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Bachelor Thesis

An Offshore Tomorrow

"How National Legislative Measures Affect the Return on Investment Gaps for Renewable Energy Investors."

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A Case Study examining the Development of Offshore Wind Energy in the Federal Republic of Germany.

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Abstract

This inquiry of this research is to elaborate on the relationship between national regulations and the development of offshore wind energy. Thorough examinations provide profound answers on the coherence between policy instruments and the return on investment (ROI) gap, renewable energy sources face. Legislative measures are estimated to affect the governance structure of Germany's energy system, hence the promotion of renewable energy. The case study uses the development process of offshore wind energy in Germany as unit of analysis, meticulously estimating the development offshore energy will perform under the German Renewable Energy Sources Act (EEG). Policy measures identified within the EEG are able to sufficiently close the ROI gap. The EEG is mainly used as the legal basis, whereas prognosticating studies, policy papers and estimations provide the data for offshore wind prices and development. The results found show that current legislative measures promote subsidies and forecast to over-subsidize offshore wind in the future.

1. Introduction

1.1 Introduction and Approach

Renewable energy sources are gaining prominence under the emerging problem of climate change. The global crisis affects every society, culture and area on the planet. Several causes were identified, which have strengthened this crisis, among them the emission of carbon dioxide (CO2). With increasing energy consumption and decreasing fossil fuels (oil, coal and natural gas), the focus has shifted towards renewable energy to reduce CO2 emission levels. Self-replenishing sources also liberate states from fossil fuel suppliers. Regarding this problem, the European Union (EU) and its Member States have set the goal to reduce carbon dioxide emission by increasing its energy consumption from renewable sources. On supranational level *Europe 2020* was established, defining renewable energy targets for the Union. These targets include increasing the final consumption of renewable energy to 20%, while decreasing greenhouse gas emission by 20%. An additional target was set to increase energy efficiency by 20% (European Commission, 2017). To level the way towards a sustainable green Europe, in the context of renewable energy supply, the European Commission together with the European Council and the European Parliament drafted and passed a number of legislative acts on supranational EU level to achieve this target. In the light of EU directives, national regulatory frameworks were established, affecting the promotion of renewable energy.

Renewable energy sources are characterized by high capital costs since they display a relative new technology on the energy market. Offshore wind energy is one of these new technologies. While former wind parks are mostly built onshore, offshore wind parks allow energy generation under different conditions. This new technology is accompanied by high capital costs offshore wind parks bear. Compared to onshore wind, offshore wind projects are posing high construction costs. More complex building sites and weather conditions drive prices for offshore windmill instalments up. These capital costs result in return on investment gaps for renewable energy investors. Reducing the return on investment gap is crucial to achieve continuous deployment of offshore wind parks. The very real investment gap is accounted to be most hindering for projects to find sufficient funding. It is therefore in the interest of governments to reduce these gaps in order to provide investor friendly environments (Schwanitz & Wierling, 2016). The future development of offshore wind energy is hence relying on sustainable, consistent capital access.

The core element of this thesis is aiming to identify how governments approach the investment gap problem. Political actors are obligated to provide sufficient legal frameworks to fill the return on investment gap, levelling the way for renewable energy sources. Only under sufficient framework conditions is the promotion of renewable sources possible. Successful implementations are inevitable for reaching Germany's national target of reducing greenhouse gas emission by 40% till 2020 and by 95% till 2050, whereas the share of renewables in gross final energy consumption has to rise up to 60% (Appunn, 2017). The German government has therefore adopted the German Renewable Energy Sources Act (in German: Erneuerbare Energien Gesetz – henceforth referred to as EEG) in 2000. Under the EEG renewable energy sources are promoted, displaying the key pillar in the energy transition (EEG, 2017). Embedded in the EEG are several policy instruments, intending to fill the return on investment gap sufficiently. Closing the gap anticipates steadier investment access for renewable energy sources.

Through applying distinct policy instruments, national regulations might be able to fill the gap. Different forms of remuneration incentives provide certainties for investors. Hence governments are attempting to provide legal frameworks, fostering investor activity. Policy instruments need to be prepared meticulously, taking progressive development and emerging changes of the market environment into account. The clear assessment of policy instruments is therefore crucial for reducing or even closing return on investment gaps.

1.2 Social and Scientific Relevance

The context and findings of this research contribute social and scientific relevance in the field of renewable energy supply.

From a scientific viewpoint, the results deriving from the analysis part of this thesis are providing sufficient answers on how to fill the return on investment gap for investors.

Estimations are used, analysing the cost development offshore wind energy is likely to perform under progressive development. Taking the policy instruments into consideration, possible scenarios are applied under which the return on investment gap can be successfully reduced or even closed.

Social relevance is displayed by the increasing threat climate change poses. Assessing the development of offshore wind energy under national frameworks allows future estimations for renewable energy targets. Increasing the share of renewable energy is crucial to reduce CO2 emission. Rising temperatures, floods and storms drive additional awareness on the topic of climate change and possible solutions. Several movements already demand more renewable energy in Europe as indispensable power supplies in the future. Furthermore the need of renewable sources is rising under the light of decreasing fossil fuel deposits and rising energy consumption. Offshore wind parks provide renewable energy, whereas their generation is not requiring valuable landmasses or fossil fuels.

1.3 Research Question

In order to find a sufficient answer, to what extent national regulatory frameworks can close the return on investment gap posed by renewable energy source, the following research question is formulated:

RQ: *How are legislative measures on national level reducing the return on investment gap renewable energy source pose*?

Understanding the relationship between legislative measures and the development of renewable energy sources, especially offshore wind, poses the question, how national frameworks are able to sufficiently decrease return on investment gaps for investors. To understand the full extent of the research question and to consider all relevant concepts, following sub questions are formulated.

S-Q1: *To what extent is the German EEG providing policy instruments for the integration of renewable energy sources in the energy market?*

Sub-question 1 aims to determine how promising and effective the “German Renewable Energy Sources Act” (EEG) is, in developing and deploying renewable sources. In particular which policy instruments affect offshore wind energy.

S-Q2: *Which policy instruments, within the EEG, hold the opportunity to reduce the return on investment gap for offshore wind energy?*

Sub-question 2 is determining if policy instruments within the EEG are providing effective policy instruments to reduce the return on investment gap for investors. Sufficient policy instruments result in higher investments to offshore wind projects.

S-Q3: *How is progressive development going to affect the development of offshore wind prices in Germany in the future?*

Sub-question 3 estimates the price development energy from offshore wind plants will perform under progressive development. These estimations will be displayed using the method of “levelized costs energy” (LCOE) for offshore wind energy.

2. Theory

2.1 Theoretical Framework

The successful promotion of renewable energy sources is accompanied by reducing the return on investment uncertainty for investing parties. National governments need to assess how to reduce this gap through applying sufficient policy measures. The regulatory framework outlines policy measure under political aspects, whereas the economic approach is considering the real costs. Therefore is an economic approach more suitable in understanding the intended mechanism of policy instruments, reducing investor uncertainty. Economic literature provides a framework of applicable instruments. These instruments can reduce the return on investment gap sufficiently.

This section will provide an overview of the most relevant instruments and their implied mechanisms, affecting the development of renewable energy sources with special regard to offshore wind energy. Understanding the concepts of these mechanisms provides us with the expertise of what can be done to limit investment uncertainty. This is particularly relevant for the development of offshore wind energy.

Policy instruments and legislative measure aim to improve certain situations. Therefore the question rises why some fields still face a lot of difficulties to improve to its full potential. An efficient national regulatory framework that affects the development of renewable energy sources, with special regard to offshore wind energy, needs to apply support schemes, making the development feasible. Different mechanisms can affect the development of offshore wind energy in supporting ways. As any economic market, the energy market is aiming to achieve profitable return on investment. Since renewable energy sources are relatively new, compared to conventional energy supplies, the utilization process is not amply advanced. Energy from renewable sources is more cost intensive, especially in the instalment phase, posing high capital costs and a return on investment gap for investors.

In the following chapters different mechanisms are discussed, which possess opportunities to close this investment gap. This can ensure successful development of offshore wind parks. Investors only contribute money to projects when they are assured to receive sufficient return on investment. Policy instruments need to be applied, ensuring investors' commitment towards offshore projects. These instruments have to be embedded into a national regulatory framework in order to provide certainty. Renewable energy sources, especially offshore wind, still pose lots of investment risks since deployment costs are tremendously high. While the first offshore wind park, deployed in 1991 in Denmark, had an average cost of 15 M€ are new offshore wind parks bearing an average cost of 487 M€, increasing it by nearly 32 times (Rodrigues, Restrepo, Kontos, Teixeira Pinto & Bauer, 2015).

The promotion of renewable energy sources carries difficult tasks, since the technologies in the offshore sector are not as advanced and efficient as fossil energy sources. Fossil sources developed over the past decades, providing efficient energy generation tools. Additionally is fossil energy independent of weather conditions, unlike photovoltaic farms or wind parks. Energy from fossil sources has also proven to result in high profits on the energy market, representing the vast majority of energy suppliers. Hence are the rising costs of offshore wind parks a good case to explore how national regulations can address the problem and reduce the return on investment gap. Since wind energy relies on a natural resource, as generating fuel, the majority of expenses is determined by capital costs (Miller, Carriveau, Harper & Singh, 2017). These increasing costs are justified by the development offshore wind energy made towards more efficient turbines, higher hub heights and rotor diameters, resulting in more efficient kilo watt-hours (kWh). Additional costs occur from increasing distances to shore, water depths and larger seabed areas (Rodrigues et al., 2015). It is inevitable that the deployment of renewable energy sources is relying on political support to improve their position in the emerging market. Strengthening the position of renewables against fossil counter sources is crucial within the energy transition. Supporting renewables implies reducing barriers for the deployment of renewable energy sources, including a levelled playing field, renewable energy industry development and to make renewable sources cost competitive (Tupy, 2009). Projects for renewable sources need beneficial conditions in order to meet the national renewable energy targets. Seven mechanisms are discussed, offering investors a sound opportunity to become active in the field of renewable energy sources.

2.2 Instruments

The following table provides an overview of applicable policy instruments and their intended mechanism to reduce the return on investment gap of offshore wind parks. Each policy instrument is defined and displayed under which conditions it works sufficient towards the development process and under which conditions the instrument poses a hindering influence.

Instrument	Mechanism	Works sufficient if...	Works insufficient if..
Power Purchase Agreements	Agreement between government agency and private utilities company, where the private company produces electricity over a long period of time for a fixed price.	Agreement also includes the development of renewable energy sources over a long time.	Agreement is only short term based and not supporting the deployment of renewable energy source.

Pollution Taxes	A determined tax for companies, proportional to the amount of pollution produced. Measured in CO_2.	Pollution tax is legally binding and accepted by all parties involved.	Big firms not commit to it. Lobbyism against tax = Political suicide.
Tradable Permits	Offers companies the incentive to trade permits if they exceed their pollution cap. Companies, which rely on RES, can sell their permits on the market.	Companies compensate their additional pollution cap with permits from green companies.	Companies just buy permits and do not commit to renewable energy as an alternative.
Loan Guarantees	Loan guarantees offer barrier-free, low interest, financial access for renewable energy projects.	Barrier-free financial access is granted limitlessly for renewable energy projects to foster development.	Barrier-free financial access is used to maximise investors profit.
Feed-in Tariffs	Feed-in tariffs set a fixed price, above the market price or as a bonus on top of the market price, for selling the energy to the grid	Feed-in tariffs compensate the extra costs, when energy is sold to the gird.	Feed-in tariffs still function even if operators can compensate the expenses on their own through sold electricity.
Tendering Procedures	Tendering procedures offer companies to bid for projects. The lowest bid is awarded with the commissioning.	Firms reduce their bids to the extent they can afford it without subsidies.	Firms overestimate their capabilities and need to withdraw a project that they were awarded with.
Turbine Technology Development	Accelerate the development of offshore wind technology in order to maximise the efficiency and return on investment.	Development increases efficiency of offshore wind parks and therefore resulting in higher electricity efficiency.	Development stagnates due to limited financial support.

Table 1. Instruments for reducing Return on Investment Gap

2.2.1 Power Purchase Agreements

The first instrument, employable to ensure sufficient flow of investments, consists of power purchase agreements. These agreements are general contracts between a government agency and a private utilities company. The agreement outlines that the private company produces electricity for the government agency over a long period of time (Miller et al., 2017).

Reichardt and Rogge (2016) state that only political long-term targets provide firms with the initiative to invest (in Research Development & Deployment) (Reichardt & Rogge, 2016). Power purchase agreements are an example for a third party ownership, where the government agency is the sole client of the private energy company. Often separate investors act as system owners, such as big technology firms. The incentive for a separate owner to invest is stimulated by the long-term purchase agreement, with a long-term return on investment certainty. Power purchase agreements are designed to mitigate costs and offer access to capital. Furthermore these agreements are ensuring the success of projects since they are offering long-term revenue (Miller et al., 2017). Power purchase agreements could therefore ensure long-term return on investment for projects in the field of offshore wind energy. They depict a suitable mechanism to reduce the return on investment gap by contracting long-term partnerships with set prices for the electricity produced. Nevertheless power purchase agreements can backlash when the estimated contract time is too short. Missing incentives to further stimulate the development of renewables could also influence power purchase agreements negatively.

2.2.2 Pollution Taxes

Pollution taxes offer the second mechanism to increase the development and deployment of offshore wind parks. The mechanism behind this conventional instrument is a tax proportional to the amount of pollution, produced by firms (Mantovani & Vergari, 2017). If certain firms are increasing their pollution share, are theses firms obligated to contribute more in pollution taxes. Therefore are firms eager to decrease the overall pollution by relying on clean energy from renewable sources. This mechanism foresees that firms will turn towards renewable energy sources as electricity supply. To satisfy the demand of electricity from renewables, investors increase their contribution towards offshore wind projects as renewable energy sources. Through the increasing demand for renewable energy, investors are provided with a long-term target. Pollution taxes can amplify the development of renewables rapidly. The increasing demand of renewables is therefore positively affecting the return on investment gap. Nevertheless has to be foreseen that firms might not be fond of this tax, since renewable energy is more cost intensive. Under this scenario, the tax could result in a political suicide, with firms lobbying their demand to annul this tax.

2.2.3 Tradable Permits

The third applicable instrument consists of tradable permits in the field of renewable energy consumption. Tradable permits have the basic mechanism that every company or country has a pollution threshold. Since economic growth required burning coal and oil, as fossil fuel for production, this was the greatest damage made towards our environment (Dahlberg, 1999). Pollution permits offer an attractive alternative to pollution taxes, since permits are tradable throughout the market, establishing an indirect tax. While one firm buys more permits, in order to maximise their production, other firms can sell their permits under the light of a newly developed technology that inexpensively reduces pollution (Dahlberg, 1999). Implementing the mechanism of tradable permits allows policymakers to rest, while the level of pollution is controlled through the "invisible hand" of the market, which let firms comply at costs most profitable for them and society (Dahlberg, 1999). In the light of reducing the return on investment gap for renewable energy sources, tradable permits be can used to achieve a minimum share of electricity from renewable sources within a company or country. Investors and operators of renewable energy plants, with special regard to offshore wind parks, have the opportunity to sell permits in order to generate revenue for their capital costs and to subsequently close the return on investment gap. It might still occur that some firms just buy massive amounts of permits to compensate their high pollution share. Therefore a regulatory framework is needed, which demands a minimum share of renewable energy consumed.

2.2.4 Loan Guarantees

The next instrument, applicable to reduce the return on investment gap, is a guaranteed loan. Since off-grid renewable energy projects face significant challenges in accessing financial support, mechanisms like loan guarantees need to be embedded in the regulatory framework (Xunpeng, Xiying & Lixia, 2016). Under the umbrella of loans are different types. On the one hand special funds can be established to provide sufficient financial means of off-grid renewable projects. On the other hand crowd-funding might constitute an option where the "crowd" is able to provide loans with a zero interest rate to projects they support (Xunpeng et al., 2016). The general mechanism behind loan guarantees is barrier-free access to financial means, provided by national banks with a preferential interest rate or through interest free crowd-funding (Xunpeng et al., 2016). Accessing financial means is most vital for successful renewable energy projects, hence for reducing the return on investment gap. Loan guarantees are most of the time implemented by governments and therefore likely to be found in policy papers. The contracting procedure of loan guarantees needs thorough examination. Firms who are able to finance the renewable energy project themselves might apply for low interest loans to maximise their profit. A clear and transparent assessment of firms is therefore needed to estimate their need of guaranteed low-interest loans.

2.2.5 Feed-in Tariffs

Closing the return on investment gap also implies that operators and investors need certainty that their electricity is sold on the market for reasonable prices. Feed-in tariffs display another mechanism to achieve that. Under feed-in tariffs lawmakers are obligating regional or national transmission system operators to feed-in the full share of ‘green’ electricity at politically fixed prices (Ringel, 2006). Capital and generation costs vary for each renewable energy source. Sufficient feed-in tariffs set fixed tariffs above the average market price to compensate renewables additional costs. It might also occur that feed-in tariffs consist of a bonus on top of the market price. The general approach, feed-in tariffs seek, is the compensation of disadvantageous costs (Ringel, 2006). Since offshore wind is still too costly compared to conventional fossil sources, development was only achieved through subsidies. These also include feed-in tariffs for offshore wind energy. Feed-in tariffs are the most used instrument all over the world to promote renewable power generation. Nearly two-third of all countries which have some type of policy to promote renewable energy had feed-in tariffs in 2010 (del Rio, 2012). Feed-in tariffs are a proven instrument in reducing return on investment gaps all over the world. The downside of feed-in tariffs is their promising long-term remuneration. The long-term tariff is still effective when the sold energy compensates capital costs. Under this scenario, the operator receives additional profit.

2.2.6 Tendering Procedures

Tendering procedures are a commonly used instrument to accelerate the development of renewable energy sources. Main mechanism behind tendering procedures is the idea of public tenders. These tenders are open for bidding firms, whereas the firms compete with each other for lower remuneration amounts. Participating firms will bid on the reference value of the project (Kilgus & Bader, 2017). Public tenders are implemented by national agencies, keeping costs as low as possible. The bidder with the lowest bid is successfully awarded with the commissioning of the project. In the field of offshore wind energy, low bids mean lower prices for one kWh produced. Most of the time tenders are awarded to the firm with the lowest subsidy demand. The long-term target consists of zero subsidization for offshore wind projects (Kilgus & Bader, 2017). On the one hand, tenders are offering a sufficient way to reduce costs by awarding the lowest bidder. On the other hand, the lowest bidder might miscalculate costs, which results in a withdrawal of the project at later stage. Under that scenario the bidding process would have to be iterated. Reducing subsidy compensation would therefore result in a backlash. Overall can be said that tendering procedures show that return on investment gaps are not as big as assumed. Bidding parties foresee to commission projects with a zero subsidy support.

2.2.7 Offshore Wind Technology Development

The last instrument discussed in this thesis, applicable to reduce the return on investment gap, is technology development in the field of offshore energy. Onshore wind energy might still be the most present form of wind energy, but the future of onshore wind parks is limited due to rare inexpensive landmass (Bilgili, Yasar & Simsek, 2011). Offshore wind on the other side offers opportunities far from inhabitable space, where wind conditions are more frequent, hence allowing turbines steadier electricity generation. Since capital costs for offshore wind are tremendously higher, onshore wind is, most of the time, the cheaper alternative (Bilgili et al, 2011). The last mechanism aims to accelerate the development of offshore wind technologies in order to make plants more efficient. From the first offshore wind park in 1991, with a capacity of 0,45 MW, huge progress was made. Current offshore windmills in 2016 possess capacities (of) up to 8MW due to bigger rotor diameters, hub heights and more efficient turbine technology (Dong Energy, 2016). Even though efficiency has improved vastly in the past decade, the development progress was not enough to close the return on investment gap. In order to make offshore wind energy feasible, development needs to receive steadier support, achieving technological breakthrough. Continuous development of offshore wind technologies is reliant on steady flows of investment. Without investment, development is likely to stagnate.

Remuneration and financial access for electricity from renewable energy sources is therefore needed, providing firms and investors with incentives to invest and develop. The regulatory framework accounts as legislative measures for making the development possible. Setting political long-term targets and offering remuneration for electricity generated by renewable energy sources are the key instruments for reducing the return on investment gap.

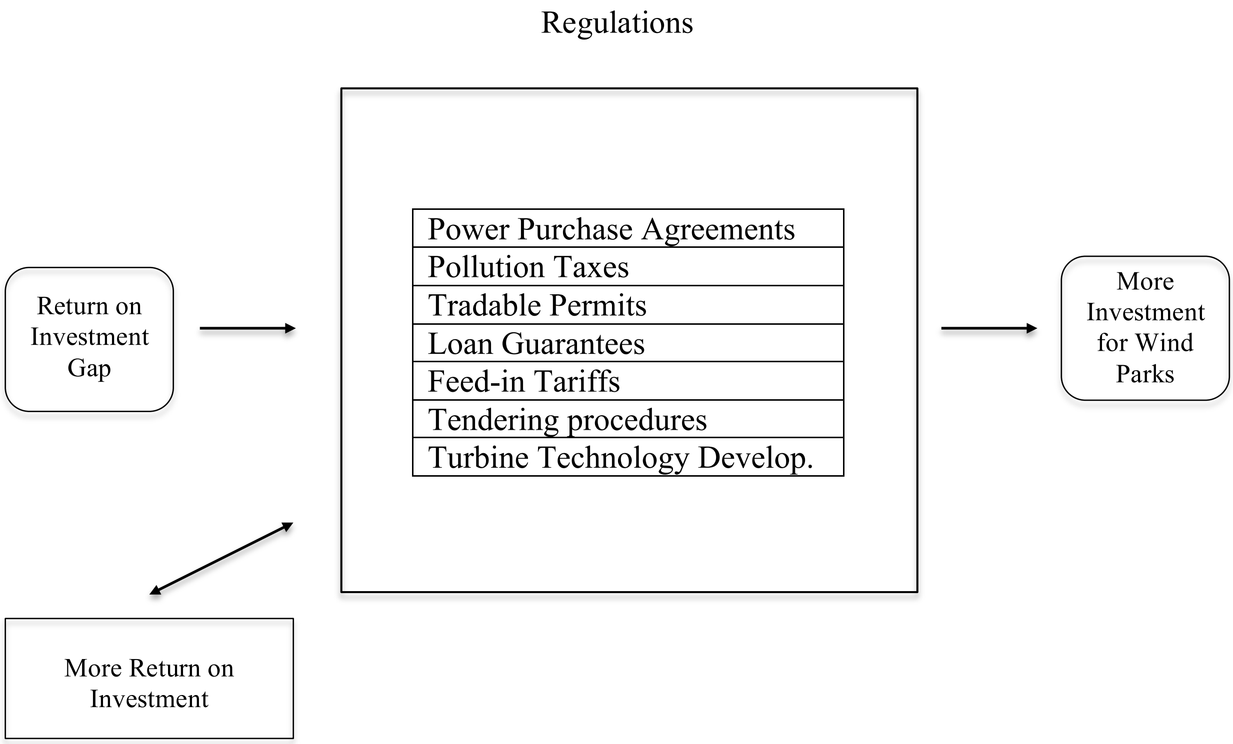

Figure 1. Theoretical heuristic of regulations affecting renewable energy development

Figure 1 illustrates a theoretical heuristic of the problem discussed. The return on investment gap needs to be decreased with the help of regulatory frameworks on national level. Within the regulatory framework, policy instruments need to be adopted. Policy instruments and their intended mechanisms possess the possibility in successfully providing more investment for offshore wind parks, hence closing the return on investment gap.

3. Methodology

3.1 Research Design

A case study research design is employed for conducting the thesis. The prognostic aim of the case study concerns the relationship between national regulatory frameworks and the development of offshore wind energy in Germany. Through evaluation an ex ante forecast can be made, which does not display actual outcomes. It provides outlooks how the mechanisms, discussed in the theory, affect the development offshore wind energy. The thesis is based on the descriptive research question: *How are legislative measures on national level reducing the return on investment gap renewable energy sources pose?*

The qualitative approach, analysing the national regulatory framework, influences the research design. Scientific studies will also be examined to display previous findings or forecasts. Previous researches mainly influence the study, providing it with distinctive knowledge and a solid background about offshore wind energy. Case studies offer the advantage of a detailed examination of a specific unit of analysis, in this case the Federal Republic of Germany, under a certain influence, which in this thesis is displayed by national regulatory frameworks.

Germany's driving interest in deploying renewable energy sources in the future makes it a useful and interesting case to study. The data collection for this thesis consists of national regulations and the accompanied support schemes as well as relevant articles. This provides a sufficient legal framework for the instruments, in which the research will be embedded.

Academic literature is of great importance when it comes to conceptualizing relevant instruments. Data sets are needed to estimate the price development offshore wind energy made and to forecast future price performances. Finding relevant literature and extrapolating sufficient data is not the difficulty. Connecting the instruments with the development of offshore wind price is the key difficulty in estimating a forecast.

3.2 Operationalization

The following section operationalizes the most relevant concepts for this thesis in order to measure the analysed findings on development of offshore wind energy. Subsidy instruments and return on investment gap display the relevant variables that need to be made measureable.

3.2.1 Subsidy Instruments

The successful transition towards renewable energy sources is accompanied by high capital costs. Renewable sources are a relative new technology on the energy market. Their counter sources, relying on fossil fuel, have proven to be efficient and reliable energy sources, producing a high return on investment. Renewable sources are relying on subsidies in order to compensate accompanied high capital costs.

Since the EU promotes the use of renewable energy sources Member States are eager to reach their national target of renewable energy shares. Subsidies display an essential policy instrument to tackle investment barriers and to provide investors as well as operators with much-needed incentives to commit towards renewable energy projects. The idea of subsidising renewable energy offers remuneration through different instruments. Furthermore subsidies are implemented to foster progressive development of energy sources, making them more cost efficient. A successful subsidy instrument provides the investor with certainty to compensate the additional costs until the profitability of the energy source is able to do so itself. It has to be acknowledged that subsidies are only needed until the operation and capital costs are covered by the generated profit. Thorough calculations are needed to avoid a backlash in the field of renewable energy remuneration. Subsidies need to compensate additional costs for the electricity price until it falls on or below the market price for 1 kWh. Policy measures such as remuneration instruments are adopted for long periods to provide long-term incentives for investors.

Figure 2. Estimated subsidy period (Example)

As shown in Figure 2 subsidies are aiming for long-term remuneration, promising financial compensation up to X years with a fixed price above the market price or on top of the market price. Subsidies are fixed policy instruments promoting long-term operation and are therefore prone to changes. Whereas, for example, in year 2017 subsidies of 12,3 ct/kWh compensate the initial capital and operation costs, subsidies of the same amount are unnecessary in 2030. Over the years the generation costs are compensated by the profit made selling renewable electricity. Implementing sufficient time-scaled subsidy instruments is important to avoid tremendous profits for operators, which in the end consumers have to pay for through taxes and levies. Clear price estimations are needed to assess how offshore wind energy prices will develop over the next decades.

3.2.2 Estimated Price of Offshore Wind Energy (Return on Investment Gap)

The second variable, which needs to be operationalized, is the estimated price offshore wind energy will perform in order to determine the return on investment gap. Prices change in unpredictable patterns due to development processes, market changes or crises. Renewable energy, as a new generation technology in the established fossil fuel energy market, is therefore facing several barriers in gaining prominence. As mentioned in preceding sections are fossil fuel sources an established high return on investment energy source. Offshore wind energy therefore faces a lack of investment in Research Development and Deployment (RD&D). The analysis part will serve the cause to examine whether overall cost-efficiency of offshore wind energy can develop positively under national regulations and their intended policy instruments. Estimating the price development offshore wind energy will perform allows determination of whether it is a sustainable and cost-effective alternative in the future. Since offshore wind energy purchase is located above the general market price subsidies are necessary to compensate the financial loss. In order to determine to what extent remuneration is needed, an estimated price development needs to be assessed.

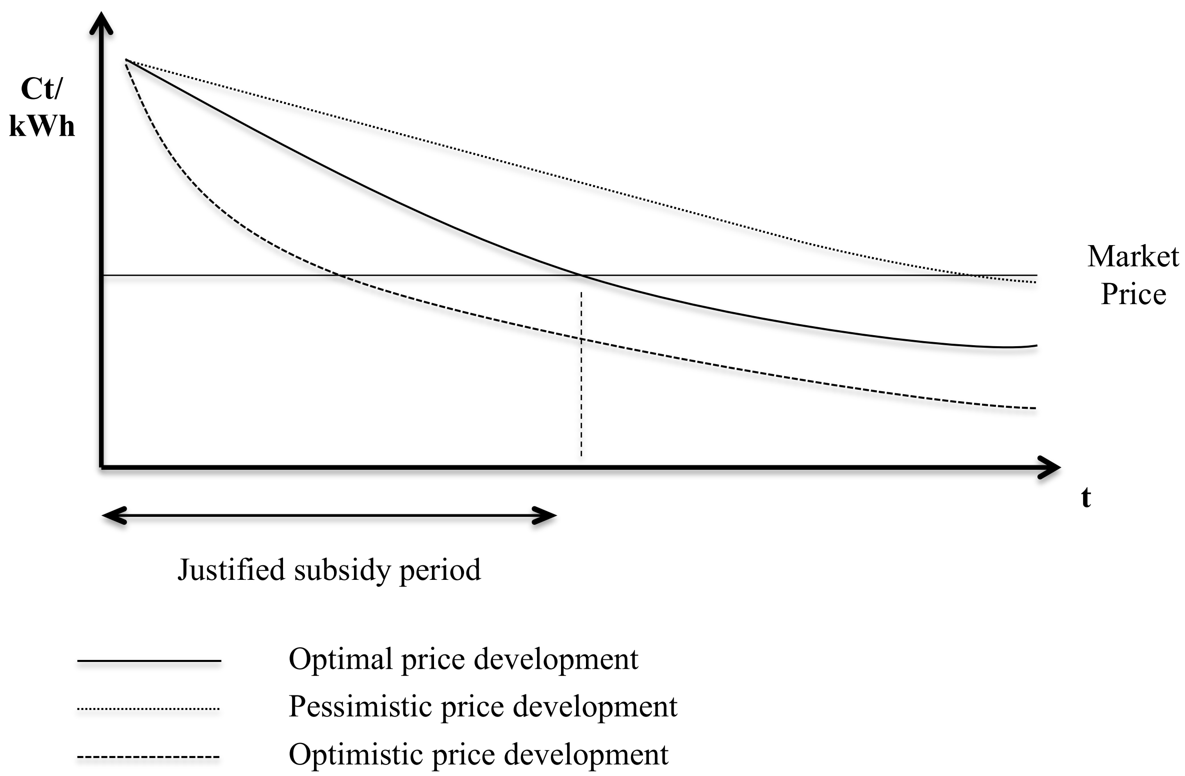

Figure 3. Price estimation of offshore wind energy (Renewable generation cost plus profit margin)

Figure 3 graphically depicts price estimations offshore wind energy is likely to perform. The optimal price development shows that subsidies are only needed until the price per kWh falls below the general wholesale market price of energy. This scenario displays the perfect coherence between the development of offshore wind energy and subsidy time duration. Remuneration is granted for the period until offshore wind energy compensates its own generation cost while achieving profitable return on investment. Pessimistic price development foresees the break-even point, the point where the price for 1 kWh is on or below market price, at a later stage outside the subsidy period. In that scenario offshore wind energy price development is not profitable and cannot be sold on the energy market due to high prices. This development would result in an even higher lack of investment. The last price development is foreseeing an optimistic outcome in which the break-even point is reached before the end of the justified subsidy period. In the case of an optimistic price development, return on investment would exceed to a maximum. Composed by profitable energy generation and subsidy compensation, this scenario foresees huge profits due to unnecessary long-term subsidies. In this scenario offshore wind energy will experience overinvestment.

3.2.3 Levelized Costs of Energy

Under "Levelized Costs of Energy" (henceforth = LCOE) all costs during the life of a power station are divided by the lifetime output from the power station. LCOE incorporates all costs that occur during the life of power plants, including capital costs, operation and maintenance costs plus fuel and decommissioning costs. If the LOCE is relatively low, energy can be produced cost effective and result in high return on investments. Under high LCOE, energy is expensive and unlikely to be sold on the market (EWEA, 2015).

$$\text{LCOE} = \frac{\textit{All discounted costs during the lifetime of a power plant}}{\textit{Discounted lifetime output}}$$

3.3 Data and Documents

Deriving from the preceding sections, legal documents as well as academic literature is needed to conduct a sound analysis of the development of offshore wind energy in Germany. Legal documents on national level are needed to find the relevant policy instruments subsidising renewable energy sources. Academic literature is needed to emphasize previous findings on the development process of offshore wind energy. Additional reports and fact sheets are needed to estimate the price development offshore wind energy will perform in the coming decades. Empirical data from agency reports as well as renowned newspapers provide most recent data and findings and therefore are also included in the data gathering process.

3.4 Limitations

Research designs aim to provide certain requirements in order to conduct sound research with profound results. The case study research design, employed in this thesis, aims to provide a framework for the analysis of the development of offshore wind energy under national support schemes in the Federal Republic of Germany. Nevertheless each research design is prone to threats. Analysing the relationship between two variables always poses the threat that researchers miss reliable factors, which can be accounted to the actual relationship. It might occur that results found for the development in the analysis part are not accountable to the regulatory framework. A third variable, also called omitted variable, causes in this scenario the correlation between independent and dependent variable. Omitted variables might be caused by fossil fuel crises, resulting in higher investment activities towards renewable energy sources, hence accelerating their development process rapidly. Also decreasing oil prices might result in bigger investment gaps due to the fact that investors commit towards oil as cheap and reliable investment opportunities. Therefore this study is limited to effects of the national regulatory framework on the development of offshore wind energy. Through applying a broad range of mechanisms, which affect the development, the study aims to reduce omitted variables to a minimum but is not able to fully extinguish them.

4. Legal Basis of the EEG

Providing sufficient solutions, to reduce the return on investment gap, demands implementing policy instruments embedded into regulatory frameworks on national level. Governments and their national agencies regularly initiate policy instruments, which are most of the time legally binding. From this legal framework intended mechanisms can be retrieved to evaluate the impact they have on the situation it needs to solve. In the light of the energy transition throughout Europe, Germany committed itself to transit towards renewable energy sources as the main pillar for future electricity generation. In order to accelerate the promotion of renewable energy sources throughout the country, a regulatory framework was established as national legally binding law.

In 2000, the "German Renewable Energy Sources Act" (Erneuerbare Energien Gesetz, henceforth EEG) entered into force, marking a milestone of the key driving force, expanding renewable energy in Germany (BMWi, 2017). Electricity prices in the Federal Republic are orientated at generation costs for 1kWh but neglect initial investment costs. Therefore fossil fuel sources are the dominant electricity supplier in Germany, facing low instalment costs while producing high return on investment. Renewable sources bear high instalment costs, whereas generation costs are low or equal to zero (Bundesregierung, 2017). Therefore investment was stagnating due to the rising belief that return on investment from new renewable energy sources is too little, compared to their proven fossil counter partners.

The first version, the EEG 2000, aimed to promote young technologies. Among them wind and solar, to enter the market by providing fixed tariffs and purchase guarantees (BMWi, 2017). In the following years, the EEG was substantially changed and amendments were included in the EEG's original form. First major EEG revision was entered into force in the year 2012, encouraging direct marketing, allowing plant operators to sell the electricity themselves while receiving a market premium instead of the feed-in tariff when selling their electricity to the grid (BMWi, 2017). Nevertheless was the second revision of the EEG, the version of 2014, stipulating new larger installations, while halting the rising electricity prices (BMWi, 2017). Most recently the last amendment of the EEG was adopted, giving the EEG 2017 its name. Major amendments were introduced, such as the auction procedure. The revised version of the EEG changed the funding mechanism under market premiums and feed-in tariffs. Funding under the EEG 2017 is no longer fixed by the government, but has shifted towards a market-based auction mechanism, where bidders haggle among each other for the awarded remuneration amount, whereas the lowest bidder is awarded with the project. This mechanism changes the game of funding renewable energy sources fundamentally (BMWi, 2017). Defining Germany's national target in renewable energy is highly influenced by the EEG and will initiate the next step of the energy transition, focusing more on competition, continuous expansion with effective steering, improvements in cost intensity and promoting stakeholder diversity to impede monopolistic incentives as well as dovetailing grid expansion (BMWi, 2017).

Whereas the original version of the EEG promised fixed funding support for renewable energy operators, has the EEG 2017 shifted its funding mechanism toward an auction based funding approach, determined by the free market. Through applying a tendering procedure with market-based auctions, renewable energy projects are funded regarding the demand commissioned in the auction, preventing exaggerating remuneration payments for operators.

Analysis

5. Policy Instruments of the EEG

In order to retrieve a profound answer to the posed research question, "*How are legislative measures on national level reducing the return on investment gap renewable energy sources pose?", s*ubstantive sub-questions need to be answered. The following sections will analyse the current national regulatory framework thoroughly. Sub-section 1 examines the national regulatory framework of the Federal Republic of Germany in order to identify supporting policy measures for offshore wind energy. The second sub-section illustrates prognostic scenarios offshore wind energy is likely to perform in the following decade(s). In sub-section 3, the return on investment gap development under policy measures is analysed.

For the analysis of the EEG, the original version of the year 2000 and the latest version, of 22nd December 2016, are used to retrieve information about national support schemes in the Federal Republic of Germany. Since 2000, the EEG is legally binding within the sovereign territory of Germany. EEG 2017 was adopted in December 2016 and is from that date onwards applicable to all matters regarding renewable energy sources.

In the preceding sections of the EEG, not regarding support schemes in particular, the general application and targets of the legal framework are outlined. Paragraph 1 (1) of the EEG explicitly depicts the promotion of renewable energy sources under the special interest fighting climate change and to preserve the environment (§1 (1) EEG, 2017). Subsection 2 of §1 further establishes Germany's future goals to increase the share of renewable energy till 2025 to 40-45% whereas in 2035 an overall share of 55-60% is set. Until 2050 an overall share of renewable energy in Germany is set to increase to 80% of its overall energy consumption (§1 (2) EEG, 2017). These targets need to be forcefully promoted, nevertheless can the actual achievement not be granted and is not punishable by law.

Deriving from paragraph 1 EEG, Germany's overall national target is defined as to improve the use of renewable energy sources and to increase the overall share of renewable energy. This provides long-term targets, which reduces overall uncertainty and ensures operators that renewable energies will emerge in the existing market.

5.1 Tendering Procedures

The EEG formulates tenders as following: a transparent, non-discriminatory and competitive procedure to determine the entitlement of projects including the compensation value (§3 (4) EEG, 2017).

Paragraph 2 EEG explicitly outlines the integration of renewable energy sources and the marketing of the energy produced of such (§2 EEG, 2017). The paragraph is split into several sub-sections, which provide detailed information for the procedure of the integration process of renewables, as well as their purchase procedure within the electricity market. Paragraph 2 subsection 3 concerns explicitly the importance of remuneration payment for electricity generated by renewables, which is ascertained through tenders on national level. Tendering procedures are therefore occurring as the first mechanism that can be identified in the EEG, as they display a legally binding policy instrument within the Federal Republic of Germany (§2 (3) EEG, 2017).

In the case of offshore wind energy guidelines for tendering procedures are formulated in the "Windenergie auf See Gesetz" (henceforth = WindSeeG, 2016). The WindSeeG was established under the EEG and focuses in particular on the forceful promotion of offshore wind energy as a reliable form energy from renewable sources. Within the legal framework of the WindSeeG, Germany's national offshore target is formulated, promoting offshore wind capacities installed up to 15 GW (GigaWatt). National targets, such as the overall national target, are set to provide a specific amount that needs to be achieved. The forceful promotion of achieving this goal is prioritized but cannot be legally fined if the goal is not reached within the timeframe. In terms of tendering procedures the WindSeeG is estimating the market premium under § 22 EEG for offshore wind parks operating after 31. December 2020.

Offshore wind energy might depict the most complex form of renewable energy sources, posing difficult instalment conditions and high capital costs. The EEG covers the promotion of all renewable energy sources and is applicable in all cases unless the more specified WindSeeG determines it differently for offshore wind energy. In the case of tendering procedures is the WindSeeG applicable instead of the EEG. Section 3 of the WindSeeG is concerning this matter. The new tendering procedure was introduced with the amended EEG and replaces feed-in tariffs with competitive auctions leading to lower prices offered for offshore wind power (Offshorewind, 2017). Paragraph 14 (1) entitles operating firms a market premium in accordance with paragraph 19(1) EEG, if the plant is within the economic zone and coastal sea area of Germany (§14 WindSeeG, 2016) (§19 EEG, 2017). Formal tender conditions, §15 WindSeeG, are outlined in §§ 30 till 35a, 55 and 55a EEG, regarding bidding volume among market premium limitations, which shall not exceed 12 ct/kWh, and publication of the projects open for bidding (§15 WindSeeG, 2016).

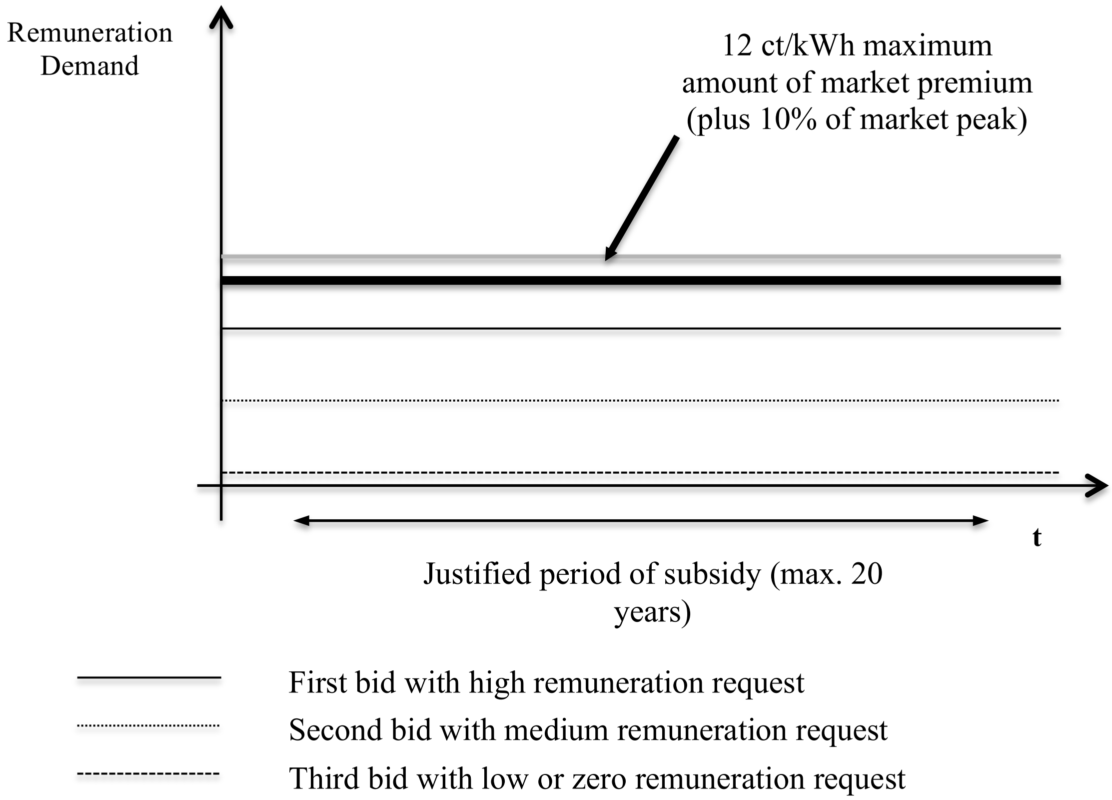

Figure 4. Bidding procedure on tender offer (WindSeeG, 2016) (EEG, 2017)

Figure 4 graphically depicts the bidding procedure of tender offers, whereas the maximum price for offshore wind (plus the 10% additional amount of the market peak) is displayed as the highest amount of remuneration receivable. Three different bids are displayed, proposing offers with high, medium and low to zero remuneration requests. According to the WindSeeG in accordance with the EEG 2017 is the offshore wind project awarded to the third bid with low or zero remuneration requests. Crucial in the decision making process is also the requested time period. Overall the bid with the lowest remuneration request and shortest subsidy period is awarded with the project. Tender procedures might result in project awards with zero subsidy requests. In that case, the offer has to be thoroughly assessed. Bidding parties are overestimating the development process, calculating with higher efficiencies in the future. These estimations are purely relying on forecasts and therefore not displaying the actual development process. Overall tender procedures are, as legally binding instrument, suitable for awarding offshore projects. Under the pressure of the free market are bidding firms lowering their remuneration requests, impeding overinvestment.

5.2 Power Purchase Agreements

Power purchase agreements, where private utility firms agree on a long-term contract with a government agency, cannot be found within the national regulatory framework for renewable energy in Germany. Henceforth power purchase agreements are no longer considered in this analysis.

The EEG provides purchase guarantees for electricity from renewable energy sources to be sold to the grid but is not explicitly outlining long-term agreements between operating firms and government agencies. Paragraph 8 ensures renewable energy sources grid connection and prioritizes energy from renewable sources to be sold to the grid (§8 EEG, 2017). Amendments in updated versions of the EEG can annul purchase guarantees. Purchase agreements differ from power purchase agreements to the extent of missing long-term agreements, ensuring sufficient remuneration over a long period. Nevertheless purchase guarantees are incentivising firms to contribute capital in progressive development to increase the overall efficiency of offshore wind parks.

5.3 Payment of Market Premium and Feed-in Tariff

Since the very first version of the EEG, remuneration in term of fixed prices was present. Paragraph 19 of the EEG entitles operating firms, of solely renewable energy plants, to claim to receive market premiums or feed-in tariffs (§19, 20, 21 EEG, 2017). Receiving remuneration in form of market premiums or feed-in tariffs requires certain obligations, which need to be fulfilled by the operator. Market premiums are only applicable if the operator or a third party sells the energy generated. In addition the operator is obligated to characterize energy from renewable sources as such (§20 EEG, 2017). Estimating the competitive assessment of market premiums can be found under paragraph 22 (5) EEG. Regarding to the EEG remuneration for offshore wind energy is only available for plants that went online between 1. January 2017 and 1 January 2021(§22 (5) EEG, 2017), in which case market premiums and feed-in tariffs are limited to a maximum of 20 years (§25 EEG, 2017).

The EEG 2017 explicitly outlines the amount of remuneration for energy generated by offshore wind parks. General subsidization of 3,90 ct/kWh is applicable and legally binding under §47 (1) EEG (§47 EEG, 2017). Additional remuneration is available under two different models. On the one hand, additional 15,40 ct/kWh can be commissioned over a period of twelve years. On the other hand, additional subsidize can rise up to 19,40 ct/kWh over a period of eight years (§47 (2) EEG, 2017). The subsidized period can extend an additional 0,5 month for each offshore sea mile extending the twelve sea mile coastal line and additional 1,7 month for each meter exceeding the water depth of 20 meters (§47 (2) EEG, 2017). If plant operators choose the 19,40 ct/kWh remuneration model over eight years the remuneration amount for the extension period is set to the initial 15,40 ct/kWh (§47 (3) EEG, 2017). In the event of an offshore power plant not gaining access to the grid for 7 consecutive days, §17e of the "Energiewirtschafts Gesetz" becomes effective, extending the remuneration period beginning with the 8^{th} day without grid connection (§17e EnWG, 2005) (§47 (4) EEG, 2017). Estimated values are only applicable for offshore wind parks put into operation in 2017. If offshore wind parks are put into operation in the years 2018 and 2019, the estimated value decreases by 0,5 ct/kWh to 14,90 ct/kWh over twelve years and 18,90 ct/kWh over eight years. Whereas when offshore wind parks are put into action in the year 2020, the estimated value decreases by 1,0 ct/kWh to 14,40 ct/kWh over twelve years and to 18,40 ct/kWh over eight years (§47 (5) EEG, 2017). These adjustments were made under the light of progressive development. The day offshore wind parks are enabled to produce electricity marks the operation date. This prevents wind farm operators from delaying their generation date (§47 (7) EEG, 2017).

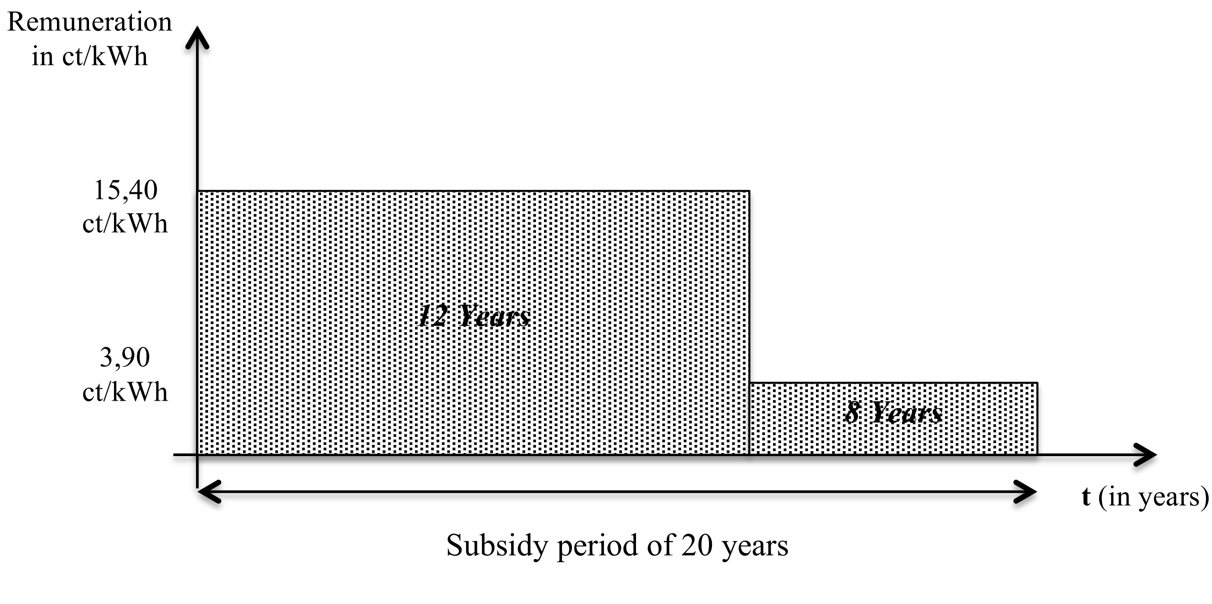

Figure 5. Remuneration in form of feed-in tariff under §47 (2) (EEG, 2017)

Figure 5 graphically displays the remuneration mechanism under §47 (2) EEG under which plant operators are entitled to receive 15,40 ct. for each kWh fed into the grid over a 12-year period. After 12 years the amount of remuneration decreases to 3,90 ct/kWh for the last 8 years until the maximum subsidy period of 20 years is reached, if not commissioned differently.

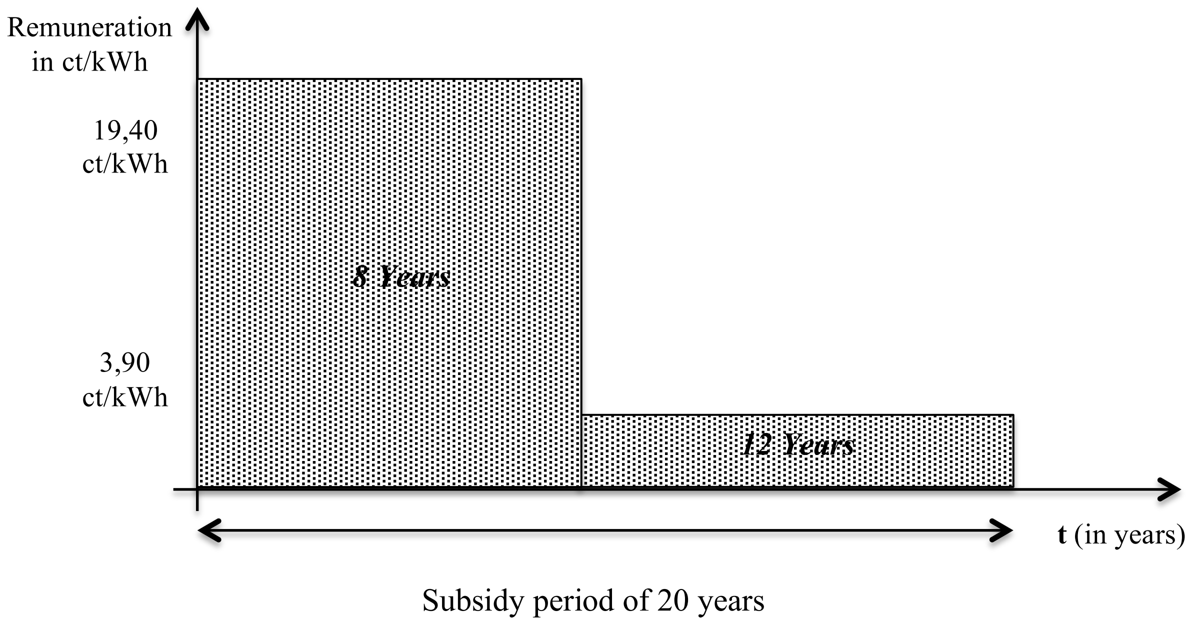

Figure 6. Remuneration in form of feed-in tariff under §47 (3) (EEG, 2017)

Figure 6 displays the remuneration mechanism under §47 (3) EEG under which plant operators are entitled to receive 19,40 ct. for each kWh fed into the grid over an 8 year time period. Afterwards the amount decreases to 3,90 ct/kWh for the remaining 12 years of subsidization until the maximum subsidy period of 20 years is reached, if not commissioned differently.

In the event that offshore wind parks are located further away from shore then the 12 sea mile costal line or in deeper waters, the 12- or 8-year period might extend with regard to the distance and water depth of the plant. With the incentive to prolong the subsidy period, operating firms are not reluctant to build offshore wind parks under extreme conditions.

Conclusively can be determined that remuneration in form of market premium and feed-in tariffs can be found within the regulatory framework on national level in the Federal Republic of Germany.

5.4 Loan Guarantees

Accessing capital to initiate projects in the offshore wind energy sector is necessary to accelerate the development of offshore wind parks in Germany. Under the EEG, special conditions for loan guarantees cannot be found. With the absence of loan guarantees will this policy instrument no longer be taken into consideration.

Even though loan guarantees are not embedded in the EEG offshore projects are able to apply for loans at the KfW (Kredit für Wiederaufbau) credit institute. The KfW banking group is a German government-owned bank helping the Federal government achieving its development policy and international development cooperation since more than 50 years (KfW, 2017). In the field of offshore wind park projects is the KfW offering special loans for projects within the German economic zone or the 12 sea miles in the North and Baltic Sea (KfW, 2015). Loans are only provided for plants that comply with EEG requirements. The KfW credit institute is never solely acting as the single credit provider. There are three scenarios under which the KfW provides financial support for offshore wind projects. Scenario A offers funding up to 400 Mio. Euro through a direct credit, composed by one or more commercial banks and the KfW bank, whereas the contributed amount has to be equally distributed between both or more parties (50/50 share). Scenario B offers financing packages up to 700 Mio. Euro, under which commercial banks contribute to offshore projects, whereas they refinance their commissioned credit through the KfW bank (up to 70% covered by KfW). Scenario C provides credits for unforeseen costs, covering up to 100 Mio. Euro, whereas the credits are composed as in scenario A (KfW, 2015). These loans have a period of 20 years, whereas the first 3 years offer a grace period. KfW credit institute, offering special loans for offshore projects, reduces uncertainties for investor groups, hence reducing the return on investment gap some might foresee. Even though the KfW provides special loans for offshore wind projects, these loans cannot be accounted as an EEG policy instrument.

5.5 Pollution Taxes and Tradable Permits

The policy instrument of pollution taxes was not found within the legal framework of the EEG, since renewable energy sources have low or zero carbon-dioxide (CO_2) emission. Henceforth pollution taxes are not taken into consideration, analysing the policy instruments affecting development of renewable energies in Germany.

Implementing a sufficient CO_2 tax in Germany was never realized, even though many political and societal actors demanded it (Wetzel, 2017). Even after the climate summit in Paris 2016 the German government was not showing any attempts to adopt sufficient taxes reducing CO_2 emission. In the light of this missing pollution tax, Germany is likely going to fail its' target of reducing CO_2 emission by 40 percent compared to its level in 1990. Foreseeing that raises the importance towards pollution taxes and fixed minimum prices for CO_2 (Wetzel, 2017). A sufficient pollution tax would increase the demand for renewable electricity in the German energy market. Conclusively improving development and deployment rapidly. Pollution taxes are absent in the legal framework and therefore not affecting the governance structure of the German energy system.

Tradable permits are not embedded in the EEG as a policy instrument affecting the promotion of renewable energy. Tradable permits are from this point onwards not taken into consideration, analysing the policy instruments affecting development of renewable energies in Germany, especially offshore wind.

Tradable permits can be found on EU level. The European emission trading system was designed to reach the EU’s target of reducing CO_2 emission by 20 percent compared to the level in 1990. Through the emission trading system power plant operators are allowed to emit CO_2 under the condition of having purchased sufficient amounts of permits (Wetzel, 2017). Germany’s CO_2 emission from coal-fired power plants can partly be blamed on the low prices of EU emission trading certificates. It was found that too many permits were available for the biggest carbon market in the world (Appunn, 2014). Nevertheless the trading system is a sufficient way to decrease CO_2 emission. Reducing the availability of permits or increasing their price can bring the desired result. In the context of the German energy system are tradable permits not affecting the German energy market on national level. Big plant operators are obligated to purchase sufficient EU permits, but this will not be enough in reaching Germany's national target.

5.6 Turbine Technology Development

The last mechanism examined is the technological development progress from offshore wind plants. Optimising the efficiency of offshore windmills results in higher capacities of final energy production and consumption. Consistent development within the field of renewable energy was implemented through paragraph 1 EEG, stating that sustainable development has to be made in the energy supply (§1 (1) EEG, 2017). The increasing renewable energy demand requires optimization in the field of offshore wind efficiency. Turbine capacities play a big role for the development of offshore wind parks, since higher capacities result in higher return on investments, hence reducing mentioned return on investment gap. Since the first offshore windmill was deployed in 1991 in Denmark tremendous progress was made.

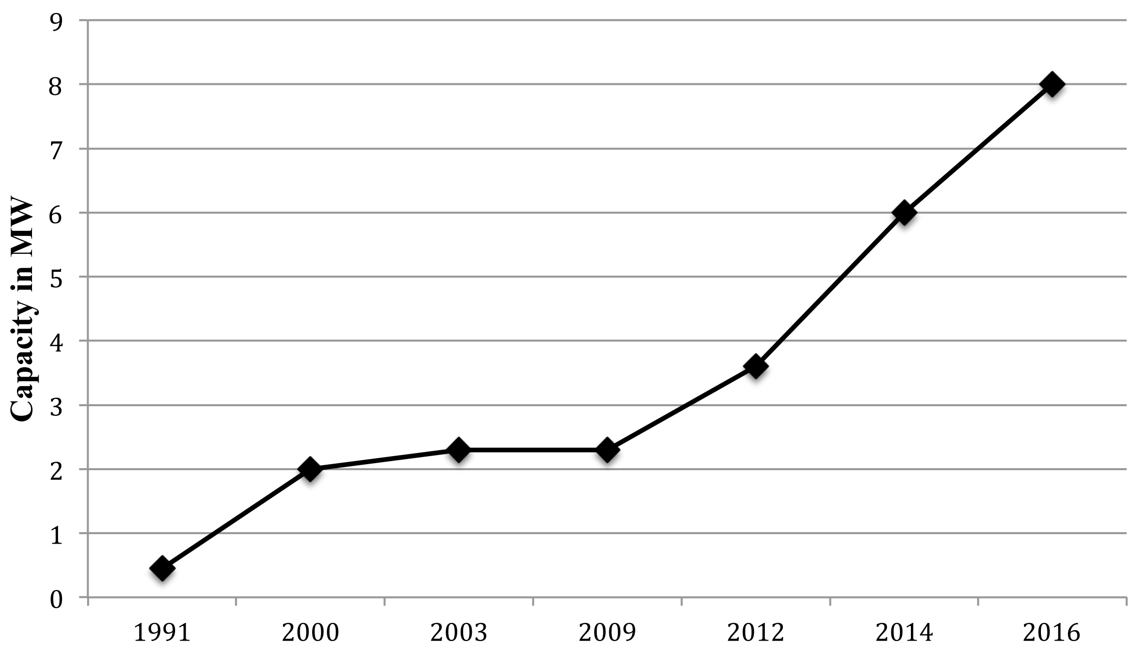

Figure 7. Capacity development of offshore wind turbines (Dong Energy, 2016)

Figure 7 graphically displays the development process of offshore windmills from 1991 till 2016 in Germany. The X-axis depicts the time in years, whereas the Y-axis depicts the capacity in megawatt (MW). Offshore wind energy had little prominence before the turn of the millennium, but small continuous progress was made. Especially since 2009, capacities of offshore windmills increased rapidly. From 1991 till 2016 the installed capacity for one offshore windmill increased twentyfold. Higher turbine capacity accompanies higher electricity output, which can be fed into the grid, hence receiving more remuneration according to EEG instruments. Increasing the capacity of offshore windmills from 4 MW to 8 MW reduces the specific operating costs per MW sustainably (Fichtner & Prognos, 2013). While capacities were increasing, due to larger rotors, hub heights and turbine efficiency, did also capital costs rise. Whereas the first offshore wind park in 1991 had average costs of 15 Mio. Euro commercial projects costs have been increasing to an average installed capacity cost of 487 Mio. Euro (Rodrigues et al., 2015). While capital costs are rising, operation and maintenance costs are reducing under higher capacities, hence securing the possibility of more return on investment. One might foresee that capacities will steadily increase, resulting in larger rotors and higher hub heights. Technical development of offshore wind plants might therefore be crucial in reducing the return on investment gap.

5.7 Germany's Energy Regulation System for Renewable Energy

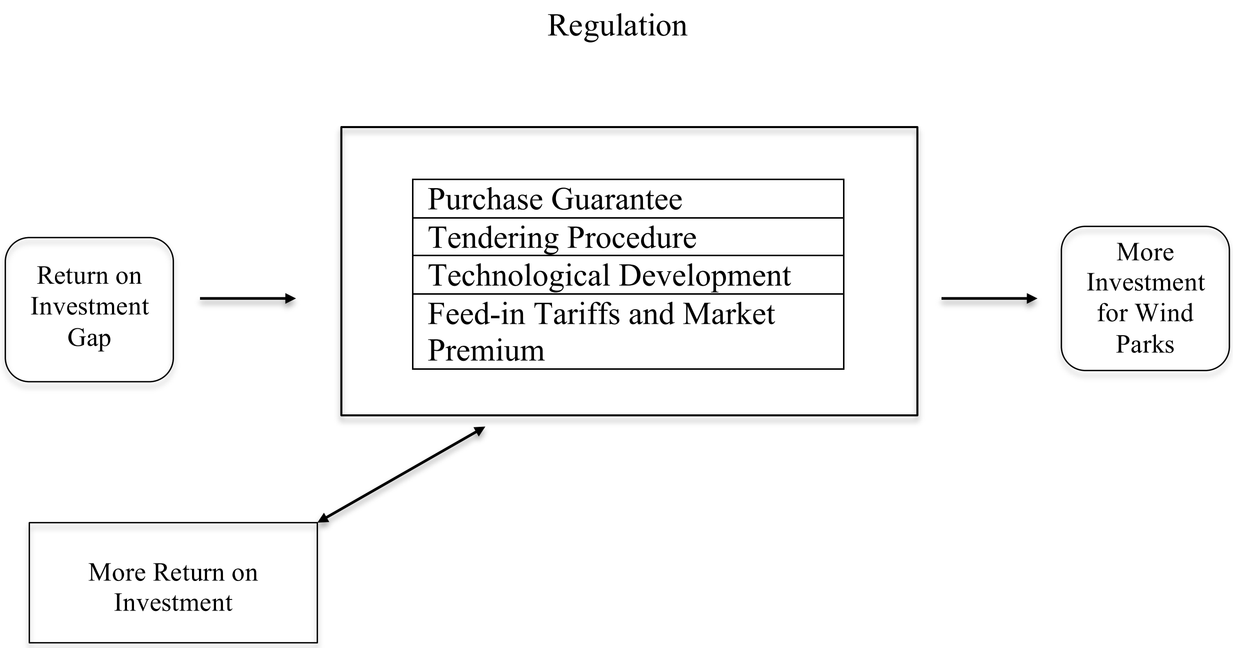

Figure 8. Governance structure of electricity regulation in Germany

Figure 8 depicts graphically the energy regulation system in Germany. Deriving from the preceding sections following policy instruments were found, affecting the return on investment gap in Germany. Purchase guarantees provide operators with certainty to sell their energy into the grid, which results in continuous income for each kWh generated. Tendering procedures allow market-based auctions for offshore wind projects, hence reducing remuneration costs for the government. Technological development affects the generating capacity of offshore wind parks to the extent that they might be able to finance themselves in the future. Feed-in tariffs and market premiums offer compensation for high capital costs, hence providing the incentive to invest even if high capital costs arise due to more complex construction side. These regulations were identified to have the most striking impact on the development of offshore wind parks in Germany.

Sub-question 1 can therefore be answered as following: The German EEG provides policy instruments for the integration of renewable energies in the energy market. These instruments serve renewable sources remuneration for green energy fed into the grid.

6. Price Development of Offshore Wind Energy

6.1 Construction Site and Development Scenarios of Offshore Wind Plants

Measuring the price development of offshore wind energy cannot be generalized since offshore windmills are located in different environments, i.e. deeper water or further distance to the shore. Therefore are capital costs prone to changes, affecting the levelized cost of energy (LCOE). To predict future developments of offshore wind energy prices, estimations need to be assessed. Two different scenarios are constructed under which price development of offshore wind energy is varying. Scenario 1 foresees that offshore wind energy prices are decreasing in the future due to technological achievements and cheaper instalment costs. The 2^{nd} scenario foresees that offshore wind prices are rising in the future. This forecast is built on the assumption that offshore wind energy will lose the investor's attention due to high capital costs, whereas technological development is not present, making offshore wind plants more cost intensive. In both scenarios the wholesale energy price for Germany remains the same.

Year	Capacity of Wind Generators	Hub height	Rotor diameter
2018	4 MW	90 m	120 m
2021	6 MW	100 m	140 m
2024	6 MW	105 m	155 m
2027	8 MW	110 m	165 m

Table 2. Offshore wind plant development and configuration under scenario 1

Year	Capacity of Wind Generators	Hub height	Rotor diameter
2018	4 MW	90 m	120 m
2021	4 MW	95 m	122 m
2024	4 MW	100 m	125 m
2027	4 MW	100 m	128 m

Table 3. Offshore wind plant development and configuration under scenario 2

(Estimations in Table 2 and 3 inspired by: Fichtner & Prognos, 2013)

Table 2 and 3 display the offshore wind plant development and configuration progress from 2018 till 2027. Under scenario 1, displayed in table 2, continuous progress is visible, hence allowing higher overall outputs. Under scenario 2, shown in table 3, continuous progress is missing. Development is stagnating, resulting in less overall output and higher LCOE.

6.2 Energy Price Composition in Germany

The German energy market is still dominated by fossil fuel sources, accounting for the vast majority of consumed electricity. As mentioned previously electricity prices in Germany are orientated at generation costs for 1kWh, neglecting initial investment costs. Therefore fossil fuel sources are still contributing most of Germany's electricity, ensuring high return on investment and lower instalment costs. Under the light of the on-going energy transition renewable energy sources are still too costly.

The German electricity price is composed by three factors, contributing different shares to the final market price. The first factor is made up by electricity generation and market sale costs. It is determined by the market and accounts 25% to the final energy price in the Federal Republic of Germany. The second factor is made up by regulated network charges, including measurement, settlement and metering point operation. With only 23% of the final energy purchase price, this factor makes up the smallest amount. Taxes, fees and levies are combined to the last factor, accounting for 52% of the final energy price. These components display the average composition of the German energy price for consumers with an annual consumption of 3.500 kWh (BDEW, 2015). The wholesale price is therefore composed by factor 1 and 2, displaying costs for energy without taxation and levies. In the following sections of the analysis, the Germany electricity wholesale price development until 2015 is displayed before future estimations are calculated. These estimations consist of a stagnating development with marginal changes in the price development till 2027. The estimated price development is only forecasting stagnation and not displaying the actual outcome energy price are going to perform.

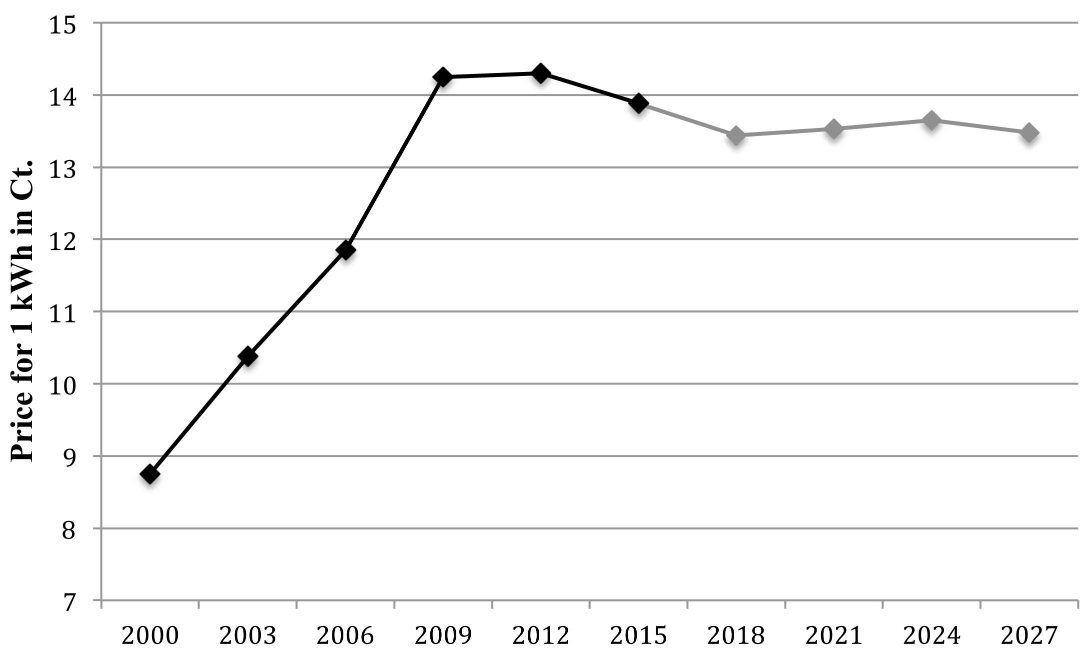

Figure 9. Price development of the German energy wholesale (data till 2015: BDEW, 2015)

Figure 9 illustrates the price development in Germany from the year 2000 till 2027. The black line displays available data from 2000-2015 (BDEW, 2015). The grey line displays estimated data for 2018-2027. For the years 2000-2015 actual data was retrieved and therefore displays the actual price development of the German wholesale price for 1kWh. From 2015 onwards on, the wholesale prices are estimated to remain relatively constant, with little fluctuation. These estimations are serving a prognostic cause and do not display the actual performance of energy wholesale prices in Germany. Deriving from figure 9 can be retrieved that energy wholesale prices for consumers in Germany were constantly rising from 2000 till 2009, starting with an initial 8,75 ct/kWh and increasing to 14,25 ct/kWh. Continuing from 2009, prices remained constant performing small changes in 2015, reducing the energy price towards 13, 88 ct/kWh. In this scenario, the future predictions assume that wholesale prices in Germany will not exceed the 13 ct/kWh, offering constant prices for consumers till 2027.

6.3 Price Development of Offshore Wind Energy

As previously mentioned are two scenarios constructed for the price development offshore wind energy will perform from 20018 till 2027. In the light of progressive development and increasing efficiency is scenario 1 foreseeing a decrease in offshore wind energy prices. This scenario predicts that offshore wind plants will increase their capacity, hub height and rotor diameter, resulting in higher outputs over lifetime and decreasing the LCOE steadily. The 2nd scenario foresees that offshore wind energy prices are likely to increase. More complex constructions affect the LCOE for offshore wind energy under scenario 2. Higher turbine capacities are not taken into account, as well as increasing plant sizes. Scenario 2 foresees that development is not progressing with the intended speed, making offshore wind energy disadvantageous compared to other renewable energy or fossil fuel sources.

Year	Scenario 1	Scenario 2
2018	14,4	14,4
2021	13,9	14,7
2024	13,3	15,1
2027	12,6	15,5

Table 4. Price estimations for offshore wind energy under Scenario 1 and 2

Table 4 illustrates the price development both scenarios will perform in the years 2018 till 2027. Under scenario 1 the initial LCOE of 14,4 ct/kWh decreases continuously until 2027, estimating offshore wind energy prices to cost 12,6 ct/kWh. Scenario 2 foresees that the initial LCOE of 14,4 ct/kWh will increase over the time period, reaching the maximum amount of 15,5 ct/kWh for offshore wind energy in 2027. To illustrate how these changes affect the overall performance of offshore wind prices are both scenarios compared to the wholesale energy price in Germany.

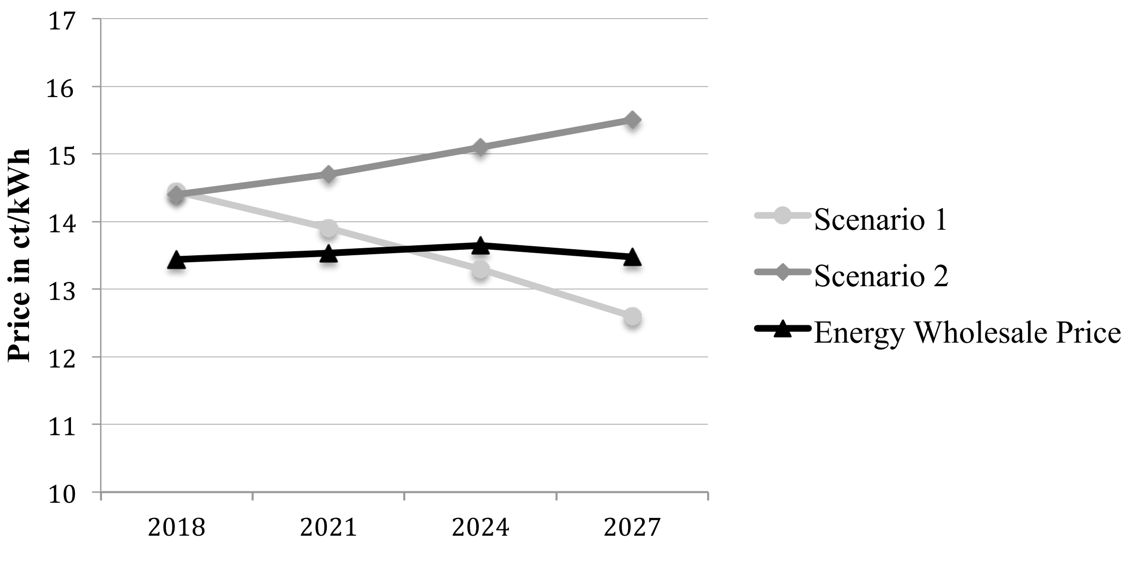

Figure 10. Offshore Price Development under Scenario 1 and 2

Figure 10 graphically displays the development offshore wind energy prices are performing under Scenario 1 and 2. The estimated energy wholesale price is also illustrated to visualize when offshore wind energy reaches the break-even point, being able to finance itself. Starting in 2018, both scenarios are located above the market's wholesale price for energy at 14,4 ct/kWh, facing identical conditions offshore wind energy is exposed to. In 2021, the price under scenario 1 is already decreasing but not falling under the average wholesale energy price in Germany. Scenario 2 is slightly increasing. Remarkably in 2024 is scenario 1, where the price is decreasing, falling under the market price level. Scenario 1 is predicting that the LCOE for offshore wind energy are financeable without additional subsidies. The offshore wind price under scenario 2 is further increasing, expanding the gap between the LCOE for offshore wind and the wholesale price in Germany. By 2027 scenario 1 foresees offshore wind energy prices falling below the average energy wholesale price by 1 ct/kWh, making it a sustainable and feasible energy sources relying on self-replenishing fuel. Scenario 2 further predicts increasing prices for energy from offshore wind plants, exceeding the average wholesale price by nearly 2 ct/kWh.

As long as the LCOE for offshore wind energy is located above average wholesale energy prices, profitable return on investment is absent. Subsidies provide investors with the incentive to commit in offshore projects, ensuring them remuneration in form of market premiums, feed-in tariffs, power purchase agreements or loan guarantees. These policy instruments are implemented under the light that offshore wind energy is not able to finance itself through its energy price on the market. Scenario 1 foresees that offshore wind plants are able to finance themselves by 2024. Since remuneration mechanisms, in most cases, provide long-term compensation, offshore wind operators are receiving additional compensation after 2024 for at least 3 more years. Under scenario 1, investors would receive unnecessary remuneration. When subsidies reach tremendously high amounts, overinvestment occurs. In the case of overinvestment investors realize the opportunity to maximise their return on investment at the expenses of the governments or third parties, who finance subsidies through taxes or funds. If, on the other hand, offshore wind energy prices tend to increase, long-term subsidies are needed to reduce investor uncertainty. In the event of scenario 2 are costs for offshore wind energy rising and exceed the average market price by 2ct/kWh. This scenario would result in underinvestment caused by a huge return on investment gap.

Sub-question 3 can therefore be answered as following: The progressive development offshore wind energy is likely to perform allows energy prices to decrease over time, making them a feasible and financeable energy source for the German market in the future.

7. Return on Investment Gap Performance under Subsidization

This section assesses how policy instruments, found in the EEG, affect the return on investment gap by applying them on the price development offshore wind energy will perform under estimated scenario 1 and 2. The following diagrams will illustrate the return on investment gap under scenario 1 and 2, compared to the wholesale price development in Germany. Scenario 1 and 2 are applied to the subsidy mechanisms, examined in section 5. Under both scenarios the subsidy accounted for is 15,40 ct/kWh over a period of 12 years, whereas in this estimation only 9 years are displayed. Therefore is the subsidy amount fixed. In order to sell energy profitably, operating firms need to reduce their generation costs to receive return on investment. Project equity target return ranges between 12-18% (NBIM, 2015). Estimating with the wholesale price development in Germany, wholesale costs need to be reduced by 16% from wholesale price levels. A 16% reduction would lower the wholesale costs to 11 ct/kWh averagely. The following graphics and tables illustrate the development of offshore wind prices and estimate the return on investment gap under wholesale costs.

Year	Scenario 1	Wholesale Cost	ROI Gap	Subsidy	Over subsidization
2018	14,4	11,424	-2,976	15,4	12,424
2021	13,9	11,5005	-2,3995	15,4	13,0005
2024	13,3	11,6025	-1,6975	15,4	13,7025
2027	12,6	11,458	-1,142	15,4	13,258

Table 5. ROI gap estimations in ct/kWh under scenario 1 (in ct/kWh)

Table 5 illustrates how the return on investment gap evolves under scenario 1. Under fixed subsidization of 15,40 ct/kWh for each year the gap reduces. While in 2018 the investment gap consists of -2,976 ct/kWh is year 2027 only facing -1,142 ct/kWh. After applying the subsidy measures, the overall return on investment gap is closed, resulting in over-subsidization. In 2018, investors make a profitable return of 12,424 ct/kWh through selling offshore energy on the market. Under the consistent subsidization mechanism, investors are increasing their return on investment to 13,258 ct/kWh in 2027. Under scenario 1 the return on investment gap is filled through subsidization of offshore wind energy. The applied subsidy measures are resulting in over-subsidization, making offshore wind investments lucrative opportunities.

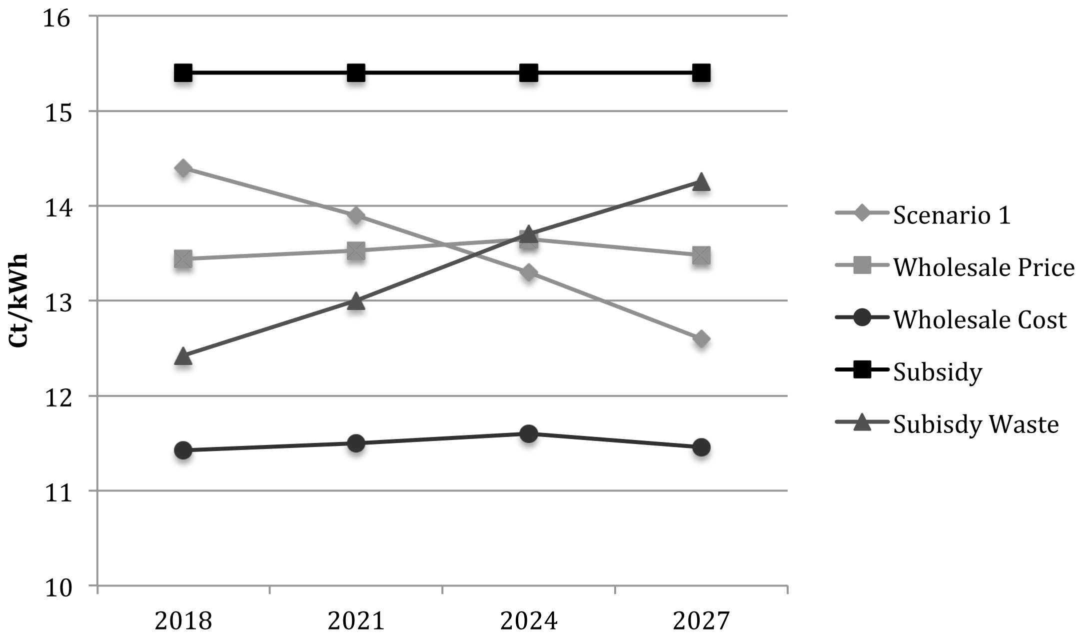

Figure 11. Estimated subsidy waste under scenario 1

Figure 11 graphically displays the profitable wholesale costs relevant for achieving profitable return on investment by selling electricity under wholesale market price conditions. Offshore wind prices are decreasing under scenario 1, therefore is the obvious assumption that subsidization is overestimated. The subsidy waste increases steadily.

Year	Scenario 2	Wholesale Cost	ROI Gap	Subsidy	Over subsidization
2018	14,4	11,424	-2,976	15,4	12,424
2021	14,7	11,5005	-3,1995	15,4	12,2005
2024	15,1	11,6025	-3,4975	15,4	11,9025
2027	15,5	11,458	-4,042	15,4	11,358

Table 6. ROI gap estimations in ct/kWh under scenario 2 (in ct/kWh)

Table 6 illustrates how the ROI gap evolves under scenario 2. With fixed subsidies of 15,40 ct/kWh the return on investment gap slowly increases. The rising costs for offshore wind energy influence this gap strongly. Whereas the ROI gap in 2018 amounts to -2,976 ct/kWh is the gap increasing to -4,042 ct/kWh in 2027. After subsidizing offshore wind energy, the ROI gap is sufficiently closed. Even in 2027, the subsidization amount of 15,40 for each kWh offshore energy sold on the market covers the investment gap and results in profitable return of 11,358 ct/kWh. Unlike under scenario 2 is over-subsidization decreasing, due to rising offshore energy prices. Nevertheless is over-subsidization the case. Under the existing subsidy mechanism is offshore wind energy still lucrative for investors.

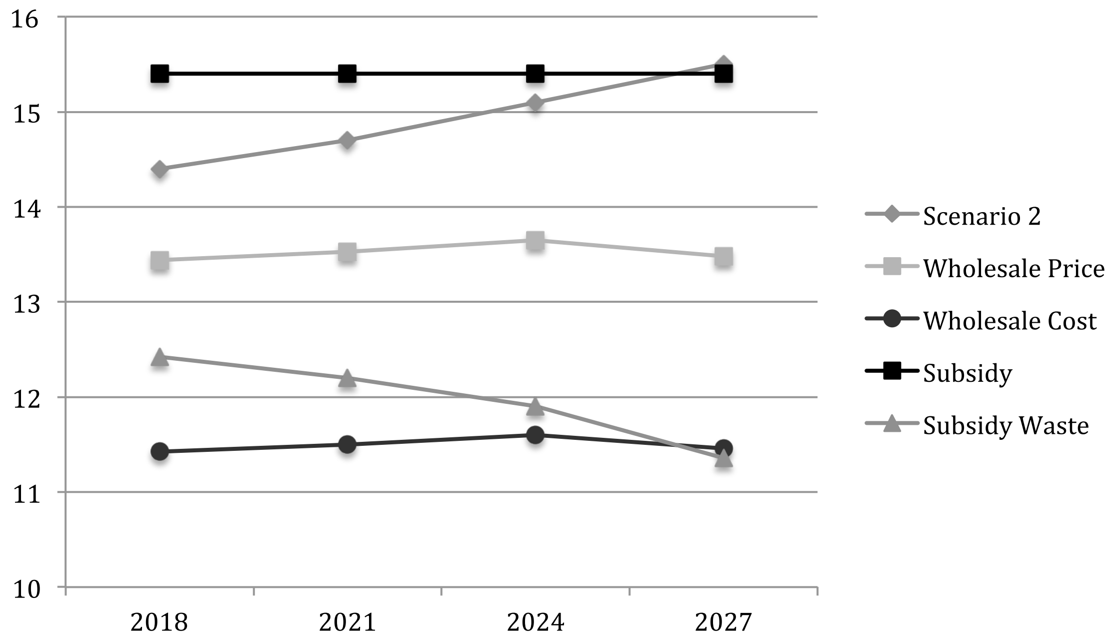

Figure 12. Estimated subsidy waste under scenario 2

Figure 12 graphically displays how profitable wholesale costs develop over time. Achieving profitable return on investment is closely connected to the wholesale price development under which offshore wind is sold. Offshore wind prices are increasing under scenario 2. The obvious result is an increasing return on investment gap. Under an increasing ROI gap, the subsidy waste is still present but steadily decreasing from 2018 till 2027.

Conclusively it can be said that return on investment is evolving differently under scenario 1 and 2. Whereas decreasing offshore energy prices reduce the ROI gap, but not fully closing it, are increasing prices for 1 kWh widening the gap. In both scenarios are subsidy measures needed to cover the costs. Through the subsidization mechanism offshore wind energy becomes a lucrative investment opportunity in both scenarios. In fact are subsidy measures consequently blameable for subsidy wastes. Applying the subsidy amounts, found in the EEG, to the estimated prices would probably result in overinvestment. Therefore are meticulous, updated estimations necessary to assess the future of subsidy measures in Germany.

Sub-question 2 can therefore be answered as following: Feed-in tariffs are able to reduce the return on investment gap for offshore wind energy sufficiently.

8. Conclusion

The inquiry of this research is concerned with the development of offshore wind energy under the existing return on investment gap. This problem was discussed under the influence of the national regulatory framework. Moreover was discussed how the EEG affects the gap today as well as in the future. Governance structures of electricity regulations in Germany are mainly influenced by four factors. Firstly, tendering procedures handle all newly commissioned offshore wind projects since the amendments made with the EEG 2017. Under the tendering procedure bidders lower their subsidy requests according to their offshore wind development estimations. The second factor is displayed by the purchase agreement, ensuring operating firms purchase conditions for offshore energy. The EEG obligates grid operators to purchase energy from renewables under prioritized measures. Technological renewals probably display the most striking factor for the development process. Offshore wind energy's increasing capacities are mainly affected through progressive development. Bigger turbines and plant configurations allow more over-lifetime outputs, hence reducing the levelized costs of energy steadily. The last factor provides sufficient subsidies for renewable energy. Feed-in tariffs and market premiums affect the return on investment gap the most. Whereas offshore wind without subsidization still faces negative profits, feed-in tariffs and market premiums are compensating red figures. Subsidy measures under the current EEG are likely to over-subsidize offshore energy, displayed in section 7, under the mentioned price estimations. This could result in overinvestment, providing huge profits for investors, whereby taxpayers cover the costs of subsidies through taxes and levies. Subsidies need to be assessed thoroughly, taking progressive development as well as unforeseen additional costs into account. Only under reasonably time-framed subsidies, offshore wind energy development and deployment is taking place in Germany. This scenario is only conceivable under an evolving regulatory framework on national level. Elaborating a national, legally binding, framework requires political actors to meticulously assess economic and political scenarios as well as estimations. Applying a sufficient national framework can be fertile ground for offshore wind energy in the future. The success of national frameworks is dependent on sustainable examinations and estimations.

9. Discussion

Under the regulatory framework and price estimations, offshore energy occurs as a suitable and feasible renewable energy source, affecting the on-going energy transition in a suitable way. It offers clean, renewable energy, located offshore. Unfortunately the consistent deployment of offshore parks is still facing barriers of high capital costs. These costs are quenching investors from contributing towards offshore projects. In order to achieve Germany’s national target in renewable energy shares, offshore wind energy is relying on a strong regulatory framework. The underlying framework needs to adopt policy instruments suiting the current situation. Offshore wind energy development needs continuous fostering through incentivising firms to invest in research development and deployment.

If development is progressing sustainably, capacities of offshore wind plants are increasing, making it the key pillar of the German energy transition. Previous policy instruments found in this research might or might not stimulate the development process in an adequate scope. Looking back at the technological development offshore wind energy has progressively performed since the first plant generating 0,41 MW on average. Offshore wind energy will likely increase its capacity even further than 8 MW. Increasing capacities in the future make energy from offshore wind the most lucrative renewable energy supplier on the market. Nevertheless the development process, analysed in this thesis, is prone to limitations.

In the broader context are only factors considered found in the EEG, neglecting omitted variables. Rapid changes in the technological development might be caused by a global resource crisis. In the event that fossil fuel becomes relatively expensive, due to decreasing natural deposits, renewable sources are gaining prominence and investors attention. Under a global oil or coal crisis the development process of offshore wind would accelerate, reaching higher capacities faster. This scenario could also occur reversely. While fossil fuel prices decrease, investors are likely to abandon renewable projects for a while. From an investor's point of view are projects with the highest return on investment most lucrative. Therefore the future of offshore energy is relying on profitable projects. Forecasting two scenarios with increasing and decreasing prices proved that LCOE are obligated to decrease in order to make investments feasible. The correlation between technological development and decreasing LCOE proves that offshore wind plants need more capacities and lower instalment costs. It is inevitable that offshore wind energy relies on political support in the future. Political actors need to provide policy instruments for investors to ensure sufficient profitability for projects.

Through the applied tendering procedures bidding firms are forced to lower their subsidy requests to a minimum. Germany just commissioned its first offshore projects with funding subsidies of 0,00 ct/kWh. Might this make offshore wind subsidies a useless necessity in the future (Offshorewind 2, 2017)? The competitive market influences tendering procedures to the extent that offers are commissioned at lowest possible costs. Commissioned projects rely on progressive development, making the offer profitable over a long-term period. These offers already calculate higher capacities to make the bid profitable. In the event that commissioned offshore projects are not built under the intended capacities, operators are likely to withdraw their offer.

Since the outcomes of this thesis are only estimations, actual changes are likely to occur. Forecasting price developments is limited to non-existing data, making it challenging to find suitable values for a progressive development. Both estimations were focusing on technological development as main influence.

It can be said that the outcome of this thesis provides an ex ante forecast how offshore wind energy will develop in the future. Deriving from the EEG, policy instruments were identified reducing the capital risk for investors and firms. Future forecasts estimate offshore wind energy prices to either increase or decrease, whereas the latter scenario is more likely to occur under progressive development. Rising turbine capacities as well as increasing hub heights and rotor diameter will result in higher outputs over lifetime. Higher capacities and lifetime outputs of offshore wind parks will reduce the levelized cost of energy, closing the return on investment gap to the extent that investors will contribute in offshore projects. Even though forecasts predict future developments the need for subsidies is not foreseeable under decreasing prices as well as under increasing ones. In order to avoid under- or overinvestment, subsidies need to be adopted or abolished, after estimating the future development stages. Acknowledging these limitations and difficulties in formulating profound estimations is crucial for future researches to meticulously assess the development process offshore wind energy performs.

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