative support for offshore wind”. It is perceived that some technologies newly implemented into the electricity market, such as SMART/Super grids, can trigger the R&D within offshore wind technologies allowing for OWE to become a part of SMART grids (Carbon Trust, 2008). Driven by the industry’s growth potential and the need to reduce costs of technology, O&M, installation and other processes, innovation and development within wind technology will remain a major focus for the players active in the offshore wind sector. Moreover, limited availability of turbine components, affordable installation vessels, suitable harbour facilities and similar equipment and infrastructures, as well as lack of skilled personnel with the necessary mix of qualifications, are currently considered to be key barriers for the future of offshore wind industry. Therefore, the industry is truly believed to possess an enormous potential for R&D and innovation within those subsectors (COM, 2008). For instance, various researchers and developers within subsea cable monitoring, operations and repair processes have been working on development of an underwater robot designed with a vacuum chamber where the cable will be fixed, thus replacing manual repair of subsea cables. Normally it takes up to two months before the damage in the subsea cable is found and fixed due to the sea storms and variable weather conditions, as well as unavailable machinery. Therefore, such innovation will allow mitigating health and safety risk eliminating the need of personnel to be present offshore, will contribute to operational cost reduction requiring less usage of cable material, and will save the time while fixing the damage.[25] Similarly, offshore vessel manufacturers and developers responding to changing market demands of an offshore industry are developing and designing its vessels with upgraded capacity, additional functions, and prolonged lifetime expectancy. Offshore vessel manufacturers expect that wind turbines installed offshore are going to move into deeper waters further from the shore, therefore preparing their vessels for installation of deeper and heavier cables.[26] Speaking of offshore wind turbines with floating platforms applied for technology installed on higher depths it is indicated that the technology can be borrowed from offshore oil and gas industry that already possesses extensive experience operating in rough and hostile environment of the North Sea through decades.[27]

In terms of threats, significant developments in other parts of energy sector, such as breakthroughs in CO_2 storage technologies, can have vital significance in enabling prolonged utilization of coal and gas-powered generation utilities, consequently creating competitive edge opposite to offshore wind sector (Eurofound, 2008). It is obvious, political pressure from the EC on implementation of new CO_2 quota system triggered interest towards and development in all renewable technologies threatening the OWE industry with continuous implementation of new innovative technologies into energy sector (Eurofound, 2008). Being heavily subsidised by the governments and officials OWE industry is vulnerable to any new renewable technology developed within the electricity sector threatening to pull the financing into its direction, thus leaving offshore wind to operate without any support. R&D within OWT requires high capital investment forcing the industry to compete with other clean energy generators, such as onshore wind power, solar technology, and nuclear power for potential investments (PwC, 2011). Therefore, OWE industry is heavily influenced by and can become greatly dependent on new technologies and innovative developments within energy sector. OWT can become easily substitutable with other innovative, cheaper, more reliable technologies discovered within offshore oil and gas industry, which is the strongest and primary competitor for OWE industry. North Sea has always been known as the oldest field for offshore gas and oil industry, therefore convincing many participants of that particular sector that their business in that region is not yet over. According to Ruud Zoon, Managing Director of GDF SUEZ

[25] DNV KEMA presentation at the Offshore Energy conference and exhibition 2012
[26] Heerema Marine Contractors presentation at the Offshore Energy conference and exhibition 2012
[27] Seaway Heavy Lifting presentation at the Offshore Energy conference and exhibition 2012

E&P Nederland B.V, innovation will kick off and shift the trend in decline of gas supply, since more technologies are evolving on the offshore market capable of finding new reserves of gas. Discoveries of high-pressure gas fields trigger the development of new technologies capable of extracting such high-pressure gas. Ruud Zoon also claims that offshore oil and gas industry is not a declining industry, on the opposite it has a growth perspective. Thus, this sector continues to attract aggressive development and investment, having the government officials intervene in order to support the industry in the future. Furthermore, new technological innovations within wave and tidal energy industry will significantly supplement to competition for space with other marine users. At the moment wave and tidal energy industry is aggressively developing in terms of new technologies being tested, potential customers attracted, attention from the governments and investors received.[28] Still, the governments progressively support OWT claiming it to be a key power generation technology for the renewable energy future, as discussed in Chapter 4.3.2 “Technological development”. Therefore, such high prioritisation and influence from policy makers will protect the OWE industry from being overtaken by any other electricity producer generating its electricity from renewable technologies.

4.4.3 Bargaining power of customers

Under new EU energy policy European electric utilities (from here on known as utilities or utility companies) are being forced to rebalance their portfolio, thus gradually increasing their share of overall purchased electricity with electricity generated from renewable technologies (Ernst & Young, 2013). It is obvious the primary customer making major purchases of electricity generated from offshore wind are utility companies, which afterwards distribute purchased electricity further on to other industries and private households. Utilities can also be engaged in generation and transmission of electricity, therefore their level of involvement on the electricity market holds significant influence on the OWE industry.

According to Porter’s Five Forces model, weak bargaining power of buyers makes an industry less competitive, however increases profit potential for the seller. When speaking of electricity market alone, majority of buyers are quite diluted incapable of integrating backwards in order to produce current commodity themselves. Moreover, buyers of the

[28] IHC Tidal Energy presentation at the Offshore Energy conference and exhibition 2012

following product are considered price insensitive since electricity demand is constant. In terms of substitute products available on the market, it can only refer to different sources of electricity generation allowing customers to choose a preferable source. However, buyers will not stop purchasing this commodity in case electricity is generated from unfavourable or unsustainable source due to overall increase for electricity demand and instability of supply. Therefore, bargaining power of electricity buyers is relatively low, what makes the industry more attractive, but still weak in terms of competition.[29]

On the other hand, speaking of the utilities market alone it is vital to understand the decision making criteria affecting electricity purchasing decision. According to Roland Berger Strategy Consultants, 70% of offshore wind farm ownership belongs to utilities, leaving 19% of ownership to IPP and strategic investors and 11% to financial investors (Roland Berger Strategy Consultants, 2013). Currently there are few major players on the European utilities market capable of influencing the development trend of OWE industry through its decision making process in relation to their choice of electricity generation source. Moreover, these utilities are directly involved into construction and ownership of the majority of offshore wind farms (Wiersma et al., 2011). Since utility companies are the main customers of wind technology designed for offshore installation, their bargaining power directly affects turbine manufacturers' profit potential. As demonstrated in Figure 5, today the biggest owner of offshore wind power in Europe is recognised to be DONG Energy holding 22% of cumulative installations, with Vattenfall occupying second leading position with 15% in shares, E.ON holding 11% of owners share, and other players dividing the rest of the market share respectively – RWE 10%, SSE 7%, and Centrica 6% (EWEA, 2013).

[29] http://www.wikicfo.com/Wiki/Default.aspx?Page=Buyer%20Bargaining%20Power%20-%20one%20of%20Porters%20Five%20Forces&NS=&AspxAutoDetectCookieSupport=1

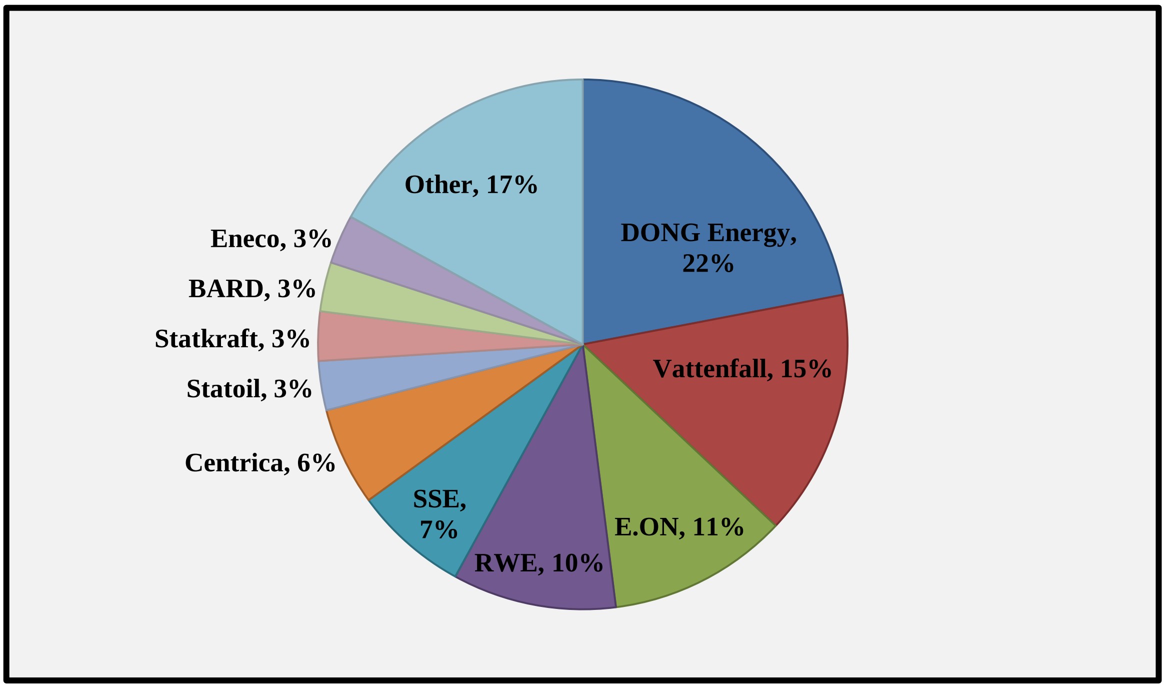

Figure 5: Owners share of installed capacity in MW

Source: Own composition from EWEA (2013)

A few number of factors are determined to be directly influencing electricity purchase decision making process. First and foremost factor is energy availability and supply, which may be dependent on geographical location and capability of a particular plant to generate required capacity, thus assuring efficiency and regularity of supply. Second, cost of the equipment applied in electricity generation including purchase price, operating and installation costs plays significant role in decision making process. Energy production and consumption can have different impacts on the environment, therefore environment is also taken into consideration.[30] Reviewing negative impacts on the environment and being pressured by new EU energy policy, utilities strive to differentiate their energy mix with various technologies. According to E.ON's energy strategy, security of supply and prosperity can only be achieved by keeping broad energy mix, ideally consisting of renewables combines with conventional energies.[31]

[30] http://oee.nrcan.gc.ca/equipment/heating/3713
[31] http://www.eon.com/en/business-areas/power-generation/energy-mix.html

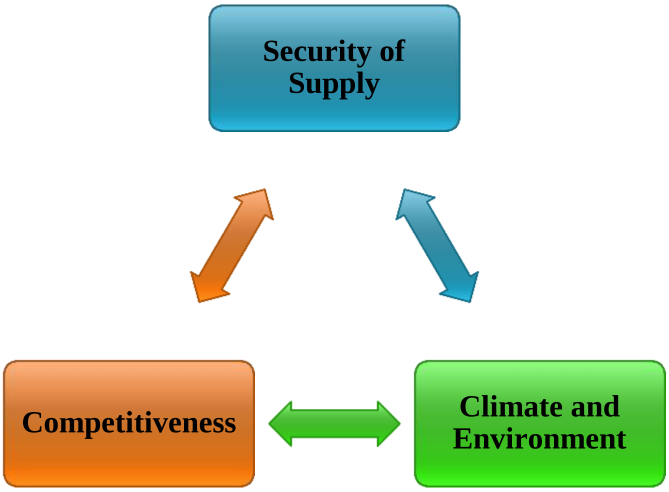

Figure 6: The Energy Triangle

Source: Own composition from Vattenfall (2011)

Above mentioned factors influencing decision making process for electricity purchase can be grouped under three key dimensions described in Figure 6 as following: 1) security of supply, 2) climate and environment, 3) competitiveness. All utility companies are strictly aware of long-term effects of operating power plants, which are impacting the environment during their life cycle. Combustion of energy sources, fossil fuels in particular, result in generation of CO_2 emissions seriously affecting the environment. Under such conditions governments impose CO_2 emission quotas and allowances aiming to reduce negative impacts on environment, consequently boosting application of cleaner technologies in the utilities energy mix. Thus, environment is one of the significant criteria considered in the decision making process. Referring to security of supply, it is clear various renewable sources are facing a technical challenge in terms of intermittence of supply and electricity storage, as well as fuel shortage creating challenges for conventional sources. Many RES due to intermittence of energy supply contribute to electricity production mix, but cannot function as *baseload power*. Having mixture of various energy sources allows quicker adjustment to variations in short-term electricity demand. Therefore, concern over meeting consumption demands and stability of supply is another vital factor considered when decision is being made. Finally, increasing competitiveness of energy mix will contribute to lowering overall costs of electricity generation, most importantly O&M costs, making it possible to combine different energy sources and technologies (Vattenfall, 2011). Competitiveness of energy mix will also create a value for businesses and consumers that are known to base their choice of energy source on reliability and efficiency. Therefore, in order to meet the society's energy needs and increase own profit potential utility companies are required to base their decision making process on balancing those three key dimensions. No matter what, utilities will include renewable technologies into its portfolio heavily relying on public opinion and political influence and intervention to support cleaner technologies with new legislations and policies, consequently indicating quite weak and low bargaining power of utilities.

4.4.4 Bargaining power of turbine manufacturers

When reviewing bargaining power of turbine manufacturers it becomes clear there are a limited number of businesses offering extensive experience in offshore wind, qualified expertise and services, competent technology, as well as design quality. As for wind turbine manufacturing process itself the wind structure is known to consist of five main components normally supplied by different suppliers each qualified in its field of expertise. The rotor, *nacelle* and machinery, and tower foundation compose up to 74% of the manufacturing cost of a wind turbine, what puts the suppliers of those components in a good position to negotiate process (EWEA, 2009a). In order to gain higher bargaining power many turbine manufacturers have begun forward integration into the market, manufacturing entire turbine with all necessary components at its own facilities. Therefore, M&A and patenting practice has been applied towards individual suppliers of turbine components to assure stability of price, quality of components, and reduce vulnerability and dependence on certain components supply. Consequently, turbine manufacturers have gained a high bargaining power on the OWE market.

Speaking of the industry overall, turbine manufacturers are the ones supplying wind technology for electricity generation offshore, and therefore under Porter's Five Forces analysis of OWE industry's competitive position turbine manufacturers take the role of "suppliers". Equipment supply to the offshore wind market is determined in terms of turbine technology available on the market. Currently there are several well-established suppliers of OWT providing its equipment and services for the North Sea region. As demonstrated in Figure 7, there are two leading turbine suppliers for offshore wind power on the European offshore wind market. In terms of total installed capacity of offshore wind turbines in the North Sea in 2012, Siemens holds the leading position with largest market share of 58%, followed by Vestas with the second largest share of 28%, and the rest of the market respectively divided between Repower (8%), BARD (3%), WinWind (1%), GE (1%) and others (1%). Siemens has a history of keeping its leading position for over 20 years now (EWEA, 2013).

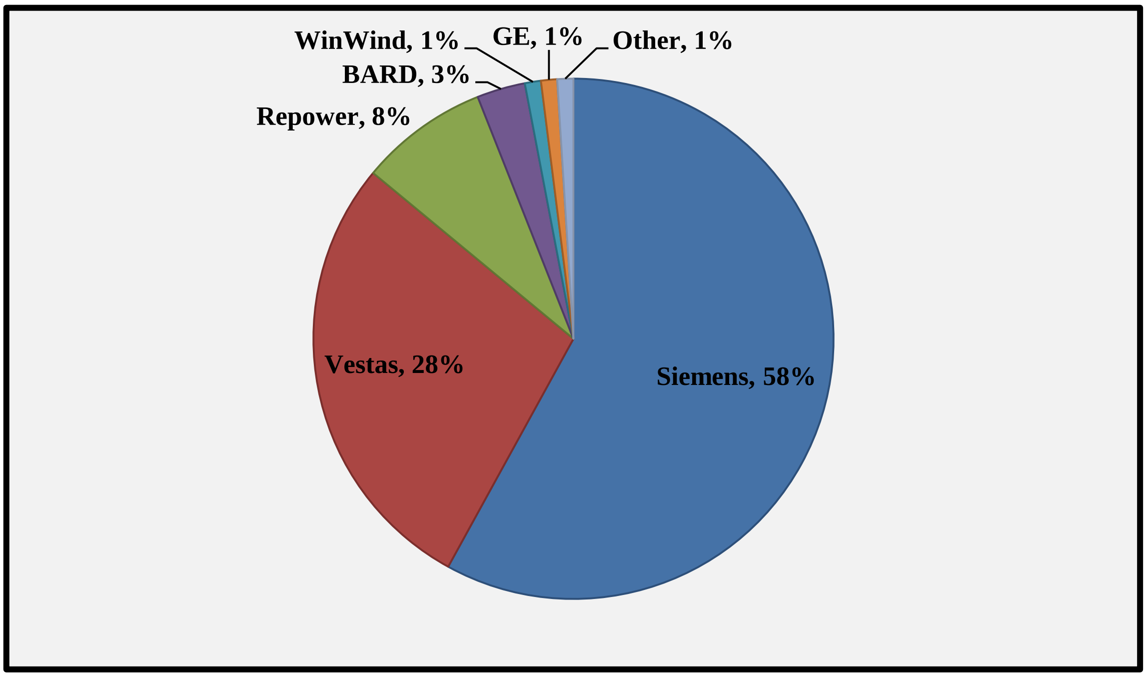

Figure 7: Wind turbine manufacturers' share at the end of 2012 (MW)

Source: Own composition from EWEA (2013)

According to current market share, suppliers of the OWE industry are very concentrated offering similar turbine types and designs, and alike services towards its customers. Therefore, an enormous potential for innovation and development of several components and technology itself opens opportunity for new market entrants. A set of new turbine manufacturers are claimed to be testing its new technologies for offshore wind, preparing to enter the offshore wind market with new turbine models intended for the offshore market both shallow and deeper waters.[32] Overall, the number of qualified suppliers with tested turbine technology and experience offering unique product and services is quite narrow to choose from, what clearly indicates suppliers' power over the industry. Normally buyers of OWT receive O&M services from the technology supplier for the first five year from the moment of turbines installation offshore in terms of warranty for technology quality. The cost of switching among different suppliers is quite high since expertise and

[32] Bluestream Offshore presentation at Offshore Energy conference and exhibition 2012

productivity of services carried out offshore is quite significant for successful performance of the industry, and therefore many buyers extend the contract with technology suppliers for further provision of O&M services (Edwards, 2011).

However, even though turbine manufacturers according to Porter's Five Forces analysis appear to hold substantial power in the industry, having only few trustworthy suppliers dominating the industry with proven OWT and expertise, offering effective and unique product, creating important input to buyers' portfolio differentiation, keeping high switching costs among turbine manufacturers, it is not in suppliers' interests to increase the price of its product and services supplies. Turbine manufacturers currently active on the offshore wind market compete for every project initiated in the North Sea region.[33] Winning the contract over new offshore project development, in particular installation of its turbine technology, grants the supplier opportunity of being involved into development and improvement across the entire project value chain. Even though there are few strong players present at the European offshore wind market, opportunities within the industry allow new players of the market demonstrate their technologies suitable for deeper waters, thus capable of reducing the bargaining power of current suppliers for OWE industry. Still, only being capable of competing on scales of economy through industrialisation of its manufacturing activities, reducing *levelised cost of energy* (LCOE) through optimisation of logistics and new installation concepts will allow the new suppliers (new players) to raise their cost competitiveness and increase their bargaining power (Roland Berger Strategy Consultants, 2013).

4.4.5 Barriers to entry

In order to enter the offshore wind market, several barriers must be overcome. The new market players within wind turbine manufacturing must first possess an efficient and reliable turbine design. Second, for successful performance and operation on the following market significant engineering, manufacturing, and construction expertise are required due to wind turbine complexity.[34] Therefore, lack of experience and qualified people can become a major obstacle for the new entrants. Superior quality at the same time is

[33] http://www.dongenergy.com/EN/Media/Newsroom/News/Pages/AnholtOffshoreWindFarmcreatesactivityinDjursland.aspx
[34] http://www.res-group.com/what-we-do/onshore-wind/engineering.aspx

correspondingly substantial in manufacturing, thus ensuring the wind turbine's long lifetime (ABB, 2010). Existing market players with well-established brand names, lasting experience and proven reliability have a significant advantage on that level over potential entrants. Finally, a large amount of capital is needed for the initial manufacturing costs, which is quite difficult to obtain taking into consideration that many private investors consider the offshore wind industry a high-risk investment due to its immaturity and enormous capital requirements (Scottish Enterprise, 2011).

From Figure 14, demonstrated in appendices, it can be seen that the market for multiple segments, including blades, bearings and gearboxes, is highly concentrated and these segments have high entry barriers based on size of investment and manufacturing *ramp-up time*. Moreover, many suppliers operating within the sector claim offshore wind market to have significant entry barriers particularly in terms of penetrating current and future supply chains, restrictions created by prevailing contract strategies and a lack of equipment and technologies. Figure 8, displayed below, demonstrates several entry barriers into offshore wind market that are of primary concern for technology suppliers. According to players heavily involved into the offshore wind sector, difficulties in penetrating dominant supply chains originate from restrictive procurement policies of turbine manufacturers, as well as timely and costly nature of the bidding process (POWER, 2005). In terms of contractual strategies developed to mitigate risk that occurs through implementation of a single offshore wind project, it can be time consuming and difficult for suppliers to negotiate the terms of a contract with both single and numerous contractors involved into the project. Turbine manufacturers also fear the lack of necessary equipment and up-to-date technologies directly impacting the performance, installation and operation processes of currently available offshore wind turbine technology.

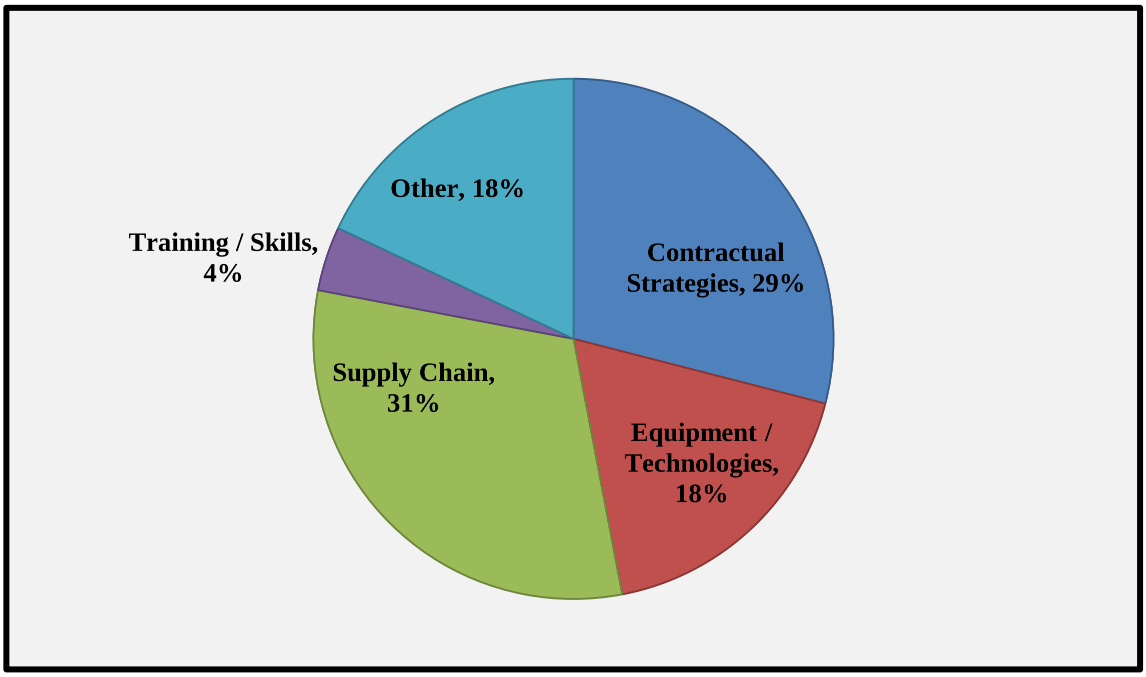

Figure 8: Barriers to entry offshore wind market

Source: Own composition from POWER group (2005)

Another entry barrier into the offshore wind market is a solid level of competition from conventional plants that in most cases are operated and maintained by government funds through former state-owned utilities. In addition, being heavily vertically integrated current electricity players tend to create obstacles for new technologies entering the market in terms of gaining grid access and obtaining fair and transparent connection costs (EWEA, 2009a). New entrants should also keep in mind that existing market players compete on scales of economy, meaning they must be able to create a large amount of turbines to have a profitable business. Manufacturing costs of one turbine are quite high due to appliance of rare earth minerals for high permeability of *permanent magnets*, high modulus *carbon fibre* for wind turbine blades, high powered *semiconductors* for control, power conditioning and *AC/DC* conversion, big amount of copper for cables, transformers and generators, and other unique and expensive materials used in manufacturing of each offshore wind turbine (Edwards, 2011). Under these circumstances new market players will only be able to compete when possessing a large investment into its manufacturing. Therefore, initial investment is a significant factor that creates very high entry barriers for companies seeking to enter the OWE industry. Only obtaining industrialisation of manufacturing, ability to compete on scales of economy and gaining substantial capital will allow new entrants to compete on the offshore wind market.

All in all, although the barriers to enter offshore market for wind turbines are significant, the industry itself is also very attractive and promising due to its extensive growth rate and demand outpacing supply. Still it is unlikely to face the threat of new entrants into the current industry, as the offshore wind projects require intensive involvement and large amount of commitment in terms of capital, assets and work. Only insignificant number of organizations possessing required capabilities and willingness to take the risk of entering yet developing sector will enter the market (Badech Raghveer Singh, 2008). Entry barriers are extremely high at the moment, however with substantial political influence and policies intervention it will be possible to ease the existing barriers making new market players only a minor threat to well-established wind turbine manufacturers.

4.5 Best practice in offshore wind – Siemens case study

Siemens name is well-recognized and respected in the OWE industry. The company has played a key role in founding the industry by installing the world's first offshore wind farm. All the turbines installed in this pioneering project are still reported to be in excellent condition, consistently operating at high availability. Providing on budget and on time project delivery, high availability project operation, optimised process across the complete project lifecycle, and offering expertise and over 20 years of experience in offshore wind power makes Siemens number one technology provider in offshore wind (Siemens, 2011).

4.5.1 Siemens wind power solutions and strategy

Energy sector is a comprehensive part of Siemens' portfolio. Siemens is a well-recognized leading supplier of a broad product selection, solutions and services in the field of energy technology. Siemens believes that with gradual increase in electricity consumption likewise grows system's complexity (Siemens, 2011). Being able to offer its innovative and efficient products in the areas of power generation, power transmission and oil and gas production makes Siemens the world's only manufacturer with knowhow, products and key components for the entire power matrix (Siemens, 2011). As for the wind power, this business sector is a vital part of current Siemens' environmental portfolio.

Siemens is by far the most preferable wind turbine supplier due to longest experience and reliability in the industry, and excellent skills in delivering offshore projects. To differentiate itself from any other offshore wind turbine supplier Siemens offers equipment for the entire energy value chain, from the wind turbine to net conversion, efficient feed-in to smart energy grids, and power distribution (Siemens, 2011). Still to better understand successful performance of Siemens in offshore market for wind turbines it is important to review the company's history and analyse its operation strategy for that business sector in particular.

Being the first and being confident in its business success gave Siemens quite a competitive advantage. As it has already been mentioned, a big success was installation of the world's first offshore wind farm in Vindeby, Denmark, in 1991, still available in operation today. 12 years later Siemens had installed the world's largest offshore wind farm at the time using megawatt-class turbines. In 2009 Siemens had installed a single wind farm with the highest capacity over 200 MW. Later in 2012 Siemens began construction of the biggest offshore wind power plant with total capacity over 500 MW, and the world's first 1 GW project. Thus, by covering more than 2 GW of installed offshore capacity and high order intake Siemens confirms its leading position in offshore market for wind power technology since the establishment of the first offshore wind farm (Siemens, 2011).

Siemens' strategy for successful operation in offshore wind power is to be "simply the best" in the industry, specifically focusing on three core areas: turbines, installation process, and provided service. As for turbines, the 3.6 MW type designed by Siemens is today in fact considered the standard for offshore projects (Siemens, 2011). Applying best technology over the years, Siemens' turbines have set the standard for robustness and reliability. The firm manufactures its wind turbine blades cast in one piece in a closed process, thus leaving no weak points at glue joint and providing optimum quality (Siemens, 2011). Such design is also claimed to offer maximum energy extraction from any available wind resource. As for the nacelles of Siemens' turbines, those are built with integrated automatic lubrication systems, which enable continued operation of the turbine during delayed maintenance at severe offshore weather conditions. Siemens' turbines design includes fully integrated climate control system of the internal environment and provides optimum lightning and fire protection as well as uses market-leading engineering practices for all of its details (Siemens, 2011). In fact, Siemens turbines comply with all relevant grid codes, since Siemens sets the standard in the field of grid compliance. To assure grid stability with growing wind power supply into the grid Siemens implemented power conversion system, which offers maximum flexibility in the turbine response to voltage and frequency control, fault ride-through, and output adjustment (Siemens, 2011).

Experience in offshore wind industry is significant for robust installation process. Over the years Siemens tested and analysed a large number of aspects in turbine installation methodology gradually establishing best practice. Understanding the complexity and challenges associated with implementation of an offshore project, Siemens applies fundamental approach in installation being able to fit project-specific requirements easily adjusting to needs of individual customer. Offering alternatives depending on the customer's skills and objectives, and deploying its optimised installation processes Siemens maximizes the value of each link in the chain, providing minimum costs and optimum predictability in project delivery (Siemens, 2011).

In general, Siemens has the reputation of a high quality service provider operating under superior safety principles, which were established by extensive experience. To optimise the output of wind turbines throughout their lifetime the firm has designed a flexible range of service solutions for offshore projects, which can be easily adjusted to match the owner's skill sets, objectives, and interest in participation (Siemens, 2011). These offshore services are offered to meet the specific context and requirements of each individual project, being based upon several areas of excellence. Siemens is aware of challenging environment operating offshore, therefore concern for health and safe operations while accessing turbines is of primary consideration. Siemens requires its personnel to attend quality training sessions, which provide training excellence in safety planning, technical skills, and survival at sea. These training courses are acknowledged as world-class. Siemens also requires its personnel to perform daily assessments what gives the firm advantage on safety standards in the wind industry (Siemens, 2011).

Siemens has a track record for securing optimum availability offshore. With help of its monitoring systems Siemens is able to analyse advanced turbine data more proficiently. Finding and fixing minor issues before they lead to a major system failure makes Siemens a highly reliable offshore service provider. Competent field service team and strategic demand planning capabilities are key components for maximizing unit availability (Siemens, 2011). Siemens is capable of providing safe access to its wind turbines installed offshore. Continuous investment into R&D allows Siemens employing sophisticated weather forecasting systems, safe transport, and stationary offshore accommodation platforms. This not only increases response time, but also provides safe working environment for its service specialists (Siemens, 2011).

4.5.2 Key success factors

Nevertheless, such successful performance in a way can be explained by a carefully planned strategy focused on various factors which altogether brought value and profitability to the company. The following factors obviously allowed Siemens gaining its current reputation and trust.

<u>Diversification key</u>

According to Andreas Nauen, the former CEO of Siemens Wind Power, Siemens capability to diversify preserves immunity to adverse economic effects. Siemens operations are diversified commercially, geographically and technologically. The firm is quite active along the wind power value chain from turbines to grid connection (Hohler, & Hopwood, 2009). Availability of world class training centres offering promotion of technical expertise and safety makes Siemens a diversified high standard service provider with the best people in service. According to John Michael Hannibal, the CEO of Offshore EMEA at Siemens Wind Power, not only with an adequate technology, but also world-class services Siemens is capable of reducing the time spent offshore and consequently bringing down the cost of electricity.

<u>On time and on budget delivery</u>

One of Siemens major strengths is on time and on budget project delivery. Combining key elements of Siemens offshore model, which are deep respect for the challenging conditions, detailed planning, and superior and consistent project management skills required during the execution phase, the firm managed to build a unique track record in successful installation of offshore wind turbines (Siemens, 2011). Delivering on time and on budget is a considerable part of Siemens' overall strategy offshore along with safe installation and maintenance operations. As stated by Samantha Jane Tidmarsh, the director of EHS Offshore at Siemens Wind Power, premature project delivery is a preferable option for Siemens, what the firm has also been capable of achieving in the past. According to Siemens track record of various projects, 3.6 MW type of turbine installed at the Burbo Bank Offshore Wind Farm in Liverpool Bay with a total capacity of 90 MW was accomplished prematurely (Hohler et al., 2009).

Best technology

Offshore wind is of high priority to Siemens believing that market rules for that industry in particular are quite different from standards. The proof of technology viability is among primary requirements from a client. Therefore, Siemens awareness of being able to prove that its technology functions offshore in harsh environments allowed gaining competitive advantage on the offshore market for wind turbines installation. Investing into R&D of new technology and frequently implementing projects for its testing throughout 20 years granted Siemens with reliable technology, unique expertise and experience that its competitors do not have (Hohler et al., 2009). Moreover, it is claimed for Siemens offshore success to be based on strong sales of its 3.6 MW turbine, which is a current state of the art wind turbine (Hohler et al., 2009). The firm also claims to have installed over 500 turbines offshore and over 1.000 to be currently under contract. Consistent with Henrik Stiesdal, the CTO at Siemens Wind Power, for the years to come this machine is believed to play the key role in the offshore wind markets.

In 2004 Siemens acquired the DDT and began testing it on 3.6 MW offshore turbines in 2008. Replacing the gearbox in a turbine with permanent-magnet generators requiring no *excitation power*, *slip rings* or *excitation control system* allowed Siemens building less complex machinery. Being assured that with fewer moving parts DDT has the potential to reduce O&M costs and make the technology more reliable and durable, the DDT became particularly attractive for offshore use. DDT is now applied in the 6.0 MW turbines already available for the offshore market. Even though DDT makes the nacelle both heavier and more expensive in manufacturing, Siemens expects to reduce this differential over time and anticipates this cutting edge technology to become a competitive alternative to gearbox turbines (Larsen, 2008). As for the new 6.0 MW DDT turbine it is believed to be the future for the offshore wind market in the years to come. According to Henrik Stiesdal, one of the reasons for the high reliability in robustness of the new machine is that Siemens applied into this design all the learning from its 20 years of experience.

Experience

Over 20 years of experience in offshore market for wind turbines gives Siemens the highest amount of expertise in the industry comparing to other wind turbine suppliers. The reliability proof is significant when choosing adequate supplier in offshore wind power sector and in virtue of such extensive experience Siemens possesses all the knowledge and techniques necessary to make the turbine operate for over 25 years. Consistent with Jan Kjaersgaard, the CEO of Wind Power EMEA at Siemens Wind Power, Siemens is also capable of meeting its client's requirement to find the supplier that is in offshore for the long-term. Overall Siemens has earned the reputation for having the world class project management capabilities gained throughout lasting experience, which in offshore wind industry considered an essential and unique resource.

Industrialisation of manufacturing and services

Siemens admits that the large scale wind farms have made it possible to industrialise their manufacturing. Siemens values industrialisation of the offshore wind quite significantly, since this process is capable of reducing the LCOE. According to Richard Luijendijk, the director of Siemens Service Renewables, currently Siemens manufactures its 3.6 MW turbine nacelle on a real production line and produces its 3.6 MW turbine blades in an industrial scale. Siemens is also concentrated on industrialisation of offered services. Consistent with John Michael Hannibal, focus has long shifted from the single units towards the entire wind farm in order to optimise the output of the whole wind farm. Thus, ability to achieve economies of scale directly impacts the cost of the energy-generating system granting Siemens an opportunity in lowering initial investment, operations and maintenance and other costs of any project's lifetime.

Financial stability

It is also significant that Siemens is stable financially. Throughout recent financial turbulence Siemens has remained rock steady persisting its financial base. As stated by Jan Kjaersgaard, diversified investment in other businesses and industries gives Siemens certain financial strength to mitigate its risks. Siemens claims to possess a sound capital structure providing the firm with ready access to capital (Siemens, 2011).

Customer loyalty

According to Samantha Jane Tidmarsh, Siemens is concerned over success for the whole project, not only its personal performance. Customer satisfaction is a key to loyalty and future business opportunities for Siemens. Therefore, every client is considered a business partner, whose expectations have to be met on a high level.

All in all, Siemens has the right technology, experience from more than 20 years, well-established name, and a strong balance sheet to back up its operations in offshore wind market. Installing turbines in a safe way and pursuing strong commitment to bring down the cost of offshore wind in the years to come not only grants, but also consolidates Siemens in its leading position on the offshore wind market.

4.5.3 Key challenges

For Siemens being successful mean being challenged at the same time. Pioneering in offshore wind industry comes with great responsibility. As in order to maintain its reputation and trust Siemens is forced to take higher risks and deal with hazardous situations mainly build on its own experience. Some obstacles are still difficult for the firm to tackle.

Optimisation

The biggest challenge in offshore market for wind turbines is great cost of energy generation. The gradual reduction of these costs can be achieved with optimisation in every stage of development, manufacturing, installation and operation processes (Edwards, 2011). Concern over reduction of LCOE is directly related to offshore wind industry's potential to compete against conventional energy sources as independent and mature industry. Siemens' introduction of its innovative DDT into wind turbines and *quantum blade technology* indicates the potential solution for cost reduction, however does not solve the issue of LCOE.

Speaking of installation processes, it is important to ensure availability of adequate vessels suitable for mounting of offshore wind turbines and its components. It is claimed that current wind turbine installation vessels provide the capacity that limits certain turbine design options. Bigger offshore wind farms consisting of numerous turbines will require vessels capable of carrying adequate amount of turbine parts to increase efficiency in installation process and tolerate fuel costs associated with amount of vessels used for installation of each wind farm. Currently there is also a shortage of vessels capable of installing cables, which slows preparation of wind farms for full operation. Furthermore, existing and new vessels are expected to become highly in demand by the oil and gas industry from 2015 to 2020. It is predicted that the planned peak for installation of offshore wind farms is likely to overlap with a peak in oil and gas decommissioning activity, what will probably be the tail end in construction of gas production platforms in the Southern North Sea (Edwards, 2011). Not only installation optimisation, but also technology optimisation is of significant concern. Composite technology for large machines is yet unproven, and therefore makes it impossible to optimise for large projects farther offshore (Musial, 2012).

Qualified personnel

With growing OWE industry raises the demand for qualified engineers and technicians capable of installing and operating turbines offshore. Availability of suitable qualified people becomes a concern due to similarity of basic qualifications required in the offshore oil and gas industry. Migration of skilled workers from offshore wind sector to the offshore oil and gas sector happens on a daily basis due to better pay and conditions in that sector. In the long term both industries will require more skilled workers, and therefore it is vital to establish education and training centres to provide an adequate supply of qualified personnel in the near future (Edwards, 2011). With gradual increase in projects size Siemens is likely to face the challenge in allocating its current human capital, meanwhile being incapable of attracting more employees with necessary qualifications and skills.

Project financing

Currently a lot of subsidization from national governments is provided towards the industry, what raises concern over political uncertainty into the economics of offshore wind. Financial institutions and banks consider subsidies a commercial risk since any financial aid from the government can be as easily awarded as removed. This criterion significantly affects the ability of wind farm owners to raise the capital required for implementation of any offshore projects in wind industry (Edwards, 2011). Under these circumstances Siemens risks to face the challenge of being incapable to find new customers for provided services and available technology.

Grid connections

Another biggest challenge offshore is a problem with supply of grid connections. Integration of a newly installed wind farm into electricity grid is especially challenging with increasing depth and distance from the shore. Allocation of sub-stations and amount of cabling used for each project that meets the following circumstances requires prolonged installation time and increases installation costs accounting for cabling, transmission lines and shoreside interconnections. Nevertheless, operation and maintenance of cables installed on the seabed is time-consuming, quite dangerous in manual operation since applying human capital, and difficult to access.[35] Siemens being capable of delivering and installing its turbines offshore is likely to face the challenge of being incapable to put accomplished projects into operation lacking adequate grid connection system.

All in all, important steps still need to be taken towards cost efficient installation and industrialisation of all processes (manufacturing, installation, etc.) in order to reach benefits of scale. In order to provide stability in operation offshore wind industry needs to address potential conflicts with other users of the same marine areas, most obviously offshore oil and gas industry (UNEP, 2012).

4.6 Alternative scenarios for offshore wind deployment potential in the North Sea

Aiming to achieve the goal of more secure, cleaner and affordable energy future WindSpeed project, initiated to support OWE industry in the North Sea, analysed the obstacles preventing development of offshore wind and suggested alternative scenarios for further deployment of OWE technology in the regions of Central and Southern North Sea. Through thorough analysis of resource availability, state of technology and supply chain development path, transmission and system integration requirements, existing and future regulatory environment WindSpeed developed a set of four scenarios based on a two-dimensional framework (Veum et al., 2011). Overall, based on own comprehensive

[35] DNV KEMA presentation at the Offshore Energy conference and exhibition 2012

analysis and evaluation it is determined that OWE industry further development and deployment in the North Sea severely depends on several factors, accurately described and in-details analysed in Chapter 4.3 “Offshore wind energy industry in the North Sea” (designed accordingly to PESTEL analysis) and Chapter 4.4 “North Sea offshore wind competitive position in the electricity market” (designed accordingly to Porter’s Five Forces model). Evaluating all the aspects of the following analyses it can be concluded that few factors will have the most influence on developing OWE industry. New innovative technologies as within the industry itself as within competitive industries may seriously change the development path of offshore wind. Political support, implementation of various environmental policies and regulations, as well as public support and influence shape the direction for further development of offshore wind in the North Sea. Therefore, taking WindSpeed observations and own analyses into consideration the two-dimensional framework for alternative scenarios of OWE development is first and foremost based on differing viewpoints on technology development and its costs, and secondly, prioritisation of offshore wind by government officials and policy makers. Consequently, these dimensions, further displayed in Figure 9, reflect the uncertainties that have the greatest impact on the future deployment of OWE in the North Sea (Veum et al., 2011).

Taking earlier mentioned dimensions and reviewing speed and path of technological development with involved cost level on horizontal axis, and influence of policy makers as well as public support on vertical axis shapes four alternative scenarios describing further potential development and deployment of offshore wind in the North Sea. **Scenario 1** is formed under high prioritisation of offshore wind by government officials and policy makers, involvement of public support, and having the industry receive substantial political support on one hand, and substantially reduced costs within the industry and boosted innovativeness and continuously expanding R&D of existing technology on the other. **Scenario 2** is formed under substantially reduced costs within the industry and boosted innovativeness and continuously expanding R&D of existing technology on one hand, and insignificant prioritisation of offshore wind by government officials and policy makers, with absolutely no public support, and having the industry operate without any political support in terms of subsidies on the other. **Scenario 3** is formed under high prioritisation of offshore wind by government officials and policy makers, involvement of public support, and having the industry receive substantial political support on one hand, and remaining high costs within the industry and slower technological developments on the other. **Scenario 4** is formed under insignificant prioritisation of offshore wind by government officials and policy makers, with absolutely no public support, and having the industry operate without any political support in terms of subsidies on one hand, and remaining high costs within the industry and slower technological developments on the other.

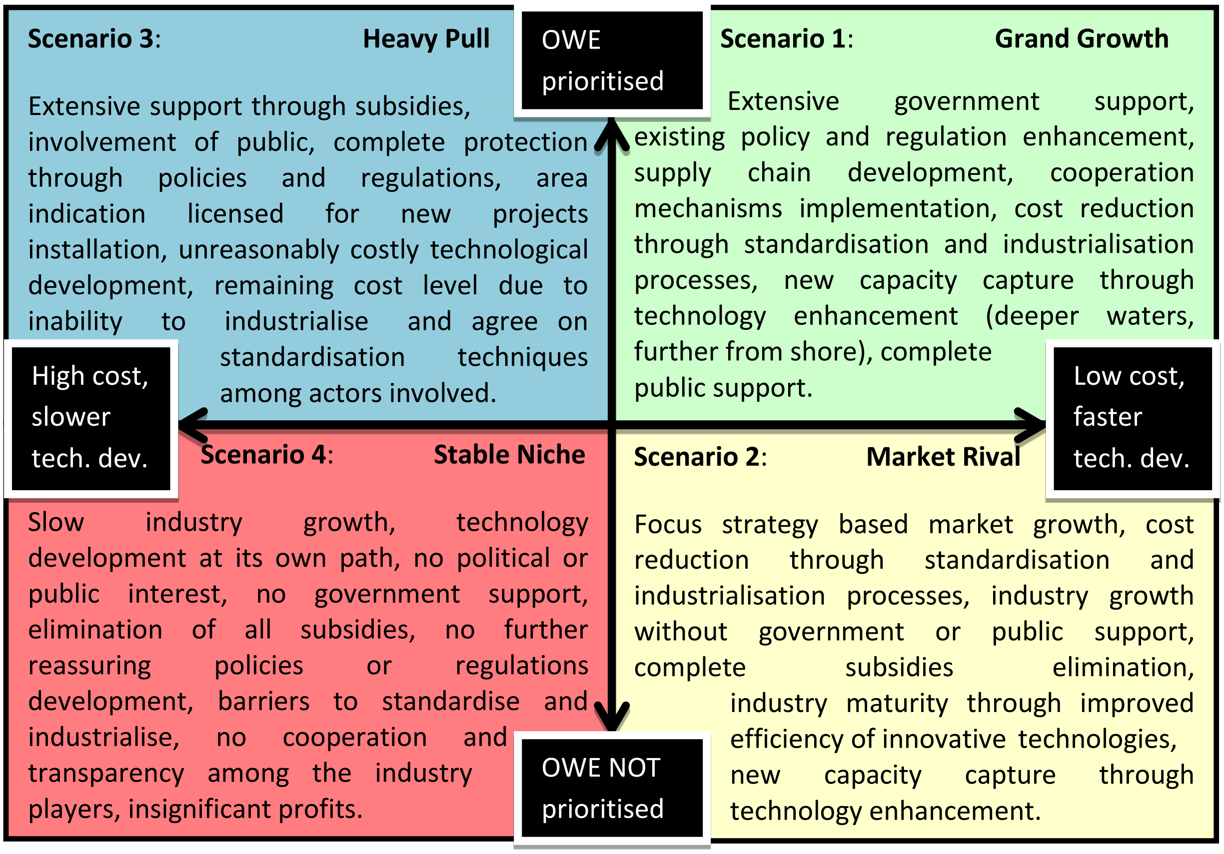

Figure 9: Characterization of four scenarios

Source: Own composition from Veum et al. (2011)

4.6.1 Level of technological development

Speaking of technological developments, booming innovativeness of existing offshore wind turbine technology allowing to exceed permissible water depths and distance to shore will significantly contribute to expansion of available area for new OWE projects in the North Sea (Veum et al., 2011). Consistent with Professor J. Owen Lewis opinion, CEO of Sustainable Energy Authority of Ireland, technology innovation remains a crucial driver for the potential level of deployment of OWE in the North Sea. Moreover, through OWT acceleration, installation of large size wind turbines on floating platforms in greater depths, applications of new material, improvement of O&M techniques consequently to be tested and deployed afterwards, will create new opportunities in this region with possibilities of lowering various industry costs (Gaudiosi, 2012). As properly described in Chapter 4.3.2 "Technological development" of offshore wind industry in the North Sea, further developing current technology and implementing standardisation of wind turbine technology and certain processes will greatly contribute to cost reduction, what turns to be a critical measure for further offshore wind deployment competing in line with other forms of energy sources (AREG, 2012).

However, the costs involved under each project execution offshore do not necessarily have to be the lowest being normally considered in balance with pay off and profit potential. Today several European countries are challenged by existing wind technologies installed offshore in the North Sea region lacking shallow waters near its coastline, and thus turning out to be unsuited for present technologies. Accelerating the development of floating structures for offshore wind turbines will allow exploiting much higher capacity of wind resources, potentially at lower costs and sound pay off in the long run (van der Zee, 2012). Clearly a larger part of the world's offshore wind resources are located in deep waters, and therefore striving to deploy such potential several companies operating within the offshore technology sector are already testing its floating wind turbines. According to John Best, the head of Sustainable Energy at Fendercare Marine, a combination of experience**,** innovation and validation can guarantee optimal performance and reliability in the offshore wind, thus innovation within offshore wind turbine technology and its constant R&D is inalienable component of OWE industry.[36] Taking the alternative scenarios in mind under successful development of wind turbine technology, in particular realising floating technologies effectively, will more than double the total spatial OWE potential, which will also depend on availability of cost effective floating solutions (Veum et al., 2011).

On the opposite, decreasing R&D and slowing innovativeness of turbine technology will obviously allow different redistribution of accessible financing; however substantially effect capability of further cost reduction, efficiency of existing technology, and capacity present in prevailing winds of the North Sea.[37] Remaining focused on existing technologies and eliminating possible technology stretch for the deeper waters will certainly contribute

[36] James Fisher and Sons plc presentation at Offshore Energy conference and exhibition 2012
[37] http://breakingenergy.com/2013/06/11/5-ways-technological-innovation-is-making-offshore-wind-more-efficient/

to improving the technology reliability. Thus, advancing currently exploited in the North Sea wind turbines will consequently allow increasing capacity of turbines, but not necessarily making the technology cheaper or reducing any involved costs. Such development path for OWT is strictly unlikely, having numerous potential industry entrants anxious to test their technologies in the open space of North Sea, and existing players, such as shipyards, vessel constructors, and other offshore sector related businesses seeking potential for expanding existing pool of its service users and growing their profits. According to Jonathan Cole, Managing Director Global Offshore Wind at Iberdrola, looking forward offshore wind provides the greatest opportunities for growth in the renewables sector, claiming innovation and technology development to be constant, followed by initiation of standardisation processes by various supply chain players, consequently beginning the process of industrialisation what will finally improve offshore wind competitiveness (Hill, 2012). Having related to OWE industry players advance their technologies and improve offered services adjusting for the new needs in turbine lifting, transportation and installation processes, consequently resulting in steady cost reduction, it is in the industry's interest to sustain innovation and technology development of offshore wind (The Crown Estate, 2012).

4.6.2 Level of governmental prioritisation

As for governments subsidising the industry and supporting it with implementation of various environmental policies and regulations, the offshore wind remains highly prioritised and significant. Several Member States have been heavily involved into implementation of supporting policies and legal frameworks designed for enhanced development of offshore wind in the North Sea region, as in-details described in Chapter 4.3.1 "Political and legislative support for offshore wind" and Chapter 4.3.5 "Environmental policies and regulations". Policy makers became actively engaged into site selection for new OWE projects installation, and assisting in granting licence and planning permissions in the North Sea basin. Political power and leadership is considered vital for enhanced development of the industry. Assuming that Europe refuses from application of nuclear-based power sources, decreases number of plants operating on coal power, refrains from gas imports and runs out of currently available oil sources, it is in the interests of all Member States to develop and expand capabilities of RES to their full capacity in order to secure future electricity supply. According to Jonathan Cole, Managing Director Global

Offshore Wind at Iberdrola, realising opportunities in the North Sea politicians grant all necessary support to ensure confidence within the OWE industry, not being a question of election-to-election politics. However, he claims that such steady support is to be gained by the industry participants actively targeting further cost reduction and creating economic benefits for the countries contributing towards the industry deployment. Therefore, further innovation and R&D activities within OWT are a key for the further development and successful deployment of OWE in the North Sea. Mr Cole also indicates that the governments are to ensure stability and support towards the industry specifically at hazardous economic times, thus allowing utility companies further develop anticipated offshore wind projects, and consequently providing credible business plan down the supply chain (Hill, 2012).

In terms of public support towards the offshore wind, its influence has been thoroughly described in Chapter 4.3.4 “Public opinion and its influence”. Public in general shows a positive attitude towards wind energy, and many individuals are given opportunity to personally contribute into development of cleaner technologies by making their electricity consumption CO_2 neutral and buying power from operating offshore wind turbines.[38] Many single individuals in several Member States have frequently shown a willingness to invest into wind power technology through co-operatives and other investment mechanisms. A single offshore wind farm Middelgrunded located close to Copenhagen harbour is currently the largest cooperatively owned wind farm, thus indicating public complete engagement into development of offshore wind (Greenpeace, 2004).

Change of political support will certainly have substantial consequences for the industry. By eliminating adequate attention towards offshore wind policy makers will not hinder the development of OWE entirely, yet will slow certain processes facilitating its active growth. Political support is a significant component for OWE industry maturity along with cost competitiveness and industry excellence. Joint effort of turbine manufacturers, foundation suppliers, grid suppliers, construction companies, project operators, and investors through cooperation and transparency can result in cost competitiveness, however operating outside the political protection and support various actors engaged in the offshore sector may feel threatened and insecure in sharing valuable industry data (Roland Berger Strategy

[38] http://www.nordjyskelhandel.dk/privat/el

Consultants, 2013). Assumingly governmental prioritisation of RES can change with development of other cleaner technologies, such as SSC technology applied in coal-fired plants in-detail described in Chapter 4.4.2 "Development of new technologies" and Chapter 4.4.1 "Intensity of competition" in the European electricity market. Finally, combining level of governmental prioritisation and level of technological development form the following four scenarios:

4.6.3 "Grand Growth" scenario

The Grand Growth scenario is **most likely** for further development of offshore wind in the North Sea having involvement of industry players into innovation and R&D of current technology at full speed, and government's complete engagement into supporting the industry through various policies and regulations. Innovation and development of new technology, which is already present within the industry, triggers standardisation of equipment, turbines, foundations and other components, as well as standardisation of safer practices, economical and efficient solutions. With significant support from policy makers and governments heavily prioritising OWE industry, it will be easier to initiate cooperation between industry players, secure information transparency through official sources, and encourage industrialisation processes. Extensively applying elements of *green marketing* will assist the industry in gaining public support and encouraging numerous end-users to voluntarily pay additional margins for electricity generated by green technologies. Extensively supporting SMART grid projects and promoting SMART meters through political sources will boost the expansion of OWE industry allowing as existing as entering players increase its profit potential, market share and capability competing against other electricity generators. Moreover, according to KPMG 2010 market survey, many companies become involved into offshore wind activities being motivated by first and foremost strategic opportunities, secondly exploration of future markets and last but not least gaining a green image (KPMG, 2010). This indicates complete engagement of businesses into the industry striving to decrease the costs and speed up technological development in offshore wind. Therefore, by having governments keep their full attention and interest towards OWE development and deployment in the North Sea will grant access to all existing opportunities within the industry and allow the market players to exploit every benefit to its full potential. The most considerable elements shaping Grand Growth scenario are described in Figure 9 under Scenario 1.

4.6.4 "Market Rival" scenario

The Market Rival scenario is **quite likely** for further development of offshore wind in the North Sea having turbine technology developed to its full potential and involved costs substantially reduced, however having the industry operate without any political support for the industry. Taking all the factors described in Chapter 4.3.2 and Chapter 4.4.2 related to technological developments into consideration, it can be concluded that political and public support towards offshore wind may change with development of more viable and efficient technologies likewise generating electricity from renewable sources. Other clean technologies reaching breakthroughs with innovation and development may potentially create higher employment capacity, boost economic growth, and comprehensively contribute to existing energy and environmental policies. Under these circumstances government may reallocate available subsidies towards more promising renewable technology. Industry, however, will continue vigorously innovating and developing its technology motivated by great strategic opportunities for growth in the renewables sector and other factors accurately described in Chapter 4.6.1 "Level of technological development". Overall, governments revoking its support for the OWE industry will not necessarily weaken the industry, but certainly induce challenges related to permissions, regulations, legal frameworks and other system operations described in Chapter 4.3.1 "Political and legislative support for offshore wind". The industry has a strong ambition to continue fast growth, which can be achieved in case wind turbines are moved further from the shore to profit from the more favourable wind conditions on the sea. Therefore, in order to achieve costs reduction of technology, its installation and operation, improve reliability and grid integration considerable research efforts are required.[39] The most considerable elements shaping Market Rival scenario are described in Figure 9 under Scenario 2.

4.6.5 "Heavy Pull" scenario

The Heavy Pull scenario is **less likely** to develop in terms of future development and growth for offshore wind in the North Sea. It has already been stated that it is unlikely for the industry to drop innovation and reduce R&D of wind turbines installed offshore. However, it is possible for the industry participants to focus its R&D on single segments of

[39] http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=research-wind

the industry, and have the existing technology developed at much slower speed than anticipated. Incapable of reducing the industry related costs and refining the existing technology in the foreseeable future leaves the industry operating with strong dependency on political and public support. Under current scenario the future of OWE industry will heavily depend on protection and support of policy makers through new energy and environmental policies and regulations, assistance with licensing procedures, and ability of the governments to ensure maturity and competitiveness of offshore wind against other electricity generators. The most considerable elements shaping Heavy Pull scenario are described in Figure 9 under Scenario 3.

4.6.6 "Stable Niche" scenario

The Stable Niche is **the least possible** scenario for future offshore wind deployment and development in the North Sea. The most considerable elements shaping Stable Niche scenario are described in Figure 9 under Scenario 4. As already mentioned under "Market Rival" scenario it is possible for the government and policy makers to chance their support for offshore wind. Influencing factors and conditions supporting this assumption are already described in Chapter 4.3.1 "Political and legislative support for offshore wind", Chapter 4.3.2 "Technological development", Chapter 4.4.1 "Intensity of competition", and Chapter 4.4.2 "Development of new technologies". Concerning cost reduction and technology development those processes can be quite deliberate and time consuming as describe under "Heavy Pull" scenario. Even though anticipated cost reduction and further development of technology may be slow, yet involved industry players ambitiously strive for strategic opportunities, higher profits and exploration of future market, therefore being vastly motivated to bring down the costs and improve efficiency and viability of existing technology. Under these assumptions further development and deployment of offshore wind in the North Sea is expected to follow either Scenario 1: "Grand Growth" or Scenario 2: "Market Rival".

5. Conclusion: Future competitive pattern

Based on comprehensive analysis and evaluation of the offshore wind energy industry, it has been determined that various satisfying conditions present at the European electricity market established foundation for firm and intense development of the industry in the North Sea. Pleasant business environment surrounding the industry not only supplemented the development of offshore wind, but also supported the competitive position that the industry currently occupies on the European electricity market. Studying the competitive position of the offshore wind energy industry on the European electricity market showed that the industry currently possesses weak competitive position, however appears to be in transition from niche market to independent business sector, simultaneously gaining strength to compete with other well-established industries on that market.

To support the following statement it is worth indicating that the market liberalisation process initiated to introduce an effective and sustainable competition, improve reliability and security of supply, and create one common electricity market, played a significant role for offshore wind by opening the European energy market for introduction of new forms of electricity generation, consequently setting a pleasant business environment for new market entrants (ref. to Chapter 3.1). Likewise, various market trends and driving forces on the European electricity market, such as continuous development of new technologies, energy resource scarcity, growing electricity demand, European dependency on import of fossil fuel, climate change awareness, and other trends within the energy sector forced the operating industries to evolve accordingly, and built a foundation for the industry birth and its further development in the North Sea (ref. to Chapter 3.4).

Most significantly, firm foundation for the industry development created through market liberalisation and existing business environment based on several factors strongly supports the industry in achieving higher intensity of rivalry. Evaluating the competitiveness of offshore wind in the European electricity market it has been concluded that rivalry within the market is quite intense having numerous suppliers generate electricity from different energy sources. As for offshore wind energy industry, it has been determined that the current competitive position of the industry is quite weak, however indicates high attractiveness of the industry with great profit potential. As a result, many industry players believe that offshore wind is becoming close to competitive against other market players generating its electricity from both conventional and alternative energy sources.

First and foremost, geographical location for the offshore wind deployment analysed in the following study is determined to possess a world leading position possessing all necessary facilities to perform relevant activities and adapted to the specific needs of the sector, likewise indicating major growth potential in the next 30 years (ref. to Chapter 4.3). Furthermore, through evaluation of the business environment for the offshore wind energy industry in the North Sea, it has been determined that political support for offshore wind, implementation of numerous policies and regulations, intense technological developments within the sector, public support for the industry and more positively affects the competitive position of the industry by strengthening and increasing it (ref. to Chapters 4.3.1 – 4.3.5). Yet, the analysis of offshore wind competitive position in the electricity market clearly indicated weak competitive position of offshore wind revealing high entry barriers for new industry players, adequate amount of complementary products and services threatening to overtake the offshore wind energy industry, insufficient bargaining power of customers, but sufficient bargaining power of turbine manufacturers, and finally quite moderate intensity of rivalry among existing players, especially offshore oil and gas industry and onshore wind (ref. to Chapters 4.4.1 – 4.4.5). Even though, continuously growing industry makes it very attractive for new players to enter the market with new technology prototypes ensured by political support and the governments. Therefore, it can be concluded that the industry growth in the North Sea and its ability to achieve better competitive position is accelerating and gaining strength against other players through vast support and influence from political power and leadership, as well as support of other external forces (ref. to Chapter 4.3).

Throughout the analysis it has also been determined that several influential factors create uncertainty for further development and deployment pattern of offshore wind energy industry in the North Sea region. The in-depth analysis of surrounding business environment (ref. to Chapter 4.3) and evaluation of competitive position of the industry on the European electricity market (ref. to Chapter 4.4) indicated two factors possessing most significant influence on further development of the industry. Political influence, existing and developing policies and regulations, as well as public influence on one hand, and further technology R&D and innovation on the other, shapes four alternative scenarios for the future of offshore wind mutually excluding one another. As in-details described under Chapter 4.6 “Alternative scenarios for offshore wind deployment potential in the North Sea” the level of technological development in wind turbines and supporting industries, as well as the level of governmental prioritisation towards the offshore wind, will point the direction towards one alternative scenario or another. Assuming the industry to push further striving to achieve lower costs and higher profits it is without a doubt expected to observe faster technological development through innovativeness and decrease in costs through optimisation and standardisation processes, as well as industrialisation of manufacturing and transparency of significant data, thus indicating either “Grand Growth” or “Market Rival” scenario in terms of direction for the industry’s future (ref. to Figure 9).

Speaking of foreseeable future for the offshore wind energy industry in the North Sea, it is presumed that in the short-term perspective (approx. 5-10 years) the industry will keep developing towards the scenario described as “Grand Growth” (ref. to Chapter 4.6.3), remaining to receive extensive government and public support, being greatly subsidised, and at the same time having the costs of technology reduced throughout manufacturing standardisation and industrialisation processes, boosted innovativeness and continuous expanding of R&D in existing technologies (ref. to Chapter 4.3.2). In such a short time frame the industry will remain in need for support in terms of eased access to potential investments and financing, granted permits for future projects implementation, clarified common legal frameworks, in other words fully applying political power and leadership to reach maturity (ref. to Chapter 4.3.1).

Under the long-term perspective (approx. 30-35 years), it is presumed that the industry will follow development pattern described as “Market Rival” (ref. to Chapter 4.6.4), operating without any political support or subsidies, and approaching maturity strictly through innovativeness in technologies and considerable cost reduction. The ability of offshore wind to facilitate growth of other economic sectors operating in the North Sea seriously enhances R&D and attracts innovation, thus leaving the industry to be primarily driven by technological developments (ref. to Chapter 4.3.3 and 4.4.2). However, competing strictly on technological level allows other clean electricity generating technologies rival for some share of the electricity market (ref. to Chapter 4.4.1), thus leaving the competition within offshore wind entirely to the rules of free market economy.

As for active industry players, it is presumed for Siemens and its followers to consolidate their current business position, leaving Siemens the dominant player in the industry due to the first-mover advantage (ref. to Chapter 4.5.1). Reviewing the best practice in offshore wind built on a case study of Siemens, it has been determined that several factors define the level of success for the technology suppliers and manufacturers on the offshore wind market. Reliable technology, unique technical expertise, extensive experience, high standards of services and safety, sound capital structure, as well as many other significant features assuring successful performance in offshore wind energy industry essentially differentiate Siemens from players alike, consequently putting the firm ahead of its primary competitors (ref. to Chapter 4.5.2). Likewise, ability to overcome challenges faced by the industry players will determine the future competitive pattern for each player (ref. to Chapter 4.5.3).

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6.3 List of e-sources

DONG Energy - http://www.dongenergy.com

European Commission - http://ec.europa.eu

EWEA - http://www.ewea.org

Global Wind Energy Council - http://www.gwec.net

International Energy Agency - http://www.iea.org

OECD - http://www.oecd.org

PwC - http://www.pwc.com/utilities

Renewable Energy World - http://www.renewableenergyworld.com/rea/home

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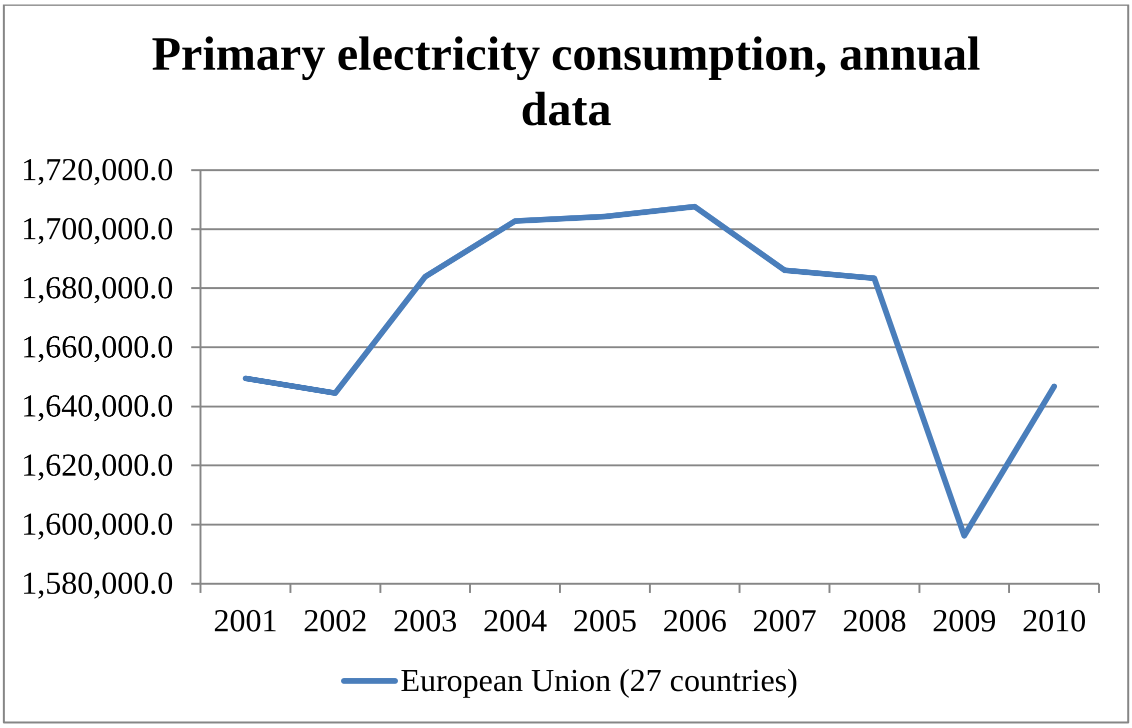
State of Green - http://www.stateofgreen.com

Vattenfall - http://www.vattenfall.com

Wind Energy The Facts - http://www.wind-energy-the-facts.org

7. Appendices

Figure 10: Electricity consumption in EU



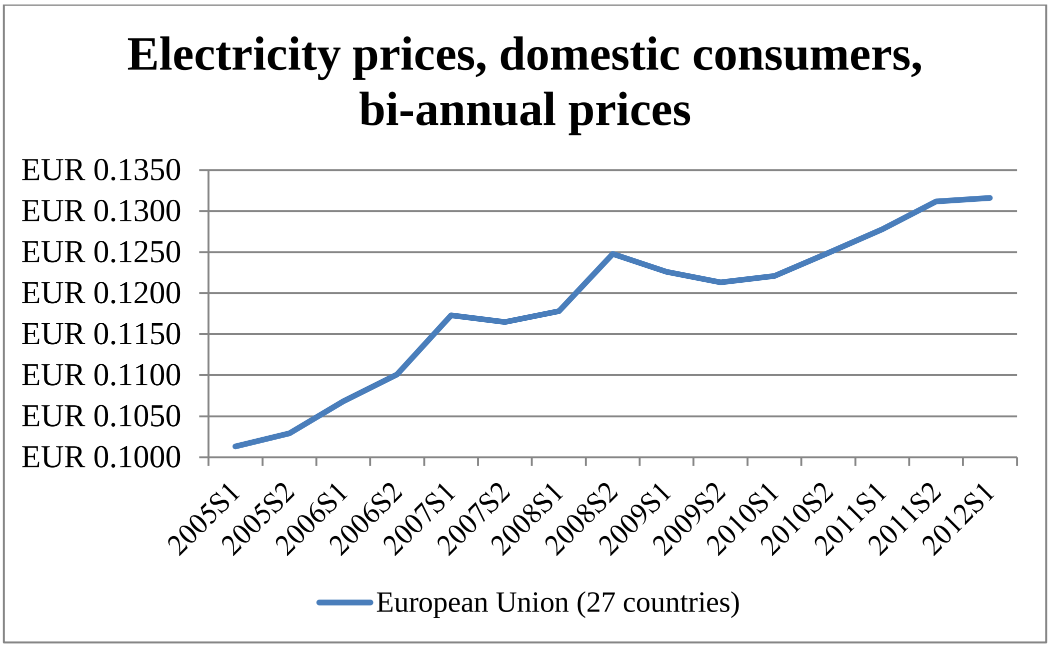
Source: Eurostat, Feb. 2013

Figure 11: Electricity Balance (incl. transport, agriculture and non-specified uses of electricity), Worldwide, 2000-2030

	2000	**2010**	**2020**	**2030**	**Average annual growth 2000-2030 (%)**
Gross generation (TWh)	**15,391**	**20,037**	**25,578**	**31,524**	**2.4**
Coal	5,989	7,143	9,075	11,590	2.2
Oil	1,241	1,348	1,371	1,326	0.2
Gas	2,676	4,947	7,696	9,923	4.5
Hydrogen-fuel cells	0	0	15	349	n.a.
Nuclear	2,586	2,889	2,758	2,697	0.1
Hydro	2,650	3,188	3,800	4,259	1.6
Other renewables	249	521	863	1,381	5.9
Own use and losses (Mtoe)	**235**	**304**	**388**	**476**	**2.4**

Source: Birol, 2004

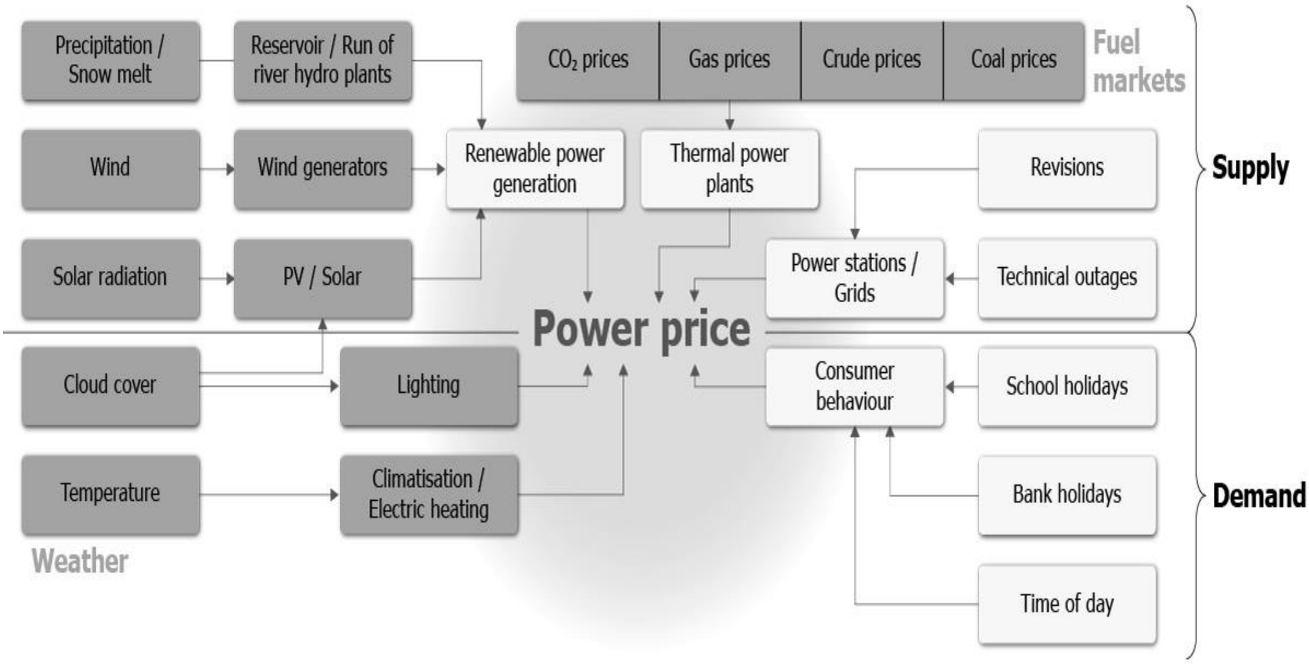
Figure 12: Electricity prices in EU, 2005-2012



Source: Eurostat, Mar. 2012

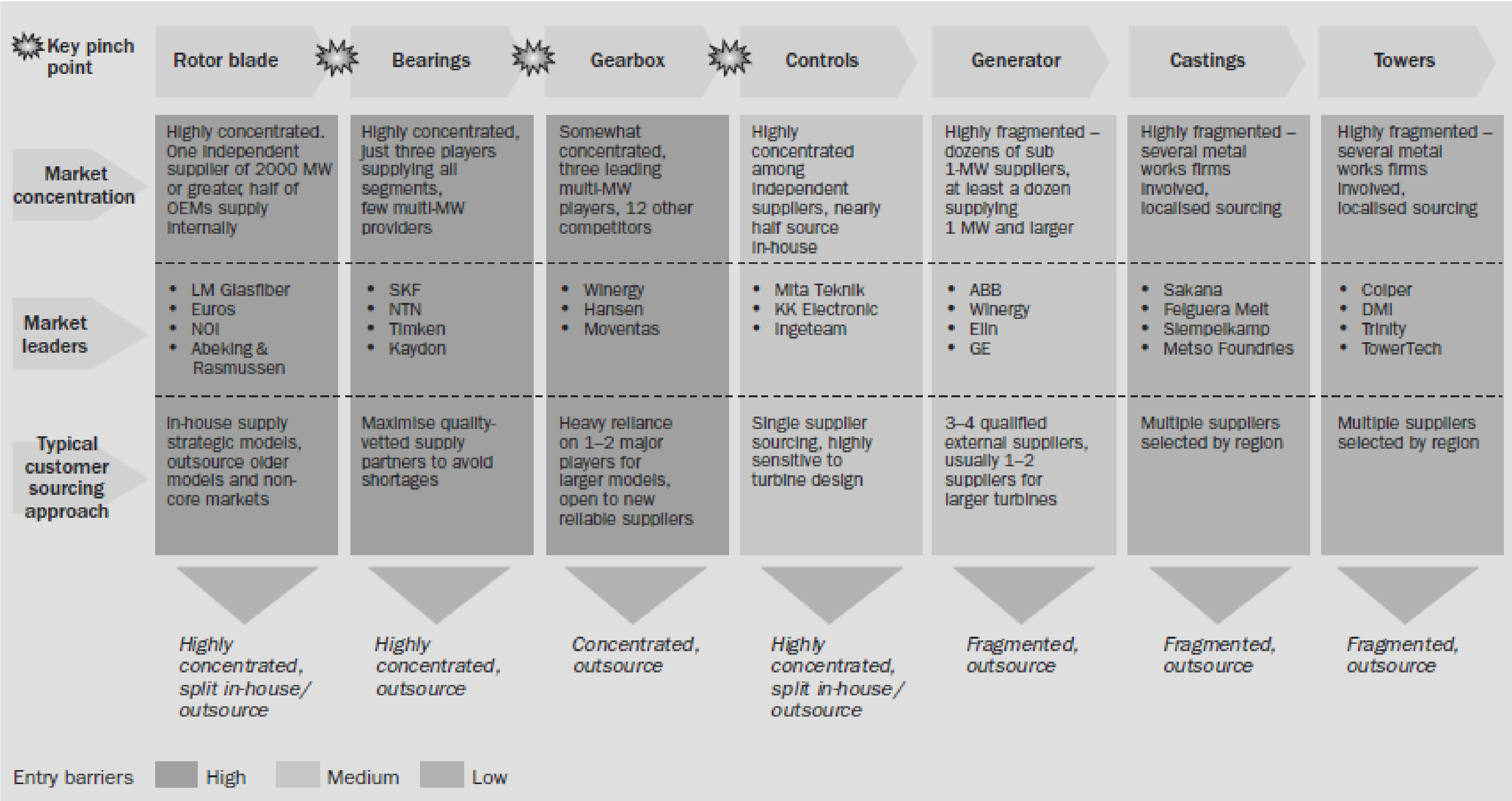
Comments: Electricity price shown per Kilowatt/hour

Figure 13: Factors influencing electricity price formation



Source: http://www.rwe.com/web/cms/en/403722/rwe/press-news/specials/energy-trading/how-the-electricity-price-is-determined/

Figure 14: Turbine component supply chain overview



Source: EWEA, 2009a