NOVA School of Business and Economics

Master's Thesis

A scenario based approach to strategic planning: Future scenarios for the Portuguese offshore wind energy industry until 2025.

MSc. in Management

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Table of Contents

List of Tables

List of Acronyms

CAPEX	Capital Expenditure
EDP	Electricidade de Portugal
ENE 2020	Estratégia Nacional para a Energia 2020
FIT	Feed-in-Tariff
INETI	Institute for Industrial Engineering and Technology
LCOE	Levelized Cost of Electricity
OEM	Original Equipment Manufacturer
OFF	Offshore
OPEX	Operational Expenditure
R&D	Research and Development

1 Introduction

Growing concerns over environmental degradation, scarcity of valuable natural assets and the overall sustainable supply with essential resources have growingly influenced the global political agenda. Prevailing and restoring the planet's climate by effectively mitigating greenhouse gas emissions has become a focus issue for governments and enterprises around the globe. Climate change effects are ranked amongst the 'Megatrends' that global communities are transformed and challenged by in the upcoming decades (Barreneche et al., 2016; European Environmental Agency, 2016).

Moreover, experts project that the demand for energy – mainly driven by a globally growing middle class, the transformation towards an information society as well as a rise in global population – could grow up to 50% in the next two decades (National Intelligence Council, 2012). Therefore, developing alternative, unconventional energy sources as well as efficient distribution and storage capabilities have the potential to play an essential role in finding viable solutions for a growing global climate and energy challenge.

In most European and corporate energy strategies the development of maritime renewable sources is projected to be a vital part of their future energy mix and portfolio. While offshore wind power in shallow water areas has become commercially feasible with wind farms around the globe that have been commissioned and operated presently, the largest potential is identified in deep water areas that remain largely untapped at this moment in time.

Especially Portugal with access to vast deep water areas could lead the way into a sustainable European energy future by pioneering in the development of operational as well as economically feasible floating offshore wind farms. However, the perseverative downward pressure on the Portuguese public budget, a stagnant extension of grid connections throughout the Iberian Peninsula, as well as little empirical value in regards to deep water offshore energy projects and an optimal operation and maintenance model depict just some challenges potential investors are facing.

In that sense, the main objective of this thesis is to outline different scenarios that investors and developers of renewable energy have to account for when assessing the Portuguese offshore wind sector until 2025. In the course of this paper a methodology is developed that allows to display challenges and uncertainties the sector is currently facing, while serving the purpose to build profound scenarios representing feasible futures for the Portuguese offshore wind industry.

2 Literature Review

With the rise of the increasingly accelerating digital transformation, shorter timespans of company and product lifetime cycles (Foster & Kaplan, 2001) and major shocks to the world markets with unpredictable consequences the economic climate has become more uncertain than ever before. While there has always been uncertainty about corporate environment and its influencing factors as well as its future – the degree of uncertainty has changed.

In a world where operating equipment is monitoring itself and detecting possible damages way ahead (Siemens AG, 2014) and autonomously driving plug-in hybrid cars enter the mainstream market (Davies, 2016), it is questionable if the established strategic planning frameworks, business leaders use today, can keep up with the pace, since they might be based on static assumptions that no longer hold (O'Donovan & Rimland Flower, 2013). This risk is especially present in the energy sector where "all three most powerful drivers […] - demand, supply, and effects on the environment - are set to undergo significant change, [consequently] facing an era of revolutionary transitions and considerable turbulence" (Shell International BV, 2008, p. 10).

The first efforts made, to think about possible scenarios for the future, were in corporate America in the 1960’s. In fact, Shell Oil Company was one of the first corporations to think about future scenarios within their industry, gaining the ability to act faster and better than every competitor. Once oil prices slumped, due to the Yom Kippur war in the Middle East in 1973, Shell paved their way to lead the industry (van der Heijden, 1997).

In the following decades more corporations inherited strategic planning functions within their organizations, accompanied by academic research and comprehensive literature. This provided theoretical backgrounds and frameworks, used to simplify and standardize strategy formulation (Ansoff, 1965; Porter, 1980). Strategic planning became a methodical process of strategy creation. It began with setting up targets and guidelines before scanning the companies’ environmental influencing factors as well as its own resource base and capabilities. Consequently, formulating and implementing a strategy based on prior analysis hereinafter monitoring the predefined targets closely (Grant, 2003). The ambitious objective of strategic planning has always been to structure and substantiate clarity within a complex and unpredictable ecosystem, thereby stressing pragmatism in a corporate environment (Ansoff, 1965; Wulf, Meißner, & Stubner, 2010).

With Mintzberg’s publication in the mid 1990ies, opposing the traditional ‘planning school’ - claiming that successful strategies could arise in a creative emergent process at any moment through informal learning within a corporation – the term strategic thinking became popular (Mintzberg, 1994). The authors Wulf et al. describe strategic thinking as “directed at synthesis instead of analysis [involving] intuition, creativity and learning” (Wulf, Meißner, & Stubner, 2010, p. 5). Especially the ‘emergent process school’ anticipates that the strategy creation leaves room for creativity and intuition thus breaking the ground to challenge existing ideas, biases and corporate hieratic. Grant

(2003) further develops this idea by stating, that rather on focusing on one ‘best strategy’ one should consider several options (Grant, 2003).

In order to overcome the antagonisms between the ‘planning’ and ‘emergent process school’ a practical tool-based approach that simultaneously leaves room for creativity and adaptation to environmental changes is required. An approach that attempts to close this research gap was introduced by Wulf et al. in 2010. The authors present a framework of strategy creation that combines the planning and process elements of strategy creation while simultaneously fulfilling four necessary requirements. Wulf et al. (2010) take multiple options and perspectives in consideration (1), while at the same time providing a practical (2), systematic tool-based process (3) that leaves room for flexibility (4) (Wulf, Meißner, & Stubner, 2010). It is the goal of scenario based planning “not to predict, but to present and illuminate alternatives [with a methodology], of how the external world will evolve to influence us” (Gordon, 2008, p. 212). It is still to be scientifically proven that scenario based planning and the approach that Wulf et al. consolidated from existing research associates directly with an improved company’s performance (Shermack, Lynham, & Ruouna, 2001; Phelps, Chan, & Kapsalis, 2001).

The main objective of the next chapter is to define a methodology for a structured approach that results in plausible future scenarios for the Portuguese offshore wind industry. Aiming to help raise organizational awareness and readiness for wind farm developers and investors by stimulating creative and disruptive strategic thinking as a consequence. Hence, it could result in support for the preparation process to face the range of plausible futures that might unfold.

This work project is composed of three main steps; the first is to merge stakeholder feedback and secondary research into an impact/uncertainty grid in order to analyze industry trends. The second step contains the selection of two key uncertainties thus creating multiple plausible futures while simultaneously making sense of complexity. Finally, the last step includes the scenario synthesis into strategic intent thus reflecting growth opportunities.

3 Methodology

The aim of this thesis is to shape a plausible answer for the following research question, utilizing the below described research methodology.

> *What scenarios do renewable investors and developers have to account for when assessing the Portuguese offshore wind sector until 2025?*

In order to develop and assess influencing factors for the Portuguese offshore wind industry – marking the fundamental starting point before assessing critical uncertainties and designing four possible scenarios that developers and investors have to cope with in the future – the following approach has been used.

Methodology

Guided by (Creswell, 2013) it is crucial to select an appropriate research method in order to set up a profound research process. An integrated mixed methods approach is identified and utilized in order to provide a qualitative literature review with supportive information from quantitative research in the form of a questionnaire. As a consequence, it is assumed that a combined approach expands the understanding of the research problem itself. Especially, when identifying critical uncertainties within the impact/uncertainty grid in step three of the model, it is indispensable to gain expert insights in order to determine what shapes and influences the Portuguese offshore wind industry. Complemented by quantitative research to gather background evidence and identify influencing factors in the first place - a comprehensive research methodology is set. Although the use of questionnaires and the combined research approach faced criticism in the past (Ackroyd & Hughesand, 1981; Burke, Johnson & Onwuegbuzie, 2004), it fits the intended research objective. It does add value by not only quantifying influencing factors for the offshore industry in Portugal but moreover delivering and backing up these findings with resilient data from industry experts. This thesis does not raise the claim to represent an exhaustive set of influencing factors upon which plausible scenarios could be built upon. It rather depicts a set of scenarios that is likely to occur in the near future, based on research and expert feedbacks at this juncture. Thereby concentrating on essential criteria which are displayed and assessed in the following paragraph.

Research Design

As the central strategic framework, this thesis adapts the scenario planning model published by Wulf et al. within the Roland Berger research unit. Coupled with the literary evidence that this model offers a scenario-based approach by synthesizing scenario- as well as strategic planning, it offers above all an integrative framework for strategy creation reflecting today's state of the science.

Table 1: Adapted from HHL-Roland Berger Approach to Scenario Based Strategic Planning (Wulf, Meißner, & Stubner, 2010)

In order to develop strategic suggestions and outline a strategic intent, the following six steps will be undertaken:

1. *Definition of Scope* - Defining the overall frame of this research paper by specifying a research question. The first step specifies the goal, the strategic level of analysis, involved stakeholders and the time horizon.
2. *Perception Analysis* - Firstly a comprehensive list of drivers of the future is identified in a literature review, mainly consisting of industry expert's publications and presentations as well as historic and future government policies. Throughout a survey, answered by industry experts, the influencing factors will be contemplated by an internal view and hence gain validity.
3. *Trend/ Uncertainty Analysis* – With the Impact/ Uncertainty tool the list of factors will be assessed in two dimensions – their potential industry impact and their degree of uncertainty (composed of direction and speed of occurrence) for the future. Thus deriving critical factors that influence the development of the offshore wind power industry the most. These key uncertainties are the significant outcome and are used as a basis to develop scenarios in the subsequent step.
4. *Scenario Building* -With the visualization tool of a scenario matrix, consisting of one critical uncertainty dimension on each axis, four possible scenarios are developed and their influence on the industry is evaluated.
5. *Early Warning Indicator development* – To each of the four scenarios that were built in the previous step an early warning indicator is set up. This further allows investors and developers to spot and act on future developments faster and more prepared than their competitors.
6. *Strategy Definition* – The goal is to define a core strategy that is applicable in all possible four scenarios. It is accompanied by strategic options for each individual scenario, thus creating a synthesis of thinking about the future and deriving specific strategic alternatives.

Limitations of the Methodology

The Methodology and research approach presented in the prior paragraph holds limitations that were identified and altered throughout the academic process. These limitations are discussed in this paragraph and a possible impact of results is allegorized.

Firstly, the *sample size* of the gathered survey results is too small in order to reflect a representative distribution of the population and therefore cannot be considered representative. Thus, the research paper at hand displays first trends gathered by individual industry professionals in a standardized manner but is not able to find significant relationships from the data as statistical models would require it.

Secondly, there is a *lack of reliable data,* since the Portuguese offshore industry is currently in its initiation phase and commercial wind farms have not been installed up to date off the Portuguese coast. Therefore, the assessments gathered from professionals in the survey are based on theoretical models, international experiences with wind power offshore or test-stage turbines installed. However, they do not include insights from operational wind farms in Portugal. Therefore, the validity is limited and leaves room for further research.

Thirdly, the *self-reported data* gathered through the standardized questionnaire can only sporadically be validated independently. Therefore, statements made could be biased by individual experiences and might turn out to be incoherent when conducting a study with a bigger sample size.

The structure of the subsequent section begins with an introductory to reflect on the state of the Portuguese offshore wind industry. This includes general information in regard to the sector as well as decisive legislative developments in the past, current challenges and a future outlook. Thereupon, scenarios are derived from the impact/ uncertainty grid as described in the preceding methodology chapter displaying possible futures for the industry. Lastly, recommendations based on the four scenarios are given, thus deriving a hypothesis in regard to the research question.

4 The Portuguese Offshore Wind Industry

Despite a difficult and highly uncertain economic climate in the past years, Portugal made continuous progress on developing and adapting its energy policies. Simultaneously shifting the countries strategic focus to cover the majority of domestic energy demand with renewable energy sources in the future, therefore establishing Portugal as one of the leaders in clean energy transition. It is a result of this strenuous effort – stated in the *Estratégia Nacional para a Energia 2020* (ENE 2020) - that "these changes have resulted in greater economic activity in the energy sector, increased renewable energy deployment, further market liberalization and greater emphasis on energy efficiency in policy making" (International Energy Agency, 2016, p. 161).

In fact, Portugal's energy demand was met by renewable sources alone for a timespan of four days in May 2016, substantiating the countries efforts and claims for a clean energy future (Institute for Energy Economics and Financial Analysis, 2016). Next to oil, coal, natural gas, biofuels and hydro energy sources wind power is currently one of the biggest contributors to the Portuguese energy mix climbing from 1.8% in 2004 to 23.3% in 2014 – the second highest share of wind power in the world, according to their domestic energy mix after global pioneer and leading country Denmark (International Energy Agency, 2016). Whereas Portugal had a total capacity of 5.079 MW (Pierrot, 2016) installed by the end of 2015, the majority of wind turbines is located onshore whilst offshore wind energy still awaits its breakthrough. The different constraining factors and developments are assessed in the following paragraphs.

4.1 Past Developments

Paving the path for Renewables until the Economic Crisis

The country's dependency on fossil fuels from foreign suppliers and the effects of volatile market prices contributed to the setup of Portugal's renewable energy strategy early on. The countries first efforts to guarantee access for small independent power producers that wanted to feed into the national grid date back to 1988 (Shukla & Sawye, 2013). Therefore, Portugal was one of the first European countries opening up to renewable energy generation. With an amendment to the existing legislation the government regulated the production of renewable energy and incentivized investors and developers for commercial renewable energy developments in Portugal. In the early 1990's the government fostered the development of renewable energy technology further, by introducing the Institute for Industrial Engineering and Technology (INETI). Moreover, Electricidade de Portugal (EDP), back then a public energy utility, created the subsidiary Enernova to explore Portugal's potential for wind power development. Combined with the newly created National Renewable Energy Association (APREN) Portugal's administration laid the groundwork in creating an enabling environment for growth of the wind energy sector.

With the publication of a wind atlas for Portugal to indicate beneficial high wind speed regions in Portugal by INETI in combination with accessible project financing, the development of onshore wind power projects increased in the early 2000s (Shukla & Sawye, 2013). As a consequence of this increase in wind power projects the national grid infrastructure had to be adapted, resulting in project delays and higher connection costs (ibid).

With a directive from the European Commission in 2001, originating in the signature of the Kyoto Protocol two years earlier, renewable energy production targets were set for each member state. Therefore, the Portuguese government launched a series of initiatives in order to streamline administrative procedures, actuating the energy market through financial incentives, establishing competitive feed-in tariffs (FIT) as well as clarifying the licensing process for grid access[1] (Shukla & Sawye, 2013). Economic pressure, triggered by the economic crisis from 2008 onwards, and a significant mismatch between market energy spot prices and FITs lead to an overall deficit that effects Renewables development in Portugal up until today (Linden, Kalantzis, Maincent, & Pienkowski, 2014).

Consequences of the Economic Crisis for the Portuguese Offshore Wind Industry

As a consequence of Portugal's bailout from the European Union together with the International Monetary Fund, FITs were drastically cut for new installations at the end of 2011 (Rosa & Lucas, 2012). As a result of the economical challenging times in Portugal the country faces a substantial tariff deficit (*Figure 1*)– were electric retail prices undercut costs, including subsidies granted for renewable energy for several years (International Energy Agency, 2016). This resulted in an overall slump in renewable energy investments and development of new projects from 2011 onwards (Liebreich et al. 2011).

[1] Decree-Law no. 339-C/2001 passed on 29 December 2001 with following amendments. // Decree-Law no. 68/2002 passed on 25 March, and amended in 2007 (Shukla & Sawye, 2013).

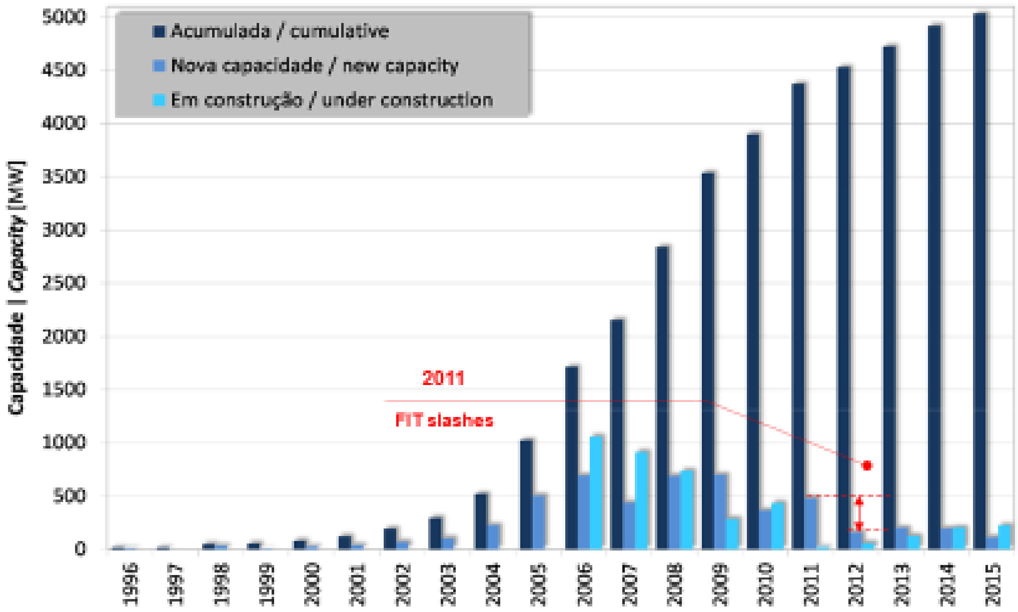

Table 2: Adapted from Wind farms in Portugal (Matos, 2015)

At the same time the offshore wind technology had its break-through in Europe (Offshore Wind Works, 2016) and was prospected to have the potential to significantly change the European energy landscape (Suna, Diangui, & Guoqing, 2012). Whereas in Portugal offshore wind farms have not been commissioned for commercial use until to-day, first research and development (R&D) projects were set up in the past. A floating 2MW offshore turbine has been commissioned in December 2011 for pilot testing pur-poses in order to develop a Portuguese offshore energy scheme. The testing results of the first WindFloat project were promising enough, in order to secure European and na-tional funding for a second, pre-commercial test phase. The second, upcoming Wind-float project will consist out of multiple floating turbines totaling 25MW located off the coast of Viana do Castelo and is expected to be operational in 2018 (Maciel, 2012).

> *"The WindFloat Atlantic project, with Portuguese State and the EU's NER300 scheme support, is a 3-unit, 25MW array of WindFloat systems, already under an advanced stage of development [...] in Portugal"* Luis Manuel Executive Director of EDP (Principle Power, Inc., 2016, p. 1).

Commissioning the pre-commercial WindFloat Atlantic project will resemble a key step on the path to develop offshore wind power projects in the deep water zones identified off the shore of Portuguese mainland (Costa, Simões, & Estanqueiro, 2010). Nevertheless, significant challenges remain and multiple stakeholder involvement is needed in order to establish an enabling environment for wind power developers and investors in the upcoming years.

4.2 Current Challenges

A number of studies have analyzed commercialization developments for floating offshore wind power structures, but only few have come up with substantial recommendations what the pathway in the upcoming years would look like and which measures would have to be taken in order to accelerate its development. Lopes (2016) substantiates in her recently published study that the current capital costs for offshore wind technology are too high and her estimations show that offshore wind energy is currently not profitable in Portuguese deep waters. Her research states that "Levelized Cost of Electricity[2] (LCOEs) and Capital Expenditure (CAPEX) estimates remain too high compared with alternative energy sources, such as fossil-fuels, [therefore] net present value (NPV) estimates were found to be negative" (Lopes, 2016, p. 1). Nearly coinciding assessment results were delivered by EDP in this year's Investors presentation – displaying traditional, foundation based offshore wind energy as only in a minority of cases compatible with conventional energy (Manso Neto, 2016).

Despite the current state Lopes (2016) further notes that due to technological advancements the cost of capital will decrease. Thus, fostering commercial scale feasibility in

[2] The LCoE approach allows for a comparison between different energy technologies considering the costs occurring during the overall life cycle of a power plant. The LCoE is typically taken as basis for evaluating and comparing alternative options for investments into power plants. The LCoE reflect the minimum price at which electricity has to be sold to ensure that the investment made pays off (de Visser & Held , 2014).

the medium term. EDP calculates with an operational expenditure (OPEX) reduction of three percent per annum (Manso Neto, 2016), contributing to an accelerated offshore wind technology maturity. Moreover, the Iberian energy utility tries to keep maximizing productivity levels by holding technical availability of their wind farms above 97.5% as well as upgrading and modernizing older wind turbines. By modularizing their maintenance model while simultaneously insourcing critical, cost-intensive competencies EDP inherits learnings for future wind farm operations (ibid).

Regardless of the push from original equipment manufacturers (OEM) and energy utilities to lower the LCOE's (*Figure 2*) for competitive offshore wind technology - investors and developers have to cope with several uncertainties. Ranging from a Portuguese policy environment that is still under pressure due to excessive FITs as well as the ambitious objectives of the European Commission's renewables targets. Furthermore, a substantial tariff deficit that will eventually only be obliterated by 2020 and the integration of the Iberian peninsulas grid connections to the European energy grid through France is considered a key driver for the development of renewable energy sources (ENTSOE, 2016; Jacobs, 2016).

4.3 Plausible Futures

In the near future it is expected that offshore technology utilizing fixed bottom transition pieces will continue to lead in offshore wind power development projects. However, the next decade "will be an important development period for floating technology, with more prototype demonstrations and pilot arrays to prepare the technology for commercial projects from 2020–2025" (Castro-Santos & Diaz-Casas, 2016, p. 5).

In a market intelligence study released in 2015 by FTI Consulting, researchers project that the following market drivers will have a fundamental impact on the offshore development in Europe and therefore Portugal (Arapogianni, 2015):

- *European Commission legislation*

  The European Commission's goals to slowly phase-out government regulated power prices and expose renewable energy to market dynamics. Secondly, new climate targets for reduction of greenhouse gas emissions by 2030.

- *Declining cost for offshore wind power generation*

  Through technology maturity and adjusted power system operations offshore wind costs will decline and is projected to reach competitive price levels by 2020.

- *Ageing coal fleets*

  With coal having a share of 12.7% in Portugal's total primary energy supply in 2014 (International Energy Agency, 2016) estimated to be shut down by market forces after 2020 - a void will be created that offshore wind power could support to fill.

- *Capital availability*

  New, alternative forms of financing are expected to pick up in the aftermath of the economic crisis. Meaningful contributions are expected to be made by institutional investors, development banks and through public funds accessed through initial public offerings (IPOs) – as it can be seen in the Portuguese WindFloat project meant to be commissioned in 2018.

- *Grid Infrastructure*

  With the trend towards an interdependent European domestic energy market significant investments need to be made in order to modernize old assets, adapt the grid infrastructure and implement storage solutions for renewable energy. Therefore, FTI Consulting predicts that the growth rate of wind power offshore developments will be constrained by the rate at which grid infrastructure is upgraded.

After assessing the Portuguese offshore wind industry, displaying the historic development, institutional legislation changes and discussing development constraints and enablers the next chapter is dedicated to scenario development. Therefore, the approach described in the methodology section of this paper is utilized to design four possible scenarios the Portuguese offshore industry could face in the future.

5 Scenario Development for the Portuguese Offshore Wind Industry

In this section of the research paper four scenarios for the Portuguese offshore wind industry are developed. Therefore, the framework discussed in the methodology section of this paper is utilized and contemplated by data gathered in an external survey from industry experts as well as specified framework tools.

Definition of Scope

The starting point of this process marks the formulation of the research question as it is displayed in the beginning of this paper. Additionally, the strategic level of analysis is set to be on a macroeconomic level focusing on the offshore wind power industry providing an analysis on possible future scenarios that the Industry could face until the year 2025.

Perception Analysis

The second process step identifies perceptions as well as assumptions of involved stakeholders which they may hold in regard to the Portuguese offshore industry. Therefore, key factors that influence the industry are identified through literature review as well as an industry expert interview (*Figure 3*). In a second step these factors are evaluated by stakeholders involved in the European wind power offshore business in regard to their potential influencing impact on the industry as well as their degree of uncertainty. The centerpiece of this assessment is an online distributed survey instrument (*Figure 4*) with closed as well as open questions. The overarching goal of this perception analysis is to establish an exhaustive list of influencing factors, evaluated by different stakeholder groups from different functions within the industry (*Figure 5*). Overall a list of sixteen influencing factors as well as trends were identified, ranging from political factors such as expected ‘change in ENE 2020’ to technological trends such as ‘smart grid solutions’ or the threat of a ‘new form of energy generation’.

Trend/Uncertainty Analysis

The purpose of the third process step is to structure the stakeholder feedback by visualizing via the Trend/Uncertainty grid the most influential trends and uncertainties that have the highest potential impact on the future wind power offshore industry in Portugal. Therefore, the grid is divided into two axes. On the x-axis, the factors potential impact is displayed. The higher the factors score from the stakeholder survey the higher it is placed on the axis. On the y-axis the degree of uncertainty, mainly distinguished by its speed and direction is displayed with a scoring range between one and five. Ultimately the grid displays three different areas. The bottom area (‘secondary elements’) displays factors that have a relatively low impact on the offshore industry even though their degree of uncertainty ranges from lowest to highest. The area on the top left part displays ‘trends’ – all these influencing factors that have a high potential impact on the industry but their uncertainty is relatively modest. Lastly, the ‘critical uncertainties’ area, displayed in the upper right part of the grid, contains the factors which are assessed to have the highest impact on the industry as well as the highest level of uncertainty. These critical uncertainties, namely ‘operational cost uncertainty’, ‘introduction of trade barriers’, ‘high capital cost and cost of energy’ as well as the ‘change in ENE 2020’ are the principal result of the Trend/ Uncertainty Analysis and substantiate the development of scenarios in the next section.

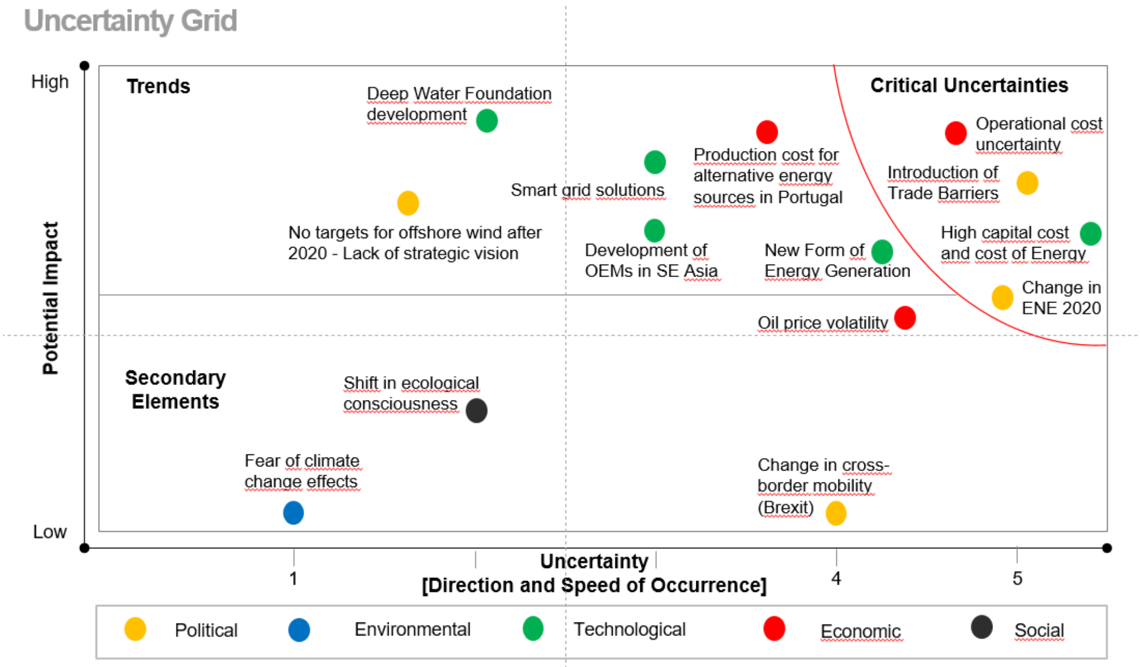

Table 3: Adapted from Impact/ Uncertainty grid (Wulf, Meißner, & Stubner, 2010)

Within the next section four possible scenarios for the Portuguese offshore wind industry are developed, based on the results displayed in this section. In order to develop these four scenarios, a scenario matrix is formed by an axial comparison of two major uncertainties.

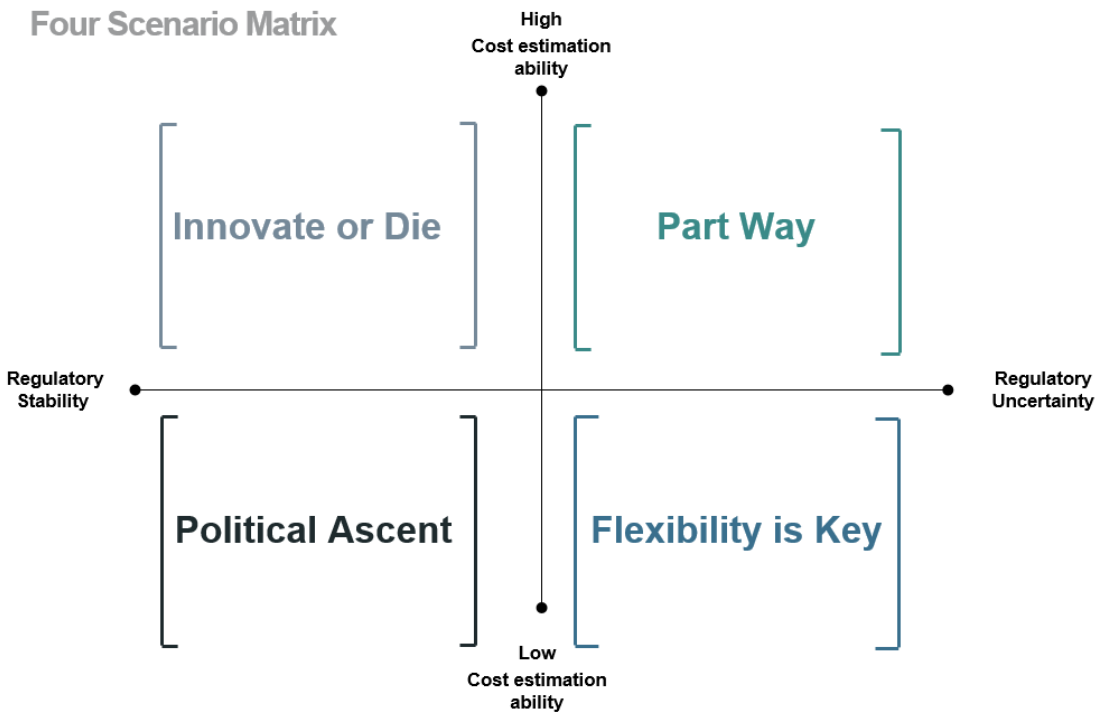

Table 4: Four Scenario Matrix

The context described in each scenario has a direct impact on the energy mix and investment cycles in offshore wind technology in Portugal. Every scenario represents a unique composition of technological advancement, policy making as well as external events that influence investments, energy consumption levels as well as overall economic growth. Strengthening the stance on climate schemes affects energy security, pace of technological developments and the composition and level of economic growth. The developed scenarios are paired with early warning signals in order to offer investors as well as developers of potential offshore-based wind projects the opportunity to react faster and more efficient than their competitors.

5.1 Scenario I – Innovate or Die

Innovate or Die is a scenario driven by market forces, through technological innovations as well as policy stability in which renewable offshore energy has reached competitiveness with conventional energy sources in Portugal. Key drivers of this scenario are innovational efforts from domestic utilities linked to early-stage governmental support focusing on the development of floating offshore wind power technology. Another determinant is the EU legislation pushing towards an energy transition as well as an integrated Iberian energy market. Thanks to successfully installed test turbines in 2011 and the first commercially feasible wind park commissioned in 2018, the offshore wind sector for floatable devices benefitted from an early mover advantage resulting in short-span technological leadership. Consequently, leading the way to mature deep offshore wind technology, revealing high growth potential in the long term (*Figure 6*).

A report by Castro-Santos (2016) forecasting a spike in floatable wind power technology capacity installation in 2017 and 2018 with approximately 240MW installed in Europe turns out to be true (Castro-Santos & Diaz-Casas, 2016). Especially the fast technology advancement in turbine power capacity from the initially installed 2MW in the

WindFloat project towards 6MW turbines in the commercial stage contributed to the achievement in reaching the capacity predictions and fostered significant growth within the Portuguese sector. From 2020 onwards supplies of renewable offshore wind energy became available to the Portuguese market at competitively low price levels, further fueling a ramp up in offshore based wind projects. Recent highly efficient turbines meet the incremental growth in electricity demand and additionally supply the load that is shed by retiring coal and gas plants. Since the fuel mix in this scenario shifts towards Renewables, especially wind power, emission levels accelerate their downward trend. Domestic energy policy is characterized by minimal interventions after the tariff deficit has been significantly reduced over the last decade. Simultaneously encouraging investments in renewable energy supply, specified in the successive national energy strategy paper and backed by stable, market-compliant FITs. As a direct reaction to the renewed policy framework and the new energy strategy by the Portuguese government, private investments in exploration and commissioning of offshore wind power spikes. By 2021 reaching capacity levels of cumulative output of one Gigawatt for newly commissioned turbines – a value that had been reached lastly in 2006 (Table 2).
In this scenario, a newly integrated French-Iberian electricity market stimulates an increased level of competition and technological innovation, mainly in the exploration and generation as well as grid-interconnection technologies. End consumers benefit through transparency, free competition of operators as well as economic efficiency driven by market liberalization.

5.2 Scenario II – Part Way

Part Way is a scenario driven by ongoing energy policy and grid integration negotiations, market forces as well as public-private partnership investments support innovations.

A FIT scheme that still exceeds the spot prices of electricity sold on the Iberian market-place as well as an insufficient grid capacity connection with Spain[3] restrains the development and commercialization of carbon reducing technologies in the Portuguese deep water zones.

While more European member states foster the development of Renewables to meet the obligatory EU renewable energy targets, publicly listed technology companies are ramping up their R&D investments for upstream technology in order to explore the chance for untapped market potential. As near-shore wind power investments stagnate on a European level due to insufficient pre-approved assisted areas, floatable offshore wind becomes a viable option. Especially developers and investors of near-shore technology benefit from the learning curve effects made in earlier investments regarding accurate Capex and Opex (*Figure 7*) estimations, leading to innovation and technology transfer to the Portuguese market. The anticipated operation and maintenance schemes from offshore wind farms in Europe were able to prove themselves effectively in public-private partnership pilot projects in the Portuguese deep water zones, thus contributing to further reduction in LCOE.

However, the portrayal and the promoted numbers of Portugal as a European leader in renewable energy production "proved to be more hype than reality as the country is way off achieving its 2020 target of 60% of energy production from renewable sources, and will remain behind target unless government strategy is steered back on course" as the Algarve Daily News determined in 2016 (Algarve Daily News, 2016, para. 10).

The Portuguese government brought forward a memorandum of understanding as a continuative proposal for their energy strategy after 2020 - that did not pass the Assembly of the Republic up to this date due to contrary notions of opposing parties. Therefore,

[3] Interconnection capacity is limited to 2.800MW between Portugal and Spain (2016), a strategy declaration paper signed in 2015 planned an electricity exchange capacity for Spain and France of 8.000MW by 2020 (Hollande et al., 2015).

renewable dismantling projects are increasingly lacking governmental commitment – a key driver of *Part Way*. This policy inconsistency and the lack of a medium term predictable commitment by the Portuguese government led to a scaling in oil and gas usage in the national energy mix, advancing an energy supply focus shift, downgrading Renewables.

5.3 Scenario III – Political Ascent

The scenario Political Ascent is shaped by governmental long-term commitment for an irreversible exit from fossil fuel energy as well as an intense technological competition between wind power energy forerunners trying to eventuate the transition to commercial use of floating offshore wind power.

The early-stage development initiative for floating offshore wind concepts like the WindFloat test site in Portugal brought together a wide range of stakeholders from various backgrounds which appeared to officiate as an enabler for a viable project pipeline. The political intent driven by European legislation in line with the Portuguese government's intent to develop renewable energy solutions as a domestic future key technology, amplified the ambitious efforts made in renewable technology developments and led to fierce technological competition among original equipment manufacturers (OEMs). Within the *Political Ascent* scenario political initiatives, regulatory standards and legislation enable an environment encouraging new benchmarks for technological improvements as well as environmental progressions.

The outspread and increased maturity level of wind power technology enables utilities to acquire operational experience by integrating and storing renewable energy into their grid, constituting persuasive precedent cases for commercially feasible floatable wind projects.

With five pre-commercial stage WindFloat projects commissioned off the coast of France, Japan, UK, the U.S. and Portugal by 2025 Capex costs can be reliably analyzed due to an almost decade long track record. In contrary Opex costs are still challenging to predict for developers and investors and display a risk in their business case financials. Especially since operation and maintenance costs are estimated to account for "approximately 25% of the total cost of ownership for a life of 20 years" (Lewandowski & Oelker, 2014, p. 38). Since most floatable offshore turbines were installed in the early 2020's, therefore operating less than five years in deep sea regions empirical values for servicing intervals, main component exchanges, spare part as well as wear and tear have not yet been sufficiently quantified and are estimated in contingency calculations.

5.4 Scenario IV – Flexibility is Key

Flexibility is Key is a scenario characterized by political discrepancy and uncertainty on a national as well as European level, based on a high frequency of challenging events not only for Portuguese energy sector contestants but for the European marketplace.

Scenario four outlines a complex and opaque economic and political environment. A scenario affected by national tendencies on a Pan-European level as well as domestic immunization efforts, where the idea of a truly European Union seems to have reached its peak point.

The European partners struggled to establish policies for an overarching and interlinked energy market, thus member states are challenged by counterbalancing supply and demand resulting in domestic price spikes in electricity. By contrast lowering overall energy prices and decreasing spot-price volatility on the Iberian energy market (Rodrigues & Pereira, 2015). Thus, further fostering skepticism towards a fast roll-out of small, decentralized and unconventional power production. With the strategic ENE2020 phasing out and a stall for a continuative strategic paper, due to heated Portuguese election campaigns in 2019 as well as a long-lasting process of forming a new government slowed economic growth and tarnished investment rates for Renewables. Moreover, the countermeasures taken to reduce the tariff deficit proved to be not as effective as officials had hoped for and the initial reduction target to eliminate the tariff deficit by 2020 was not met.

As FITs for matured and competitive Renewables such as hydro, solar and onshore wind were discontinued in summer 2016 and an introduction of subsidies worth several millions for developers of unconventional energy technology was awarded – hopes rose among wind power offshore investors and developers. The euphoria did not last long as a threshold of €5 million per developer was passed by an act of parliament. The Apren member Antonio Sa da Costa argued that “a €5 million cap is a drop in the ocean for developers thinking about pre-commercial commissioning of three 5MW or four 6MW machines on floatable foundations” (as cited in Weyndling, 2016).

The pre-eminent concern of the new government after the ENE2020 ran out has been domestic energy security as well as a moderate electricity price level. Therefore, new oil and gas concession contracts were issued for the Algarve region even though these operations were ceased by parliament in July 2016. This focus shift leading to a resurrection of conventional energy sources within the Portuguese energy mix took developers and investors of Renewable technology by surprise. Consequently, commercialization for new offshore wind power technology slowed in Portugal while Multinationals started outsourcing wind power R&D activities to other European countries. With this technology shift and the shortcomings of promises that were made for a sustainable energy future further disillusioned wind power investors and developers.

By highlighting significant possible risks, opportunities and challenges for the Portuguese offshore wind industry above, wind power developers are provided with possible future developments and how they are able to identify scenario commencements early on. Thus, developers gain insights in order to generate, assess and reconsider corporate strategic options. The following recommendation section illustrates a robust strategic approach for wind power developers that could be utilized across all four scenarios.

6 Recommendations for Offshore Wind Energy Developers in Portugal

This thesis presents a set of four different scenarios with different potential futures for the Portuguese offshore wind energy industry until 2025. The different scenarios presented in the prior section are not meant to be predictions of the future; they rather describe four plausible alternative pictures for the industries' situation in 2025. These four feasible scenarios inherit the basis for developers of offshore wind power projects to make sense of the future. Hence, these scenarios could be utilized to support strategic decision making on industry key technologies, bolster investment commitments as well as highlight critical energy policy legislation on a domestic level. Therefore, the presented scenarios could improve developer's preparation for the future, resulting in being less affected by existing uncertainty. For that reason, investors and developers should start preparing for these manifold developments today in order to be ready once the future unfolds, thus holding a possible advantage to react in a more informed way than their competitors.

In order to identify an imminent development and to determine whether a plausible scenario is about to prevail, early warning signals tailored to each scenario can be beneficial (*Figure 8*). These signals have the potential to proactively increase information certainty ahead of competition, while simultaneously expanding the time horizon to act on plausible future developments. This coherent, mid-term view until 2025 of divergent paths into the future of offshore wind energy supports creative and focused thinking whilst allowing preparations for organizational readiness. In this chapter a strategic implication is derived that is viable throughout all four outlined scenarios. However, it has to be pointed out that precise strategic recommendations cannot be given, due to their enterprise specific nature.

The underlying core strategy for Portuguese offshore wind power developers revolves around R&D activities, motivated by two main factors. Firstly, to bring the LCOE down to a competitive level in order to establish floatable offshore wind technology amongst the competitive energy sources in the Portuguese energy mix. Secondly, thriving for technological advancement holds the chance not only to generate higher yields but also to effectively safeguard from substitute energy generating sources.

This robust core strategy is accompanied by scenario specific strategic implications (*Figure 9*), providing recommendations to developers what business related activities to examine and eventually adjust when a given scenario unfolds. However, it has to be pointed out that the displayed strategic options are non-exhaustive. Moreover, every corporate strategic adjustment - amongst other things - depends heavily on the firms positioning, its competition, R&D focus, corporate resource base and possible competitive advantages that it inherits.

7 Summary and Outlook

It has been the objective of this thesis to identify, outline and determine possible future scenarios that investors and developers have to account for when assessing the Portuguese offshore wind industry. Given the complexity of the industry, its influencing factors and distinctive market forces it appeared to be reasonable to gather and evaluate insights from experts to determine the most crucial in regards to impact and uncertainty.

Furthermore, developing four future scenarios, coupling them with early warning indicators and deriving a robust strategic recommendation for wind power offshore developers provides a partial answer to the initial research question.

The need for reduction of greenhouse gas emissions by utilizing and developing efficient, carbon-neutral technologies is essential to reach the ambitious climate goals that were set for Portugal. Two insights emerged throughout this thesis. Firstly, government commitment backed by policies will be the key-driver to determine the future Portuguese energy mix – either focusing on emerging unconventional energy sources or proven technology. Secondly, floatable offshore wind power is currently the only renewable energy source that inherits long-term growth potential due to its scalability in size and area. A technology that could not only benefit Portugal's future energy security and environmental targets but moreover holds the potential to establish Portuguese developers on the forefront of global technology leadership for wind power offshore solutions.

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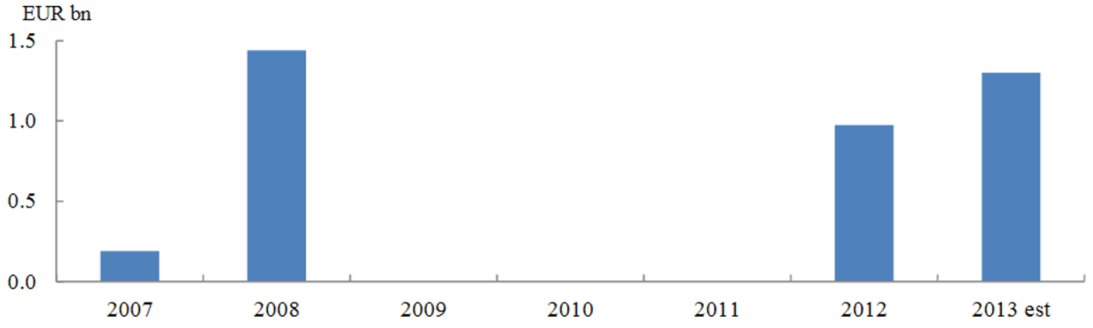
9 Appendix

Appendix A:



Source: Commission Services based on data from ERSE, EDP

Figure 1: Extracted from Linden, Kalantzis, Maincent and Pienkowksi, 2014

Appendix B:

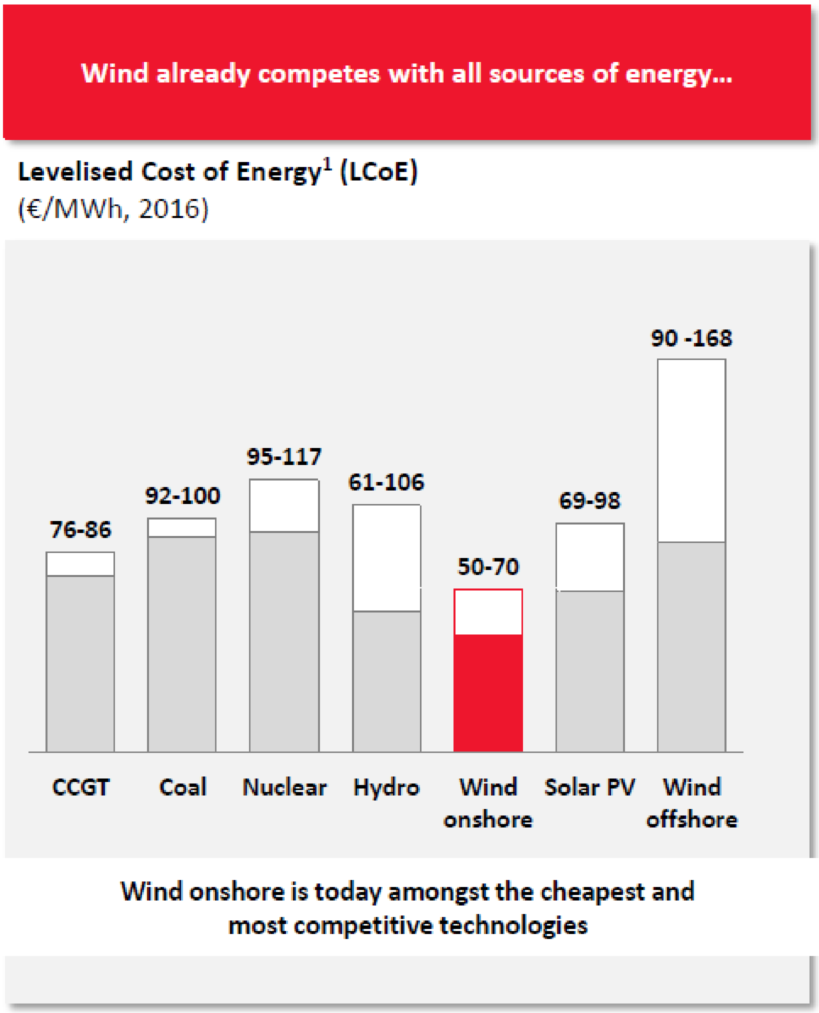


Figure 2: Extracted from Manso Neto, 2016 - NOVA SBE Block Seminar

Appendix C:

Interviewee Information:

Title: Mr.
First name: Antonio
Surname: Vidigal
Function: CEO/Head of Innovation
Corporation: EDP Inovação

Interviewer Information

Title: Mr.
Interviewer first name: Tilmann
Interviewer surname: Kramp

Place of interview: EDP HQ, Lisboa
Date of interview: 06 December 2016
Number of tapes/files: 1
[Start of Tape 1]

K: If you could roll-back from the future in 2025 – what were three things would you like to know about in detail about OFF wind development in POR?

V: […] The question you have to put yourself in 2025 is what has been achieved by that time in terms of Levelized Cost of Energy. We have expectations to go by 2025 to be below EUR 100 per MWh and therefore if in 2025 we are not very below EUR 100, EUR 90 or something – I would like to know what have been the decisions which led to that point.
[…]
The game we have to play here is the reduction of LCOE – to be competitive.

K: If Wind OFF was thriving, growing and moving in a genuinely positive direction by 2025, what would be the key drivers in your opinion?

V: We will have the need in the EU and in the world – a requirement for renewable energy, we will have a percentage of renewable energy. One implication for this is it will be in competition with Photovoltaic, which has decreased a lot in price. Therefore, the driver is we have to come from countries where there is not so much sun, like the northern part of Europe and the driver will be the requirement by those countries to incorporate in their portfolio renewable energy. […] Although what I see are markets, which are more appropriate for it – for instance Japan. Japan is a very good market for floating wind energy, because firstly they have several nuclear power plants which they want to shut down. There is a lot of population in land, therefore they don't like to have their land occupied by energy systems. Other than that their ocean is very deep – 100 meters from the coast they are at 800m depths. Therefore, they are very appropriate for it – and they are looking for it and we are working a bit with them.

K: - That is one of the locations where the WindFloat project is going to commissioned to right?

V: …We are trying to commission to because it's very appropriate. They need Renewables, they want to shut down nuclear, their land is scarce and the sea is very deep.

K: If OFF wind projects were not financially sustainable by 2025, what might have caused that collapse and why?

V: Engineering. We have to streamline a lot of the construction to be able to become towards reasonable prices. We have to be able to be able to optimize operations, because part of the LCOE are operational costs. […] And then if you want to achieve that by 2025 you have to have support now to move fast. And move fast is to put into the seed first pre-commercial systems, which will allow you to go on a learning curve – decreasing the costs. We cannot delay, we have to move. We iterate, we need several iterations, we cannot delay the first iteration.

K: That's a crucial factor?

V: Fact is, very soon – in phases of these iterations, they need public support.

K: What surprised you about the OFF sector in POR in recent years?

V: For instance, seeing that shipyards that did not seem to have a business model – they have succeeded. One example is Lishnave – she is back in business, repairing ships and doing maintenance very profitable. Also seeing that others, which should have followed, didn't succeed. Like Viana – several areas that should be able to find their markets.

K: The fifth question is a little bit of a follow-up: What have been the memorable turns and why? Probably the same that you just mentioned: profitable areas, shipyards coming back…

V: Ja […] … that fostered growth and we are betting a lot on this systems, like WindPlus could be a very good new market for shipyards.

K: What major challenges faces the POR OFF industry in the next 5 years?

V: We are putting in the first pre-commercial system at Viana do Castelho, we have it by the sea by 2018. It's our commitment towards the EU – we have to succeed. We have to be able to sell somewhere in the world the first commercial. With a capacity above 150 MW.
We have to build by 2017/2018 the pre-commercial and show that it works perfectly according to the cost that have been defined and on top sell the first commercial.

K: What are the obstacles to be overcome?

V: Some bureaucracy – to be able to get all licenses to be able to operate. And then to be able to build in a very short time with an adequate price. Not to pay more to go faster. Then to put up a field and operations team that is able to keep the system working according to the availability required.

K: So do innovative O&M models play a role?

V: Yes, especially because we are at the sea and we need windows of weather to be able to maintain. We have to be able to discover new ways to do it – we will be at deep water, on the open ocean. On the Atlantic we need special vessels to go on board, predictive models of maintenance taking the weather and the seas tide in consideration. We need to be able to think new things.

K: What would hinder developers from moving past these obstacles? What forces could constrain them?

V: These projects to go forward need to be bankable – it would be terrible if we could not bunk into bigger projects. For the projects to be bankable it has to be proven step by step that they can be profitable.

K: Imagine that floatable Offshore developments are in danger of being completely cut – What is your argument for keeping it?

V: 75% of the Earth is covered by oceans, we should use them to our benefit. We should remember that in the ocean the wind is more strong and permanent. Many more hours of wind on the oceans than on land. Further on that - the way to go is to build bigger turbines. We are already at 8MW – but should go to 12MW or 20MW you only can build that on the sea. By the simple fact that you cannot transport them on land. Either you build a site [Manufacturing plant], effectively close to the site or it’s impossible to transport blades on land – you can do it by sea to scale up.

[End of Tape 1]

Figure 3: Interview Transcript

Appendix D:

Please state below in which type of Organization you are currently employed at

Original Equipment Manufacturer
Energy Utility
Investment Banking
Research Institution
Public Organization
Consulting
Other

Please state below what Area of Expertise best describes your current position

Operations
Strategy
Business Development
Investment Banking
Researcher/ Analyst
Other

Please RANK the Top 5 Uncertainties you see for developing OFF Wind Power Projects in Portugal until 2025 (1 highest - 5 lowest)

Items

- Introduction of Trade Barriers
- Development of OEMs in SE-Asia
- New Form of Energy Generation
- Domestic Energy demand volatility
- Change in ENE 2020 - (renewables legislation)
- Shift in ecological consciousness
- Development of Solar/Thermal/Hydro Power in Portugal
- Fear of climate change effects
- Oil price volatility
- Production costs for alternative Energy sources in Portugal
- Operational cost uncertainty due to lack of references in Portugal
- Change in cross-border labor mobility (Brexit)
- Power Efficiency development
- Deep water foundation development
- High Capital costs and cost of Energy
- Smart grid solution development

1

2

3

4

5

Please rate the POTENTIAL IMPACT of your five choices

Items

Introduction of Trade Barriers

Development of OEMs in SE-Asia

New Form of Energy Generation

Domestic Energy demand volatility

Change in ENE 2020 - (renewables legislation)

Shift in ecological consciousness

Development of Solar/Thermal/Hydro Power in Portugal

Fear of climate change effects

Oil price volatility

Production costs for alternative Energy sources in Portugal

Operational cost uncertainty due to lack of references in Portugal

Change in cross-border labor mobility (Brexit)

Power Efficiency development

Deep water foundation development

High Capital costs and cost of Energy

Smart grid solution development

Highest Impact

Medium Impact

Low Impact

Is there any uncertainty - with significant impact - you are aware of for the Portuguese Wind Power Offshore Industry that was not listed in the questions before? Please state below.

Powered by Qualtrics

Figure 4: Qualtrics Master Thesis Survey

Appendix E:

Identified Assumptions on key influencing factors

- •Introduction of trade barriers
- •Development of OEMs in SE-Asia
- •New form of energy generation
- •Domestic energy demand volatility
- •Change in ENE 2020 - (renewables legislation)
- •Shift in ecological consciousness
- •Development of solar/thermal/hydro power in Portugal
- •Fear of climate change effects
- •Oil price volatility
- •Production costs for alternative energy sources in Portugal
- •Operational cost uncertainty due to lack of references in Portugal
- •Change in cross-border labor mobility (Brexit)
- •Power Efficiency development
- •Deep water foundation development
- •High Capital costs and cost of energy
- •Smart grid solution development

Appendix F:

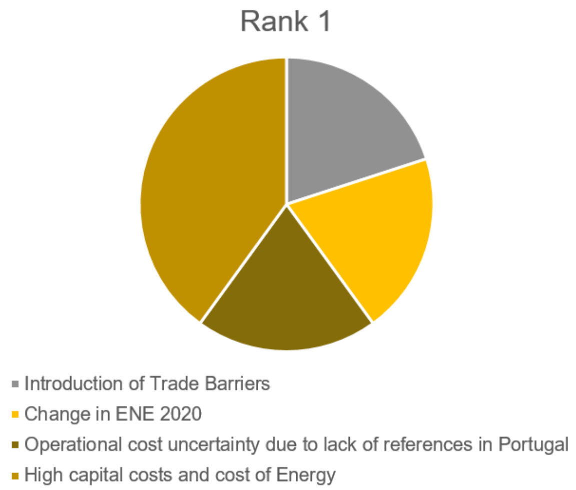
Q1 - Please state below in which type of Organization you are currently employed at

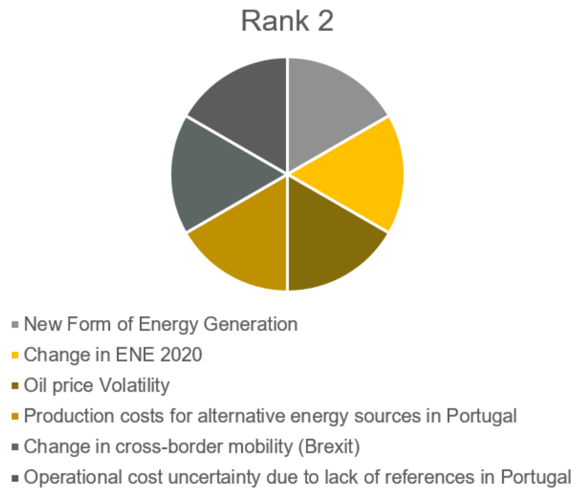
#	Answer	%	Count
1	Original Equipment Manufacturer	42.86%	3
2	Energy Utility	42.86%	3
3	Investment Banking	0.00%	0
4	Research Institution	14.29%	1
5	Public Organization	0.00%	0
6	Consulting	0.00%	0
7	Other	0.00%	0
	Total	100%	7

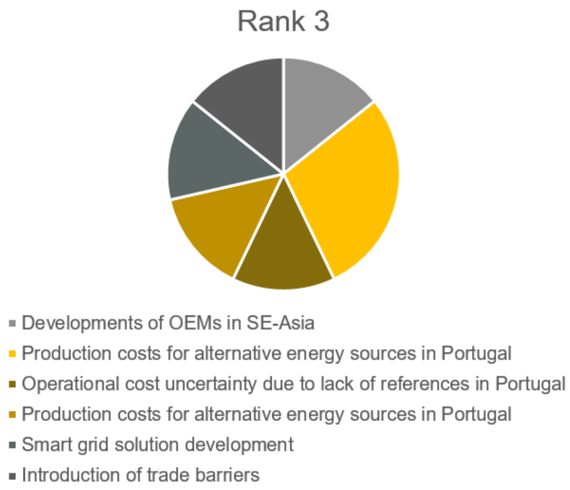
Q2 - Please state below what Area of Expertise best describes your current position

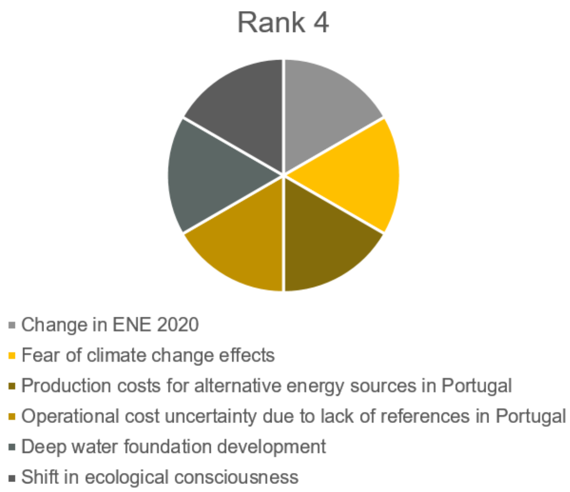
#	Answer	%	Count
1	Operations	57.14%	4
2	Strategy	0.00%	0
3	Business Development	0.00%	0
4	Investment Banking	0.00%	0
5	Researcher/ Analyst	14.29%	1
6	Other	28.57%	2
	Total	100%	7

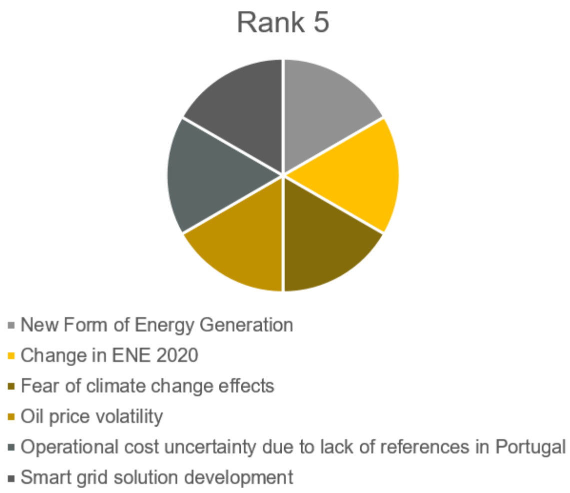
Q3 - Please RANK the Top 5 Uncertainties you see for developing OFF Wind Power Projects in Portugal until 2025 (1 highest - 5 lowest)



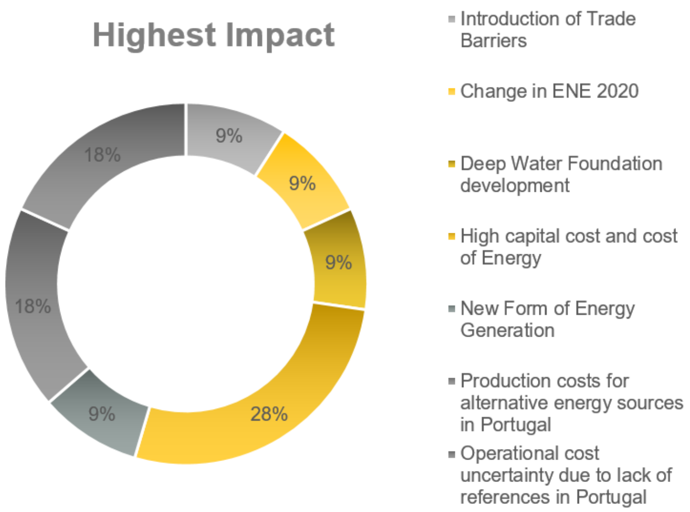


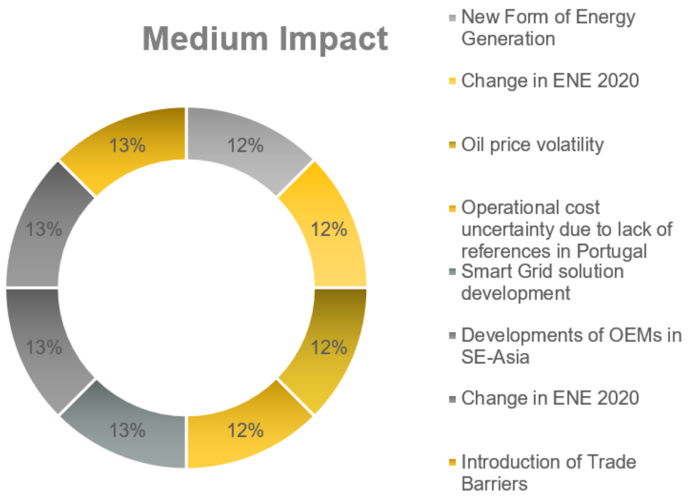

Rank 3
Developments of OEMs in SE-Asia
Production costs for alternative energy sources in Portugal
Operational cost uncertainty due to lack of references in Portugal
Production costs for alternative energy sources in Portugal
Smart grid solution development
Introduction of trade barriers


Rank 4
Change in ENE 2020
Fear of climate change effects
Production costs for alternative energy sources in Portugal
Operational cost uncertainty due to lack of references in Portugal
Deep water foundation development
Shift in ecological consciousness



Q3 - Please RATE the POTENTIAL IMPACT of your five choices





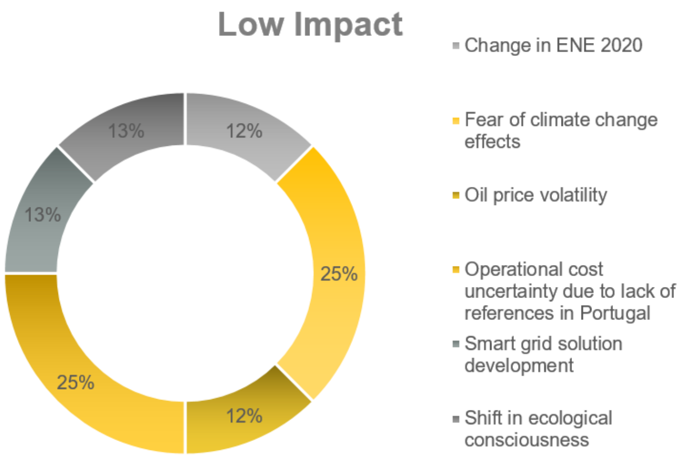


Figure 5: Survey Results

Appendix G:

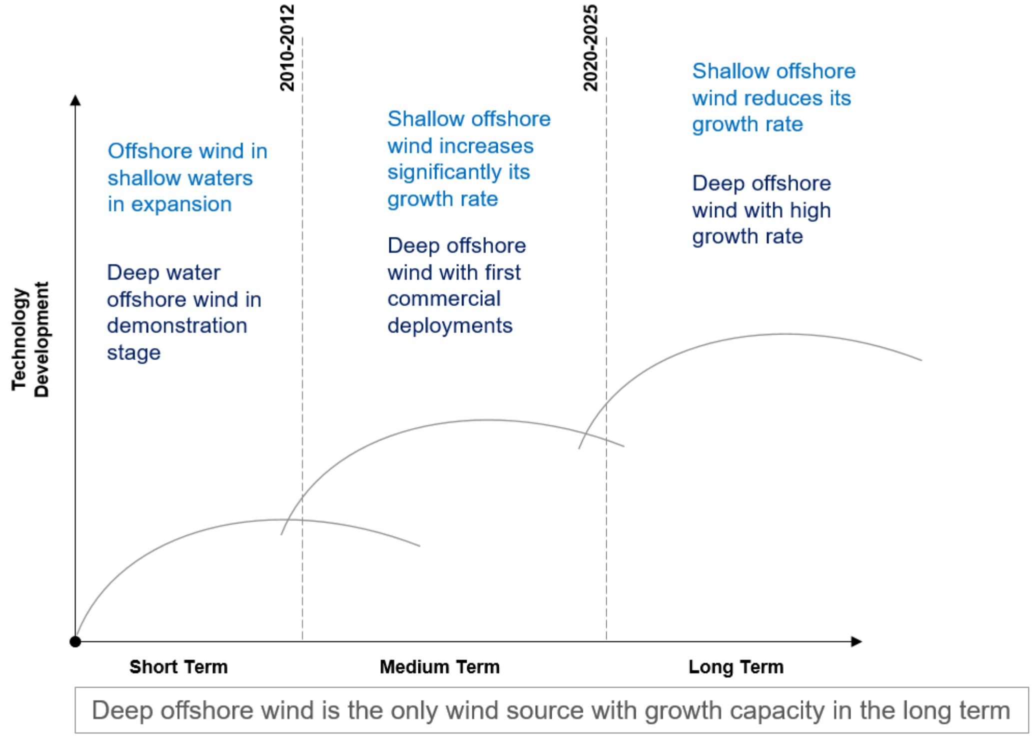


Figure 6: Modified from Maciel, 2010

Appendix H:

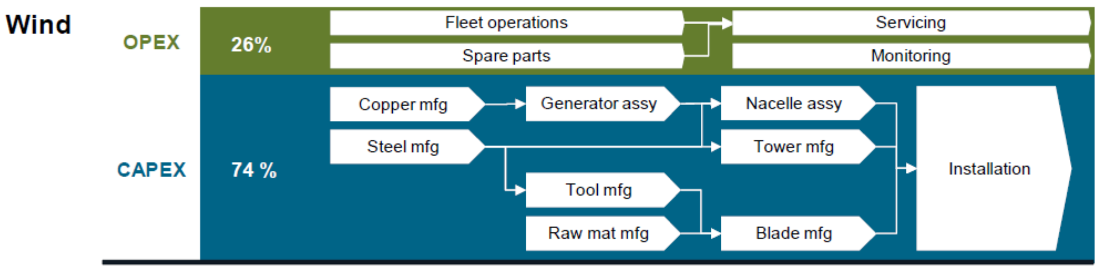


Figure 7: Extracted from SCOE Siemens AG, 2014

Appendix I:

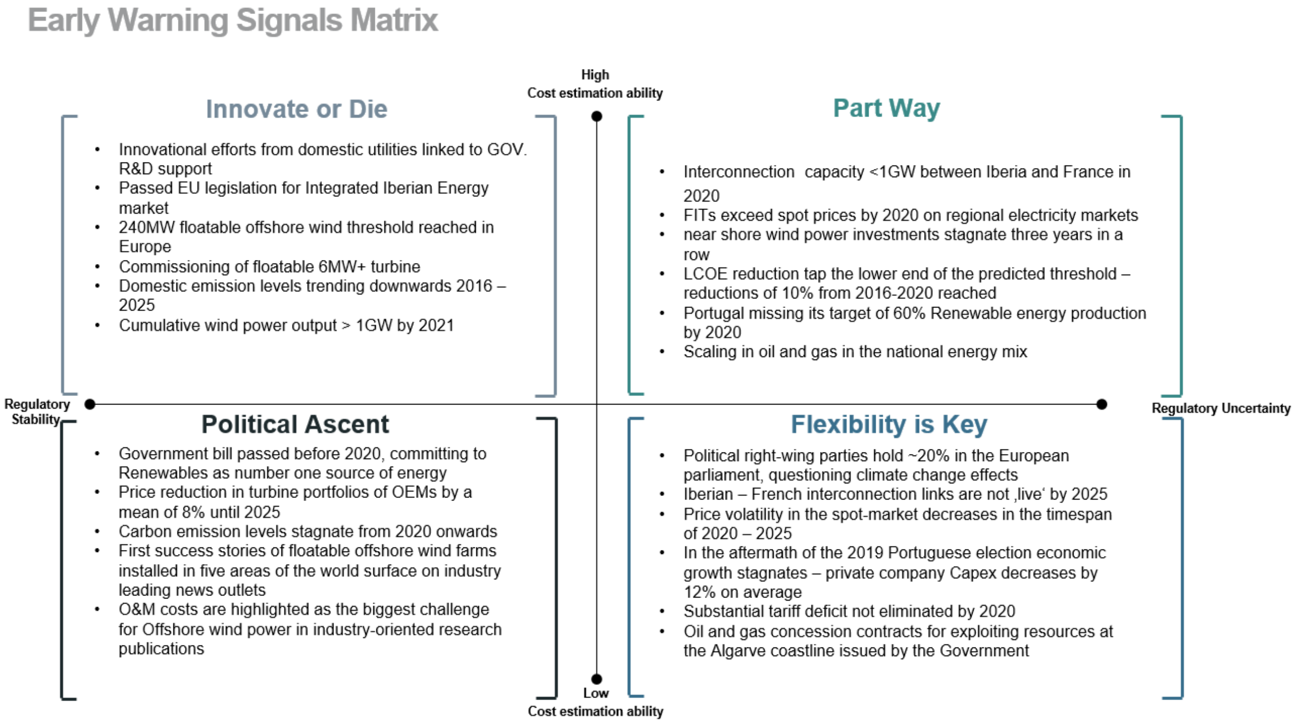


Figure 8: Early Warning Signals Matrix

Appendix J:

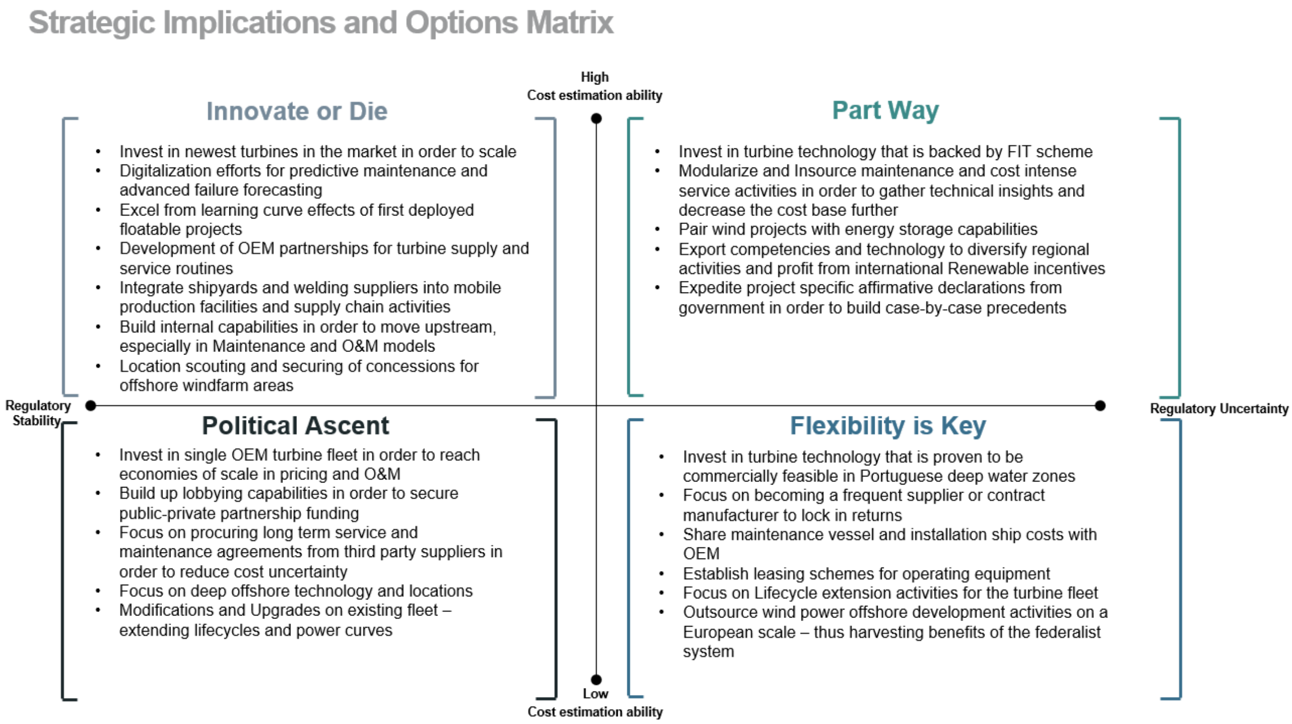


Figure 9: Strategic Implications Matrix