Maintaining the project financing opportunity for Dutch offshore wind parks

When Corporate PPAs take over from the SDE+ subsidy

By

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Preface

In front of you lies the final report for my MSc. Sustainable Energy Technology at Delft University of Technology. Over the last 10 months, I aimed to find a governmental support mechanism that translates the SDE+ financing conditions to project financing facilities for Corporate PPA based offshore wind parks.

In completing this thesis I have been supported by a number of people, who I would like to thank in advance.

This research would not have been possible without the guidance of Prof. dr. Kornelis Blok, whom I would like to thank for his extensive feedback and guidance throughout this intensive period. Furthermore, I would like to thank Dr. Daniel Scholten and Dr. ir. Michiel Zaayer for their feedback and willingness to take part in my thesis committee.

I would also like to thank all the respondents for their time and the pleasant conversations. I have learned a lot from your valuable insights, which have enabled the thesis to reach its current form.

Last but not least, I would like to thank my family for their unconditional support. Mom, I feel grateful that we have been given the time to still share this moment together.

Thomas P.M. Smits
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Abstract

This thesis describes the identification and cost calculation of WACC[1] stabilizing support mechanisms for new Dutch offshore wind parks, which are funded with PPA[2] based project financing facilities, in a non-SDE+[3] and electricity price volatile market.

Firstly, it is assessed if the Dutch renewable energy market characteristics fulfil the requirements for the use of project financing facilities. To provide a framework for this assessment, the global renewable energy sector is analysed on its predominant investors and their investment behaviour. Furthermore, their preferred financing mechanisms are also assessed. The conclusions of the analyses are used to create private investment criteria for the identified investors. These private investment criteria form the framework against which the Dutch offshore wind market is assessed. This assessment mainly focusses on the regulatory framework and the current development of the offshore wind market. From the assessment it can be concluded that the Dutch market is favourable for private investor, under the condition that the SDE+ subsidy is still present. Overall, the governmental stability and market participants provide a healthy market in which further development can certainly take place. Afterwards, the conclusions of the assessment are validated via semi-structured interviews with market participants, which include financiers, financial advisors and developers/operators from the energy and electricity sector.

Secondly, it is assessed what kind of support mechanism could act as drivers for the application of project financing and PPA based wind parks. To do this, a dataset is created which is used for qualitative and quantitative analyses of financing parameters, which are performed to identify success factors for offshore wind parks. The outlines of the support mechanisms are based on these success factors. The dataset comprises wind parks which are mainly situated in (or around) the North Sea. This scope is established to maintain comparability between the wind parks, so that technical influences would not influence the database. The qualitative assessment includes the use of regressions, which target the relations between financing parameters and the presence of project financing facilities and financial investors. It is deemed that the presence of financial investors means that the wind park is financially sound. Furthermore, it is observed that developers often sell (part of) their shares in wind parks to financial investors, so that they can recycle their capital to develop new projects. This working principle is of vital importance to the offshore wind industry, and is called ‘farming-down’. Furthermore, the British market also showed that governmental equity investments can stimulate the market when the investors are still hesitant to fully participate.

Furthermore, to include the influences of PPAs on financing mechanisms, the risks and uses of PPAs are analysed. This also includes the assessment of financial risks from PPAs on project financing facilities and the assessment of the use of PPAs in the wind parks which are included in the dataset. The identified wind park success factors and subsequent support mechanisms are evaluated through semi-structured interviews, from which a top three of the support mechanisms is retrieved. Overall, the support mechanism either included governmental investments, investment incentives, subsidies for ancillary systems like hydrogen, and the introduction of marketing platforms for PPAs. From the interviews it is concluded that the following specific support mechanisms form the top three: a governmental price guarantee, a governmental subordinated loan and a PPA subsidy mechanism. These mechanisms aim to reduce the credit risk which comes along corporate PPAs. The risk of default is simply higher for a corporate than a government. A governmental price guarantee would materialize when a PPA offtaker runs into a default and terminates the contract. The government would then be the backup counter party and remunerate the wind park against the original PPA prices. The subordinated governmental loan aims to reduce the cost of capital by providing interest free loans, as a safety cushion for the commercial loans. This mechanism could be used a temporary system until the market dynamics have become more clear now the SDE+ subsidy is terminated. The PPA subsidy remunerates the difference between the strike price of the PPA and the LCOE of the wind park via two opposite CfD systems. Such a system would widen the market for corporate PPAs, since it provides the aggregation of PPAs. The government would only open new wind park tenders when the previous tender for PPA demand is filled. This way, the difference between supply and demand, and thus market instability, is minimized.

Finally, the top three mechanisms are analysed on their governmental cost behaviour. In this analysis a reference scenario is created, against which the cost behaviour of the mechanisms is assessed. The reference scenario contains a LCOE[4] range under SDE+ circumstances. These circumstances includes financing parameters as they were observed to be negotiated when the subsidy was still applicable in the Netherlands.

[1] Weighted Average Cost of Capital
[2] Power Purchase Agreement
[3] Stimulus Duurzame Energieproductie: Dutch subsidy programme for renewable energy production
[4] Levelized Cost Of Electricity

The governmental loan and the offtake guarantee only have cost at risk, and not fixed costs like the PPA subsidy. Although it could be thought that it is likely that a guarantee would be the best system for a government, it is important to assess the cost effectiveness of the other systems relative to each other. For instance, the PPA subsidy would provide a platform for the PPA market to aggregate and grow organically. However, when comparing the costs, it turned out that this option is significantly more expensive than the other options. For the governmental loan and the offtake guarantee the cost at risk is multiplied by the rate of default of investment grade corporates, which are deemed to be a good reference group for PPA counterparties. The risk weighting resulted in significantly lower costs. All in all, the analysis lead to the conclusion that a governmental guarantee would best be suited to support project financed, PPA-based, offshore wind parks in the Netherlands.

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1. Introduction

In this chapter the foundation for performing this research is provided together with the research objective and scope. Secondly, the research structure is explained by stating the sub-objectives and the accompanying research methodologies.

1.1. The Climate Agreement: reducing the Dutch greenhouse gas emission

On the 28th of June 2019 the Dutch Cabinet presented the Climate Agreement. This agreement outlines a development plan towards decreasing the Dutch carbon emission, in order to reduce global warming. The agreement sets the goal for a renewable energy production of 84TWh by 2030 (1). To reach this production level, a significant amount of renewable capacity has to be developed. For instance the offshore wind sector is set to install 11.5GW of offshore wind capacity by 2030 (1). Realising the accumulated funding, needed for the envisaged development of such a large scale, requires the contribution of a variety of investors.

1.1.1. Strong reliance on offshore wind capacity, also after 2030

Post 2030 the carbon emission reduction target has to be further increased towards 95% by 2050 (1). It is thus unavoidable that the offshore wind capacity has to increase. PBL has estimated the 2050 capacity to range between 35-75 GW, signalling a significant increase in capacity (2). This will lead to the reinstallation of existing parks and the addition of new wind parks.

1.1.2. Project financing of offshore wind projects

In general, offshore wind parks are financed via project financing, corporate financing, or project bonds. By 2016 project financing covered circa 50% of the offshore wind financing market. Over the past years this market share has grown to reach a market coverage of 80% of the financing of new offshore wind parks in 2019. Project financing has thus become the dominant financing mechanism to fund new offshore wind projects (3). Earlier research by Steffen also concluded the importance of project financing, and characterized it as a specialized and highly tailored way to invest debt into complex projects (4). As for example often occurs in offshore wind projects, the Financial Close[5] of a project includes the project financing agreement. The project financing agreement serves as keystone, after which the construction phase starts (5). Project financing is a complex mechanism which fully relies on the cash flows of the project with no recourse to its shareholders, which causes the lenders to prefer low-risk projects (4). To accommodate these preferences the projects are de-risked by acquiring as much electricity income security as possible, to secure transparent revenues and debt repayment capacity.

1.1.3. Pricing security: subsidies and PPAs

This could have the form of a subsidy and/or a Power Purchase Agreement (PPA). For offshore wind the Dutch government has installed Certificates of Origin (GVO) and the SDE subsidy. The SDE+ subsidy provides a long term feed-in-premium to increase the price competitiveness of offshore wind generated electricity (6). A GVO is a tradable certificate which proves the renewable origin of 1 MWh of produced electricity, which is supplied to the generator (7)

A PPA concludes the agreement between the generator and the offtaker to trade electricity over a certain time period. This provides the certainty that the electricity is actually bought and thus (partly) secures the revenue of the project. However, this does not mean that a fixed offtake and price is agreed (8). For instance, a route-to-market PPA merely involves the agreement that the electricity is sold. This could be done against the real time market prices. One can conclude that such a route-to-market PPA can become feasible under the condition that the government subsidy provides (part of) the difference between the tendered electricity price and the market price.

1.1.4. Increasing electricity price volatility and decreasing price security

The reliance on project financing is on itself not a problem for the market. However, the Climate Agreement notes the intention of the Dutch government to permanently end the availability of the SDE subsidy by 2025 (1). This decreases the secured cash flows, which are an important condition for the application of project financing.

Earlier research concludes that the increasing reliance on RES increases the volatility of prices of wind energy in Germany (9). In the Netherlands the increase of offshore wind production is thought to significantly increase the risk of electricity prices nearing zero, or even decreasing sub-zero (10). This would lead to shut down of offshore wind parks. This could happen for a maximum of 25% of the time in 2030, which can yield significant reductions in

[5] When the all the investments (debt & equity) needed for construction are agreed upon.

revenues (10). Together with the absence of the SDE subsidy, this could drastically decrease the project financing possibilities. This is also signalled in the Dutch business press. 'Het Financieele Dagblad' concludes from interviews with financiers that equity stakes could have to increase from the current average of 30%, to make up for the increased project risk (11). Due to the increased risk the financiers are willing to lend less debt, which forces the equity investors to fund a larger part of the wind park with their own money. Another article quotes a prominent Dutch project financing banker, which states that the subsidy free Hollandse Kust Zuid wind park of Vattenfall will have to prove itself with respect to attracting sufficient revenue security, so that debt opportunities could be discussed (12).

Now the subsidies are falling away, the PPAs are the only major secured cash flow left. Moreover, this does not hold when the PPA is agreed as a route-to-market but only when it provides price certainty.

However, the Dutch merchant bank Kempen states that PPAs are not likely to fully cover for the absence of subsidies, since the demand for long-term contracts would be too low. This would lead to higher project risks and subsequent project equity stakes (13). When regarding the SDE as a PPA variant, no other offtaker has a credit risk as low as a government. Rabobank therefore notes that the credit risk of the offtaker in a PPA is likely to lead to a decrease in debt to equity ratios (14). Although this is concerning onshore wind in the UK and Germany, it can be concluded that this still signals a trend in the industry.

1.2. Problem statement

Now the Climate Agreement development objective of 2030 is introduced, and the market developments are discussed, this section will describe the potential implication of the funding problem towards the development described in the Climate Agreement. Furthermore, the lack of specific research on the project financing cost behaviour related to electricity price volatility in a subsidy free system is discussed. Subsequently, the main research objective and sub objectives are presented. This is complemented with the scope in which the research will be executed.

1.2.1. The Climate Agreement's strategy gap: funding is assumed to be abundant regardless of subsidies

The Climate Agreement has set out a path to reach the greenhouse gas emission reduction. However, this path sets out a development route but does not reflect on any changes in financing mechanisms. The market already signals that the decreasing revenue security of wind parks will affect the financing costs, which will subsequently affect the LCOE[6] for the new offshore wind parks. It can be considered that an increase in pricing is not beneficial for the further diffusion of offshore wind in the Dutch energy mix. Furthermore, the market also signals that there is not enough PPA demand to cover the output of the offshore wind projects. This would lead to the need for a higher share of risk capital (equity) in projects and a decrease in project financing coverage of the funding for a wind park. This could also be paired with an increase in debt pricing.

The LCOE of a project is determined using the following formula (15):

$$LCOE = \frac{CAPEX + \sum_{t=1}^{L} \frac{OPEX}{(1+i)^t}}{\sum_{t=1}^{L} \frac{AEP}{(1+i)^t}} \quad \text{(Eq. 1)}$$

CAPEX denotes the capital expenditures needed to fully commission the offshore wind park. *OPEX* contains the operational expenditures, and *AEP* represents the Annual Energy Production of the wind park. *L* denotes the total lifetime of a wind park, where *t* denotes the year of operation. *i* is the discount factor which, as discussed by amongst others Klessmann et al. and Levitt et al., generally equals the WACC of the project (15) (16). The WACC is the weighted average cost of capital and equals the average required return on debt and equity, as shown in the following formula:

$$WACC = \frac{E}{V} * R_e + \frac{D}{V} * R_d * (1 - tax) \quad \text{(Eq. 2)}$$

[6] Levelized Cost of Electricity: Electricity price which covers CAPEX and OPEX over the total lifetime of the project

In this formula *V* denotes the total value of the project, which refers to the *CAPEX* described above. *E* is the equity invested to fund the project and D is the attracted debt. Together, *D* and *E* equal *V*. R_e is the return on equity the investor requires for its investments and R_d denotes the cost of debt, which is the interest rate applied to the attracted debt. Lastly, *tax* represents the tax rate to which the project is subjected.

As is for instance shown by Fraunhofer, R_e is generally higher than R_d (17). It can be considered that this is caused by the fact that equity has a higher risk of not making a return than debt. For example, in a project financing facility the debt repayments are made before potential dividend payments can be made to the equity investors (4). Due to this de-risking the debt holders also require a lower return on their invested capital.

All in all, an increase in the required equity per offshore wind park is therefore likely to lead to an increase in LCOE. This could potentially slow down the development of offshore wind parks and subsequently decrease the likelihood that the Climate Agreement targets will be reached.

1.2.2. Literature research

When researching the literature it is found that there is an absence of research on project financing cost developments caused by PPA relying offshore wind parks, in a subsidy-free system. This solidifies the scientific justification for the research performed in this thesis. The literature used for this thesis consist mostly of consultancy reports, and to a lesser extent of peer-reviewed literature. The latter does not provide the same in depth information about project financing developments and cost financing cost drivers, as consultancy reports do. The platforms used for the literature research consist of Science Direct, Google Scholar and ResearchGate.

The specific influence of a subsidy-free system on the project financing costs of PPA relying offshore wind parks had not yet been addressed in literature when this thesis was commenced. During the writing of this thesis, AFRY published a report on the influences of cancelled subsidies on financing costs (18). Furthermore, the identification of specific support mechanisms and the assessment of their cost characteristics has not yet been assessed. In general, financing cost developments have only been assessed when looking back in time. It is evident that the basis of this cost research would not hold anymore when subsidies are cancelled.

The existing literature is summarized below and consists of literature research on; offshore wind cost developments over time, the relation between subsidy mechanisms and financing costs, the effect of electricity prices on offshore wind development, and the support mechanisms for a PPA based electricity market. All these topics are thought to be (partly) related to financing costs and the influence of the (absence of) subsidies on electricity prices and offshore wind development.

1.2.2.1. Literature research on offshore wind cost developments: past and future

Cost research on the Dutch offshore wind sector is predominantly executed in cooperation with TKI Wind op Zee (TKI-WoZ). TKI-WoZ is a knowledge institute which aims to further reduce the cost of offshore wind development. However, it should be noted the produced reports focus on a reduction in financing cost when assuming a non-volatile subsidized offshore wind electricity market. Furthermore, the research predominantly focuses on cost reductions till 2020 and the monitoring of the developments in the years in between.

In 2015, a consortium of PwC, DNV GL and Ecofys conducted research on cost reduction options for the Dutch offshore wind sector (19). In their report they presented a decrease in financing costs as a result of lower cost of capital and lower insurance costs. The costs of capital were estimated to decrease due to lower interest rates and debt risk premia, combined with an increase in competition and a lower perceived industry risk by the equity investors. In their analysis the effect of leverage is estimated to have a small effect on change in cost of capital. Furthermore, the analysis also estimates that future market price impact is likely to occur but will have a low impact on IRR. The specific impact of project financing on the LCOE is noted to be difficult to determine compared to balance sheet financing due to tax structures. PwC, DNV GL and Ecofys note that project financing cost developments did not fit within the scope of their research but recommended further research on this specific area.

Both their main conclusions are the opposite of the current market signals as described earlier in this introduction. It is worth noting that the assumptions for this analysis are based upon a 2010 subsidized offshore wind market scenario with limited electricity price volatility.

When providing an outlook for the period after 2020, the research consortium notes that institutional investors are thought to enter the market. Furthermore, the report notes that further financing cost reductions could be offset by an increase in risk premium. This premium is however not further elaborated on. Additionally, the report notes that further research should elaborate on the phasing out of subsidies without a significant increase in regulatory risk.

In 2015, TKI-WoZ commissioned a report by PwC which describes the cost effect of subsidy mechanisms on LCOE (20). However, this research focuses on direct effects of changes in tax incentives and subsidies on LCOE and public expenditures, and not on cost of capital developments as a result of changing investor risk. This report concludes that the adoption of support mechanism from surrounding countries has a marginal effect on LCOE developments. However, they do conclude an increase in LCOE when the risk of the project is shifted towards private investors instead of public investors. Furthermore, their research is based upon the assumption that subsidy schemes still persist as they were at the moment of writing. Based on their report, a termination of the SDE subsidy would thus result in an increase in LCOE. Specific contributions by cost of capital however fall outside of the research scope but are noted to be suitable for further research.

In 2016, TKI-WoZ together with RVO commissioned a report from Royal HaskoningDHV and Ecofys, which elaborates on the current state and potential of cost reductions in the Netherlands (21). The main focus of this report was the effect of an increase in offshore wind park sizes and the placement further offshore. The report is also partly based on market consultations. As a result of their research the authors deem the financing risk to decrease in terms of bankability since a larger group of banks would be willing to take part in the structuring. However, market price risk is deemed to increase and further accelerate due to an increase in project sizes.

The decrease in bankability risk due to a larger number of participating banks is seen in the industry, however now the risks of the industry are increasing the project exposure of banks is likely to decrease. This could reverse the conclusion of this report. Furthermore, the reports also mention the necessity for further research on support mechanisms which, amongst others, involve governmental offshore wind investments. However, the potential need for governmental equity is identified to mainly serve a financing gap as a result of a too large construction CAPEX.

In 2017, TKI-WoZ commissioned a report by Ecofys on the current state of the cost reductions as forecast earlier in 2015 (22). In this report the forecast decrease in financing costs is identified, which is caused by a lower perceived market risk. Furthermore, the report also notes that offshore wind could become fully competitive without subsidies by 2030. However, the specific statement of the Dutch government to terminate the SDE subsidy by 2025, as presented in the CA, was not yet known by then.

In 2018, Algemene Rekenkamer conducted research for the Dutch House of Representatives on the cost behavior of the tendered wind parks in the Netherlands (23). This report also presented a view on cost developments till 2030. In this report one of the identified cost reduction drivers is the decrease in financing costs but also the decrease in market risk provided by incentives from the Dutch government. It is evident that the influence of the latter will decrease once the SDE subsidy is terminated.

Furthermore, the report mainly focuses on the effect of the offshore transmission networks being developed by the Dutch TSO TenneT. Since these networks are not part of the offshore wind park tenders, this considerably decreases the risk of the project for the investors. Algemene Rekenkamer describes that the absence of the offshore transmission network in the tender has the highest effect on the decrease in R_e and R_d. However, focusing on the offshore transmission network effects also undervalues the influence of the SDE subsidy. Notably, the report also notes the effect of global macroeconomics on R_d, stating that low costs of debt might not hold in the future. Considering the recent COVID outbreak this becomes more important.

In 2019, Lensink and Pisca (PBL) conducted research on the cost development of offshore wind for the tenders being held in 2019-2026 (24). In their research they concluded that there is potential for cost reductions applicable to the newly tendered wind parks. However, they also concluded that CAPEX and OPEX increase significantly for wind parks which have a larger distance to the shore/harbour. The CAPEX of IJmuiden Ver are for instance estimated to be 15% higher than for Hollandse Kust Zuid III&IV. OPEX is estimated to be 35% higher. The wind resources however offset (part of) these costs. Lensink and Pisca expect the past cost reduction trend to persist due to an increase in tender competition. However, this is accompanied by the remark that the magnitude of this cost reduction is highly uncertain due to amongst others the financial markets and the offshore wind market dynamics.

It could be concluded that, assuming higher offshore wind electricity price volatility, the higher CAPEX and OPEX for the wind parks, with a larger distance to the shore, would not be offset by the better wind resources. This would merely increase the risk of such parks. The previously mentioned uncertainty caused by market dynamics and (subsequent) financial market developments are not further described in their report.

In 2020, Junginger et al. have researched the LCOE reduction of offshore wind development for both hard factors and soft factors (e.g. WACC) as a result of technological learning (25). The research concludes that WACC has decreased over time, on a global scale, and that this could possibly be allocated to a lower perceived market risk. However, they also note that the decrease in WACC could well be canceled when interest rates start to rise again. Furthermore, the authors note that only the electricity production volumes are discussed and not the electricity price developments. The report concludes that with an increase in renewable capacity the risk of (temporarily) low electricity prices increases. They note that this could then decrease profit margins, which would lead to a scenario where policy support will have to be extended. Overall, Junginger et al. conclude that more research into WACC developments should be conducted and that a larger deployment of offshore wind parks is needed to provide a better view on the developments.

In 2016, Wiser et al. held an expert elicitation survey on future wind energy costs (26). The article identified a 10% WACC decrease from 2014 towards 2030. Relative to onshore wind the offshore wind industry its decrease in WACC was mainly explained by the fact that offshore wind is a younger technology and is still maturing more. However, in this research a termination of subsidies and an increase in price volatility is not identified. It could be concluded that a new market consultation, based on the new assumptions, could supplement this research.

As discussed by Wiser et al., learning curves fit past trends in a set of assumptions to produce an industry outlook. The larger part of the above summarized literature is based upon learning curves, which would not adequately fit the cost of capital changes in their outlook, provided that subsidies are to be terminated and price volatility is set to increase. Furthermore, most of the research left WACC development out of the scope of research, whether or not combined with the notion that WACC can have a large impact on their forecast cost reductions. Also, the presented literature identifies electricity price volatility as a risk but does not primarily research its effects on development and cost of capital.

1.2.2.2. Literature research on the relation between support mechanism and financing costs

In 2012, Klessmann et al. refer to a study of Rathmann, De Jager et al. (27), who describe that the LCOE of solar and wind projects can differ significantly over varying support mechanisms (16). Furthermore, Klessmann et al. also refer to Wiser et al. (28), who state that a longer debt amortization period will lead to lower LCOE. It can be concluded that a shorter period of secured cash flows (in the form of subsidies or PPAs) would subsequently lead to a shorter debt amortization period and thus an increase in LCOE.

Furthermore, Klessmann et al. also concludes that WACC is strongly dependent on the project remuneration risk of the investment. This is supported by research of De Jager and Rathmann (29), who conclude that risk mitigating policies can reduce the LCOE with 10-30%. Klessmann et al. also note that perceived policy risks are a general no-go criterion, which will have severe impact on the future participation of the investor in the industry. Furthermore, the report also states that an increase in electricity prices during the phase-out of the subsidy mechanism would lead to the attraction of additional investments.

Although the above described research is written in relation to accomplishing the 2020 energy transition targets, these conclusions are applicable to the current state of the market.

1.2.2.3. Literature research on offshore wind electricity prices and its effect on development

In 2014, P. Boot et al. described that the SDE subsidy could be needed for a longer time when offshore wind parks are further integrated in the energy mix (30). This is caused by the ‘profile effect’ of offshore wind, which describes the uncorrelation between demand and supply of offshore wind electricity. Due to an increase in electricity production by wind parks, electricity prices in the Netherlands would decrease to a level where operating a wind park would not be feasible anymore.

The profile effect is broadly used in calculating subsidies for Dutch renewable energy projects and is on itself not a new factor. More recently, in 2019, PBL published the Climate and Energy Outlook in which it has estimated the electricity price of offshore wind to be 16% lower than the merchant price of electricity in 2030 (31).

Algemene Rekenkamer has provided an outlook on offshore wind developed, in which they note the effect of low electricity prices in a subsidy-free system (23). The report states that the costs of operating an offshore wind park under low electricity prices might be higher than the termination fee which must be paid when the tendered project is abandoned. Hence, this could lead to subsidy-free projects not being constructed. However, the report only mentions this as a possibility but does not quantify this in any way. Furthermore, the report identifies the cost in offshore wind development as the main cause for potential underdevelopment, and not the effect of zero or even negative electricity prices. Furthermore, offshore wind parks have an average lifetime of 25 years (17). Considering that this report covers an outlook up to 2030, the outlook for future wind park tenders is rather limited.

A more detailed view on offshore wind electricity price volatility risks and development implications is provided by Hers and Otte of CE Delft (10). In their report the authors note the complexity of a project financing facility and the de-risking which is required to attract such loans. Furthermore, they also note the importance of a PPA for capital heavy projects such as offshore wind parks. Hers and Otte conclude that, despite of the future cost decrease of offshore wind development, the electricity prices will decrease to such low levels that the business case for offshore wind will deteriorate when the SDE subsidy is terminated. The report notes that this would lead to a halt in offshore wind development after 2025, if no measurements are taken by the Dutch government.

Apart from a proposed continuance of offshore wind subsidies, Hers and Otte also note that alternative measurements could be the further development of storage solutions, interconnection, and flexible renewable energy generation. It could however be considered that such solutions will require a considerable amount of time before they are integrated in the energy system. Furthermore, no specific support mechanisms and related costs are proposed in this report. Apart from noting the importance of a PPA, its role as price risk mitigant is not researched.

In 2020, the Dutch government commissioned AFRY to provide a report on new support mechanisms which would ensure a further roll-out of offshore wind energy in a merchant market (18). In this report AFRY states that the development target of 2030 will only be accomplished when the return on investment does not increase materially. In other words, when the perceived risk of the merchant market does not differ from a subsidized non-volatile market. Furthermore, the report also states that when 'cheap' capital and the best project sites are exhausted, it could become difficult to attract additional capital without adhering to an increase in cost of capital or a decrease in regulatory risk. As a result, the Netherlands will have to compete with other countries in securing sufficient financing to accomplish its climate goals.

1.2.2.4. Literature research on the new electricity market: support mechanisms and PPAs

The role of PPAs in the new electricity market is predominantly described by consultancy companies. In 2018, McKinsey&Company issued an article which states that merchant pricing can yield between 20-40% of CAPEX value at risk (32). This is reported to potentially increase the required return on equity by 150-250bps[7], which translates into 20-30% of total CAPEX. Furthermore, the article states that PPAs are thought to be the (partial) substitute for the departing subsidies. In the case of Germany, McKinsey&Company estimates that 40% of the total renewable production should be covered by PPAs to still function in a full merchant market. However, a shortfall in PPA demand is expected. The role of PPAs is also underwritten by the German Energy Agency, which however notes that there is still room for improvement to properly integrate PPAs in the electricity system (33). Their report also lists barriers to entry for a full PPA integration, which amongst others contains credit risk of the offtaker.

In 2020, the Dutch government commissioned AFRY to provide a report on new support mechanisms which would ensure a further roll-out of offshore wind energy in a merchant market (18). In this report AFRY states that a certain level of support remains vital for the industry to reach its climate goals. One of the mentioned business case improvements for offshore wind is identified to be a clear trajectory for demand as well as supply to minimize the mismatch as much as possible. This would resemble a route map for demand, similar to the Routekaart Wind op Zee (34). Hence, the merchant price risk would decrease. Incentivising flexible generation is also mentioned as a solution, which could for instance include hydrogen or batteries. Furthermore, the report also mentions the importance of a decrease in capital costs, by improving risk allocations and the developing of hedging strategies. The latter includes PPAs.

AFRY also concludes that these measures could reduce the need for regulatory interventions, but that it could be possible that regulatory support can not be removed without bringing development to a halt. Potential support mechanisms which could incentivize the offshore wind industry would be government backed debt (such as EIB), and governmental investments (such as GIB). Other more 'severe' market interventions are described to be the funding of part of the offshore wind park development via grants, the installing of a regulated asset base model, or the application of a revenue stability mechanism. The latter could for instance result in maintaining the SDE subsidy.

Furthermore, long term price hedging is also seen as a potential solution. This would mitigate the risks allocated to capture prices and base load pricing. Potential solutions are identified to be corporate PPAs, tolling contracts and

[7] bps: basis points, the equivalent of 0.01%.

financial hedging products. The PPA market is however described as a relatively new market, which needs further research to better understand the market mechanisms.

All in all, AFRY underwrites the market mechanisms which lead to the interest of writing this thesis. However, the report merely indicates broad solutions instead of calculating costs of specific support mechanisms.

1.2.2.5. Conclusion

Reflecting on the above presented literature it can be concluded that the influence of cost of capital, covered in WACC, on future offshore wind development is underexposed to research. Cost reductions papers which make use of learning curves fail to catch the changing market mechanism in their framework. Furthermore, a number of the papers describes that WACC could have a significant influence on their cost outlook but that this did not fit the scope of their research. WACC research is therefore recommended in a number of the papers. The need for a new support mechanism is only addressed very recently by AFRY (2020), however in their report they merely supply a list of potential mechanism outlines. Throughout the studied literature PPAs have been mentioned as potential price hedging mechanisms, which could (partly) substitute subsidies. However, boiling down the studied research it becomes clear that the PPA market too should be the subject of further research. The influence of PPAs on cost of capital is therefore also underexposed to research.

1.2.3. Research objective: identifying a new support mechanism

The objective of this research is to identify support mechanisms which stabilize WACC for Dutch project financed offshore wind project in a subsidy free market with increased electricity price volatility. Since PPAs are identified to be the remaining secured cash flows when subsidies are terminated, the absence of secured PPAs is taken as deal breaker for future project finance facilities. A potential support mechanism will therefore be finetuned on the condition that PPAs are present. Support mechanisms would then support PPA based mechanisms and/or incentivize the use of PPAs itself, by deepening the market. This is subject to the outcomes of industry consultations.

Altogether, this translates into the following research objective:

"Identification and cost calculation of WACC stabilizing support mechanisms for new Dutch offshore wind parks, which are funded with PPA based project financing facilities, in an electricity price volatile market without SDE"

To achieve the research objective, the below research questions are answered. Each research question is accompanied by sub objectives, which are achieved to answer the question.

Research question 1: Do the Dutch offshore wind market characteristics fulfil the requirements for the use of project financing facilities?

- Sub objective 1: Assessing the global renewable energy sector on its predominant investors and their investment behaviour.
- Sub objective 2: Identification of the preferred financing mechanisms per investor type.
- Sub objective 3: Creation of private investment criteria for the identified investors, to assess the Dutch offshore wind sector on its suitability for their preferred financing mechanisms.
- Sub objective 4: Analysis of the Dutch offshore wind sector on the regulatory framework and current developments.
- Sub objective 5: Assessment of the Dutch offshore wind sectors against the private investment criteria.
- Sub objective 6: Validation of the assessment conclusions, through industry interviews.

Research question 2: What kind of support mechanisms could act as drivers for the application of project financing to Dutch offshore wind parks?

- Sub objective 7: Creation of dataset comprising financing parameters per offshore wind farm in, predominantly the North Sea.
- Sub objective 8: Identifying the offshore wind regulatory frameworks per country present in the dataset.
- Sub objective 9: Identification of success factors for past project financing facilities.
- Sub objective 10: Validation of the identified success factors, through industry interviews.

Research question 3: What kind of support mechanisms can best support PPA based wind parks, taking into accounts the risks and uses of PPAs?

- Sub objective 11: Identifying the most prominent forms of PPAs and its use.
- Sub objective 12: Assessing the financing risks of PPAs and its effect on project financing facilities.
- Sub objective 13: Establishing outlines of risk mitigating PPA support mechanisms.
- Sub objective 14: Establishing outlines of PPA incentivising support mechanisms

Research question 4: What are the governmental costs of the identified support mechanisms, which are applied to PPA based project financed wind parks?

- Sub objective 15: Evaluation of the support mechanisms through industry interviews.
- Sub objective 16: Conduction of a cost analysis of the top 3 most preferred support mechanisms.

1.2.3. Research scope

The research is divided into different parts with unique research methods. Therefore, to provide a clear picture of the scope, it should be specified per part. This can be found below, per set of sub objectives.

1.2.3.1. Sub objective 1-3

Since the power investment market has a global coverage, this part of research will cover global investment activities. Where possible, the research will narrow down to North West Europe. Furthermore, overlapping investment sectors will be covered as well to give a clear overview of the investment dynamics. It is thought that performing the research in this order would give the most rigid set of investment criteria.

1.2.3.2. Sub objective 4-6

In this part only Dutch offshore wind will be covered. This scope is set to provide a thorough understanding of the current circumstances in the Dutch market on itself. This can later be reflected upon when interpreting the results of the analysis needed to achieve sub objectives 7 to 10.

1.2.3.3. Sub objective 7-10

In this part only offshore wind will be covered, nearshore wind is left out of the scope. Furthermore, floating wind will be left out of the scope to minimize the effect of immature technologies on the financing parameters. Furthermore, floating wind will also be of less importance to the Netherlands due to, amongst others, the shallow seabed conditions. To minimize further influences by natural circumstances, such as ocean depth, the dataset will predominantly comprise offshore wind parks situated in the North Sea. Due to the low number of wind parks, the Baltic Sea and the French part of the North Atlantic Ocean is also covered.

1.2.3.4. Sub objective 11-13

Since the PPA is relatively unestablished, a global scope will be applied to this research. To provide the best fit to this research, the scope will be narrowed down to Europe where possible.

1.2.3.5. Sub objective 14-16

The support mechanisms are designed to fit the Dutch market. This leads to sub objective 14 and 16 covering the Dutch market. The interviews used to accomplish sub objective 15 will focus on, from most to least preferred coverage:

- The Netherlands
- North West Europe
- Europe

The eventual spatial coverage of the interview questions will depend on the availability and experience of the respondents.

1.3. Research methodology

This section will also elaborate on the research approach and structuring of the research.

1.3.1. Research approach and structure

Each of the five parts of this research makes use of its own research method. This paragraph will first provide a short summary of the structure, and will further elaborate on this throughout the paragraph. At the end of this paragraph a table is provided which summarizes the research methodologies used throughout this thesis.

In short, this thesis is based on an assessment of the Dutch market against private investment criteria. The retrieved market framework is complemented by an assessment of offshore wind financing parameters in similar geographies. From these assessments a set of potential support mechanisms is set up, which is later discussed during interviews with industry experts. During these interviews the previous findings are also verified. From the interviews the best suited support mechanisms are chosen, which are then evaluated on their cost behaviour.

In the first part, a literature review will be conducted to better understand the investment environment and to establish investment criteria. In the second part, the criteria will be used to assess multiple small-scale case studies in the Dutch offshore wind market. This is done so that a thorough understanding of the current Dutch market framework. This can later be reflected upon when interpreting the results of later sections in this thesis, which also span non-Dutch projects and market frameworks. The third part will make use of regressions to extract success factors of project financing facilities. This part covers multiple geographies, since the offshore wind industry is a global industry with only limited assets per country. The fourth part will validate the conclusions drawn from the assessment by validating it in a semi-structured interview with investors. The fifth part will provide calculations on governmental support costs and the influence of WACC on the project costs. This will be done by applying financial modelling. The first four methodologies are discussed below:

Method 1: Literature review

To be able to identify the role of project financing in the Dutch renewable energy industry, it should first be assessed if the market itself will stay suitable for the application of project financing. Therefore, the global investors in renewable energy will be analysed on their investments and investment methodologies. The use of project financing will also be assessed relative to the other identified investment methodologies. Furthermore, it will also be assessed if project financing is still predominantly used in the strategy of financial, non-utility, investors. This translates into the following sub objectives:

- Sub objective 1: Assessing the global renewable energy sector on its predominant investors and their investment behaviour.
- Sub objective 2: Identification of the preferred financing mechanisms per investor type.

After this assessment the Dutch market should be assessed on the suitability for its investors. Without the interest of investors, project financing would not be applied at all. Therefore, a set of criteria is established against which the Dutch energy market will be assessed. This set includes investment case criteria for the investors, and criteria for the application of project financing during the investment. This translates into the following sub objective:

- Sub objective 3: Creation of private investment criteria for the identified investors, to assess the Dutch offshore wind sector on its suitability for their preferred financing mechanisms.

Furthermore, the regulatory frameworks of the countries used for the data analysis will be analysed by reviewing literature. This will also be done to assess the current state of the PPA market. This translates into the following sub objectives:

- Sub objective 8: Identifying the offshore wind regulatory frameworks per country present in the dataset.
- Sub objective 11: Identifying the most prominent forms of PPAs and its use.
- Sub objective 12: Assessing the financing risks of PPAs and its effect on project financing facilities.

Method 2: Assessment against criteria

After the identification of the criteria, the set will be used in the assessment of the Dutch offshore wind industry. The conclusion of the assessment can later be used to place the identified use of project financing in the Netherlands in the context of the market. Subsequently, the operational and developing Dutch offshore wind projects will be assessed against the set of criteria. This can be translated into the following sub objectives:

- Sub objective 4: Analysis of the Dutch offshore wind sector on the regulatory framework and current development.
- Sub objective 5: Assessment of the Dutch offshore wind sector against the private investment criteria.

The results of this assessment will be used to conclude:

- The investment suitability of the Dutch offshore wind market for the identified renewable energy investors;
- The suitability for the application of project financing, and;
- The actual use, and users, of project financing.

The above conclusions will result in the validation of the importance of project financing for offshore wind projects in the Netherlands.

Method 3: Data analysis in the form of regressions

The inputs for the dataset have been retrieved from the online dataset provided by Inframation (35). This dataset provides financing and ownership information per wind park and per transaction. The information can be retrieved upon payment for a corporate subscription. However, for this thesis a trial-account has been awarded. For each regression a suitable method has been identified. The methods are listed below:

- Probit; for regressions which have a binary endogenous variable, such as presence of financial investors (36).
- Tobit; for regressions which have percentual ownership and leverage as endogenous variable (36).

This answers the following sub objectives:

- Sub objective 7: Creation of dataset comprising financing parameters per offshore wind farm in, predominantly the North Sea.
- Sub objective 9: Identification of success factors for past project financing facilities.

Method 4: Validation of conclusions through consultation of investors and advisors

In the last two parts of the research semi-structured interviews will be used to validate the conclusions of the research and to retrieve information for the new support mechanisms. Since the regressions made in Part 3 are only reflecting on offshore wind parks in subsidized environments, their forecast potential decreases now subsidies are terminated. Such a limitation is also described by Wiser et al. (26). To minimize the impact of this discrepancy, interviews with the industry are used. The interviews are also used to identify the potential for old financing patterns to be reused.

During a semi-structured interview, the conclusions of the criteria assessment will be validated. This is primarily done to identify potential discrepancies between theory and practice. Since the assessment is done by identifying patterns in multiple small-scale case studies, this does predominantly result into conclusions about current and past developments. The conclusions would give a proxy on the upcoming development potential. Validating this with investors could supplement this research with insights which would not be captured in the chosen research approach. More specifically, such interviews could identify an industry sentiment which is not yet captured in publicly available information. Such information would most ideally cover insights into the financial structuring of early stage developing projects or insights into foreseen changes or additions to financing structures, which are likely to be introduced in the upcoming years.

The outcomes of the interviews will be compared to the conclusions of the assessment. Potential discrepancies could subsequently form recommendations for further research. Furthermore, such discrepancies could thereafter be used to evaluate the research methodology, in order to establish a more robust framework which could be used in further research. This is captured in the following sub objectives:

- Sub objective 6: Validation of the assessment conclusions, through industry interviews.
- Sub objective 10: Validation of the identified success factors, through industry interviews.

The interviews will also be used to extract support mechanism preferences from the industry. The conclusion of the interviews will later be used to re-establish both the PPA support mechanisms themselves and their effects on project financing, where needed. Furthermore, financing parameters will be discussed which can be used as input for the calculation of the mechanism costs. This can be translated into the following sub objective:

- Sub objective 15: Evaluation of the support mechanisms through industry interviews.

The consultation of the industry to retrieve inputs for (cost) development forecast has been used in earlier research. For instance Wiser et al. (2016) used consultations to retrieve offshore wind cost sensitivities (26). Furthermore, the offshore wind industry is relatively young, which makes it harder to identify stable patterns.

The respondents are chosen on their experience in the industry. The Inframation dataset has been assessed on the involved lending banks, investors and advisors. The top tier institutions have been contacted for the interviews. Furthermore, institutions which are involved in the development of previous Dutch wind parks are also contacted. For each contacted institution the interview request is issued to the most senior team member, often Global Heads. After contacting the teams the respondents have been selected going down in seniority, upon availability. The gross cumulative developed capacity of the respondents yields to over 30GW. This could be compared to the dataset used for the regressions approximates, which has a total capacity of about 30GW. Furthermore, this can also be set in perspective against the total planned Dutch offshore wind capacity, which is about 11GW by 2030. The list of respondents is provided in Appendix C.1.

Given the need for in-depth information the use of structured interviews would not be suitable (37). Furthermore, given the sensitivity of the discussed subject, unstructured interviews are deemed to decrease the likelihood of interviewing useful respondents. Therefore, to explore the motivations and thoughts of the respondents during the questioning and to retrieve in-depth information, the semi-structured interview method is chosen (37).

In total, 14 respondents are interviewed by using Skype or a telephone. It was not possible to conduct in-person interviews due to the Corona virus circumstances. The questions were sent upfront so that the respondents could prepare the interview. Given the sensitive nature of the questions, the interviews have not been voice recorded. The answers of the respondents have been written down in outlines. The respondents have reviewed the outlines of the interview. Where possible and deemed fruitful, a second view on the subject has been acquired by conducting a second interview. The interview questions are provided in the Appendix C.2. and C.3. It is important to note that due to the seniority and subsequent availability of the respondents, the respondents are only interviewed once instead of twice. The latter is was the original set up. However, this turned out not to be feasible when conducting the interviews. Therefore, the creation of the support mechanisms is based on the first interviews, where the selection of the support mechanisms is based on the other interviews. The period over which the interviews have been conducted provided the possibility to adapt the questions accordingly. It is however decided to still present the interviews in two separate chapters, since this still best conveys the intended set up of this thesis.

Summary of used methodologies

Below the methodologies are listed per section of the thesis. This table can be used as reference when reading the thesis.

Table 1: Summary of the research methodologies which are used in this thesis.

Chapter(s)	Methodology	Reasoning
Chapter 2	**Literature review** To set up investment criteria	▪ Retrieving investment criteria from the global investment sector would work best when assessing the Dutch offshore wind market on its attractiveness and hurdles.
Chapter 3	**Small-scale case studies** To thoroughly screen the Dutch market	▪ In-depth analysis of the Dutch market against the criteria would provide a thorough understanding of the market dynamics and investment structuring of project financing facilities. ▪ Small-scale case studies would provide the methodology to fully vet the Dutch market, and avoids the underexposure of critical factors by using less in-depth methodologies. ▪ The amount of wind parks in the Dutch market also provides the opportunity to actually perform case studies in a timely manner.
Chapter 4	**Large-scale quantitative analysis** To assess the drivers of project financing under different regulations	▪ This way the drivers behind project financing facilities can be quantified, which gives a basis for the structuring of support mechanisms. ▪ Offshore wind is a global sector, with only limited assets per geography. To grasp the industry development, a wider scope, including neighbouring areas, has to be implemented. ▪ Introducing other geographies also enables the quantification of the effect of the respective support mechanism on project financing success.
Chapter 5	**Semi-structured interviews** To validate the previous conclusions in the industry	▪ Financing is a very hands-on industry, with a lot of negotiation. Interviewing practitioners provides the opportunity to amend or complement the relations which are discovered in the qualitative assessment of Chapter 4.
Chapter 7	**Semi-structured interviews** To assess the effectiveness of support mechanisms in the industry	▪ Semi-structured interviews with industry experts can best be used to assess the feasibility of theoretical support mechanisms in the industry. ▪ The respondents of financing institutes will scale their project financing facility to the support mechanism. Therefore, a theoretical support mechanism will only work if banks are willing to lend against it.

1.3.3 Conclusions and recommendations

The conclusions of this research will lead to the validation of the importance, and the identification of the suitability, of project financing for renewable energy projects in the Netherlands. Furthermore, it will validate if project financing is still primarily of importance to financial, non-utility, investors. Also, the interviews will shed a light on the research framework and conclude its viability. Furthermore, further research recommendations will be provided for assessing the viability of project finance under different development environments.

All in all, the conclusions of this research will lead to the recommendation of PPA support mechanism(s) to the Dutch Government, in order to maintain the interest in offshore wind investments through project financing.

Furthermore, this research aims to provide recommendations for further research on other financing methods and renewable energy subsectors.

1.4 Contribution of the research

The contribution of this research is both practical and scientific, both contributions are elaborated below.

1.4.1 Practical contribution

Identifying the suitability for project finance, and the actual use of project finance, could lead to a threefold of insights regarding the financing of the energy transition.

In case of a validated importance of project financing for the Dutch renewable energy development, insights could be provided on which other countries can base their regulations to leverage the use of project financing in reaching their decarbonization goals.

In case of a underutilization of project financing this research would either provide insights in the barriers for applying project financing, or provide insights into alternative financing methods which prove to be successful in the Netherlands.

Regarding the end product, the identification and cost calculations of PPA supporting mechanisms the practical contribution is providing a qualitative and quantitative insight into the industry for the Dutch government.

1.4.2 Scientific contribution

This research aims to contribute by establishing a framework which can be used to test financing mechanisms on their autonomous viability in the context of, and on the contribution towards, successfully executing transformational processes, such as the energy transition.

Specifically to PPAs, the main contribution of this research is providing insights in the effect of (Corporate) PPAs on financing conditions. Furthermore, the influence of support mechanisms on the dynamics of (Corporate) PPAs will be described. This is not yet described in peer-reviewed scientific literature.

These subjects are not (yet) widely evaluated in the academic field, while the current regulatory framework in the Netherlands is moving towards a stronger PPA reliance. Furthermore, this research aims to contribute by establishing a foundation for a framework which can be used to assess other financing mechanisms as well. Furthermore, it gives a valuable insight in the considerations of investors. This would lead to insights on the cost effects of subsidy free electricity generation in a renewable energy dominated energy mix. This could be used in further research when assessing other countries or renewable sources other than offshore wind. Furthermore, this research also aims to serve as an example for interpreting past cost developments in an industry of which the cost fundaments are changing.

1.5 Report structure

This report consists of 10 chapters. This chapter has introduced the problem statement, the resulting research objectives and the accompanying approach. Chapter 2 will discuss the results of the literature study by presenting the current investor landscape and investment mechanisms. This chapter will conclude by establishing the investment criteria which will be used in the multi small-scale case study. Subsequently, the assessment against the criteria will be presented in Chapter 3. In this chapter the current development environment as well as the recent offshore wind projects will be assessed. In Chapter 4 the structuring of the dataset and the data analysis will be discussed. This chapter will also include an elaboration on the regulatory frameworks present in the covered countries. Chapter 5 will evaluate the conclusions drawn from the criteria assessment and the data analysis through semi-structured interview with investors. Chapter 6 will cover the literature research on PPA fundamentals and the market development. This chapter will also describe the construction of the support mechanism outlines. Chapter 7 will describe the conclusions from the semi-structured interviews with regards to the chosen support mechanisms. Chapter 8 describes the cost calculations, which result in a scaling of the costs for the top 3 of the support mechanisms. Chapter 9 will elaborate on the discussion of the conducted research. Chapter 10 will conclude this research by providing a conclusion on the cost behaviour of the top 3 support mechanisms.

Appendix A.2. and A.3. will include the renewable energy project used for the onshore renewable energy projects, a list of the wind parks used for the data analysis, a list of the interview respondents and the interview questions, and the input and outputs of the cost calculations.

2. Investor landscape: analysing the funding of renewable energy projects

This chapter covers the identification of investors and their investment mechanisms. From this information, investment criteria will be established which will be used to assess the Dutch offshore wind sector on the suitability, usage, and importance of project financing.

The majority of private renewable energy project investors can be divided into financial and non-financial investors. The sorts of funding these investors use can be divided into two categories: equity- and debt financing mechanisms (38). A debt mechanism is often supplied by a commercial bank, in the form of a loan (39).

The financial investors are predominantly institutional equity investors. This chapter targets the equity investments of private investors and their use of debt mechanisms. The largest non-financial investors are power generators and energy firms (40). Table 2 shows a summary and short description of the different kind of industry players which are covered in this thesis.

Table 2: Definition of industry players

Investor	Description
Private investors	▪ Investing for financial gains ▪ Do not operate assets
Power producers	▪ Operate (a portfolio of) power generating assets ▪ Can also have a consumer base to which they sell electricity
Energy companies	▪ Oil & gas companies looking to take part in the energy transition

The investor analysis will result in a set of investment criteria. This set includes both the investor specific preferences and the criteria needed for the application of project financing.

2.1. Financing structures

Investing in infrastructure, of which renewable energy is a sub set, is executed either directly or indirectly. Direct investments can be done via Public Private Partnerships and/or project financing, or corporate financing. However, PPP is not often used in specific renewable energy projects. Indirect investments are executed by investments in unlisted infrastructure funds (41). These forms of financing commonly involve corporate or project financing. When looking at the attraction of debt the availability of these commercial debt options increases with the maturity of the renewable energy industry in the specific country (42). Corporate financing relies on a financing of assets which relies on sources which come directly from the balance sheet of the equity investor, which can be raised by equity issuances or general debt programmes. On the contrary, project financing places the project in a new company, which is owned by the equity investor(s) (4). In this case, debt is attracted at the project company level and not at the level of the general parent companies. The financing industry in mature renewable energy countries was commonly dominated by corporate financing, but now shifts towards project financing. For instance in The United States the project financing method is commonly used for renewable energy investments, raising over $100bn of funding by 2016 (43). This is also visible in the global offshore wind industry, where project financing is now predominantly used to finance new assets (3) (42). Together with the shift to more specialized and tailored project financing the lending periods also increased to around 15 years, according to the project advisor Green Giraffe (42).

Since project financing is a complex way of funding a project, it is further discussed in more detail below.

Project financing

Project financing is a specialized and highly tailored way to invest debt into complex projects (4). As for example often occurs in offshore wind projects, the financial close of a project includes the project financing agreement. The project financing agreement serves as keystone, after which the loans are attracted and the construction phase starts (5).

Rather than just lending a company who executes a project a sum of money, the project itself is seen as a special entity to which the debt is provided. This kind of entity is called a special purpose vehicle (SPV), which receives initial equity investments from equity sponsoring parent companies. The advantage for these parent companies is that the SPV will repay the debt with its operational cash flows. The equity sponsors are paid with dividends which remain after debt service, if this is allowed in debt agreements. This way the parent companies are not directly exposed to the project, since the lenders can only receive repayments from the SPV. This is called 'non-recourse'. The equity investor does not have to guarantee repayment of the debt by its other businesses (4).

Since the lenders can only be repaid from the project, they require the projects to be as de-risked as possible. These risks can for instance be mitigated by requiring certain credibility at the address of the debtor or through certain guarantees for the project revenue. This guarantee is often a PPA since such agreements can (partly) remove the price risk and the offtake risk (44). The creditworthiness of the power purchaser is therefore of key importance to be able to apply project financing. Apart from securing the revenue of the project, the lender can also demand strict conditions on criteria as management, ownership and construction progress. Furthermore, some parts of the loan might only become available after specific construction milestones are achieved. This might be a new loan from an existing lender, but this can also mean that a new lender will only take part in the financing structure after certain milestones are reached (43).

2.2. Use of financing structures

Investments in renewable energy projects require significant construction funding, which power generators can not always fund on their own. Due to the large investment size and long asset lifetime a long-term financing plan can be created (45). This way the investment cost is lower and can actually be paid off by the utility. To achieve this, power generators often try to attract private co-investors with a similar long-term investment appetite, as for instance pension funds and other institutional investors. These large institutional investors predominantly seek such long-term inflation linked investment opportunities (46). By selling (part of) the project shares, the construction investment can be realised and power generators also free up their capital so that they can start new projects. When capital heavy power generators are involved in the project, they can choose to fund the construction themselves and sell the shares after commissioning. This is commonly referred to as the 'farm-down' model (47).

Larger power generators can fund the projects from their balance sheet, since this provides a cheaper source of debt than project financing (4). This also holds for the larger energy companies (39). On the contrary, as shown for Germany by Steffen (2018), financial investors have a strong preference for the use of project financing facilities (4).

It can be considered that for power generators the development of renewable energy projects is their core business. Furthermore, energy companies have been seen increasing their shares in renewable energy generation to sustain their business for the years to come (48). However, for financial investors the investments are purely financially focused and not strategically. For strategic players such as energy companies and power generators, portfolio optimization or expansion can also play a role when investing in new renewable assets. Therefore, financial investors are further examined below.

Financial investors

Public pension funds lead the global renewable energy investments with 17% in 2017 (49). The combination of public- and private pension funds and insurance companies accounts for 41% of the global investments in 2017 (49). An example of a renewable energy targeting pension fund is the Canadian CPPIB, world's second largest real assets investor (50). CPPIB increased its renewable energy exposure with more than 100-fold, from $30m to $3.1bn, over 2016-2019 (51).

The investors each have their own specialized funds to realise the investments. The renewable energy projects are predominantly realised by funds which invest in infrastructure, of which renewable energy investments are part of their portfolio (49). The institutional investors active in infrastructure are generally large, with 39% having $1-9.9bn assets-under-management in 2019 (52). The overall infrastructure asset class is characterised as a low-risk investment class, with a long-term and stable profile (53). It seems however that, despite of the low-risk characteristics, institutional investors still struggle to find suitable infrastructure opportunities. With a median target assets-under-management allocation of 5% only 2.2% was allocated in 2018 (52).

According to an industry survey of I&PE Real Assets, including the most important infrastructure investors, the institutional investors predominantly seek holding periods of 10-15 years or longer (50). However currently these opportunities seem to be decreasing according to the Canadian conglomerate Desjardin. Furthermore, over such a holding period the infrastructure investors predominantly require an IRR of at least 5-10% (50).

As discussed above the upfront costs of renewable energy projects are very large. This is shown by an average investment size in 2016 of $250m, realised by unlisted funds in renewable energy (54). This fits the preferred investment size of institutional investors, which musts be large enough to ensure efficient allocation of the fund capital (55). On the contrary the operational cost risk is relatively low, especially for renewable energy generation.

For instance wind farms do not have the risk of fuel price changes, which is the case for fossil-fuel fired power plants (56). However, with the lowered risk the return on the investments decrease as well. Compared to fossil fuel investment funds, renewable energy funds have shown lower returns but also a lower spread in their returns (49).

However, the infrastructure sector and especially renewable energy sources still have their own risks. Since this is of such a large importance to the institutional investors the renewable energy risks will be discussed beneath.

Key criteria for the institutional investor: risk

Although the production cost risk is relatively low, the volatile characteristics of renewably energy sources provide higher production volume uncertainties compared to fossil-fuel electricity plants (56). Lack of wind or irradiation could stall the electricity production. With the introduction of renewable energy generation, the overall costs were too high to be competitive with fossil-fuel energy. Governments have decided to introduce support mechanisms for renewable energy production, to make up for these cost differences (56). Country specific support mechanisms are therefore of large importance to renewable energy investors which are seeking to de-risk their investments.

Therefore, institutional investors seek to invest in stable OECD countries and mainly focus on North America and Europe (57). An example of this focus is the 2018 founded Maple Power JV, partly owned by CPPIB[8], which states that it will invest in the European renewable energy market because of its maturity and stability (51). The stability and maturity are sought after because they offset the risk of a decrease in capital flexibility, resulting from a long investment period. The cash flows in this repayment period are dependent on specific regulations, which can significantly change the business case of a project when they change (41). The regulatory risk can therefore make or break the investment case.

Next to the production and regulatory risk, the risk of renewable energy projects also differs per project stage. Ecofys, a renown renewable energy advisor, uses the following three main stages to describe the status of a project; planning and development, construction, and operation (58). As described by Breitschopf and Pudlik (2013), each of these stages has a different risk profile (58). The difference in risk attracts different investors per project stage. Investors could choose to provide equity in the development and construction phases, where the investment risk is still relatively high due to the large number of uncertainties. The investors willing to take the development and construction risk are often specialized infrastructure investors with a lot of technical knowledge. They are willing to take the risks in exchange for a larger return on their project shares once the uncertainties are taken away and the share price increases. These specialized investors normally have both greenfield funds as well as brownfield funds. They are often backed by institutional investors, which invest in their funds to mitigate their portfolio risk (57).

Next to investing directly in renewable energy projects or other infrastructure funds, institutional investors could also diversify their project exposure by investing in renewable energy companies, which operate multiple renewable energy projects. This is for instance shown by the intention of PGGM, together with Royal Dutch Shell, to acquire the Dutch utility Eneco (59). However in general, when executing such large investments, institutional investors generally prefer to invest into projects directly, often with an experienced industry player (57). An example of a direct investment is the stake of the Dutch pension fund manager PGGM in the Irish 367MW Walney offshore windfarm, which it recently (July, 2019) increased to 24.8% (60). Other examples for PGGM would be the investment in a solar PV portfolio of SolarCity or the 50/50 investment in a 920MW, combined onshore wind and solar PV, portfolio of the French utility EDF Renewables (61). Another major Dutch pension fund manager, APG, acquired a 64% stake in the German 396MW Merkur offshore windfarm in December 2019 (62).

McKinsey&Company concluded that in 2016 investors predominantly preferred to invest in proven brownfield assets, to avoid the risk of unexpected underperformance (57). However, with the industry maturing, an increasing number of institutional investors is willing to invest in greenfield projects (63). For instance, APG facilitated the total equity investment needed for the construction of the 288MW Askalen windfarm in Sweden (64). This is also clearly visible in the offshore wind sector, where the share of pre-commissioned projects applying for acquisition financing grew from 35% to 80% over 2014-2017 (42). Moreover, Dutch pension giants PGGM and APG recently urged the Dutch government to create investment opportunities of scale, so that they can further contribute to the energy transition (65).

[8] CPIBB: Canada Pension Plan Investment Board. World's second largest infrastructure investor (16).

Conclusion

From the above it can be concluded that investors with a long-term strategy prefer to invest in infrastructure projects, of which they see renewable energy as a subsector. These investors are predominantly institutional investors, which are the pension funds and the insurance companies. The target projects fulfil their preference for large investments and match their liabilities over time. These projects are actively de-risked, which subsequently comes with a lower return than for instance the fossil fuel industry. This matches the low-risk profile of institutional investors since they have their obligations to their clients. The investors are thus willing to decrease their upsides, in return for downside protection of the projects. Once fully producing, these desired long-term and low-risk projects are often (still) subject to governmental support mechanisms. To mitigate the governmental and political risk the investors mostly seek to invest in stable regions as North America and Europe. But furthermore, and especially when looking at renewable energy projects, the investors are looking to avoid or mitigate construction risks of greenfield projects. However, with the industry maturing an increasing share of investors is willing to invest in these greenfield projects. On the contrary, despite the low risk and OECD governments widely exclaiming the need for the development of green infrastructure, investment funds still don't realise their full investment potential and are waiting for an increase in new opportunities.

2.3. Criteria

Based on the analysis above the investment criteria for institutional renewable energy investors are created. These criteria are used to assess the Dutch offshore wind sector on its suitability for investments and the use of project financing. The criteria cover equity investment requirements as well as requirements for the use of project financing. The list can be found below.

1. Minimum investment opportunity of €100m
2. Application of project financing
3. Revenue is secured over the long-term
4. Stable production and revenue over project lifetime
5. Minimization of regulatory risks by clear and stable support schemes for operations

It is important to note that the criteria are constructed in such a way that it covers the preference of all of the investors discussed in this chapter. For instance, criteria 1 is not necessarily true for energy companies and power generators but does hold for the large-scale institutional investors. Criteria 2 is also not a prerequisite for power generators and energy companies, but is strongly preferred by the financial investors.

3. Dutch offshore wind market assessment pre 2030

In this chapter the Dutch offshore wind market will be assessed against the private investment criteria, as composed in Chapter 2. To be able to do so the current market framework, the Climate Agreement implications and the currently operational, and developing, projects will be analysed. This chapter will assess the suitability, usage, and importance of project financing in the Dutch renewable energy market.

The onshore sector is also researched, to clearly picture the Dutch renewable energy market. This way potential interactions between the sectors can be identified and the offshore wind sector can be set in perspective in the Dutch renewable energy market. This would also yield the assessment of the presence of investment problems with the same nature as the offshore wind problem. The onshore sector assessment can be found in Appendix E.1.

3.1. Governmental development plan

With a planned 2030 production of 49TWh, representing 58% of the total renewable target production, the Dutch energy transition relies mostly on offshore wind energy generation (1). The Netherlands have a very suitable offshore development area in the North Sea, due to its relatively shallow waters and stable high wind speeds (66). The shallow waters require lower capital expenditures for the construction of wind mill foundations, which fills 18% of the total installed costs on a global average (67). The Dutch government has recognised these favourable conditions and composed a development framework consisting of a roadmap and a support scheme. This has led to The Netherlands being one of top offshore wind countries in Europe, not only due to the natural conditions but also due to the maturity and subsequent stability of the market (66).

To further establish the offshore wind market the Dutch government created the 'Routekaart Windenergie op Zee'. This agreement covers a development pathway and tender planning towards the 11.5GW capacity target by 2030 (1). The map covers 6 zones, which are all accompanied by a (set of) tender(s) up to 2026 (68). The tender roadmap is constructed to provide the necessary stability to investors. This roadmap has proven its reliability, by successfully attracting renowned industry players to bid for development. For example, the broad composition of the winning tender consortium for Borssele III&IV, with a combined capacity of 732MW proves the attractiveness of the tender scheme. This 'Blauwwind consortium' consists of Shell, Van Oord, Eneco, DGE and Partners Group (69). Oil and gas majors as Shell, power generators as Eneco, and contractors as Van Oord all prove that they trust to invest in this market. Foreign interest is shown by the investment of DGE (Diamond Generating Europe), which is owned by the Japanese conglomerate Mitsubishi (69). Partners Group, a global private investor, later joined the investor group by acquiring 45% of the shares (70). This underlines the interest of financial investors in this industry.

3.2. Regulatory framework and development implications

The governmental framework for offshore wind power development predominantly consists of the tender scheme. This tender scheme was originally shaped as a subsidy tender. The so-called SDE+ subsidy is however not the permanent subject of tendering anymore. Instead of bidding for a subsidy, the bidders are now assessed on their likelihood of completing construction, reliability and project quality. The SDE+ subsidy round is however still optional and can serve as second round when the non-SDE+ tender yields no success (71). The old and new systems are briefly described below.

3.3. SDE+ tender system

This framework used to be based upon a Contract for Difference (CfD) with a cap and floor structure (8). This mechanism provides a Feed-in-Premium, which is a premium to the electricity price which the utility receives from the market (6). The premium consists of the difference between the bid electricity price (cap) and the average market electricity market price. The electricity market price is limited by a minimum value (floor) (72). This premium is corrected for weather circumstances by an imbalance and profile factor (73). The winning bid is granted permission to develop the wind farm, grid connection, and a subsidy. The government tries to provide as much project site information and transparency in the tender process as possible, to encourage consortiums to bid for the development. This resulted in the Netherlands being one of the favourite countries for offshore wind developers (66). For instance, for the Borssele III&IV tender 7 consortia handed in a total of 26 bids (74).

The largest portion of the total energy price are however incurred by the expensive offshore grid connection. However, the Dutch government organizes and funds the offshore grid connection, so that the investors are not discouraged to develop the projects (75). The tactics of the Dutch government reached its goal; the fast-paced reduction of offshore wind energy prices. This market development even leads to the expectation that the first 'negative bids' will be entering the market any time soon, where the developer is prepared to pay for the development permit (76). This would also align with the plans of the Dutch government to fully terminate the SDE+ option for offshore wind projects by 2025, as stated in the Climate Agreement (1).

3.4. New tender system

The decreasing bid prices facilitated a tender system where the SDE+ subsidy is not permanently attached to the tender. The tender rounds are now decided on, amongst others: the reliability of the parties, the quality of the wind park, the capacity of the wind park. If the tender round does not receive suitable bid, an original SDE+ tender will be held (71). Furthermore, this stimulates the competition in the market, which resulted in strongly decreasing tender bids (73). This causes The Netherlands to be one of the most low-cost offshore wind development areas (5). This is underlined by the Hollandse Kust Zuid I&II tender process, which Vattenfall won with a bid price of 0 €/kWh (77). More recently, for the 700MW Hollandse Kust zuid III&IV tender 5 consortia submitted a bid for development. These consortia held renowned industry players as for instance the power generators Ørsted and Vattenfall, and the investor Green Investment Group (78).

Although this system significantly increases the merchant risk, it can still count on interest of experienced bidders. The previously discussed Hollandse Kust Zuid tenders are all successfully executed in this new framework. However, as discussed in Chapter 2, it could be considered that this merchant risk best fits power generators and to a lesser extent energy firms or financial investors. This is in line with Vattenfall winning the first two subsidy free tenders. It is however not publicly known how Vattenfall finances these projects. Furthermore, Vattenfall has also announced that it will not bid for the Hollandse Kust Noord tender due to adverse market conditions (79). It is therefore not known if commercial banks were interested in financing these projects. From public information it can be retrieved that the first subsidy free tender, Hollandse Kust Zuid I&II, received predominantly tenders from power generators (80). The second subsidy free tender, Hollandse Kust Zuid III&IV, saw an increased diversity of bidders, including financial investors and energy firms (78).

3.5. Assessment against private investment criteria

The offshore wind projects are the most capital heavy form of renewable energy projects and therefore naturally attract investors with an infrastructure and utility focus. This is reflected in the assessment against the investment criteria. The wind parks used for this assessment can be found in Table 9, Appendix A.1.

The private investment criteria are established in Chapter 2, and are listed below:

1. Minimum investment opportunity of €100m
2. Application of project financing
3. Revenue is partly secured through PPA
4. Stable production and revenue over project lifetime
5. Minimization of regulatory risks by clear and stable support schemes for operations

Looking at the wind parks listed in Table 9 it is evident that all of the projects provided the opportunity to invest such amounts. An example is private investor Mitsubishi, which acquired 50% of the equity in wind park Luchterduinen for €225m (81). In 2018 the German insurance company consortium Alte Leipziger-Hallesche bought the 10% equity stake of Van Oord in Gemini for at least €100m (82). For Borssele III&IV it is not known which debt to equity ratio is used. However, when applying the 70% debt ratio of Gemini, the 45% equity share of private investor Partners Group would be worth around €175m. Furthermore, the application of project financing is used in at least 4 out of the 8 projects. From 2 out of the 8 wind parks, the Hollandse Kust Zuid tenders, it is not yet known how the parks will be financed

From the data set it can be concluded that 37.5% of the projects applied project financing. However, this increases to 50% if we only use the 5 projects from which the financing mechanism is known. Furthermore, Borssele I&II, the only known balance sheet financed project is currently applying for a loan with the EIB.

From public information it can be concluded that the projects which did not apply project financing are predominantly funded by power generators. As discussed in Chapter 2 this kind of investor also uses its balance sheet to fund these projects. However, power generators such as Ørsted are also stating that they intend to explore new financing mechanisms. Ørsted´s recent loan application at EIB for the construction of Borssele I&II underlines this (83), since the project is originally balance sheet funded.

The revenues of the wind parks are also partly secured through PPAs. Examples would be Gemini and both Borssele wind parks. Gemini has a PPA with Delta (a Vattenfall subsidiary) for 85% of its produced electricity. The remaining 15% is supplied to HVC (84). Borssele III&IV negotiated a 15-year contracted with its shareholders Shell and Eneco, to supply each of them with 50% of the electricity (85). Furthermore, Eneco signed a contract with Microsoft for a PPA covering 90MW for a period of 15 years, starting 2022 (86). From the above it can be concluded that the financial investor-owned, and project financed, wind parks have PPAs in place.

For both Hollandse Kust Zuid wind parks there is no public information available about the project specific PPAs. On a more general level, information is available for Vattenfall´s offtake strategy since it states that it is actively focusing on securing PPAs for their assets (87). However, since these parks are won by a utility, PPAs with third parties could be of less importance due to their pool of clients. Vattenfall has a substantial consumer base in the Netherlands, which could be supplied by (part of) these wind parks. The same also goes for the wind parks of Eneco. This is underlined by the fact that some of the utility owned wind capacities are not fully secured by PPAs. This is visible at Borssele III&IV, where public information research has only yielded to a 90MW offtake agreement with Microsoft. Also, in the case of Luchterduinen, public information research has yielded to a 100GWh offtake agreement, which covers circa 20% of yearly production, with NS (88). In 2014 Eneco and VIVENS, a consortium of all train operators, already agreed upon a renewable energy supply of 1.4TWh. Half of this energy should be produced by Eneco's offshore wind parks. Upon comparing this with Eneco's wind parks and its current PPAs, it could be concluded that this energy can only be generated by pooling multiple of Eneco's wind parks (89). It is however not publicly known which wind parks this would entail specifically and how much is contracted per wind park.

The provision of site data by the Dutch Government provides a good basis on which production can be estimated (90). It is thought that this would enhance the predictability of future production. Furthermore, the shallow waters and good harbour facilities are also providing a relatively easy construction process.

All wind parks except the Hollandse Kust Zuid wind parks are covered by a subsidy. Therefore, the risks of these projects are deemed to meet that of financial investors. This is also shown by the appetite of Partners Group and the Alte Leipziger-Hallesche consortium to invest in respectively Borssele III&IV and Gemini. For the subsidy free wind parks the regulatory risk is also low. The revenue risk might be higher due to the absence of the SDE+ subsidy, but the tender still provides the guarantee to operate the wind park. The regulatory risk is thus deemed to be low in the Netherlands for the current wind parks. The revenue risk is increased due to the absence of subsidies for the future wind parks. For the subsidy free wind parks, it is not known if banks were willing to finance the construction under the new remuneration terms.

3.6. Conclusion

From the above it can be concluded that all the Dutch offshore wind projects meet the private investment criteria. The subsidy free tenders would not meet the stability of a subsidy, which is preferred by financial investors and banks. However, the winning bids of Vattenfall underline that tenders still prove to be interesting for power generators. The absence of Vattenfall in the Hollandse Kust Noord tenders however also shows that this interest has its limits. Furthermore, Vattenfall is a Swedish state-backed utility with a subsequent very low cost of capital, and a relatively short line to back-up reserves. This can enhance the competitiveness of the bid through an increase in completion certainty.

The first subsidy free tender round did not see any interest of financial investors, the second round however received a bid from Green Investment Group (78). This is a subsidiary of the global heavyweight financial investor Macquarie. Furthermore, it can also be concluded that the use of project financing is of large importance to the Dutch offshore wind industry, and predominantly for the financial investors. For both the Hollandse Kust Zuid projects it can however (yet) not be concluded from public information if project financing will be applied as well, now the subsidies have fallen away. Applications of project financing would have proven the shift of power generators towards an increased used of project financing, as was identified in Chapter 2. The absence of project financing could however thus also be caused by the absence of subsidies.

4. In depth offshore wind analysis

This chapter will provide an in-depth quantitative analysis of the offshore wind sector in European countries similar to the Netherlands. This analysis is performed to identify drivers behind private investments and the use of project financing in the wind parks. First, the selection of the countries is discussed. Secondly, the regulatory frameworks are discussed per country. Thereafter, the researched variables for the regression are discussed. Finally, the results of the regressions are discussed. These results are subjected to the semi-structured interviews in Chapter 5 and are used when setting up the support mechanism outlines in Chapter 6.

4.1. Selection of countries

To minimize the influence of natural conditions on the costs and risks of offshore wind parks the dataset originally only included wind parks situated in the North Sea. However, this dataset only contained about 50 wind parks, which did not yield significant results when evaluated. Therefore, the selection has been extended to the Baltic Sea, France and the Irish Sea as well. The Baltic Sea has been added to fully cover Germany and Denmark. Other countries with offshore wind parks in the Baltic Sea have been excluded due to market immaturity, a mismatch in political characteristics. This has led to the exclusion of Sweden, Finland and Poland. The Irish Sea has been chosen since including these parks would result in a full UK coverage. France is chosen since it borders Belgium and since it has a relatively developed offshore wind sector. Belgium was already included in the dataset. The newly included wind parks appeared to have cost ratios which closely matched the North Sea dataset, indicating that including these new wind parks would not bias the dataset.

The wind park dataset contains 96 wind parks and is specified in Table 3 below, the list containing all the wind parks can be found in Table 12 in Appendix A.4.

Table 3: Specifications of the dataset, per country

Country	Number of wind parks	Total capacity (MW)	Contribution to total capacity of dataset	Sea(s)
Belgium	10	2,308	7%	North Sea
Denmark	9	2,178	7%	North Sea, Baltic Sea
France	6	2,966	9%	Atlantic Ocean, Gulf of Biscay
Germany	26	7,675	24%	North Sea, Baltic Sea
The Netherlands	8	3,900	12%	North Sea
The United Kingdom	37	12,813	40%	North Sea, Irish Sea
Total	**96**	**3,184**		

4.2. Support mechanisms and PPA developments

In this section the development of support mechanisms and PPAs are discussed per country included in the dataset.

4.2.1. Belgium

Support mechanism

The Belgian offshore wind sector is supported via a Feed-in-Premium (FiP) subsidy (20). The FiP is remunerated per green certificate and consist of the difference between a yearly averaged electricity market price and a guaranteed strike price. When the average price exceeds the market price, no FiP is paid out. All the awarded green certificates are bought by the grid operator Elia. Which effectively pays the FiP to the wind parks by collecting a premium from the consumers. The electricity is directly sold at the current market price by the wind park operator.

The average electricity price is reduced by 10%, depending on the difference between long-term contracts and the market price. Such a reduction is set in place to correct for the pricing effect of PPAs, which are a requirement when attracting financing. Pricing agreements of the PPAs are often set under the market price, as a compensation for agreeing on long-term contracts. The value of the strike price is set by the Belgian government. There is no imbalance cost compensation or full load hour restriction in place.

Furthermore, the support periods went down from 20 years to 17 years over 2014-2018 and only covers 63,000 full load hours (35) (91). The guaranteed strike price will also not be secured during the first 72 hours of imbalance, measured per 15 minutes. Originally the guaranteed strike price was set by the government. However, to minimize state aid, the strike price has now been subjected to a tender mechanism. The tender mechanism will provide a 30-year operational permit and a support period with a maximum duration of 15 years.

PPA market

Little corporate PPA activity is going on in the Belgian offshore wind sector (92) (35). Google has agreed upon a 92MW PPA with the Norther wind park, which is roughly 15% of the wind park capacity (93). However, recently the owners of the Rentel has published to set up a tender, in which offtakers can bid on a 16-year PPA (94).

The PPA sector is predominantly filled with utility PPAs. An example is the PPA between Mermaid and Seamade wind parks and Eneco. However, it is not known what pricing characteristics is agreed upon and if Eneco has managed to pull through PPAs with its clients on these wind parks. Another utility PPA example is the PPA between RWE and Northwester 2 (95). It is however not publicly available how this electricity is sold by RWE.

4.2.2. Denmark

Support mechanism

The Danish offshore wind sector is supported via a Feed-in-Premium (FiP) subsidy (20). The premium consist of the difference between the hourly electricity market price and a guaranteed strike price. The strike price is guaranteed for 50,000 full load hours and/or a 20-year maturity. Previously, the subsidies were awarded via an open-door procedure, where every developer could apply to be considered for a subsidy (96). CfD subsidies have also been awarded, but via tenders, following the same pricing mechanism. In 2018, the Danish government has decided to only continue with the CfD tenders.

When the hourly price exceeds the strike price, a negative premium is imposed on the wind park operator. Negative electricity prices are also corrected for in favor of the wind park operator. The grid operator Energinet.dk pays the FiP to the wind parks by collecting a premium from the consumers. The electricity is directly sold at the current market price by the wind park operator. The operators are remunerated for any temporarily shutdowns caused by economical optimization of the electricity market, for a period of 25 years.

The CfD wind parks, such as Anholt and Horns Rev 2&3 wind parks, are not remunerated for shutdowns or negative prices (96). This risk is also reflected in the financing of the projects. For the Anholt wind park, only 18% of the wind park was financed through the public development bank NIB (97).

PPA market

Little corporate PPA activity is going on in the Danish offshore wind sector (92).

4.2.3. France

Support mechanism

The French offshore wind sector is supported via a Feed-in-Premium (FiP) subsidy, which is awarded upon the results of a tender (98)**.** The FiP consists of a market premium and a management premium, and is paid by EDF. The market premium consists of the difference between the monthly average electricity market price and the tendered guaranteed strike price, and has a duration of 20 years. When the electricity price exceeds the strike price, the generator has to compensate EDF. The management premium covers all the costs involved with the direct marketing of the electricity. Previously, the subsidy consisted of a Feed-in-Tariff which was guaranteed for 20-years (20). The tenders for Feed-in-Tariff are however terminated since it would resemble too much to state aid.

There is also a mechanism in place which guarantees offtake when the electricity can not be sold in the market (99). In this case the operator can agree upon a PPA with a maximum duration of 5 years. Furthermore, the electricity price will be (less than) 80% of the combination of market price and Feed-in-Premium.

PPA market

Little corporate PPA activity is going on in the French offshore wind sector (92). The onshore sector however sees PPA activity in both the onshore wind and solar PV sector.

4.2.4. Germany

Support mechanism

Originally, the German offshore wind sector is supported via a Feed-in-Premium (FiP) subsidy, which is awarded upon the results of a tender (100)**.** The FiP consists of the difference between the monthly average electricity market price and the tendered guaranteed strike price, and has a duration of 20 years (101).

Previously, the generators were remunerated via a Feed-in-Premium with a strike price set by the government (20). The generator was remunerated over two periods. For the first 12 years, the guaranteed strike price was set at €154/MWh. For the last 8 years the price was set at €39/MWh. The generators also had the opportunity to apply for an accelerated subsidy, which paid €194/MWh for the first 8 years and €39/MWh for the subsequent 12 years.

However, the first zero subsidy offshore wind park, Borkum Riffgrund III (900MW), is underway in Germany (102). This park consists three smaller parks, all owned by Ørsted, which were tendered separately at a zero subsidy.

PPA market

Little corporate PPA activity is going on in the German offshore wind sector (92). The onshore sector however sees PPA activity in both the onshore wind and solar PV sector.

However, despite the low PPA activity, the German PPA market is still notable due to the PPA of Borkum Riffgrund III. This subsidy free wind park has agreed upon a fixed-price 10-year 100MW PPA with the conglomerate Covestro (102). This PPA underlines the importance of the presence of revenue securing mechanisms, when subsidies are absent.

4.2.5. The Netherlands

Support mechanism

Originally, the Dutch offshore wind sector was supported via a Feed-in-Premium (FiP) subsidy, which is awarded upon the results of a tender (103)**.** This FiP consists of the difference between the yearly average electricity market price and the tendered guaranteed strike price, and is limited by a number of full load hours based on the P50 production of the project (20). This normally leads to a subsidy period of 15 years. The average electricity price is corrected for imbalance costs, which reduces the electricity price with about 10%.

The FiP has a double price cap. This means that the paid-out FiP is limited by a lower limit (floor) and the tendered strike price. The floor is set at two third of the long-term electricity market price. When the yearly average electricity market price is lower than the floor price, only the difference between the strike price and the floor price is paid to the generator.

Since 2017, the first zero subsidy offshore wind bids have entered the Dutch market. Vattenfall has won the tender for the Hollandse Kust Zuid I&II (700MW) and Hollandse Kust Zuid III&IV (750MW) wind parks by tendering subsidy free (104). Furthermore, another subsidy free tender, Hollandse Kust Noord, has attracted bidders and is closed in May 2020 (105).

A subsidy free tender is decided on different factors than the strike price. In this tender the most important factor is the experience and knowledge of the parties involved in the bidding consortium (103). Furthermore, extra focus is applied on the capital requirements of the bidding consortium. In the old SDE+ tenders the equity capital of the bidding consortium itself should at least cover 10% of the investment costs. In the new subsidy free tender scheme this has to be 20%. All in all, these measures are taken to maximize the likelihood of (timely) commissioning.

When a subsidy free tender has had no applicants, a second round is opened which enables the applicants to tender for a subsidy.

PPA market

Little corporate PPA activity is going on in the Dutch offshore wind sector (92). This does not mean that there are no PPAs involved in the Dutch offshore wind sector. For instance the Dutch railway company NS and Delft University of Technology have negotiated a PPA with the Dutch power producer Eneco. Overall, the direct offtake of the electricity from the wind parks is done by the utilities, who redirect the electricity via back to back PPAs with the corporates such as NS and Delft University of Technology. Most of the parks have utility PPAs in place. This is discussed in section 3.2.5. The nature of the PPAs is however not known. The onshore sector sees PPA activity in both the onshore wind and solar PV sector. It is not yet publicly known if the subsidy free Hollandse Kust Zuid wind parks have covered their output with corporate PPAs.

4.2.6. The United Kingdom

Support mechanism

The UK offshore wind sector is supported via a Contract-for-Difference (CfD) subsidy, which is awarded upon the results of a tender (20). This CfD consists of the difference between the hourly average electricity market price and the tendered guaranteed strike price, and has a duration of 15 years. When the hourly average electricity market price exceeds the tendered guaranteed strike price, the difference is paid by the generator. When negative prices occur, only the strike price is paid to the generator.

Furthermore, depending on the project, the generators have to construct the offshore grid connection as well. This is later sold to an Offshore Transmission Owner, which in turn transports the electricity in exchange for a connecting fee. With or without a connection already being in place, the bidders have to include the connecting fees in their bid.

Before the CfD tender scheme, a Renewables Obligation (RO) scheme was used (20). This scheme made use of tradable green certificates which are assigned per produced MWh (106). Each year all of the electricity generators had to present sufficient green certificates to cover a defined part of their production. When a generator did not present enough green certificates, it had to pay for the missing certificates. The proceeds from these payments were distributed to the renewable generators, depending on their production and subsequent awarded green certificates.

In 2019, the UK has seen the first offshore wind bids which have a strike price under the expected average market price (107). When the market price stays above the strike price for the project lifetime this would result in the government being paid only for the insurance that it stabilizes the price when the market price tumbles. In this case the generator pays for a certain price security.

In the past, the UK government has invested equity in the offshore wind market through the Green Investment Bank (GIB). The GIB provided debt and equity investments. The debt investments were predominantly made in the construction of wind parks. The equity investments were predominantly made in commissioned offshore wind parks which were subsidized via the RO scheme. These investments were made to bring about the ‘farm-down’ principle in the UK offshore wind market, since most of the investors regarded the wind parks to have a too large financial risk (108). Without these farm-downs the developers and utilities would not have sufficient funds to start new projects. Furthermore, it was thought that the financial investors had to be made comfortable with the industry so that they would start investing in greenfield projects as well.

PPA market

Compared to the number of operational offshore wind parks, little PPA activity is going on in the UK industry (92). The onshore sector sees PPA activity in both the onshore wind and solar PV sector.

An example of a UK offshore wind PPA is the agreement between Nestlé and Ørsted. This fixed-price PPA covers 31MW for a period of 15 years and is supplied by the Race Bank wind park (570MW) (109). Another example is the PPA between Northumbrian Water and Ørsted, which covers 23MW for a period of 10 years and is also supplied by Race Bank (110).

4.3. Quantitative analysis of offshore wind dataset

In this section the quantitative analysis of the offshore wind dataset is discussed. The rationale and results of each regression step will be discussed below. The results of the analysis will also be evaluated in the semi-structured interviews, which are discussed in Chapter 5. The conclusions from this analysis will be one of the main inputs when structuring the outlines of the support mechanisms in Chapter 5.

4.3.1. Identifying the success factor of project financed offshore wind parks

Rationale

In Chapter 2, the ‘farm-down’ principle is identified to be a key working principle for the continuance of the offshore wind sector. Farming-down is the sale of (parts of) wind parks by power producers/developers to financial investors, to free up capital which can be used to start new projects. Based on this conclusion, a project financed wind park is deemed to be successful when it attracts the interest of financial investors, to enable the farm-down of the wind park. Furthermore, the presence of financial investors can also indicate the financial sanity of a wind park. Financial investors namely invest in wind parks for the cash flows of the wind park, which are a direct result of the financial structuring of a the wind park. They would not invest for portfolio synergies, like utilities can. Financial investors would also not invest in financially suboptimally structured wind parks just to increase their market share.

The presence of financial investors is measured in a binary way. The number of financial investors is not taken into account since this depends on fund and deal specific factors, such as available capital per bidder and competition. Furthermore, financial investors are defined as private parties, which are not government backed. Government backed funds could have lower return requirements and therefore agree upon different financial structures.

A probit model is used to determine which factors have a negative/positive effect on the presence of financial investors in wind parks, since the presence of a sort of shareholder is binary (36). A full list of the evaluated parameters can be found in Table 4. The rationale behind the inclusion of the initial regressors is provided below. For the performed regressions 'leverage' is defined as the total debt portion as a percentage of the total investment.

Table 4: Parameters which are researched on their potential influence on investments and leverage

Parameter	Leverage	Presence of financial investors
Closing year	✓	✓
Country	✓	✓
Debt portion (Leverage) (%)	✗	✓
ECA coverage (%)	✓	✓
Equity of financial investors (%)	✓	✗
Lifetime of the facility	✓	✓
Loan life coverage, by subsidy (%)	✓	✓
National Bank loan coverage (%)	✓	✓
Project life coverage, by subsidy (%)	✓	✓

The closing year is expected to have an effect on leverage since market maturity could lead to an increase in confidence at the address of financial investors. Furthermore, the country in which the wind park is situated is also expected to have an effect on the leverage of a wind park. This is expected since differences in national support mechanisms can lead to differences in perceived risk at the address of financial investors. Also, ECA[9] coverage of the loans is expected to influence leverage since ECA insurances are often applied to projects which are perceived to be risky. ECA coverage could have supplied the necessary security for the financial investors. The lifetime of the facility is expected to have an effect on the presence of financial investors, because longer repayment periods could lead to a higher profitability. The loan life coverage of the national support mechanism is included in the regression since it is expected that financial investors want to maximize the repayment period of the loan. Furthermore, the project lifetime coverage of a support mechanism is expected to have an effect on the leverage of wind park. An increased coverage could provide extra comfort at the address of financial investors, since this assures the financial investors of secured revenue. Lastly, debt investments of national banks could have an effect on the interest of financial investors since national banks lend to support renewable energy projects. Including this regressor could indicate the influence of their financing conditions on the interest of financial investors.

Results

When making use of backward elimination, it is concluded that a higher leverage leads to a higher presence of financial investors. The closing year did not yield a significant influence. Furthermore, financial coverages of national banks and ECAs did not yield significant effects. Coverages in terms of time did also not yield any significant effects. The geographical location of the wind park has also not shown any significant effects on the interest of financial investors. Detailed numerical results of the final regression is shown in Table 13 in Appendix B.1.

[9] Export Credit Agency: supports the export of products by providing insurances or loans to projects in which the products are used.

4.3.2. Identifying the drivers behind leverage of a project financing facility

Now that the leverage of an offshore wind park is identified to have a positive effect on the farm-down, the drivers behind the leverage have to be researched. Since the leverage is a non-binary number within the range 0-1, a tobit model with inclusive boundaries 0 and 1 is used, to determine what has a positive/negative effect on the leverage applied to a wind park (36). The boundaries are inclusive, since the data is censored instead of truncated; a leverage of 0% or 100% is an observable quantity (36). A full list of the evaluated parameters can be found Table 4. The rationale behind the inclusion of the initial regressors is provided below.

The closing year is expected to effect leverage since market maturity could lead to an increase in confidence at the address of financiers. Furthermore, the country in which the wind park is situated is also expected to influence the leverage of a wind park. This is expected since differences in national support mechanisms can lead to differences in perceived risk at the address of financiers. Also, ECA coverage of the loans is expected to have an effect on leverage since ECA insurances are often applied to projects which are perceived to be risky. The lifetime of the facility is expected to have an effect on the leverage of a wind park. Support mechanisms with a shorter lifetime have less years with secured cash flows, which could decrease the years over which financiers are comfortable that the loans can be repaid. Subsequently, repayment possibilities decrease when the lifetime of a loan decreases, which could lead to smaller loans. To avoid the influence of other factors on the decreased loan lifetimes, the loan life coverage of the national support mechanism is included in the regression. Furthermore, the project lifetime coverage of a support mechanism is expected to have an effect on the leverage of wind park. An increased coverage could provide extra comfort at the address of financiers when projects can still access secured cash flows after the original loan lifetime. This could be seen as a leeway in case the project was not able to repay its debt obligation within the original lifetime of the loan. Lastly, debt investments of national banks are thought to have an effect on the leverage of a wind park since national banks lend to support renewable energy projects. Including this regressor could indicate the correlation of their activity to leverage.

Results

When assessing the results of the preliminary regressions, it is concluded that the closing year did not yield a significant influence. Furthermore, financial coverage of ECAs did also not yield any significant effects. Coverages in terms of time did also not yield any significant influences. When assessing the correlation of the geographical location of the wind park to leverage, only a limited number of countries have shown to have an effect on the presence of financial investors. When making use of backward elimination, it is concluded that the following factors have a significant effect on leverage:

- National Bank or EIB loans have a negative correlation to the leverage of a wind park.
- Denmark has a negative effect on the leverage of a wind park.
- The United Kingdom has a negative effect on the leverage of a wind park.

Positive effects have not been found. An overview of the analysis result is shown in Table 14, in Appendix B.1. The negative correlation of National Bank and EIB loans could be explained by their presence as financier when a financing can't be closed. The EIB would then lend to the project to bridge the minimal debt gap, so that the projects could actually be built. This results in the construction of wind parks with a minimal leverage. The negative effect of Denmark could be explained by the fact that all of the project financed wind parks in Denmark were only funded by the public bank NIB, resulting in debt portions ranging between 20%-36%. The Danish offshore wind projects are funded by balance sheet heavy, state-backed, developers and power generators such as Ørsted and Vattenfall. These players do not necessarily require large loans to fund an offshore wind park since they are already very well capitalized against low costs of capital. Subsequently, they can invest in wind projects with relatively large equity stakes. Furthermore, they do not have to attract debt in the form of large project financing facilities to improve the return on investments.

The negative effect of the United Kingdom to leverage can be explained by the fact that a relatively large portion of dataset consists of UK wind parks which were constructed when offshore wind was a relatively new sector. The immaturity of the sector then led to banks not being comfortable with the sector, which was translated in low leverage. Most of the older wind parks are also operated under the Renewable Obligation scheme. This support scheme could not provide the necessary long-term revenue stability for the financiers (111). The yearly remuneration was namely provided from a buy-out fund which was funded by penalties which were imposed on power generators who did not meet their yearly renewable generation requirements. This induces a certain 'gaming' element, which could lead to yearly variations in the remuneration of the wind parks. This scheme is discussed in Section 4.2. The UK CfD scheme has seen more interest of project financing banks, and provides a more precise revenue security. Furthermore, one can now also conclude that the low leverage of the wind parks resulted in low interests of financial investors. As discussed in Section 4.2 the UK government increased this interest by funding projects through the GIB.

No specific PPA effects could be found when performing the regressions. This is also caused by the fact that little information is present about each of the PPAs due to its business sensitivity. Therefore, the PPAs could also not be extensively researched via the regressions.

4.4. Conclusion

When researching the offshore wind industry for the countries included in the dataset, it can be concluded that there is little corporate PPA activity going on. Furthermore, the quantitative analysis did not yield any significant effects from PPAs to leverage and financial shareholder presence. This is caused by the fact that little information about the PPA is publicly available, due to its business sensitivity. Furthermore, the corporate PPA industry is still immature and does not provide enough datapoints to facilitate a quantitative analysis. However, when studying the recent offshore wind parks qualitatively, it can be concluded that almost all zero subsidy wind parks are attracting corporate PPAs. However, these PPAs are still very small and only cover small parts of the total production of the wind parks. As a comparison, the onshore wind sector sees more PPA activity, but also has smaller capacities which could be covered more easily by PPAs.

When evaluating the success factors behind project financed offshore wind parks it can be concluded that leverage positively influences the presence of financial investors. Leverage on itself has a negative effect on the presence of public financing institutes such as the EIB. However, it should be concluded that the presence of such public institutes actually brought about the feasibility of the projects, where they were deemed to be too risky by private institutes. By bridging the financing gap the public institutes made it possible to close the financing of the wind parks. Subsequently, this did not yield the financial structuring with a high leverage, due to the low appetite from the market. Taking this into account, it can be concluded that public loans have had a positive influence on setting up project financing facilities when market risks are deemed to be high.

Furthermore, it can be concluded that a lack of government-backed revenue security negatively influences leverage. The UK namely shows an overall negative effect on leverage. When qualitatively evaluating the data one can see that most of the UK wind parks with a low leverage are supported via the Renewable Obligation scheme. Over time both the leverage and financial investor interest has increased. This can however not solely be explained by the introduction of the Contract-for-Difference system, since the industry has matured significantly over time as well. Furthermore, the UK government has also made use of governmental equity investments through the GIB. It could therefore be evaluated during the semi-structured interviews if financiers deem governmental equity to be a potential support mechanism when risks are increasing.

5. Validation of qualitative and quantitative research

In this chapter the conclusions from Chapter 4 will be evaluated and validated in the industry. This includes the results of the quantitative analysis as well as the qualitative analysis of Chapter 3. This will be done via the execution of semi-structured interviews with financial investors, power generators, energy companies and financial advisors which are active in the Dutch and/or North West European offshore wind sector. A list of all correspondents can be found in Table 15 in Appendix C.1. This section describes the validation in the same sequence as this work is reported in the previous sections. The interview questions can be found in Appendix C.2.

This section will start with addressing the view of the respondents on the research problem of this thesis. Secondly, the criteria which are identified in Chapter 2 will be discussed on their relevance for the respondents. This is followed by a discussion covering the conclusions from the qualitative research in Chapter 3. Having discussed the general conclusions, the PPA specific conclusions from Chapter 3 and 4 will be discussed as well. Finally, the quantitative assessment results will be discussed with the respondents. This will cover the validation of the identified drivers behind shareholding and leverage and is supplemented with the identification of additional drivers.

5.1 Research problem

Overall, the problem is recognised by the respondents. The decrease in revenue security is identified as the key driver behind an increase in cost of capital. However, the problem is mostly recognised by the respondents which are depending on project financing facilities. This group consists of respondents active in the project financing banking and the power generation sector. However, this does not include all power generators which are interviewed for this thesis. Other respondents have recognised the problem to be a broad industry problem, but not as a problem for their own development. Potential mitigators were said to be the partnering with other capital heavy power generators or energy companies, or increased balance sheet financing.

Interviews with financial advisors yielded to a confirmation of the above conclusion, with one of the respondents saying that *“It is not clear yet if the climate goals will be achieved when the subsidies are terminated this soon.”* Another financial advisor said that *“It is likely that the Dutch government will reinstall subsidies, to ensure the climate goals are reached in time.”*

Financiers have indicated that they are still interested in supplying project financing facilities to zero-sum subsidy or subsidy free wind parks, but under strict conditions which provide the required revenue security. In this case zero-sum subsidy mechanisms are defined as mechanisms which include a balancing mechanism which repays the government if the price exceeds a certain level. One of the financiers said that *“A Contract for Difference subsidy would ideally minimize governmental costs, and could even benefit the government.”* Subsidy free wind parks would still be possible, however only if a (set of) PPAs is in place, which provide enough revenue security. All financiers agreed with a respondent from a financing bank, who said that they need *“Secured cash flows on which debt can be modelled.”*

Financiers indicate that the use of Corporate PPAs would result in higher debt costs, due to the credit risks of the offtakers. Multiple financiers have agreed that *“No corporate offtaker can match the credit rating of the Dutch state”*, and that they are *“Not likely to lend to a project when it has a PPA with a party the bank itself would not provide with a project financing facility.”* Furthermore, the financiers also indicate that the Corporate PPA market does not provide enough demand to cover the planned development of wind parks. One respondent from a power generator however stated that they are confident that they can fill their parks with PPAs, and said that *“It could become challenging, but certainly possible given our market position.”* Another respondent from a power generator however indicated that it is not sure yet if PPAs will provide enough revenue security.

However, it should be taken into account that power generators would be commercially incentivised to state that their Corporate PPA sourcing is successful. Furthermore, specific PPA information is financially sensitive information. All the respondents from energy companies and power generators stated that they will not elaborate on specific PPA cases due to the financial sensitivity. However, they have indicated that they can pool clients in green electricity products. Furthermore, it should also be noted that power generators who state that they are willing to work with route-to-market PPAs also state that they are less dependent on debt financing. In general, route-to-market PPAs are set in place to guarantee offtake but not pricing, which could be the market price.

Power generators base their view on the Corporate PPA market with examples from recent agreements, such as the 10-year 100MW fixed price PPA between Covestro and Ørsted, for the production of Germany’s subsidy free wind park Borkum Riffgrund III. However, financiers and financial advisors have indicated that even global corporates do not all need electricity of the magnitude of an offshore wind park. One of financiers said that *"A company as large as Nestlé agreed upon a PPA of only 31MW with Race Bank, which has a total capacity of around 570MW"*. Furthermore, offshore wind parks are increasing in size, which makes it harder to cover their output with Corporate PPAs, with multiple financiers agreeing with a financial advisors who said that *"With the growing offshore wind park capacities, it becomes less likely that the parks will be covered by PPAs."*

Furthermore, all the respondents indicate that Corporate PPAs generally cover a shorter period than subsidies. Multiple respondents from project financing banks, financial advisors, energy companies and power generators have agreed that *"It is not directly an advantage for corporates to fix their electricity price over the long term"*, and that it could become *"A competitive disadvantage when prices fall below the PPA price."* Financiers have indicated that this would subsequently decrease the lifetime of a project financing facility, since they only want to finance over the same, or even shorter, period as in which a revenue security mechanism is in place. This makes it less likely that an offshore wind park can pay off the conventional debt sums in the new shortened time frame. Debt facilities would therefore decrease in size, which decreases the leverage of a wind park. Furthermore, financiers and financial advisors have also indicated that the DSCR[10] of Corporate PPA backed production streams are significantly higher than subsidized streams. This further decreases the leverage possibilities of a Corporate PPA backed subsidy-free offshore wind park.

All of the financial advisors, financiers and power generators have indicated that a broader pool of capital needs to be attracted in the future. And that this is likely to be filled with capital from institutional investors like pension funds. However, most of the financiers and financial advisors have indicated that it is yet to be seen how much risk pension funds are willing to take, given that they are still getting comfortable with green field investments in subsidized systems. Corporate PPAs with a high degree of price certainty would therefore also be likely to be a requirement. One financier however stated that, in his experience, institutional investors are increasingly exploring investment opportunities in (partly) merchant risk wind parks.

A financial advisor indicated that it is likely that institutional investors will seek to decrease merchant risk through diversification of their offshore wind exposure, by taking minority shares in multiple parks instead of investing the same sum in only one park. Minority shares in offshore wind parks can however still require large investments, for which one would preferably obtain majority control of the asset. A financial advisor described that *"Institutional investors need to invest larger sums of money to ensure efficient capital allocation. It is therefore not immediately likely that they are willing to invest such sums in return for only little control."*

Furthermore, most of the financial advisors have also indicated that institutional investors prefer leverage since this increases the return on their investment. One of the respondents from a power generator has stated that it is most ideal to have the lowest possible shareholding against the highest offtake of electricity. This corresponds to the identified farm-down principle, described in Chapter 2. However, this respondent also stated that leverage is of less importance for their projects. Concluding from the above, it would be likely that a wind parks is less farmed-down to institutional investors when no leverage is in place. This is however based on the assumption that no external debt can be attracted by an institutional investor to finance the farm-down. Overall, most of the financiers, financial advisors, and power generators have indicated that it is likely that farm-down is going to decrease.

Some of the financiers and financial advisors have also stated that the subsidy free tender result of the Hollandse Kust Zuid wind parks is likely to be caused by a *"perfect storm"*. With one financier saying that *"It is likely that Vattenfall felt the need to catch up in the Dutch offshore wind market, which is made possible due to multiple factors. Being state-owned, Vattenfall also has access to cheap capital. We also currently see low interest rates, and the tendered wind parks are still relatively small and thus not require too large of an investment. Furthermore, Vattenfall has the balancing capacity from gas plants and a large 'card catalogue' filled with customers."*

5.2 Criteria

The criteria have been deemed to be appropriate by all the respondents, and are evaluated as important for the identified market players. The reflection on the possibility to invest over €100m has been described as superfluous for the specific offshore wind sector, since this is a market standard. However, about the criteria itself a financial advisor has stated that *"The criteria is certainly the number which institutional investors are looking for."*

[10] DSCR: Debt Service Coverage Ratio. To increase the likelihood that a project can pay off its debt obligations, a project needs to generate more money than it has to pay off. Therefore, a safety factor is applied to the cash flows available for debt service. Such a safety factor is the DSCR, which is a multiple of the yearly debt obligation.

Power generators have also indicated that the unavailability of capital is not the root problem but that overdevelopment leads to a mismatch in supply and demand, which drives down the prices and increases the financial risks. This in turn decreases the likelihood that market players are willing to invest. This corresponds to the significant amounts of uninvested funds of investors, as identified in Chapter 2. Therefore, power generators have stated that the government should stimulate, or at least match, the demand for the offtake of electricity resulting from the new wind parks. It should however be noted that demand for electricity directly increases the business case of the same power generators.

Project financing itself has been identified as the major driver behind the financing of offshore wind parks. It is also indicated that some power generators do not have the financial properties to develop without project financing. However, as discussed above, forward looking other possibilities might be considered. For instance a respondent of a large power generator said that *"Under the current circumstances, project financing does not increase the value of a project."*

All of the respondents have stated that the revenue stability over the loan and project lifetime is strong in the Netherlands, due to the old support mechanisms. Furthermore, there is also a consensus that the Dutch regulatory framework has a high stability, which minimizes the country risk. All of the respondents indicated that the Corporate PPA market is very young an needs to grow significantly. This criteria will be further discussed in the next section.

5.3 PPAs

Overall, all of the respondents have indicated that is hard to draw conclusions about the past ánd the future PPA market. One of the respondents has said that *"The structuring of a PPA very much depends on the investors and the regulatory framework."* A financial advisor said that *"For a Contract-for-Difference support mechanism, a route-to-market PPA suffices, since the full price is covered."* For Feed-in-Premiums with floored prices, it would become more important to agree on a PPA just below or as close to the floor. Furthermore, the agreement of a PPA also depends on the level of revenue security an investor requires. As discussed above, if an investor can use balance sheet funding, a PPA would not necessarily be a minimum requirement.

Furthermore, some financiers and financial advisors have indicated that for instance the onshore wind market is easier to fill with Corporate PPAs. The main reason is the smaller project size and the fact that this also comes with more 'standardized' PPAs which are not as complex as offshore wind PPAs. The respondents have indicated that the complexity increases with the increase in project capacity and required funding. Furthermore, onshore wind also sees interest of neighbouring corporates which are highly dependent on security of electricity supply, such as data centers. However, a respondent from a power generator said that *"It is perfectly possible that an offtaker has a PPA with a wind park in the Nordics, while it is supplied by the neighbouring onshore wind park in the Netherlands."* The PPAs of onshore wind are also more accessible for smaller enterprises, since the legal costs for these PPAs tend to be lower.

For the future (Corporate) PPA market the respondents also think that is very hard to indicate how the market will evolve. Some of the respondents have indicated that it is not clear how much electricity large corporates are willing to commit via PPAs. Some of the respondents have a conservative view and state that current PPAs of large corporates show the small demand for PPAs. Others say that the market is still maturing, which makes it logical that corporates are not fully committing yet. Respondents who stated the latter are also confident that PPA coverage will eventually work out but that this would require a long time frame. However, not all of those respondents are sure that these Corporate PPAs can cover more than the minimum coverage required for debt services.

5.4 Measuring the success of project financed offshore wind parks

The farm-down has been recognised by all respondents to be the most important working mechanism in the market to guarantee ongoing development. As discussed earlier, respondents from power generators have either stated that they are not capital heavy enough to keep the parks in their own books or to fund them at all, or they have stated that a farm-down enables them to source their electricity supply as capital efficient as possible. A respondent from a power generator stated that *"We are not looking to sell our shares to competitors, which leaves us with financial investors."* The majority of the respondents have indicated that institutional investors have the highest potential to fill a funding gap, which validates the measuring over financial investor presence. This way, the choice for farm-down to financial investors, as indicator of success, is deemed to be validated by the industry.

Financiers and financial advisors have indicated that leverage is a key principle for financial (institutional) investors, with one respondent saying that *"Institutionals predominantly invest for return, and not for portfolio synergies or market share – which are more important for power generators."* One financier however indicated that in his experience *"Institutional investors are willing to increase their exposure to the market – and are seen agreeing on lower leverage."* Financial advisors and financiers have however indicated that the willingness to compromise on leverage is highly dependent on the specific financial investor and fund characteristics. They agree with a financial investors saying that *"Institutional investors are not willing to invest if the numbers don't work, but some have created extra room by setting up green investment criteria."*

Other drivers for financial investors are identified to be the coverage of subsidies over the lifetime of the wind park. With one financial advisor saying that *"Institutional investors are generally conservative investors – it is yet to be seen if they will be comfortable with increased merchant risk."* However one financier stated that in his experience *"Institutional investors are exploring the opportunities in the new subsidy free systems."*

Some financiers and financial advisors have indicated that financial investment from governmental funds have positively influenced the shareholding of financial investors. In the interviews the respondents used the example of the GIB in the United Kingdom to substantiate this view. One financial advisor described this by saying that *"The possibility to co-invest with the government provided a situation where financial investors could limit their exposure to acceptable levels."* Furthermore, these respondents also stated that the GIB investments were vital for the farm-down in the UK, with one of these respondents saying that *"The UK government provided the opportunity for developers to recycle their investment – since other investors were not yet comfortable with the market."* Two financial advisors also pointed out that the GIB provided a period in which the production of the wind park could be tested. One financial advisor said that *"The production risk of the new wind parks was still high since the market was immature – after a few years, if the parks proved to produce as planned, the financial investors could be more willing to buy the shares of the GIB."* With the financial investor Macquarie and the pension fund USS buying the funds of the GIB (112), this tactic has proven to be feasible.

5.5 Identification of leverage drivers

The role of public banks in the financing of offshore wind parks has been described differently over the groups of respondents. However, the majority of the respondents has stated that the involvement of public banks mostly resulted in the financial close of a project which was otherwise not closed. The public banks debt tranche served as capstone to the financings. Financiers, from public and commercial banks, have stated that public banks were needed to raise the minimum amount of debt needed by the developers, since the market was still deemed risky by the commercial banks. The maturity of the market led to increased confidence at the side of commercial banks and a subsequent decrease in importance of the public banks. However, multiple financial advisors and financiers have stated that the capstone function of public banks, can return now merchant risk in entering the market. One financier stated that *"Public banks were forced out of the negotiations due to competitive pricing by commercial banks – they can however return now the market risks are increasing."* A respondent from a power generator stated that it is beneficial to have a small amount of banks contribute to the funding, and said that *"Public banks can fund large tickets, which can decrease the amount of lenders in a deal."* However, another respondent from a power generator stated that *"Public banks and export credit agencies should be avoided where possible – they are very conservative and expensive."* Financial advisors and financiers have indicated that it is also not immediately sure that public banks are willing to work towards maintaining the current leverage levels. One of the financier described that *"The role of public banks would then merely be that of a financing facilitator instead of an enhancer."* Financiers have described that insurances and bank loans from an ECA[11] have also worked as such a 'facilitator'.

All financiers and financial advisors have agreed that revenue security can increase the leverage of a project. However, revenue security can include a variety of factors, including predominantly; the lifetime of guaranteed offtake or support scheme, the annual secured offtake volume, and the pricing of electricity. The majority of financiers has indicated that for instance a Contract-for-Difference mechanism would provide the best revenue security. Also, one power generator said that "*The SDE subsidy, which is a Feed-in-Premium with a floor, would actually facilitate the risk in a merchant system, since the likelihood of pricing under such a floor increases."* The risks of a Feed-in-Premium system with a floor is also agreed upon by all of the financiers and financial advisors. The financiers indicated that the Contract-for-Difference is the most simple mechanism and that it can also turn out to be a net subsidy-free mechanism, depending on the strike price. Multiple financiers also described that a Contract-for-Difference mechanism, with a strike price at the debt costs, would work best. When the electricity price rises above the strike price, a percentage would have to be paid back to the government. It should however be noted that this directly benefits the financiers themselves, and that this positions the full risk at the address of the

[11] Export Credit Agency. Provides (insurance over) bank loans to ensure that products from their domestic country, often turbines, are exported.

equity investors. One financier proposed a variant of such a debt cost Contract-for-Difference, but proposed that the government was only (fully) paid back after the price exceeds a ‘second (higher) strike price’.

5.6 Relation between interview results and qualitative & quantitative analysis

It can be concluded from the above that all of the conclusions from the qualitative and quantitative analysis are validated by the financiers and financial advisors. It deserves attention to note that the need for a PPA is stated by the respondents. However, the respondents also stated that, without an additional support mechanism, the stabilization caused by a PPA can not directly match that of the SDE+ mechanism. The creation of such a support mechanism is the premise of this research. Furthermore, new factors have been identified which influence the shareholding of financial investors and leverage. These factors have also been assessed during the qualitative analysis and have shown the same positive/negative relation, but did not pass the significance threshold. The drivers used as (part of) the basis for the creation of the support mechanism in Chapter 6 are listed below:

- Leverage
- Governmental equity investments
- Public bank loans
- Public insurances

The latter is a relatively broad concept. Respondents active in the financing and power generation industry have indicated that such an insurance was predominantly used because of construction and generation risks, resulting from market immaturity. These risks are now well understood and the risk has moved towards electricity pricing and PPA credit risk. An electricity price insurance would mean a continuance of a subsidy mechanism. Furthermore, this thesis aims to identify support mechanisms for PPA based offshore wind parks. Therefore, in this thesis public insurance will be used to mitigate financing costs related to specific PPA risks.

6. Creation of support mechanisms

In this chapter the outlines for potential support mechanisms are constructed. The outlines are based on the conclusions from previous chapters, and additional literature. The previous sections which are used comprise the quantitative analysis and semi-structured interviews, which are discussed in Chapter 4 and 5 respectively. The literature used for this chapter covers governmental support mechanisms, and the risks and uses of PPAs.

From the interviews discussed in Chapter 5 it can be concluded that the financing conditions of subsidy free PPA based wind parks worsen, because:

- The total volume of the (Corporate) PPA market cannot cover the full production of the planned wind parks. There is not enough demand in the market (yet).
- The electricity price becomes more volatile over time and the occurrence of (sub-)zero electricity prices increases.
- The financiers are willing to lend less debt, which creates an 'investment gap'.

The above presented market problems would have to be solved by new support mechanisms. The support mechanisms are categorized per envisaged effect, and either:

1. Widen the PPA market
2. Decrease the electricity price volatility
3. Fill the 'investment gap'
4. Minimize the 'investment gap'

Each of these envisaged effects is discussed briefly below. This includes a summary of the created support mechanisms and a description of the information on which the solutions are based.

1. Support mechanisms to widen the PPA market

The ideas behind the support mechanisms are based on the results from the interviews which are discussed in Chapter 5. Furthermore, own ideas and industry literature (18) are also used. The following mechanisms are constructed:

- Standardized tradable PPAs
- Pooled inter-European PPAs
- PPA subsidy (matched CfD over supply and demand)

2. Support mechanisms to decrease the electricity price risk

The ideas behind the support mechanisms are based on the results from the interviews which are discussed in Chapter 5. Furthermore, industry literature is also used (18). The following mechanisms are constructed:

- Subsidized hydrogen PPAs
- Subsidized battery capacity

3. Filling the investment gap

The ideas behind the support mechanisms are based on the results from the interviews which are discussed in Chapter 5. Additionally, industry literature (18) and scientific literature (29) is consulted. The following mechanisms are constructed:

- Governmental equity investment
- Subordinated public loans

4. Minimizing the investment gap

The ideas behind the support mechanisms are based on the results from the interviews which are discussed in Chapter 5. Additionally, own ideas are incorporated. The following mechanisms are constructed:

- Governmental offtake guarantee
- Tax incentives on renewable energy investments

Section 6.1 discusses the support mechanisms which aim to widen the PPA market. At the end of this section the outlines of the first potential support mechanisms are listed. Section 6.2 will provide outlines of support mechanisms which aim to decrease the general electricity price risk. In section 6.3, outlines of additional support mechanisms will be presented based on the support mechanism conclusions of Chapter 4 and 5. This will be complemented with additional literature on governmental support mechanisms. Where appropriate, section 6.3 will also include outlines of support mechanisms which are formed by combining conclusions from the previous sections and the conclusions from Chapter 4 and 5. This chapter will conclude by presenting the final set of potential support mechanisms in section 6.4. These support mechanisms will be subjected to semi-structured interviews in Chapter 7.

6.1. Support mechanisms to widen the PPA market

Concluding from the interviews, the main hindrances of (offshore) PPAs are the complexity and duration of the contracts and the immaturity of the market. The complexity and duration of the PPAs are discussed in the first support mechanisms; the standardized tradable PPAs. The second support mechanism, the pooled inter-European PPAs, discuss the small scale of the national PPA markets. Finally, the issues of the market immaturity and its small scale will be addressed by the creation of a PPA subsidy mechanism. In this section the duration and offtake volumes of PPAs will be discussed, which complicate the adoption of the contract form in the offshore wind sector.

Standardized tradable PPAs

From the interviews it is concluded that the PPAs for offshore wind are significantly more complex than for onshore wind parks. This is also visible in the market, where Corporate PPAs for onshore wind parks in North West Europe outnumber the Corporate PPAs of offshore wind parks (113). Furthermore, the short duration of the PPAs is also identified to be a point of concern at the address of the respondents. The key reason for the short duration is the fact that many offtakers do not want to commit over long periods, to avoid strategic disadvantages when the energy price significantly decreases below the PPA price. A solution for this would be to standardize the PPAs into tradable blocks with a fixed duration, offtake and pricing, one could create a system in which the PPAs could be traded. The increased liquidity of the PPAs could enhance the activity in the market. An offtaker could now decide to buy more ‘PPA blocks’, knowing that they can be sold later on. This could lead to a situation where a larger portion of the yearly production is covered by PPAs and/or the situation where a longer period of years is covered by PPAs. This could both increase the possibilities to apply project financing.

Pooled inter-European PPAs

From the interviews and market reviews it is concluded that the PPA market is still very small. The demand is still low. Furthermore, in the event that only financial investors are shareholder of a wind park, it might become hard to sell the produced electricity since they lack the market position the power generators have. Therefore, a PPA marketing platform could be set up which covers the trade of synthetic PPAs in the European Union. This would increase the pool of supply and demand for PPAs.

As visualized in Figure 1, synthetic PPAs rely on financial products and the trade of renewable certificates, instead of the direct supply of electricity (114). The pricing of the renewable certificates is however based on the difference between the price in the electricity market and the PPA strike price. Since this is not based on the direct supply of electricity, the generator does not have to be located in the near vicinity of the offtake party. In this synthetic PPA structure, both parties sell or buy directly from the intraday market and balance their contract separately via financial mechanisms such as a Contract-for-Difference (115). However, extra caution has to be taken since the supplier and offtaker are located in different EU member states. This could lead to a difference in national electricity price movements, which incorporates a pricing risk (115).

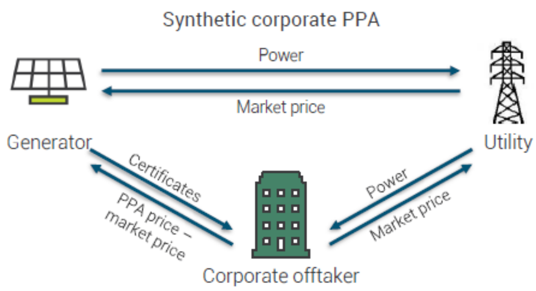

Figure 1: Visualization of the synthetic PPA working mechanism (8)

PPA subsidy mechanism

The above mentioned support mechanisms are not incentivizing the demand for renewable energy by supplying a financial stimulus. They are rather facilitating mechanisms. As concluded during the interviews, the largest PPA risk for offtakers is the electricity price risk. If the price decreases under the PPA price, the offtaker could run into significant competitive disadvantages. Where the project financing of a wind park depends on revenue security, heavy electricity consuming offtakers are depending on securing competitive operational expenditures, of which electricity expenses can take a majority share.

Recently, AFRY has consulted the Dutch government that steered demand would lead to a lower mismatch between supply and demand, and thus lower electricity price volatility (18). In their research they state that this could be solved by a demand route map, similar to the development route map 'Routekaart Wind Op Zee', which is discussed in Chapter 1 and 3. During the semi-structured interviews all the respondents from power generators have indicated that such a route map for development would be a vital solution to the price risk problem, since this would match supply and demand more closely.

Such a route map could include a Contract-for-Difference for both the generation side (wind park) and the consumption side (corporates). Under full Contract-for-Difference circumstances, two opposite contracts would balance each other when the strike prices are the same. This is visualized in Figure 2(left). This would result in a net zero-subsidy for the government. However, this does not hold in reality. Since the offtakers do not want to run into the risk of lengthy periods with a sub-PPA electricity price, their strike price of comfort could be below the strike price of the wind park. This is strengthened by the view that (temporary) low electricity prices will occur more often in the near future. If the PPA price is lower than the strike price of the production CfD, the government will be exposed to the risk evolving from the mismatch in these two strike prices, as is shown in Figure 2(right). A tender system on both sides would introduce competition, which could drive down the mismatches. Furthermore, the next tender for a wind park would only be issued when the current tender for electricity consumption is filled. The tender from the consumption side can be filled with multiple bids which vary in strike price and offtake volume. This decreases the likelihood of oversupply in the market.

All in all, this system enables the aggregation of corporates with smaller PPA needs. It is concluded from the interviews that direct PPAs between smaller corporates and offshore wind parks is mostly too costly for these corporates. Therefore, smaller corporates often negotiate PPAs with onshore wind parks, which are smaller in size. This system provides price security for both the wind park operators and the consuming corporates. The wind park operator pays the difference to the government when the electricity price exceeds the production strike price, in return for downside protection when the electricity prices become too low. The consuming corporate tops up the electricity price till the consumption strike price, in return for protection from the government when the strike prices become too high.

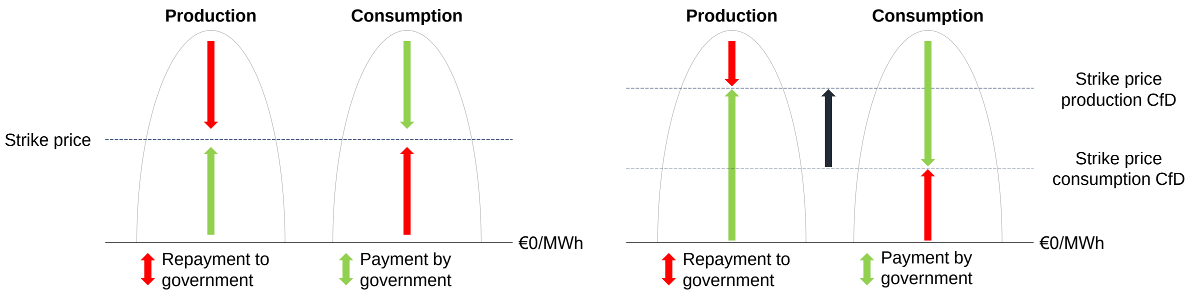

Figure 2 (left): Balancing mechanism with equalized strike prices.
Figure 2 (right): Balancing mechanism with difference in strike price. Exposure of government is marked in blue.

6.2. Support mechanisms to decrease the electricity price risk for generators

Concluding from the interviews, the PPA market is not likely to cover the full production of all of the planned wind parks. When an investor manages to partly cover its production with a PPA, a merchant risk production stream still exists. Such a merchant production stream is a part of the total production which is sold against the spot market price and thus induces 'merchant' risk. These production stream is still hard to project finance. Furthermore, if a merchant risk production stream is relatively large, the PPA covered production stream will not be large enough to lead to any project financing at all. To anticipate on this, a support mechanism could be set in place to work alongside PPAs and not with PPAs. Such support mechanisms would then be set up to decrease the capture price risk of an offshore wind park. As discussed by AFRY, the pricing risk could be decreased by increasing the storage and conversion possibilities for the generated electricity (18).

Subsidized hydrogen PPAs

A subsidized hydrogen PPA would benefit an offshore wind park in two ways. Firstly, an offtake agreement provides revenue certainty, which increases the business case for developing the necessary infrastructure to convert the electricity to an intermediate source. The electricity can also be sold in and transported in its intermediate state. Secondly, a hydrogen PPA could also be used as a secured cash flow on which debt can be modelled, just like conventional PPAs. By subsidizing parties to be an offtaker of an intermediate source, the market is also thought to increase in scale, which benefits the flexibility of the Dutch power electricity system.

The hydrogen can then be used by other companies. Chemical companies could for instance be willing to agree upon a hydrogen PPA if they need hydrogen for their production processes. Furthermore, such a subsidy could also enable the business case for the offtakers to install an electrolysis mechanisms, which converts the hydrogen back into electricity. Recent examples of the use of hydrogen in offshore wind parks are the proposals of Shell and Gasunie, and Ørsted for respectively the NortH2 wind park and Hollandse Kust Zuid III&IV tender bids (116) (117).

However, this form of subsidy is rather contract oriented. Next to a specific PPA subsidy, the tender principle from the SDE+ offshore wind auctions could be used for hydrogen.

Subsidized battery capacity

Subsidized battery capacity would serve the same goal as the subsidized hydrogen PPA mechanism. The aim of such a mechanisms is to increase the time-shifting flexibility of an offshore wind park, to decrease its exposure to capture price risk. However, batteries are smaller in scale and can store less energy than an hydrogen electrolyser can achieve (18). Though, batteries are already available, where the hydrogen market is still in an early stage.

However, batteries often lack the capacity to store the deviations in wind electricity production and are more often used for solar PV applications. Though, the battery option will be evaluated during the semi structured interviews to assess the general view of the respondents on different forms of storage.

6.3. Support mechanisms for PPA based offshore wind financing

In this section solutions to negative PPA influences on investment parameters will be discussed. This is based on the conclusions from the quantitative analysis of Chapter 4 and the interviews of Chapter 5. This is supplemented with additional literature, where deemed appropriate. The interviews yielded the following specific support mechanisms:

- Governmental equity investments
- Public bank loans
- Governmental insurance on offtake

During the interviews, financiers have agreed that the leverage of subsidy free wind parks is going down. This decrease in leverage could bring about a gap in the funding of a wind park, if the equity investor is not capable of bridging the gap. The first two support mechanisms provided above would fill such a gap. The governmental insurance on offtake aims to minimize such a gap. Therefore, the first two support mechanisms are discussed separately from the governmental insurance on offtake.

6.3.1. Filling the investment gap

Both the governmental capital investment mechanisms, the equity investment and public bank loans, have been discussed to be solutions in previous literature by De Jager et al. (29). Furthermore, both these solutions are also mentioned by AFRY in their consultancy report to the Dutch government (18). It is also thought that the current macroeconomic circumstances would facilitate the Dutch government to attract funding from the debt capital markets, which it can then pool in a debt and equity fund used to invest via the below mentioned mechanisms.

Governmental equity investments

Governmental equity investment can bridge a financing gap which originates from a situation where the market conditions force the investment to become marginal (18). The Dutch government has already shown its interest in investing in renewables, by investing in the nearshore Windpark Fryslan (118). The Dutch government could invest in the wind parks and pool the shares in a portfolio. Such a portfolio could later be sold to for instance institutional investors.

Public loans

The interviews yielded the confirmation of the positive influence of public loans to the facilitating of project financing. However, the respondents from the financing banks also indicated that this would only work if the public loans would be subordinated to the commercial loans. This way the government provides a safety cushion to the commercial loans, while the total leverage increases as well. The Dutch government has demonstrated its interest in providing subordinated loans to wind farms, by funding the nearshore Windpark Fryslan (118).

The interviews also yielded the conclusion that project financing facilities will have a shorter lifetime when they are based on PPAs. The Dutch government could partly mitigate this by supplying loans with a lifetime exceeding that of the commercial loans. Such elongated governmental loans have been discussed in literature to have a positive effect on the cost of capital (29).

6.3.2. Minimizing the investment gap

Governmental insurance on offtake price

During the interviews, the credit risk of the offtaker has been discussed to have a negative influence on debt pricing for Corporate PPA based projects. Furthermore, it is also concluded from the same interviews that public insurances have previously lowered the risks of offshore wind projects. Such an insurance could now be set in place on the pricing of the electricity. Having a guaranteed electricity offtake price, the credit risk of the offtaker is mitigated.

This support mechanism can include two different ways of remuneration by the government. The first option includes the government buying all the electricity from the wind park against the Corporate PPA strike price. The government would than sell the bought electricity on the spot market to offset the remuneration. Another option includes the introduction of a CfD between the spot market price and Corporate PPA price as strike price. When this option is applied the wind park operator sells the electricity on the spot market. When the spot market trades below the Corporate PPA price, the government pays the difference to the wind park operator and vice versa. The impact of a defaulting PPA on the revenue of the wind park gets nullified when either one of the two offtake guarantees is attracted. This could lead to a situation where the wind park can be financed against the credit risks associated to the SDE+ financed wind parks.

Tax incentive

Tax incentives have been used in the Netherlands under the EIA[12] construction. In this construction the investments in renewable energy could be deducted from the tax obligation of corporates. Furthermore, the depreciation of the assets was also accelerated to facilitate financial gains. Such tax incentives have also been discussed to bring down cost of capital, in literature from De Jager et al. (29) and the German Energy Agency (115).

[12] Energie-investeringsaftrek: Dutch subsidy scheme which made green investment tax deductible.

6.4. Final list of support mechanisms

Below all of the above discussed support mechanisms are listed and categorized per support mechanism sort. These support mechanisms will be subjected to semi-structured interviews in Chapter 7.

Support mechanisms to widen the PPA market

- Standardized tradable PPAs
- Pooled inter-European PPAs
- PPA subsidy (matched CfD over supply and demand)

Support mechanisms to decrease the electricity price risk

- Subsidized hydrogen PPAs
- Subsidized battery capacity

Filling the investment gap

- Governmental equity investment
- Subordinated public loans

Minimizing the investment gap

- Governmental offtake guarantee
- Tax incentives on renewable energy investments

7. Selecting the support mechanisms through semi-structured interviews

In this chapter the support mechanisms from Chapter 6 are evaluated on their implications and practical feasibility the industry. The creation of the support mechanism outlines is presented in Chapter 6. The outlines are based on the qualitative and quantitative analysis conclusions from Chapter 3 and 4, and the interviews which are presented in Chapter 5. The semi-structured interviews are executed with financiers, power generators, energy companies and financial advisors which are active in the Dutch and North West European offshore wind sector. A list of all correspondents can be found in Table 15 in Appendix C.1. The interview questions can be found in Appendix C.3. It is important to note that these interviews are conducted in the same period as the interviews in Chapter 5, due to the availability of the respondents.

Section 7.1 will address the general implications of Corporate PPAs on financial parameters such as leverage and interest rates. Section 7.2 covers the evaluation of the support mechanisms, by discussing each support mechanism separately. Section 7.3 discusses the top 3 support mechanisms of the respondents.

7.1. Financing implications of PPAs

In this section the implications of Corporate PPAs on general financing parameters will be discussed, which are the leverage and the interest rates. Furthermore, it is also discussed if banks are willing to offer additional services resulting from a Corporate PPA, such as a guarantee on the offtake remuneration. Also, it is briefly discussed if banks would see an opportunity to increase their leverage on wind parks if the bank regulations are loosened.

7.1.1. Financial parameters

In Figure 3, the spread in estimated financial parameters of Corporate PPA based wind parks is shown. This will be complemented with additional information from the interviews.

Of all the respondents, only 7 financiers and 3 financial advisors were comfortable estimating the financial parameters under PPA circumstances. The respondents are visualized as a number, which is kept constant across the graphs. If a respondent was not able to indicate one of the parameters, the entry at his/her respondent number is left blank. In the case that the respondents indicated a range, the average of the range is taken as input.

Leverage

In this section the leverage indications from the respondents are discussed. In this thesis, leverage is defined as the portion of the total required construction capital which is covered by debt. As visualized in Figure 3, the average leverage under Corporate PPA circumstances is identified to be 64%, the estimations range between 55% and 70%. The respondents have indicated that the current leverage on subsidized wind parks is 80-85%. This is also in line with the model used for the quantitative analysis, which shows an average leverage of 84% for the current wind parks. The identified leverage levels respond to a decrease in leverage of 11-21%, when PPA circumstances are applied.

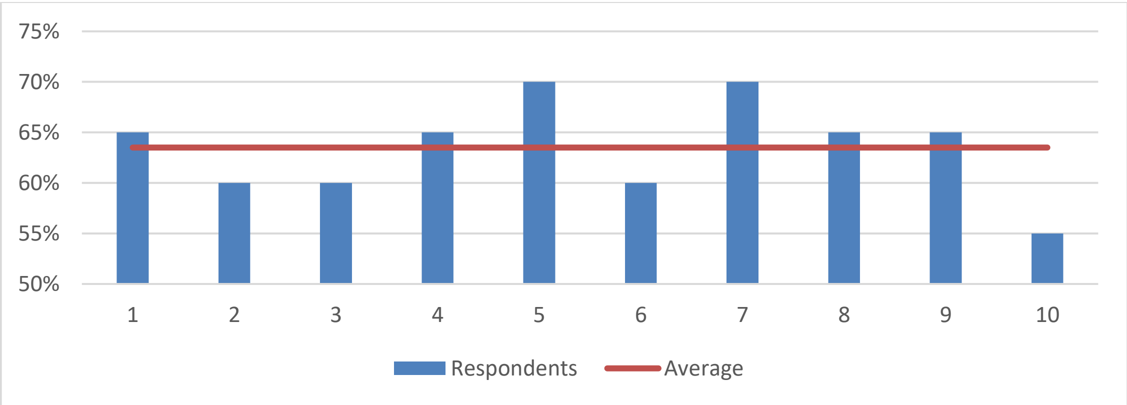

Figure 3: Estimation of leverage on Corporate PPA based offshore wind parks, visualized per respondent.

The respondents have also indicated that leverage on itself is a result of the DSCR, which can vary per production stream. 5 out of 11 respondents have indicated a DSCR under Corporate PPA circumstances. The respondents have also indicated that the DSCR strongly depends on the PPA type and the credit rating of the offtaker. The respondents have therefore indicated that such a DSCR can vary significantly per project. As visualized in Figure 4, an average DSCR of 1.27 has been identified, with estimations ranging between 1.25 and 1.30. The respondents have indicated that the DSCR normally ranges between 1.10-1.15.

It should however be mentioned that the leverage shown in Figure 3, is based on the assumption that the production is fully covered by Corporate PPAs. In reality however, the respondents have estimated that it is likely that 10-15% of the production of a wind park will be covered by a Corporate PPAs, because demand is low in the market. This is also broadly in line with the recent PPAs of Ørsted on the Race Bank and Borkum Riffgrund wind parks, which have both covered about 10% of their production over the term of the Corporate PPA (102) (109) (110). For merchant[13] production streams, which are not covered by a Corporate PPA, two respondents have indicated that the DSCR will increase to a range between 1.7-1.8. When applying this increase in DSCR, leverage will decrease. However, these increased DSCRs cannot be taken as a proxy for the leverage of merchant wind parks. This is based on the respondents stating that a fully merchant wind park cannot be financed, since there is no revenue security. Therefore, This DSCR range can only be applied to a production stream which is not secured in revenue, and which is only a minor part of the total production of a wind park.

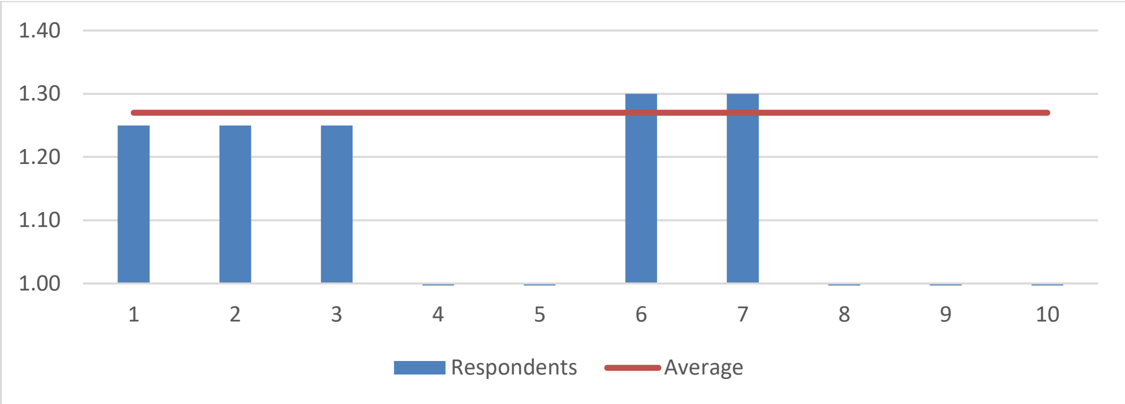

Figure 4: Estimation of the DSCR on Corporate PPA based offshore wind parks, visualized per respondent.

Interest

6 out of the 10 respondents have estimated the interest levels. The consensus amongst financiers is that this is hard to forecast, since it depends a lot on macroeconomic circumstances. Therefore, a Corporate PPA premium on interest is often supplied by the respondents. This premium is added to the interest the financiers would normally apply to a wind park which secured a SDE+ subsidy. Figure 5 shows the Corporate PPA premium which is estimated by the respondents. The average interest premium under Corporate PPA circumstances is identified to be 1.1%. 5 out of the 6 respondents estimated an interest premium of 1.0%, and one respondent indicated a premium of 1.5%.However, the respondents have also indicated that this strongly depends on the credit rating of the offtaker and the existing exposure of the financier to the offtaker. There is no benchmark for such a risk premium on interest, due to varying influences of these two factors. Financiers could already have a (high) exposure to the offtaking corporate, through other business lines. This could lead to the requirement of a higher interest on a loan to a wind park which has negotiated a PPA with the same corporate, since the risk of repayment is related to the offtaking party.

[13] Merchant wind parks are defined as wind parks which fully rely on selling the produced electricity on the spot market. In this case there is no specific revenue security.

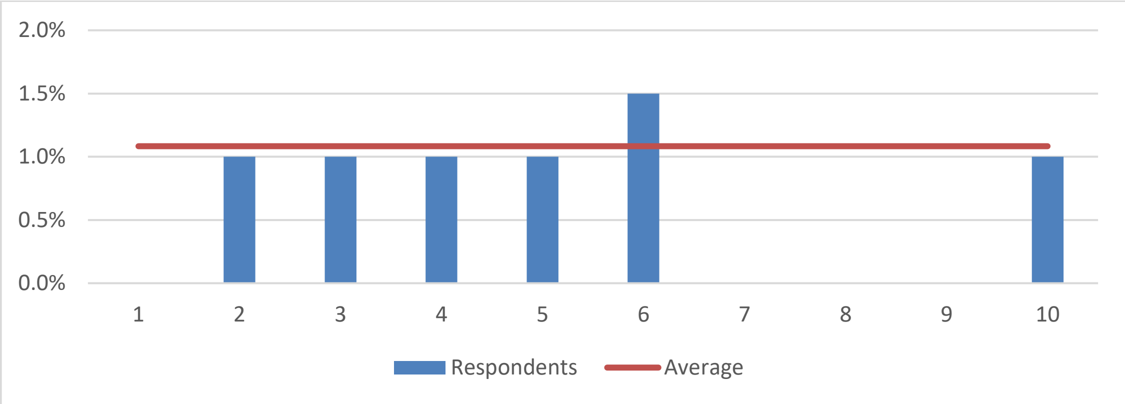

Figure 5: Estimation of the interest premium on Corporate PPA based offshore wind parks, visualized per respondent

7.1.2. Additional services of banks for Corporate PPA based wind parks

Only the financiers and financial advisors indicated that they could discuss this subject. The additional service which a bank could provide is identified to be a financial guarantee on the Corporate PPA offtake. However, the majority of the financiers said that it is unlikely that banks will provide such a service, since it implies significant financial risks. The guarantee is also very much depending on the credit rating of the offtaker. Therefore, the respondents indicated that it is hard to give a view on this matter. Financial advisors have indicated that banks could however be willing to install such guarantees, but that this would only be applied to such small amounts of the Corporate PPA, that is likely to not be significant at all. Larger guarantees would yield a too high risk. Furthermore, a majority of the financiers also indicated that applying a guarantee on a wind park which is funded by the bank itself would not make sense. This would lead to an inefficient roundtrip of money.

7.1.3. Banking regulations

This subject is discussed as a general opening question of the semi-structured interview. Only the financiers and financial advisors indicated that they could discuss this subject. Overall, the majority of the financiers have said that loosening the credit regulations of banks would not yield a larger appetite for Corporate PPA-based or merchant wind parks. The main reason the respondents gave is the fact that the overall risk of the lending portfolio of the bank does not change under a loosening of the regulation. The loosening would only free up more funds for the banks to invest in loans, taking into account the same risk appetite as before.

7.2. Evaluation of the support mechanisms

In this section the support mechanisms will be discussed on their financing implications and practical feasibility. All of the respondents have been able to take part in this discussion. This provides a viewing point from respondents working in the financing industry, financial advisory, power generating industry and energy industry. By acquiring the viewing point of these groups, it is aimed to minimize the bias in this evaluation to the extent possible. The support mechanisms will be discussed per sub group, according to the division made in section 6.4. Per support mechanism the view of each respondent group will be presented.

7.2.1. Support mechanisms to widen the PPA market

The evaluated support mechanisms are:

- Standardized PPAs
- Pooled inter-European PPAs
- PPA subsidy (matched CfD over supply and demand)

Standardized PPAs

The standardized Corporate PPA aims to decrease the strategic risk of agreeing on long-term electricity consumption, by increasing the liquidity of the product. In the standardized form, a PPA is shaped in a ‘PPA block’ with a fixed duration, volume and pricing mechanism. This could increase the production PPA coverage, which can subsequently increase the size and/or lifetime of a project financing facility.

Financiers and financial advisors

Overall, the financiers have indicated that such a concept would only increase the credit risk of a PPA. Furthermore, the majority of the respondents state that they can hardly assess if a company is able to sell the PPAs when it wants to. The Corporate PPA can therefore still run into default. One financier said that *"In the end this doesn't mitigate the pricing risk."* Furthermore, all the financiers indicated that the credit rating of the new offtake party should also match that of the old offtaker. The respondents agreed that the pricing mechanisms of PPAs are finetuned to the seller and the buyer. Where the original offtaker wanted a PPA with a fixed rate, it could be possible that potential new offtakers with a suitable credit rating only want a Contract-for-Difference. As is concluded in Section 7.1, the new Corporate PPA would subsequently not match the project financing risk anymore, due to changes in factors such as the DSCR and the interest rate.

One financier concluded the above by saying that *"Banks can't assess these risks",* where another financier said that a standardized PPA would introduce *"New risks which banks can't - and don't want to - assess, or price, in their loans."* Multiple financiers agreed that PPA engineering should be facilitated by power generators, with one financier stating that *"This should be done by the utilities – they are already credit rated – they will acquire back-to-back PPAs to pass on the risk. "However, if clients don't want PPAs, the utilities don't want the PPAs as well."*

However, one financial advisor said that this concept could work and that *"This would help PPAs to match the lifetime of the project financing facility and improve the liquidity."* Another financial advisor indicated that *"This would help on the financing side of the project."* This advisor also stated that this introduces new risks and that *"This needs the involvement of a hedging party to cover the risks – there is not enough appetite in this market"*

Furthermore, 3 respondents also indicated that such Corporate PPAs can also require the use of financial instruments, which should be used as an insurance to hedge the credit risk of the offtaker. These 3 respondents however deem these instruments to be too costly. One respondent indicated that a bank guarantee from the offtaker could be required, which should cover the cumulative value of all the 'PPA blocks'. Such a bank guarantee is deemed to be too costly for the offtaker. One respondent stated that *"This concept would better suit the onshore wind market – since this market sees smaller and less complex transactions, which require less 'tailored' PPA solutions."*

Furthermore, two financiers also indicated that such a concept would have to be rolled out over multiple countries. The concept would not work in the Dutch market alone, since they deemed the market to be too small. This would introduce new risks, such as a basis risk[14] in the electricity price. Other respondents indicated that the total financial commitment of the combined 'PPA blocks' is still too large to be feasible for corporates, since they have a significant risk that they can't sell the 'PPA blocks' in such a small market. Two other financiers agreed that *"Even for the current PPAs it is not sure if the involved parties are willing to agree on a new PPA upon maturity."* They deemed this concept to be *"Hard to sell."*

Power generators and energy companies

One respondent from a power generator indicated that this could work for the power generators. However, the respondent was not sure if financiers would also be comfortable with this. Furthermore the respondent was *"Not sure it is possible to tie the numbers together."* The respondent however indicated that the credit risk of a Corporate PPA is overestimated. In his experience there have been credit risks in the market which already materialized but turned out to be solvable. Another respondent however indicated that the risk is too high that the product is not sellable, and that *"This introduces a new guarantee problem."* Another respondent said that this does not solve the price risk of a PPA and that *"You will not be able to find a buyer for a PPA if it is 'out of the money'!"*

Conclusion

Overall, the majority of the financiers and the financial advisors indicated that this concept introduces new costs and new risks. Such risks would be too hard to price in the project financing facilities. The consensus between these respondents is also that power generators should take such risks and not banks. From interviews with the respondents from the power and energy industry, it is concluded that they deem this mechanisms to be too risky. One respondent from a power generator however indicated that the financiers generally overestimate the mentioned credit risk, and that they can provide more leeway.

[14] Basis risk: The difference in electricity price movements in different countries.

Pooled inter-European PPAs

The standardized Corporate PPA aims to widen the market by setting up a PPA marketing platform, which covers the trade of synthetic PPAs in the European Union. This would increase the pool of supply and demand for PPAs.

Financiers and financial advisors

Overall, the financiers have indicated that this is already effectively done by power generators. One respondent said that *"This should be done by the utilities – they are already credit rated – they will acquire back-to-back PPAs to pass on the risk."* And that *"They also have the international client pool."* The majority of the respondents agreed that a separate platform is still unlikely to fill the demand, even on European scale. One respondent said that this is already partly facilitated by interconnectors, and that such a platform would not significantly increase the PPA coverage of wind parks. This is also stated by two other financiers who agreed that *"This is not likely to fill 100% of the offshore wind production - this will merely be complementary."*

Another financier also indicated that inter-European PPAs are not very common in the market. However, one respondent stated that this concept would enhance the Corporate PPA market.

The majority of the respondents indicated that an increased offtaker diversification would help to decrease the offtake risk. They also indicated that offtakers prefer pooling, since this also provide them with the opportunity to diversify their exposure over different wind parks. However, they concluded that this is commonly done via utilities.

However, the majority of the financiers indicated that pooling will significantly increase the complexity of Corporate PPAs. Two financiers agreed that "*It is hard to align the interest of all the parties"* and that *"This sounds simple as an idea, but it will be complex and introduce high structuring costs."* Multiple financiers also stated that pooling would also increase the exposure to basis risks[14]. Furthermore, these financiers also indicated that pooling also increases the risk of (partial) contract termination. The credit risk improves, but multiple parties can now pull the plug on PPAs. Furthermore, the majority of the respondents also indicated that it would be hard to implement transport loss corrections via this platform. A financial advisor stated that most of the offtakers base the value of a PPA on the fact that they are supplied directly and that market premiums are not applied to their offtake. The respondent deemed it likely that this effect would be partially diminished when a pooling platform is used.

Power generators and energy companies

Overall, the respondents from the power and energy industry indicated that pooling would lead to complex situations. However, the majority of the respondents thinks that pooling could work, but under a very strict conditions. From the interviews it is concluded that such a platform would be interesting for the energy industry, since it provides commercial channels similar to those of power generators. Furthermore, the respondent said that energy companies are changing into power generators, and that part of this change requires the installation of commercial channels.

One of the respondents from a power generator stated that they are effectively already pooling PPAs for offshore wind parks. However, the respondent also stated that pooling clients into a single PPA would be new. In such a pooling platform the wind parks would first agree upon a PPA with the platform, which is later connected back-to-back to Corporate PPA tranches. The respondent indicated that an inter-European platform could add value by supplying offtake guarantees, from the European Union, on the Corporate PPA tranches. Such a corporate diversification would decrease the risk of the European Union on the full PPA, since a default would not immediately lead to an exposure to the full PPA but only to one or more Corporate PPA tranches.

Another respondent from a power generator indicated that it is likely that such a platform would not work. The respondent deemed the electricity price differences between countries to be too large.

Conclusion

Overall, the financiers and financial advisors do not prefer the pooling mechanism. They have indicated that this mechanism should be developed under the flag of power generators. The implications of such a mechanism would be too complex and could only be handled by power generators. Overall, the power and energy industry respondents have indicated that they are interested in such a pooling system. However, the majority of the financiers and financial advisors have stated that diversification of the offtake, on itself, would work to decrease the credit risk of a Corporate PPA.

PPA subsidy

The PPA subsidy mechanism aims to better match supply and demand, which would mitigate the price risk. The mechanisms consists of two Contract-for-Difference tenders, issued by the government. One contract would cover the generation side via a full CfD. The second tender issues a full CfD on the Corporate PPA. Having exactly reversed pay-out structures for the government, these two tenders could offset each other and balance the electricity price. The risk of the government is capped by the exposure to the difference between the two strike prices. The closer the strike prices are aligned, the smaller the governmental exposure is. This would eventually effectuate a pricing balance.

Financiers and financial advisors

Overall, the majority of the financiers have indicated that such a 'double-CfD' could work as a concept. However, they also stated that it is likely to become too complex. Two financiers described this by agreeing that *"A CfD could mitigate the price risk for the corporates, and a double 'reversed' CfD could further finetune this."* Another financier stated that *"This will be complicated, but it can certainly serve as a guarantee for aggregators."* These respondents also stated that this would not increase the demand for Corporate PPAs in such a way that it can cover a significant part of the subsidy free electricity production. Therefore, these respondent also agreed that, due to the low Corporate PPA demand, the SDE+ floor-CfD[15] would still work best.

Two financial advisors agreed that it could work as a concept. However, they also indicated that they are not sure if this would only increase the Corporate PPA size for corporates which are already interested, or that this would also attract new corporates. Another financial advisors said that in general a Corporate PPA subsidy could potentially generate the minimum amount of the necessary PPA coverage, but that this is not likely. Furthermore, the advisor also stated that a Corporate PPA subsidy would incentivize consumption and that a FiT Corporate PPA subsidy would therefore not work.

Power generators and energy companies

Overall, the respondents from a the power and energy industry are divided in this matter. One power generator stated that this is not likely to work, and that a floor-CfD would work best. Another respondent from a power generator however stated that such a system would work well and that fitting demand and supply is key to mitigating the electricity price risk. The respondent from an energy company is not sure if this would work, and advised that keeping the SDE+ would be better.

Conclusion

Overall, the majority of the respondents have indicated that a subsidy mechanism would still be most efficient if it is a floor-CfD. The majority of the respondents deems the Corporate PPA market to be too small. Such an incentive scheme for PPAs is therefore not likely to significantly increase Corporate PPA demand. However, the majority of the respondents have also indicated that the concept could work, but that it would also become complex. One respondent from a power generator however stated that this system would be the best solution to mitigate the electricity price risk.

7.2.2. Support mechanisms to decrease the electricity price risk

The evaluated support mechanisms are:

- Subsidized hydrogen PPAs
- Subsidized battery capacity

Subsidized hydrogen PPAs

The subsidized hydrogen PPA aims to incentivize the integration of intermediate sources in the electricity system. Such intermediate sources would provide a storage solution and flexibility in the market, which would mitigate negative pricing. It would also improve the business case for hydrogen production by offshore wind parks since long-term supply is locked in.

[15] Floor-CfD: Contract-for-Difference with a floor price. The maximum possible remuneration from the government to the wind park is the difference between the SDE+ strike price and the floor price. When the electricity price falls below the floor price, the government only remunerates the difference between the SDE+ strike price and the floor price.

Financiers and financial advisors

Overall the majority of the respondents stated that hydrogen is a subject on itself, and that grid flexibility should be incentivized regardless of the Corporate PPA solutions. However, the respondents have also indicated that the conversion of electricity is not likely to mitigate all the risks, with one financier saying *"I would be willing to have a look at hydrogen for sure. However, I don't think hydrogen on itself is can fully cover the solution for the pricing problem."* Furthermore, multiple financiers agreed with one respondent saying that *"The government should be wary to only incentivize price stability and not the overall conversion of electricity into hydrogen."* The majority of the respondents also stated that hydrogen will have to be further integrated into our electricity system, and that therefore it "*Will not mitigate the price risk in the short term."* The majority of the respondents is also not sure if hydrogen will turn out to be the main intermediate source in the future. A respondent agreed on this by saying that (s)he is *"Not sure if hydrogen will still be the go-to solution in a few years."* Two other respondents agreed that *"Technology neutral auctions or subsidies would be better."*

These respondents also indicated that the market is still very immature and that 'inhouse knowledge' is still missing. Furthermore, two financiers and a financial advisor agreed that *"It is hard to assess the production profile of hydrogen – it will not run against any electricity price and preferably not above the hydrogen PPA price."*

However, multiple financiers stated that they could work with hydrogen but only when it is captured in a PPA with significant price security. The majority of the financiers stated that merchant hydrogen will not work for project financing facilities, with one financiers saying that *"Merchant hydrogen is relying on numerous new price factors and production methodologies. Merchant electricity is already too risky, let alone merchant hydrogen."*

Two financial advisors agreed that *"Hydrogen would significantly increase the market stability, however, this should be integrated together with other measures."* Another financial advisor indicated that the business case for the wide use of hydrogen would have to be improved, but that long term PPA certainty could certainly work for both the suppliers and offtakers. However, this respondent also stated that *"Subsidies will still have to be in place to bridge the gaps."* This is also stated by one of the responding financiers, who said that *"Hydrogen has momentum – also, it has seen a few false starts – and hydrogen is likely to only work when subsidized."*

Power generators and energy companies

Overall, the respondents from the power and energy industry indicated that hydrogen should be incorporated in the system, regardless of the question if Corporate PPAs can be effectively de-risked. One respondent from a power generator stated that it is important for the *"Widening of the demand for renewable energy."* Furthermore, the respondent stated that *"There should be a larger SDE++ to further facilitate this."* Another respondent from a power generator said that a hydrogen subsidy would work best in a separate tender parallel to the offshore wind capacity tender. A respondent from the energy industry stated that hydrogen is already used in the energy industry and that further integration in the energy mix would be desirable. However, the respondent also indicated that market players will have to increase their knowledge on this subject.

Conclusion

From the above it can be concluded that the majority of the respondents sees hydrogen as a discussion on itself. The majority of the respondents also agrees that hydrogen, and broader energy conversion, should be incorporated regardless of the question if it could work in a Corporate PPA. The market is deemed to be too small to adequately fill Corporate PPAs for offshore wind in the near term. The majority of financiers is willing to look at hydrogen PPAs, but only when significant price security is incorporated. The financiers have also indicated that merchant hydrogen will not work for project financing, due to the variety of pricing risks involved with hydrogen.

Subsidized battery capacity

The subsidized battery capacity aims to incentivize the integration of storage possibilities in the electricity system. Storage would provide flexibility in the market, which would mitigate negative pricing.

Financiers and financial advisors

Overall, the respondents indicate that storage solutions should be incorporated in the electricity system and not necessarily to offset Corporate PPA issues. One financier agreed on this by saying that *"Similar to hydrogen, storage should be incorporated anyway."* However, the majority of the respondents also indicated that storage should not necessarily be provided by conventional batteries. Two financiers agreed that *"Battery subsidies should* *be detached from offshore wind parks, a more centralized use would better serve the electricity system."* One financiers agreed with this and said that *"Batteries are only financially feasible when they are loaded and unloaded frequently, not sure if this will work for the offshore wind industry."*

Furthermore, multiple financiers also agreed with one respondent saying that *"It is unfair if battery tenders would only be provided to offshore wind parks."* The majority of the financiers and financial advisors also agreed that batteries are not scalable. However, one financier stated that batteries *"Could work in the balancing market as well – which could improve the profitability and offset the low scalability."* However this respondent also said that *"Prices could be low for a significant time – not sure if it is profitable to install such large batteries."* One respondent regarded batteries to be *"Just not scalable."* Multiple respondents also agreed that the battery efficiencies are rapidly evolving, with or without subsidies. These respondents indicated that it is an inefficient use of governmental cash, and that *"It is not efficient if a government suddenly rushes to commit to sub-par batteries."* One financiers however stated that batteries would be a better solution than hydrogen to mitigate price uncertainties in the short-term.

Power generators and energy companies

Overall, the respondents from the power and energy industry indicated that storage mechanisms should be incorporated in the system, regardless of the question if Corporate PPAs can be effectively de-risked. One respondent from a power generator said that a battery subsidy would work best in a separate tender parallel to the offshore wind capacity tender. Another respondent from a power generator indicated that batteries would merely solve the imbalance effect of the electricity price, and not the profile effect. *"This only mitigates a pricing volatility range of €5-10/MWh."* However, the respondent also stated that incorporation of storage would still be beneficial to the electricity system. One respondent from an energy company stated that it is likely not to work, due to the scalability.

Conclusion

Overall, the respondents concluded that storage would have to be incorporated in the Dutch electricity system, regardless of the Corporate PPA price risks. The respondents also indicated that storage would not necessarily have to be provided via the use of conventional batteries. Furthermore, the majority of the respondents indicated that batteries are rapidly evolving, but that batteries are currently not scalable enough. Multiple financiers have indicated that batteries are thus currently not a profitable solution. Two financiers mentioned that battery supply to the balancing market could partly offset the disadvantages of scale. Furthermore, multiple respondents also indicated that batteries could however more efficiently mitigate the pricing risk in the short-term, compared to hydrogen.

7.2.3. Filling the investment gap

The evaluated support mechanisms are:

- Governmental equity investment
- Subordinated public loans

Governmental equity investment

The governmental equity investment mechanism aims to bridge the equity gap, resulting from a decrease in available debt. The government could pool its investment in a portfolio, which could later be sold to for instance institutional investors.

Financiers and financial advisors

Overall, the majority of the financiers and financial advisors have indicated that a governmental equity bridge investment could be effective in the short-term. It is thought that this support mechanisms only has a short-term effect, since it does not solve for the PPA credit risk. The government merely fills a funding gap, without mitigating the effects of Corporate PPAs on financing costs. In the short-term, the governmental investments could chip in the last bit of capital needed to realize wind parks. However, such an investment does not have a sustainable long-term effect since it does not improve the confidence of financiers in the offshore wind market. The investments would work as a plaster instead of as protection; the financiers will still apply the high financing costs and lower leverage. Multiple respondents agreed that the equity investments could be realized via an extension of the NL Invest scheme. Furthermore, the respondents also referred to government-funded Windpark Fryslan, which in their view shows that this support scheme could be feasible.

The respondents are however concerned about the role of the government in the financing process and the operational phase of the wind park. The majority of the financiers agreed with a respondent saying that *"This construction could work, however the government should not take majority shares – we want every shareholder to have skin in the game."* Multiple respondents also raised the fact that the government should not be competitive, with one financial advisor saying *"The government has to provide cheap equity in order to facilitate the financial close of the parks – however it should not be competing with market players!"*

Furthermore, the majority of the financiers also indicated the governmental investment could disturb the voting in a project financing facility. One of the respondents indicated this by saying that *"The government is not purely involved for the financial incentive of the wind park, this could disturb voting within a project financing agreement."* One of the financiers stretched this further, by saying that *"The government should only invest non-convertible equity, which is ranked below the debt, and has no voting rights."* This means that the government would only be there to fund the project, and that potential dividend distributions are made only after the full yearly debt obligation is fulfilled.

Multiple investors also expressed the concern that the government has to be fully committed to the project. One of the respondents indicated this by saying that *"The government should be prepared stay committed to the project in bad times – and has to chip in extra equity when delays materialize."* Furthermore, the majority of the respondents also indicated that the government would have to sell it shares to the market in a given timeframe, since they are convinced that the government should not act as a market player. One respondent expressed this by saying that (s)he is *"Not sure if the government wants to leave when the project generates good cashflows – and should it sell its shares against null costs, to the existing shareholders?"*

The majority of the financiers also stated that a governmental equity mechanism would not solve for the electricity price risk, but only for the temporary decrease in investment appetite in the market. Furthermore, such a support mechanism would also not decrease the risk on the issued debt in a project financing facility. For example one of the respondents stated this by saying that *"Debt is paid before equity, so for the debt risk it does not matter if the equity part is filled - the debt part should be de-risked."* Another respondent said that *"This may provide cheaper equity, but the price of debt will still be high!"*

Also a minority of the respondents also expressed the doubt if this support mechanism will mobilize enough equity to fund all of the equity gaps for the full development up to 2030. One of the financiers indicated this by saying that *"This might only facilitate one or two projects for financiers willing to take this risk – but after that, it is likely that also these investors will not further invest in other projects."*

Two financial advisor also agreed that *"This could stimulate overcapacity in the market, which is the reason of the increased price risk."* However, these two respondents also indicated that this support mechanism could provide a situation where there is enough comfort at the address of the investors. Furthermore, they also agreed that *"The government should also avoid to facilitate parks which are just not technically feasible, due to for instance their location."*

Another financial advisor however stated that there should be enough available equity in the system already, by saying *"(This is) Not per se a necessity - there is enough equity, although expensive."* Furthermore, the financial advisor also stated that *"This is not likely to provide a long-term sustainable offshore wind market – this is merely a plaster on the wound."* However, the financial advisor also indicated that there is no easy ready-made solution, except for the continuation of the SDE+ mechanism. Furthermore, the advisor also stated that *"The governments should be there to mitigate risks – and not to take significant risks themselves."*

Furthermore, the majority of the respondents also stated that the government does not have the in-house knowledge to adequately value wind parks. One respondent indicated this by saying that *"The government is not a financing expert in this field."* Where other respondents agreed with one respondent saying that (s)he is *"Not sure if the government actually wants to do this."*

All in all, it can be concluded that governmental equity investments are deemed to be a viable support mechanism for the short-term. However, the role of the government has to be clearly identified before these investments would be made. This includes voting right distributions and the requirement that the government has a full-equity minority share.

Power generators and energy companies

The majority of the respondents indicated that this could work as a short-term support mechanisms, but that they do not prefer this system. One respondent indicated that this system would not work at all because it does not generate electricity price stability, by saying that *"The SDE+ gave at least a price guarantee, this is now fully gone*."

A respondent from an energy company questions the position of the government in such an investment, by saying *"Does the government want to leave if the project generates cash? If not, will this be an EBN*[16] *construction?"*

One respondent from a power generator said that *"This is possible – as shown by Windpark Fryslan – however, it is not desirable due to a loss in market dynamics."* Furthermore, the respondent also indicated that (s)he is not sure if such a support mechanism can incentivize enough risk appetite to fund all of the upcoming wind parks.

Conclusion

All in all, it can be concluded that governmental equity investments are deemed to be a viable support mechanism for the short-term. The majority of the respondents indicated that this does not provide a solution to the electricity price risk, but that it could bridge the financing gaps which occur in the short-term. The financiers are not provided with a risk mitigated environment, in which they can adapt to new levels of comfort over time, and will thus persist in applying their high financing costs and low leverages over the longer term. Furthermore, the financiers and financial advisors have shown a more positive attitude towards this support mechanism than the respondents from the power generation and energy industry. This could be explained by the fact that the equity investors are exposed to a higher financial risk than the debt investors, since the debt investors are paid before the equity investors. It is namely also indicated by the majority of the respondents that this system would not mitigate the pricing risk, but would merely facilitate the financial close of wind parks. Furthermore, multiple respondent are also not sure if this support mechanism will incentivize enough equity for the full planned development up to 2030.

Subordinated public loans

The governmental subordinated loans mechanism aims to bridge the debt gap, resulting from a decrease in available debt. The subordinated ranking would provide a safety cushion for the other debt providers. Furthermore, the government could apply lower interest rates and a longer lifetime than the commercial loans.

Financiers and financial advisors

Overall, the respondents have indicated that this support mechanism could drive down the cost of capital for wind parks with an increased electricity price risk. The majority of the respondents also indicated that this support scheme would more effectively drive down the cost of capital than the governmental equity investment. All of the respondents also indicated that if a governmental loan should be subordinated to commercial debt and have no voting rights. Otherwise, the loan would not lead to a decrease in cost of the commercial debt.

However, multiple respondents have stated that it should be clear to all lenders what the vision of the government is. These respondents agreed with a financiers, who stated that *"This would solve itself – however, once the commercial leverage goes up again, the government would want to exit the facility."* The respondents indicated that a refinancing might not be that easy at all. The envisaged increase in commercial debt induced leverage would be based on the fact that the government provides low cost subordinated loans. The respondents expressed their concerns about the likelihood that the government would not find new investors who would be willing to lend in the same subordinate manner. A replacement loan by a commercial party is therefore likely to lead to less de-risking at the address of the senior debt lenders.

Two financial advisors agreed that such governmental loans might decrease the market dynamics. However, these two respondents also considered that these loans would effectively facilitate market dynamics which would not have been present at all if financial close was not reached. Furthermore, these respondents also stated that this provides the opportunity for the government to provide debt with a longer lifetime than the commercial debt. Since this decreases the yearly debt obligation, the risk of default on the loan is lower. Furthermore, these respondents stated that the funding gap would have to be filled with expensive equity from risk-taking investors, if the governmental loans would not be present. This would lead to very high costs of capital. The governmental loan structure would prevent such a scenario from happening.

[16] EBN: Dutch state owned financial investor which holds minority shares in Dutch oil and gas projects.

Multiple financiers also agreed that these governmental loans could fill the gap where the EIB previously used to invest. The financiers indicated that the EIB previously invested to facilitate financial closes, but that aggressive commercial debt pricing lead to a decrease of their market share. The commercial debt namely became less expensive than the EIB debt. A minority of the financiers also indicated that the cost of debt issued by the EIB is too high, and that governmental loans can substitute on this basis. However, the majority of the financiers also stated that the government will have to acquire significant in-house knowledge when it wants to successfully set up a lending arm. One respondent stated this by saying that *"You have to make sure there is enough in-house knowledge at the government – this can often be the bottleneck."* Two other financiers agreed that the EIB already has in-house knowledge and that educating the Dutch government could therefore be inefficient. These two financiers also indicated that *"It would be better to attract lenders who lend on project basis – and not on policy basis – since these lenders are more involved in the optimization of the project, they have more skin in the game."*

Two financiers also proposed that it would be even better to convert the subordinated loan into a subordinated grant with no voting rights, which will only be repaid when certain electricity price conditions are met. This would further reduce the cost of debt at the address of the commercial lenders. The respondents however also considered that this could become quite similar to a CfD system. Another financier also indicated that it is not immediately likely that the government would want to incentivize these project with debt. To do so the government would need to attract in-house financiers, it would therefore be cheaper to just incentivize via subsidies. However, the majority of the financiers and financial advisors indicated that the governmental loan in Windpark Fryslan shows that the government is willing to provide this kind of support mechanism. Multiple financiers proposed that the government could extend its Invest NL fund to facilitate debt as well.

One financial advisor indicated that it could well be possible that the governmental debt would become more expensive than the commercial debt, which would only increase the cost of capital of the wind park.

Power generators and energy companies

One respondent from a power generator indicated that this support mechanism can be efficient, on the requirement that it is fully subordinated, by saying that *"This would provide a buffer for the commercial loans, which can therefore be priced cheaper."* All the respondents from the power industry indicated that Windpark Fryslan shows that support mechanism is possible. However, one of these respondents indicated that this could become *"Very bureaucratic."* Both respondents also indicated that the lifetime of the governmental loan could be longer than the commercial loans. A respondent from the energy industry stated that subordinated loans on itself are a good support mechanism, and that this could replace the *"Conservative and expensive EIB loans."*

Conclusion

Overall, the majority of the respondents has indicated that governmental loans can work when they are subordinated to commercial debt. Furthermore, the government should have no voting rights. The majority of the respondents also indicated that this support scheme would more effectively drive down the cost of capital than the governmental equity investment. Furthermore, multiple respondents also indicated that the lifetime of the governmental loan can also be longer than commercial debt, which can drive down the repayment pressure on the wind park.

However, multiple respondents have stated that the investment could be best executed via the EIB since they already have the in-house knowledge. Other respondents however stated that the EIB would require too high costs of debt to effectuate the desired decrease in cost of capital.

7.2.4. Minimizing the investment gap

The evaluated support mechanisms are:

- Governmental offtake guarantee
- Tax incentives on renewable energy investments

Governmental offtake guarantee

The governmental offtake guarantee aims to increase the amount of available commercial debt, resulting from a decrease in credit risk in a Corporate PPA.

Financiers and financial advisors

Overall, the majority of the respondents deems this mechanism to work well. It would provide an increase in revenue security, which would de-risk the debt and increase the leverage opportunities. However, the multiple respondents has also indicated that the government would have to cover for the full offtake deficit, in order to significantly decrease the credit risk. One financier stated that this would not be necessary, but that *"The government could guarantee to cover for an electricity price which covers the cost of debt over the period. The remaining risk should be taken by the equity holders."* Another financiers proposed that the government would not have to provide the full Corporate PPA price, but that it would only have to provide a discounted Corporate PPA price.

Furthermore, a minority of the respondents also expressed their concern that the government would not be willing to take on such a risk. One financier stated this by saying that *"This involves a lot of money, and this will hit very hard when the PPA defaults."* Therefore, the respondents have stated that this would only be practically feasible when the government provides this service for a limited amount of time. One financier proposed that the other offtakers would have to obliged to take over the Corporate PPA after this limited timeframe.

However, multiple respondents also stated that it would not be straight forward to decide which projects are guaranteed, and which not. These respondents note that simply guaranteeing all applying projects would lead to economic inefficient behaviour. Therefore, they propose that a tender scheme is constructed. However, two financiers agreed that *"The government should make sure that it doesn't provide a playing field for cowboys, if a Corporate PPA defaults the offtaker will have be held accountable."*

Furthermore, the majority of the respondents also indicated that such guarantees would only be needed over the lifetime of the commercial loans. In their view, the risk taken by the government would not effectuate anything after this period. However, it should be considered that the financiers are debt advisors, and that a decrease in equity-risk is not their concern.

Power generators and energy companies

A respondent from the energy industry stated that this support mechanism is very desirable, since it provides the necessary revenue security. The respondent also indicated that market players are now seeking guarantees on their recent successful subsidy-free bids, since the market risk turns out to materialize more significantly than expected.

One respondent from the power generation industry indicated that a tender mechanism would have to be constructed to ensure economically efficient behaviour. The respondent also indicated *"This would introduce a new race to the bottom, which will be won by the larger players, and -again- narrows the playing field for the smaller energy producers."* Another respondent from the power generation industry indicated that this would reduce the electricity price risk and increase the revenue security. Therefore, the respondent deems it likely that such a mechanism would work. However, the respondent also notes that the government can only do this for a limited amount of time, since this would otherwise accumulate to a too high financial risk.

Conclusion

Overall, the majority of the respondents indicates that this support mechanism would increase the revenue security and the subsequent leverage opportunities. However, the respondents also indicated that the government can only remunerate the Corporate PPAs for a limited amount of time, due to the financial risks associated with the large Corporate PPAs. Furthermore, it should also be carefully researched how the government will introduce a tender scheme for this support mechanism. An open-door support mechanism is thought to lead to economically inefficient behaviour.

Tax incentive on renewable energy investments

The tax incentive scheme aims to increase the amount of available equity, resulting from a renewable energy investment tax discount.

Financiers and financial advisors

Overall, the respondents are divided about the support mechanism. The majority of the respondents indicates that this might lead to extra offshore wind investments, but that this is likely to be a small top-up instead of a full bridge of the equity gap. One financier stated this by saying that *"This will only increase the investments of the existing market players by a little bit, this won't solve the problem."*

Multiple financiers also indicated that this kind of investment is not healthy for the market, since the tax investors do not have full interest in the performance of the project. Two financiers stated this by agreeing that *"This mechanism is too blunt – now you're depending on the taxable profits of companies. They have no interest in the project."*

The majority of the respondents also indicated that offshore wind investments are so large that, if it would work, it is likely that each project would need multiple tax investors to fully bridge the equity gap. This could lead to a situation where there are a lot of investors present in the project, which would decrease the efficiency of the governance of the wind park.

Power generators and energy companies

Overall, the respondents from the power and energy industry think that this support mechanism would attract extra offshore wind investments. However, they are not convinced that this will lead to investments large enough to bridge the equity gaps.

Conclusion

Concluding from the above, the respondents are divided about the support mechanism. The majority of the respondents indicates that this might lead to extra offshore wind investments, but that this is likely to be a small top-up instead of a full bridge of the equity gap. Furthermore, the majority of the respondents also thinks that this system is not healthy for the offshore wind market since potential tax investors do not have a full interest in the project.

7.3. Top 3 support mechanisms

Every respondent has been asked to provide a top 3 of the most preferable support mechanisms, based on the practical feasibility and the potential to facilitate financial closes of offshore wind parks. The top 1 mechanism gets awarded 3 points, the top 2 mechanism gets awarded 2 points, and the top 3 mechanism gets awarded 1 point. Having interviewed 14 respondents, the maximum score for a mechanism can be 42 points. This has resulted in the following top 3 of mechanisms, which scored the highest amount of points:

1. Governmental offtake guarantee (22 points)
2. Subordinated public loans (17 points)
3. PPA subsidy (14 points)

When providing their top 3s, most of the respondents have indicated that they don't think only one support mechanism will solve the problem. Most of them indicated that a combination of the evaluated support mechanism should be enforced. Furthermore, multiple respondents have also said that they have not included the hydrogen and battery capacity subsidy in their top 3 since they are convinced that these solutions have to be incorporated either way, regardless of the corporate PPA problems. A list which contains the scores of all the mechanisms is supplied in Table 16 in the Appendix C.4.

It is also observed that multiple respondents decided to only include one of the governmental investment mechanisms in their top 3, either the subordinated public loans or the governmental equity investment. When doing so, the respondents stated that they wanted to include a variety of mechanisms in their top 3, since they are convinced that this would better represents the full package of measurements the government would have to enforce in the upcoming years.

Furthermore, when choosing the CfD PPA subsidy, the majority of the respondents has stated that they chose this mechanisms because of either the demand matching property of the tender scheme, or the fact that it still subsidizes the electricity generation. Multiple investors have also stated that they have not chosen the CfD PPA subsidy mechanism because they prefer the old SDE+ system. From all the respondents, 64% has stated that their most preferable option is the continuance of the SDE+, or the introduction of a CfD variant.

The majority of the respondents, which chose the governmental offtake guarantee as their top 1 mechanism, stated that the increased revenue security is the most desirable attribute of this mechanism.

8. Cost calculations

In this chapter the top 3 of support mechanisms from Chapter 7 will be evaluated on their cost implications for the Dutch government. This will be executed by standardizing the cost, per support mechanism, for a reference wind park and for the full 6.8GW pipeline. These costs will be compared to a SDE+ reference scenario.

The following 3 support mechanisms are evaluated:

1. Governmental offtake guarantee
2. Subordinated public loans
3. PPA subsidy

Section 8.1 will discuss the calculation of a LCOE range, based on the SDE+ reference scenario. Section 8.2 will cover the evaluation of each of the 3 support mechanisms. Section 8.3 compares the cost behaviour of these mechanisms and discusses the pros and cons of the implementation of these mechanisms. Section 8.3 will conclude by providing a recommendation for which system should be implemented by the Dutch government.

8.1. Reference scenario

Since the top 3 of the support mechanisms consists of a variety of mechanisms with different cost behaviour, an initial comparison on LCOE is performed. For instance, a governmental guarantee would not imply a direct expense by the government, where a subordinated loan would require large upfront expenses. The PPA subsidy would require yearly expenses.

The reference scenario LCOE is calculated as a price range, based on a deviation in the cost parameters which are supplied in section 7.1. The LCOE of a project is determined using the following formula (15) (16):

$$LCOE = \frac{CAPEX + \sum_{t=1}^{L} \frac{OPEX}{(1+i)^t}}{\sum_{t=1}^{L} \frac{AEP}{(1+i)^t}} \qquad \textbf{(Eq. 1)}$$

The WACC is the weighted average cost of capital and equals the average required return on debt and equity, as shown in the following formula:

$$WACC = \frac{E}{V} * R_e + \frac{D}{V} * R_d * (1 - tax) \qquad \textbf{(Eq. 2)}$$

Since interest is paid before tax, the cost of debt would act as a 'tax-shield' since it lowers the amount of taxable income. Therefore, the multiplication with (1-tax) is included in the WACC formula. Further elaboration on the cost calculation methodology is supplied in Chapter 1. The values which are used for these calculations are shown in Table 17, Table 18 and Table 19 in the Appendix D.1. The metrics are retrieved from research by Lensink and Pisca (24), the dataset used for the quantitative analysis, and the semi-structured interviews. The technical project parameters used in this thesis are retrieved by taking the average of the ranges which are used by Lensink and Pisca. Only the loan lifetime, leverage, return on equity and cost of debt are deviating over the scenarios. The technical 'project metrics' will be held constant, and are shown in the Appendix D.1. in Table 17.

The Corporate PPA scenario leverage is concluded from the interviews, and can be found in Table 19.The interviews yield the conclusion that the majority of the financiers is not willing to finance a production stream without any form of revenue security. The resulting WACC and LCOE are listed in Table 5 and the scenario LCOE ranges can be found in Table 5.

Table 5: Cost calculation results for the evaluation scenarios

Scenario	WACC (%)	LCOE (€/MWh)
SDE+	3.1 – 3.9	41.9 – 43.3
Corporate PPA	5.2 – 7.1	45.6 – 49.0

As can be seen in Table 5, the LCOE of offshore wind increases significantly when the revenue security decreases. Compared to the SDE+ scenario, the average LCOE of Scenario 2 increases with 11%.

8.2. Evaluation of the support mechanisms

In this section the support mechanisms will be evaluated over the Corporate PPA scenario, based on the nature of the associated governmental expenses and the ability to decrease the LCOE. The decrease in LCOE will be monitored with respect to the ability to effectuate the LCOEs of the SDE+ scenario, which are defined in Table 5.

When calculating the total governmental costs a total offshore wind development of 6.8GW is assumed. This comprises the following wind parks, which are listed on the Routekaart Wind op Zee (34):

- Hollandse Kust Noord (700MW)
- Hollandse Kust West (1400GW)
- Ten Noorden van de Wadden (700MW)
- IJmuiden Ver (4000GW)

8.2.1. Corporate PPA coverage

Public subordinated loan

As listed in Table 19, the commercial leverage on a wind park is 55-70% in Scenario 2. The SDE+ scenario assumes a 80-85% leverage. Therefore, the debt gap which the government should supply ranges between 10-30% of the total investment needed per wind park. When assuming the 6.8GW development plan and an average Capex of €1.75m/MW, this could yield governmental debt investments between €1,190m - €3,570m.

Furthermore, such a debt investment does not automatically lead to the same WACC as the SDE+ scenario, since the interest on the commercial debt has increased in the corporate PPA scenario. Since a governmental subordinated loan yields to two different debt facilities, a blended WACC has to be calculated. This yields to the below calculation, for the 'blended' WACC. The lower and upper limit for the governmental debt packages is presented in

Table 6. The below formula is a modified version of the WACC formula which is presented in paragraph 8.1.

$$WACC_{blended} = \frac{E}{V} * R_e + \frac{D_{comm}}{V} * R_{d,comm} * (1 - tax) + \frac{D_{gov}}{V} * R_{d,gov} * (1 - tax) \qquad \text{(Eq. 3)}$$

Table 6: Extreme cases of the required interest on public subordinated loan to effectuate the lower and upper WACC of the SDE+ scenario, under 100% Corporate PPA coverage assumptions

Scenario	Blended WACC (%)	Equity portion (%)	Commercial debt portion17 (%)	Governmental debt portion[17] (%)	Commercial interest (bps[18])	Governmental interest (bps[18])
Upper case	3.9	15	55	30	300	**383**
Lower case	3.1	20	70	10	400	**-1900**

As is visible in Table 6, the required negative interest for the lower case scenario shows that this support mechanism has its limits when it comes to effectuating the WACC. Figure 6 shows the full range of possible combinations of debt portions and interest rates of the public subordinated loan facilities, to stabilize the WACC at 3.1%. As one can see, only negative interest rates would effectuate the WACC stabilization. The upper case scenario however shows a required governmental interest of 383bps, which is even 83bps higher than the commercial interest in that scenario. This means that under the most optimistic circumstances, and under the largest governmental debt investment, the government can effectively reduce the WACC. However, when changing the commercial interest

[17] 'Debt portion' is defined as the share of the loan in the total project investment.
[18] bps is the abbreviation for basis points, which equal 0.01%.

rate in the upper case towards the 400bps lower case scenario, the governmental interest rate moves towards 200bps. This is however still acceptable, when looking at the current interest rates. It can be concluded that the upper case forms a positive scenario for the governmental debt, but that an increase in commercial interest rate relatively quickly forces the interest rate of governmental debt to fall below the commercial rate. It should be noted that these calculations focus on the cost of debt and that the cost of equity is held stable at 12%. An increase in cost of equity would lead to an increase in the WACC.

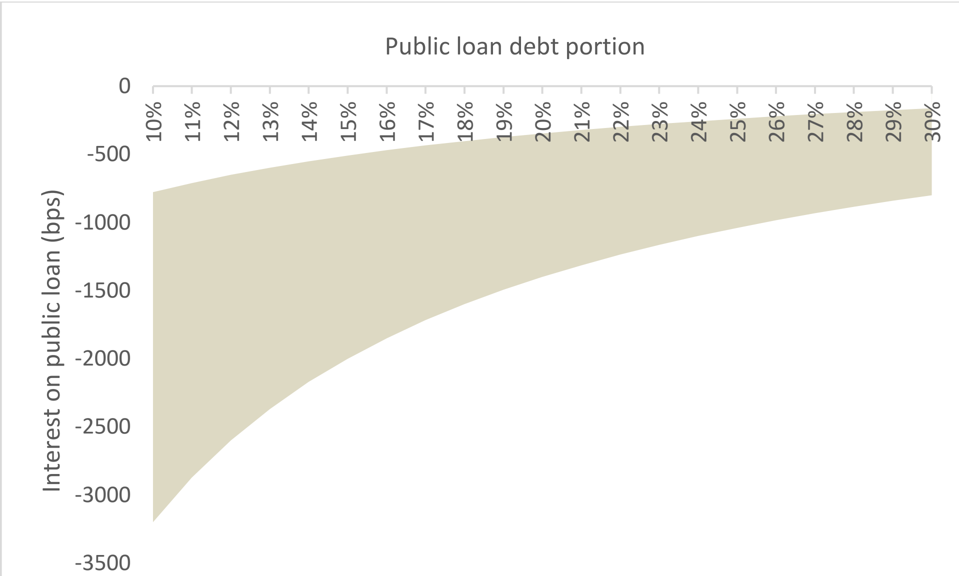

Figure 6: Possible interest rate and debt portion combinations for the public subordinated loans, to stabilize the WACC at 3.1%, in a Corporate PPA scenario. ($R_{d,comm}$ is varied between 300-400bps)

Assuming that a loan is beneficial to a government due to the fact that it is paid back over time, the lowest possible interest rate for a public subordinated loan is fixed at 0bps. An interest rate of below 0bps would nullify the advantage of a return on a debt investment at the side of the government. It could however be considered that a support mechanism should not be installed to be profitable for the government. When the public subordinated loan has an interest rate of 0bps, the minimum WACC will be 3.0% and the maximum WACC will be 4.5%. This is represented by the light and dark blue lines in Figure 7. The full range of WACC possibilities is shown in Figure 7. In this graph the interest on the public loan is held stable at 0bps while the other parameters change between the upside and downside scenario inputs, which are listed in Table 5. The grey area represents all the WACC possibilities resulting from these changing inputs and the public loan debt portion. In the graph, two main grey bands can be identified. These formation of these bands is induced by the change in equity investments by the sponsor, which ranges between respectively 20% and 15% for the upper and lower band. Within the two grey bands the WACC is affected by the change in the cost of commercial debt, relative to the governmental debt portion which is plotted on the x-axis.

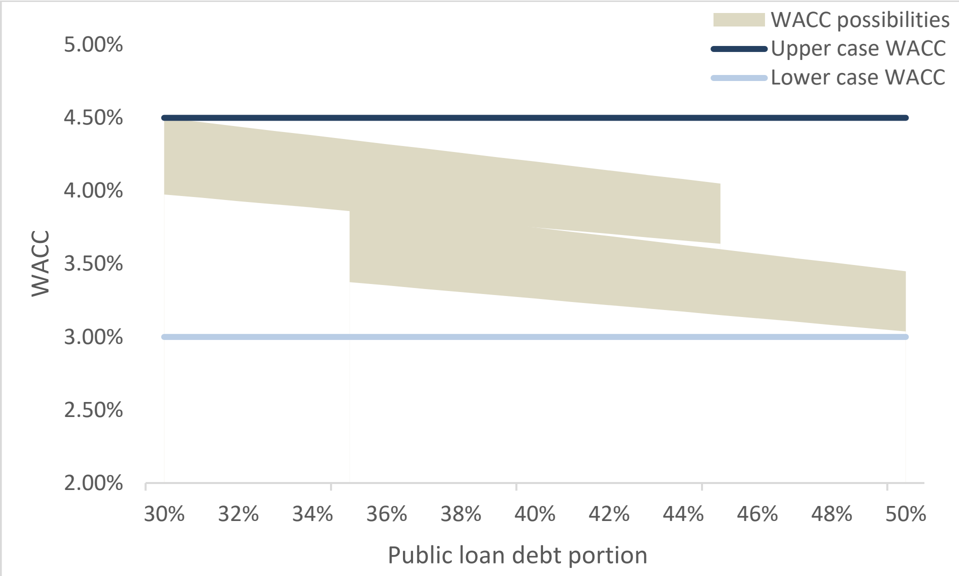

Figure 7: The grey areas visualize the WACC as a function of the public loan debt portions, while varying the equity investment portions and cost of commercial debt. The cost of governmental debt is held constant at 0bps. The variations are limited by the bandwidths which are presented in Table 19.

However, as identified in Chapter 7, one of the advantages of a public loan is the opportunity to install a longer loan lifetime than the commercial loans. The above shown WACC calculations are based upon a public loan lifetime which equals the commercial loan lifetime. To assess the influence of the public loan lifetime, the LCOE range has to be identified. As can be seen in Figure 8, by changing the length of the public loan one can decrease the LCOE of an offshore wind park, so that it falls within the LCOE range of the SDE+ scenario. The orange upper and lower limit lines represent the resulting LCOEs when the extreme cases are ran through the calculations. The grey area represents the LCOEs which result from all possible changes within the parameters, when the parameters are held between the upper and lower extreme cases. The inputs for the extreme cases can be found in Table 5.

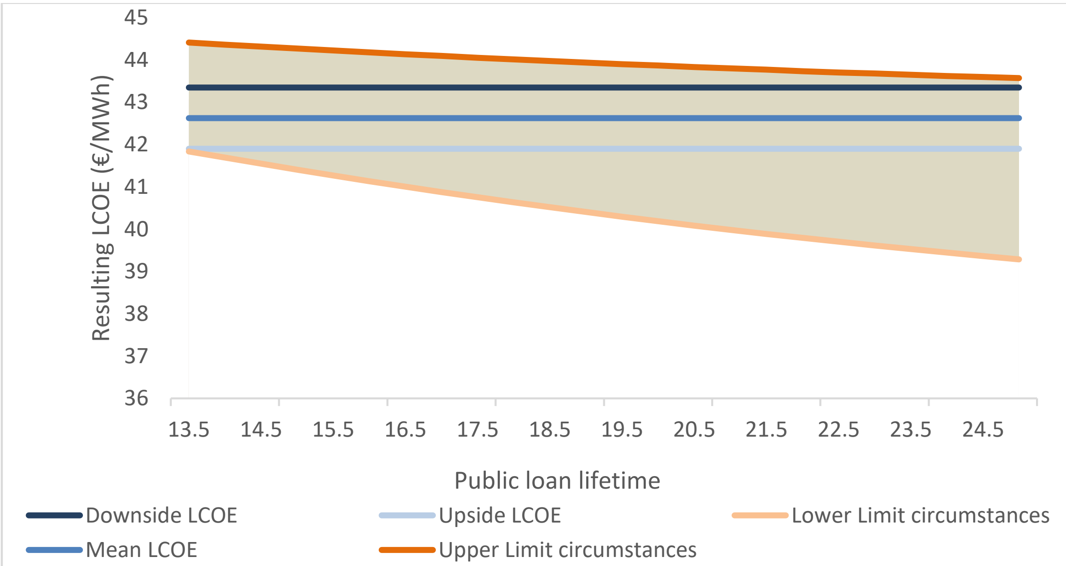

Figure 8: Possible LCOEs per lifetime of a 0bps public subordinated loan, in a 100% Corporate PPA scenario. The LCOEs in a SDE+ scenario are provided in blue, for reference. The boundaries of the area are highlighted in orange, and relate to the circumstances implied by the limits provided in Table 19.

Reflecting on Figure 8, it can be concluded that an LCOE of €42.6/MWh can be achieved by the governmental debt investments, which range between 10-30% of the total CAPEX. This is however based on a stable cost of equity of 12%. Would the cost of equity increase, the government could also have to supply loans with a longer maturity to balance the effect. When considering an average CAPEX of €1.75m/MW, as stated in Table 17, this would yield a total governmental investment between €122.50m - €367.50m for a 700MW wind park such as Hollandse Kust

Noord. For the total 6.8GW development pipeline this would boil down to a governmental investment range covering €1,190m - €3,570m of upfront investments, which are later repaid.

Governmental guarantee

When assessing the impact of the governmental offtake guarantee, the guarantee first has to be parametrized over its insurance period and length of the offtake period. Furthermore, the role of the government has to be materialized further in order to assess the governmental risks and costs. The guarantee parameters will be discussed first, followed by the description of the government's role in this mechanism.

Reflecting on the interviews, it is concluded that a guarantee would only be successful in maintaining the SDE+ LCOEs if it covers the full electricity price as stated in the original Corporate PPA. Furthermore, the offtake period would have to match the full lifetime of the commercial loan. The insurance period, the period in which the guarantee can be realized, would not have to be longer than the lifetime of the commercial loan. However, from the interviews it is also concluded that the government could not be willing to take on offtake periods with lengths larger than 5 years since this could induce a too large financial risk. The scenarios can be found in Table 7. It deserves attention to note that the insurance period can be longer than the original PPA offtake period. This however provides a situation where another PPA can be negotiated which can take over from the old one after maturity, while still maintaining the guarantee mechanism. This could provide comfort at the address of banks. The instalment of a longer insurance period provides the opportunity to accumulate PPAs over a longer period in time. This could be an advantage if the market is already saturated when the first PPA is negotiated.

Table 7: Governmental offtake guarantee scenarios

Scenario	Offtake period (years)	Insurance period (% of loan lifetime)
Scenario 1	13.5	100%
Scenario 2	10	100%
Scenario 3	5	100%

When defining the role of the government, it can be concluded that it would be fair when the government receives the electricity it remunerates. When the government would only provide the remuneration without receiving the electricity, the wind parks can still sell their electricity on the spot market. Assuming positive electricity prices, this would lead to the undesirable scenario where the government helps wind parks to increase their profitability in the event of Corporate PPA default. To avoid such a scenario, the government would have to be entitled to receive the electricity it pays for. However, to avoid large transactions of money the government can also install a CfD which offsets the Corporate PPA strike price against the spot market price. If the spot market price is higher than the Corporate PPA strike price, the difference would be paid by the wind park operator the government. In the case of a spot market price which is lower than the Corporate PPA strike price, the government pays the difference to the wind park operator. In both cases the operator would sell the electricity on the spot market. This would yield the same revenue at the side of the wind park operator as when the government buys the electricity directly.

In the event of the government buying the electricity, the government has to decide how it will use the electricity. Considering that the government would not have a variable electricity consumption large enough to cover the Corporate PPA volume, the electricity would have to be sold. This would also partly repay the expenses made while remunerating the wind park. The government could decide to either sell the electricity on the spot market during the offtake period, or it could decide to install a back-up PPA with a power company which will buy the electricity during this period. Such a PPA with a power company could (partly) mitigate the merchant risk the government experiences when the electricity would have to be sold at the spot market.

Furthermore it could be considered that a corporate, with high electricity consumption production processes, could default on its Corporate PPA when the electricity prices on the spot market are of such a low extent, for a longer length in time, that the corporate is not competitive anymore. Assuming these lower electricity prices, the government would want to mitigate these losses via a back-up PPA. Furthermore, assuming a full default of the corporate on the back of its Corporate PPA, selling all of the electricity on the spot market could impact the prices to decrease further since supply suddenly increases while demand stays the same.

When the financing conditions for the SDE+ scenario, shown in Table 18, are to be applied to a Corporate PPA-based wind park, one has to make sure that the same remuneration security as with the SDE+ is applied. A Corporate PPA would only have the same security as the SDE+ scenario when it is guaranteed by the Dutch government. Therefore, SDE+ financing conditions can't be applied over a time length which is longer than the guaranteed offtake period, which is shown per scenario in Table 7. The SDE+ financing conditions can only be applied to a period where the financier is absolutely certain that the governmental guarantee can cover the cash flows which are needed to repay the debt.

To secure that the financing period is fully guaranteed by the government, the SDE+ financing conditions can only be applied from the start of production till the guaranteed offtake period is reached. In the event of for instance Scenario 2 this would mean that SDE+ financing conditions can only be applied to the first 10 years. The remaining 3.5 years can be covered assuming the Corporate PPA conditions, which are shown in Table 19. When the Corporate PPA has not defaulted yet, and the lifetime of the wind park reaches the point where the remaining years can be fully covered by a governmental guarantee, the debt could be refinanced. In this refinancing the cost of debt will be changed to SDE+ financing conditions, shown in Table 19, for the remaining years of the loan. In the event of for instance Scenario 2 this would mean that the SDE+ financing conditions can be reinstalled after 3.5 years, for the remaining 10 years of the loan lifetime. This would not change the leverage applied to the wind park, since the debt investment is calculated under the assumptions before the refinancing took place. Therefore, the proposed refinancing includes a change in cost of debt (interest) which is applied to the outstanding debt.

When calculating the costs of this financing structure, both the cost of equity and the cost of debt are averages of the SDE+ scenario and Corporate PPA scenario, shown in Table 18 and Table 19. The averages are calculated by weighting the costs over the time length to which the scenario conditions apply. The LCOE ranges are created by alternating between the lower- and upper limit parameters, which are shown in Table 18 and Table 19. For the calculation of the LCOEs Equation 1 is used. The results are shown in Figure 9.

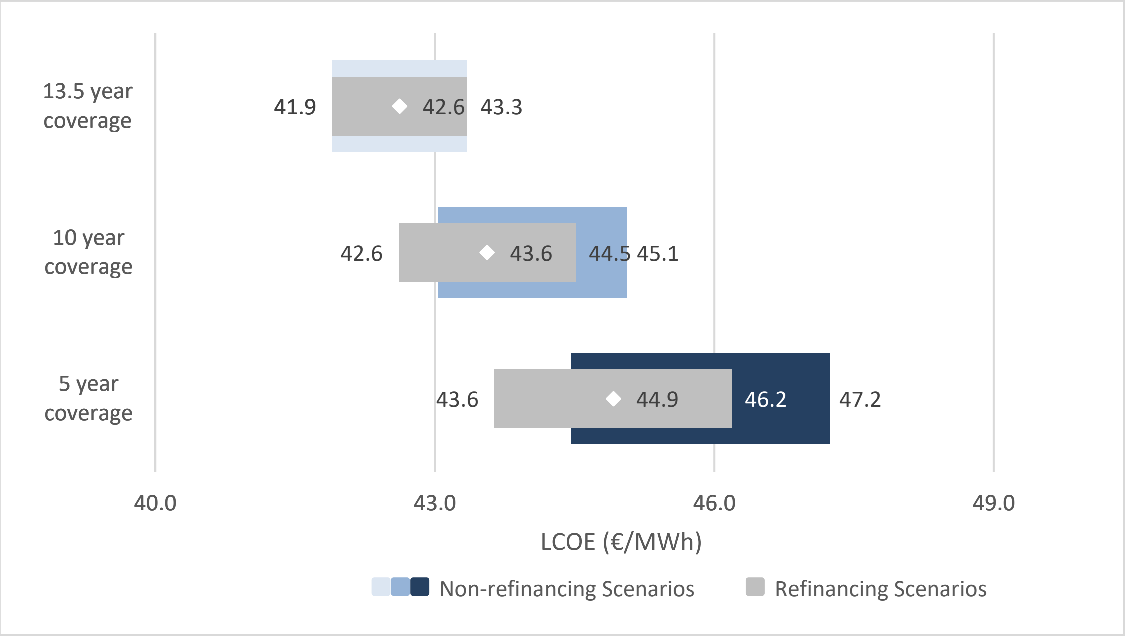

Figure 9: Visualization of the LCOE ranges per coverage scenario, distinguishing refinancing effects

Reflecting on Figure 9, one can conclude that the governmental guarantee can effectively lower the LCOE of the wind parks. As visible in Figure 8, the Corporate PPA scenario would cover the range of €41.9 - 46.2. All to the three scenarios presented in Figure 9 cover ranges below the LCOE range of the Corporate PPA scenario.

Overall, it is visible that a guarantee can effectively lower the LCOEs of wind parks. However, this is depending on the lifetime of the offtake guarantee. When comparing the calculated LCOE ranges to the LCOE range of the SDE+ scenario, visualized in Figure 8, it can be concluded that all of the three guarantee coverage scenarios can effectuate LCOEs in the range of the SDE+ scenario.

For this support mechanism the government would only have to remunerate when a Corporate PPA runs into a default. Therefore, this support mechanism does not imply the necessity of expenses. However, when a Corporate PPA runs into a default the costs of the government can become very high. For instance, if the government was to remunerate a 13.5 year Corporate PPA over its full lifetime, by paying a price within the identified LCOE range stated in Figure 9, this could incur costs between €1,821-1,884m. It is important to note that this governmental expense range is not corrected for the revenue the government can generate when the electricity is sold on the spot market. Assuming a spot price equal to the long term base electricity price of €29/MWh (119), the net costs for the Dutch government are significantly lower. This is shown in Table 8.

Table 8: LCOE ranges and net governmental costs associated with materialized guaranteed offtake periods and a sale of the electricity on the spot market

Scenario	Offtake period (years)	Difference in electricity price (€/MWh) [19]	Governmental expenses (€m)
Long	13.5	9.1 – 14.3	561 – 624
Medium	10	14.0 – 14.3	452 – 462
Short	5	*Too high LCOE range*	*Too high LCOE range*

PPA subsidy

When assessing the impact of the PPA subsidy, the mechanism first has to be parameterized over its price intervals. These intervals determine the eventual costs for the Dutch government. As discussed in Chapter 6, this subsidy is based on two CfDs, respectively on the production and consumption side. The working mechanism is depicted below in Figure 10. It is important to note that this system is not based on a fixed price PPA between a consumer and the producer. In fact, the consumer pays the spot price directly to the producer. The CfDs with the Dutch government run parallel to these transactions.

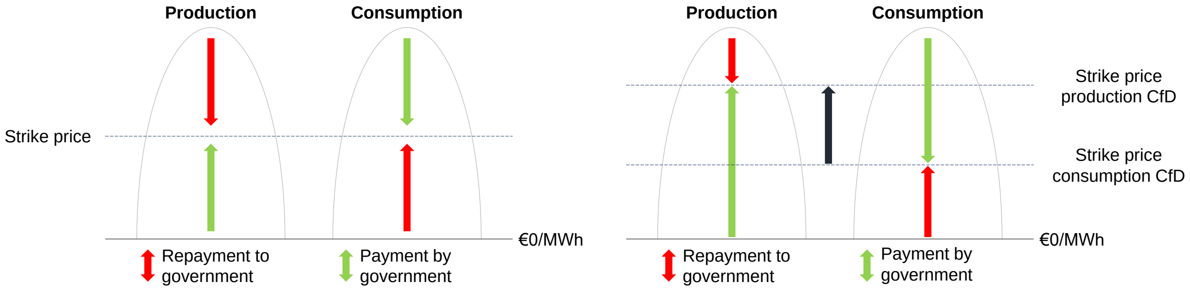

Figure 10(left): Balancing mechanism with equalized strike prices.
(right): Balancing mechanism with difference in strike price. Exposure of government is marked in blue.

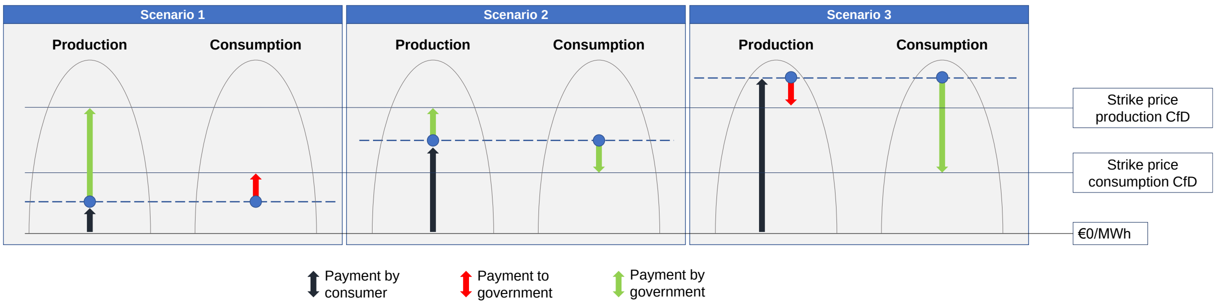

Figure 11: Different electricity price scenarios, showing that the governmental exposure always equals the difference between the two strike prices. Dashed lines represent the electricity price applicable to the scenario.

As is visible in Figure 10, the exposure of the government equals the difference between the two strike prices. This is also visualized in Figure 11, which shows the payments which result from each scenario. Scenario 1 represents an electricity price below the strike price of the consumption CfD. Scenario 2 represents an electricity price between the two strike prices. Finally, scenario 3 shows the cash flows resulting from an electricity price above the strike price of the production CfD. Therefore, this working mechanism would work best when the supply and demand

[19] Calculated from the lower limit LCOE of the applicable scenario till the €43.3/MWh LCOE limit of the 'Long' guarantee scenario. The use of large LCOEs would not resemble an effectuation of a LCOE within the original SDE+ range.

prices are situated as close as possible to each other, if not equal to each other. This could best be effectuated when supply and demand are matched in the market. This would balance the market with pricing in the vicinity of the production or consumption strike price. The auction on the consumption side are opened for bids varying in offtake volume and strike prices. This way, the government can aggregate smaller Corporate PPAs so that the production of the wind park can be covered. Using this mechanism, the government would only pursue a new auction for a new wind park if the previous auction is fully filled on the consumption side as well. This would stabilize the electricity price and thus mitigate increases in volatility.

If this mechanism would have to maintain the electricity prices at the LCOE level of the SDE+ scenario (Table 5), the production strike price should equal these LCOEs. In order to calculate the governmental costs, a range of strike prices also has to be set for the consumption side; the Corporate PPA. From the interviews it is retrieved that PPA pricing levels are often negotiated just below the floor of the CfD in the SDE+ mechanism. Based on these interviews, the Corporate PPA price has been set between the floor of the SDE+ for Borssele III&IV. The floor price of the SDE+ for Borssele III and IV is assumed to be €29/MWh (119). The floor price is decreased by 10% to form the lower limit of a range of Corporate PPA prices. This is visualized in Table 20.

As is visible in Figure 12, the governmental expenses decrease alongside the decrease in target LCOEs, which are the strike prices of the production side CfDs. This is caused by the fact that decreasing target LCOE prices move closer to the Corporate PPA strike price of €29/MWh. This decreases the difference between the strike prices, which equals the governmental expense. By steering the demand side of the electricity market, via the tenders, the mismatch between the consumption and production strike prices would further decrease. This enhances the reliability of the market, and thus the financing opportunities, and decreases the costs of the government.

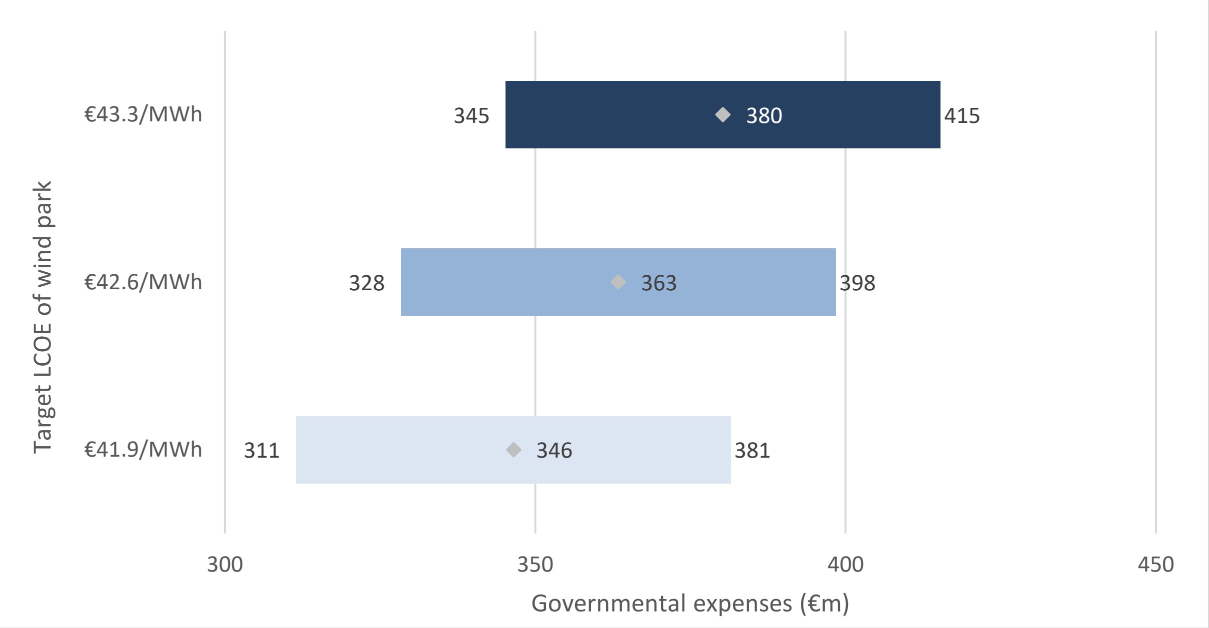

Figure 12: Governmental expenses per target LCOE, based on a consumption strike price range between €26.1-29.0/MWh

Varying the target LCOE prices of the SDE+ scenario (€41.9-43.3) lead to governmental expenses ranging between €311-415 per 700MW wind park. For the average LCOE of the SDE+ scenario, €42.6/MWh, the governmental expenses range between €328-398m, which has an average of €363m. For the 6.8GW pipeline this would accumulate to an average total governmental expense of €3.5bn.

8.3. Comparison of the scenarios

In this section the support mechanisms will be compared, based on the nature of the associated governmental expenses and the amount of governmental expenses needed to stabilize the LCOE at the SDE+ scenario range (€41.9 - 43.3/MWh).

When comparing the support mechanisms on guaranteed governmental expenses, the PPA subsidy is the most expensive support mechanism. This is due to the fact that this mechanism is based upon governmental payments in the CfD mechanism. The subordinated loan and offtake guarantee are not based upon fixed payments. The subordinated loan is repaid over time and the offtake guarantee is only materialized when a Corporate PPA defaults. Instead of standard payments, the government takes on a risk when installing the latter two mechanisms.

To compare the support mechanisms, the implied governmental expenses are discussed under the assumption that the LCOEs of the wind parks equal the average of the SDE+ scenario, €42.6/MWh. For the PPA subsidy, the governmental expenses can range between €328 - 398m, depending on the mismatch between the strike prices of the CfDs. In the case of a default of a wind park, a governmental loan ranging between €123m - €368m can be lost, as discussed in section 8.2. Based on Table 8, assuming a spot price of €29/MWh, a materialized governmental guarantee would lead to governmental costs in the range of €438 - 591m, depending on the guarantee period. These governmental costs are visualized in Figure 13. It can thus be concluded that under the least favourable circumstances the governmental costs off the offtake guarantee outweigh the costs of the subordinated loan and the PPA subsidy.

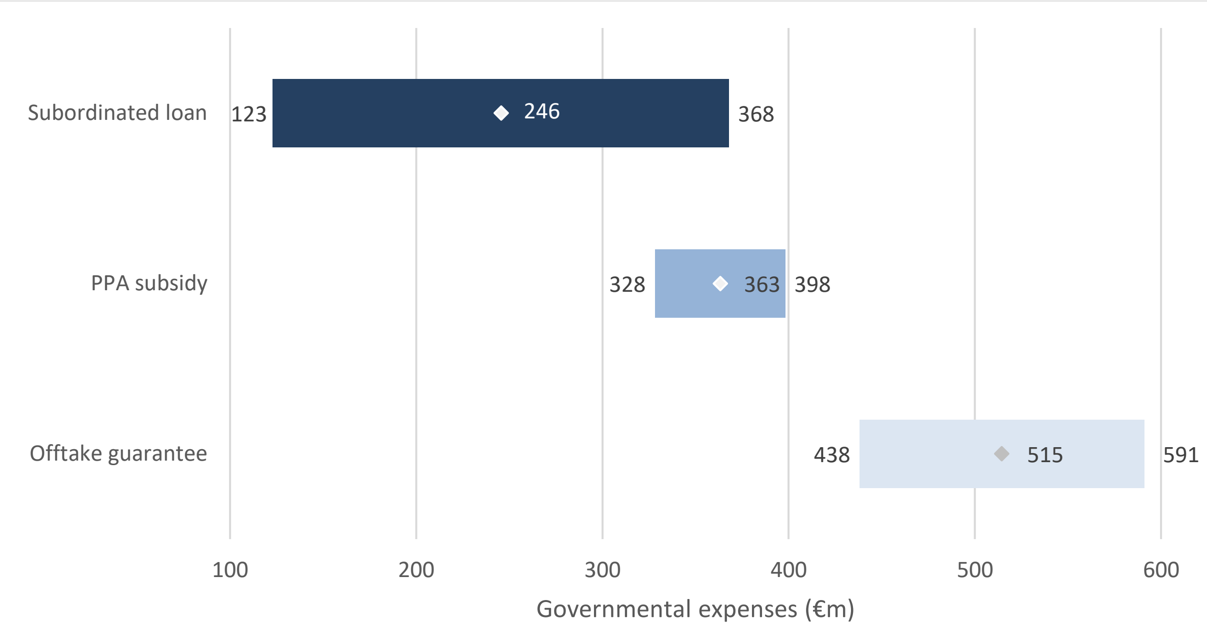

Figure 13: Comparison of governmental expenses per support mechanism, based on an LCOE of €42.6/MWh for a 700MW wind park. The governmental cost of the loan would materialize when the loan is not paid back due to a default. The offtake guarantee range shows the costs for the government when a 10-13.5 year offtake period materializes. Only the PPA subsidy has fixed governmental costs resulting from the application of the mechanism. The other two result from a default of the CPPA of the wind park.

From the two support mechanisms which do not include fixed payments, the subordinated loan and the offtake guarantee, the subordinated governmental loan has the lowest cost at risk. It would therefore be the more cost effective than the offtake guarantee in keeping the LCOEs at the SDE+ levels. However, the loans require large upfront investments, where the other two mechanisms gradually cost money. Furthermore, the lifetime of the public subordinated loans can reach 20 years, leading to a long repayment period. The offtake guarantee could, in the event of no defaults, lead to a combination where no upfront investments are needed and no costs are eventually made. However, the government would need to allocate money in funds so that it can actually remunerate the wind parks in the event of a default. It is discussed that the government could either install a CfD to remunerate the operator, or that the government could literally buy the electricity from the wind park operator. In the event of the latter, the back-up funds could accumulate to very large sums of money, which is shown in the bottom right corner of Figure 14. However, when the government uses a CfD to remunerate the wind park operator, the back-up funds can be smaller since the government does not have to execute transaction which include the full spot market price.

Looking at the ranges presented in Figure 13, if the government only has to allocate a part of these CfD expenses, it could well be that this allocation is smaller than the value of the subordinated loan. This could lead to a situation where the offtake guarantee is more cash efficient than the public subordinated loan, provided that the Corporate PPAs do not default. However, when the Corporate PPAs default, the guaranteed offtake mechanisms induces larger costs for the government, as is visible in Figure 13.

Furthermore, the offtake guarantee directly decreases the credit risk of a Corporate PPA. A subordinated loan only decreases the cost of debt, which has increased due to the credit risk of the Corporate PPA. It could be considered that the public subordinated loan does not directly solve the key credit risk problem, but that it mitigates the implications of the credit risk problem. Additionally, one could also consider that the government should keep its merchant activities as low as possible in a free market. Considering this, the offtake guarantee would also effectuate the realization of a wind park, while leaving the business opportunities to the commercial investors.

The price balancing is not effectuated by a governmental loan, which merely fixes the investment problem by bridging the gap. Looking solely at the stabilization of the demand and supply mismatch, the PPA subsidy would be the best solution due to the matching of supply and demand in its tender procedure. The next production tender would namely only be issued once the demand tender is filled. Such a mechanism could further stabilize the electricity price and make it less of a price risk for corporates to commit to a PPA. Furthermore, the government can also aggregate smaller players by lowering the minimum offtake per Corporate PPA bid. This could enlarge the market for the Corporate PPA. The other support mechanisms do not enlarge the market but merely enhance the financing conditions of the wind parks. For instance the offtake guarantee will only be applied to mitigate financing costs on Corporate PPAs in the current market. The demand for PPAs is thus not enhanced.

However, when looking at the PPA subsidy mechanism, it should also be considered what will happen in the event of a default of (one of) the consumers. To mitigate such a situation, the government could have installed a back-up PPA with a utility, which will acquire the electricity at a small discount. This would limit the risk of the wind park. Another solution would be the combination of an offtake guarantee and the PPA subsidy, where the combination is activated when the Corporate PPA defaults. The government would then buy the electricity against the production side strike price and sell it on the spot market. This combination would however further increase the governmental costs due to the difference between the Corporate PPA and production strike prices. This would however become less costly when the production side strike price is close to the long term average spot price. Considering that the PPA subsidy is already the most expensive support mechanism, a further increase in costs would not be desirable.

When considering an increase in temporary electricity price drops, each of the support mechanisms reacts differently. When the electricity price drops the governmental expense for the PPA subsidy does not chance, since the exposure of the government equals the difference between the production CfD and consumption CfD strike prices. When applying the governmental guarantee, the price drops would induce larger governmental costs since the difference between the Corporate PPA price and the spot price increases. For the public subordinated loan it is important that the debt repayments have to be met each year, this can become harder for the wind parks when the electricity prices drop. However, since the public loan has a 0bps interest component, the pressure on the repayments is eased.

Considering all of the above, the governmental guarantee is deemed to be the most cost effective support mechanism to effectuate a decrease in financing costs. This mechanism both eases the credit risk of the Corporate PPA and can be free of governmental expenses. Although the public subordinated loan would be less costly in case of a default, it could be considered that merchant behaviour of a government should be limited as much as possible in a free market. However, the PPA subsidy mechanism would balance the market in terms of demand and supply. Furthermore, it would also allow the aggregation of smaller electricity consumers and subsequently increase the Corporate PPA opportunities. It would however not fully mitigate the credit risk of a corporate PPA, since the CfDs can't be executed when the corporate defaults.

9. Discussion

In this chapter the research performed for this thesis will be discussed. The discussion focuses on the influences of the research methodologies, the used data, and the assumptions on which the support mechanism cost calculations are performed.

9.1. Research methodology

Firstly, the dataset used for the regressions is relatively small. An extension of the dataset was deemed to be undesirable because this could introduce the influences of technical factors, such as water depth, in the financial data. Furthermore, countries with unstable governmental circumstances could show different comfort at the address of the financiers. This could lead to outliers in terms of low leverage. Although the Jarque-Bera test held for the regressions, a larger sample size could have led to the identification of regressors with lower standard errors.

Furthermore, the models have assumed linear relations which would not necessarily have to be in place in reality. A financing negotiation would not necessarily have to follow linear logic. Also, the model assumed that all regressors function independently from each other. This would not necessarily be the case when a financier is estimating the level of comfort in lending a certain amount of money to the project. In such a process the financier can weigh different regressors against each other, which leads to relations between the regressors. Furthermore, risk management within the financing institutes can also influence the financing negotiations. For instance portfolio management of the financiers and client exposure measures can lead to a difference in lending appetite for new offshore wind projects. It could for example be the case that a financier is not willing to lend to a wind park if the financier is already exposed through other loans to activities of the PPA offtaker, regardless of the wind park itself. It is not possible to catch such effects in when applying the models which are used in this thesis. Further research could work to identify such interrelations.

When making use of the semi-structured interviews, one can retrieve specific in-depth information. However, the interviews can also convey a form of prejudice. Most of the respondents are financiers, which would benefit from governmental support mechanisms when they include as little government influence as possible. Therefore, it could be considered that the need for governmental support mechanisms could actually be lower, or against less stringent conditions, than the financiers state. This can be solidified further, when it is concluded that the financial advisors were less outspoken about the need for, and form of, support mechanisms. Though, it is considered that the respondents represent a good reflection of the industry. Overall, more financiers are present than developers because multiple financiers are needed to realise the capital heavy wind parks.

9.2. Data

When making use of the wind park dataset it should firstly be noted that the data is retrieved from a professional source. However, since investment details are mostly private, it should also be considered that sometimes the data can be based on tips or estimates. However, the dataset provider is also widely used in the financing industry, which enforces the trust in the accuracy of the information. Furthermore, given the detailed nature of the information it is thought that small deviations in the data would not materialize in large differences in outcomes of the regressions.

Furthermore, the wind parks which are used for the dataset also include wind parks for which the investment sum is corrected for offshore connection costs. This is done since the Dutch government funds the offshore connection costs, and not the developer. However, often the offshore connection costs are not mentioned separately in the dataset. Furthermore, the debt for the offshore connection were not always supplied in separate debt tranches. Therefore, one can't specifically assess the debt which is used for the sole construction of the wind park. To make up for this, the portion of the offshore connection in the total debt package is taken pro rata to the ratio between the offshore connection costs and the wind park construction costs. Making these assumptions can lead to the converging of the outcomes of the financial analyses. However, it is considered that with the industry maturing this convergence would not lead to the overlooking of outliers.

9.3. Cost calculations

When discussing the cost calculations the most important subjects are: the electricity price assumptions, the assumptions behind the SDE+ reference scenario, the suitability of the SDE+ reference scenario and the comparability of the support mechanisms.

When setting the lower and upper limits for the parameters used in the cost calculations, the assumptions of Lensink and Pisca are used (24). In this research the costs of wind parks is analyzed per wind park, by varying financing and technical parameters. In this thesis the average of each these applied parameters is used. The research of

Lensink and Pisca focusses on the planned pipeline from the 'Routekaart Wind op Zee'. It is therefore deemed reasonable to take the average of their project assumptions, to provide an outlooks for the near future costs of the support mechanisms. However, the Routekaart Wind op Zee does not look further than 2030. In reality, the Dutch government plans to install much more offshore wind capacity than the 2030 capacity target. This could lead to the necessity to develop wind parks in areas with less favourable wind resources and construction conditions. This could subsequently lead to scenarios which are not comparable with the scenarios used in this thesis. Furthermore, the cost of equity is held constant during the cost calculations, in order to model the influences of the cost of debt on the total costs of the wind park. A deviation in the cost of equity can however lead to significant changes in the WACC of wind parks. This could be subject to further research.

Also, when assessing the costs of the mechanisms it should be taken into account that the evaluated mechanisms differ significantly in their cost behaviour. For instance the governmental guarantee and the governmental loan only materialize into governmental costs when the wind park defaults. Only the PPA subsidy mechanisms incurs direct, and constant, costs. Therefore, it could be argued that the mechanisms can't be compared like for like. However, all of the three support mechanisms represent (partial) solutions or mitigants to a selection of problems which occur from the PPA relying offshore wind industry. Therefore, it is thought to be compare the mechanisms so that one can compare the solvability of the different industry problems which form the basis for the mechanisms. However, since the mechanisms differ significantly in their properties, a common level of comparison had to be created between them. It could be considered that this has led to the situation where the level of in-depth research per mechanism would be relatively shallow. Further research could specialize in one of the support mechanisms and further specify the behaviour under for instance mechanism modifications and different scenarios.

Also, when calculating the price of the PPA subsidy mechanisms a strike price of €29/MWh is used. It could be considered that the electricity prices would have to go up over time, since otherwise it wouldn't be supportive enough for subsidy free offshore wind parks. As a result, a strike price of €29/MWh would be too low when it is used for cost calculations over the longer term, towards 2050. However, for the shorter term the electricity price is still considered to be feasible, since the Dutch energy mix still holds significant non-offshore wind, non-renewable, energy sources. In the near future the demand for higher electricity prices, coming from offshore wind, is therefore deemed to be too small compared to the full energy mix. A higher electricity strike price would lead to lower governmental costs for the PPA subsidy mechanism. Furthermore, it would also decrease the cost at risk for the governmental guarantee.

Lastly, it could also be considered that the LCOEs of the SDE+ reference scenario represent an electricity price range which is not able to sustain subsidy free power generation over the long term. An increase in the LCOEs of the SDE+ reference scenario would however keep the proportional cost relationship between the three mechanisms intact. However, the PPA subsidy mechanisms is the only mechanisms of which the costs for the government are guaranteed. Considering that the other two mechanisms only have costs at risk, the PPA subsidy mechanism would become relatively less feasible. However, taking into account that the €29/MWh base electricity price could be considered relatively conservative, the disadvantage of the PPA subsidy could be offset by a moderate increase in this base electricity price. It is recommended that further research elaborates on electricity price developments, which could later be used as an input to evaluate the three support mechanisms.

The robustness of the guarantee can be assessed by looking at the default rate of larger corporates, who would be interested in agreeing upon PPAs. Overall, the credit rating of corporates can be divided into 'investment-grade' and 'speculative-grade', depending on their financial robustness and indebtedness. The 'investment' or 'speculative' grade refers to the nature of the investment rationale an investor would have when it would invest in bonds of the respective corporate. For this thesis only 'investment-grade' corporates are considered. Reflecting back on the interviews with industry experts, it is concluded that 'speculative-grade' corporates would be considered to be too risky to serve as a reliable PPA counterparty for a project financing facility. Furthermore, it is also considered that a global scope has to be set up when looking for default rates, since larger corporates often have a global nature. From current research of the leading global credit rating agency S&P Global, it can be concluded that 0.060% of the global investment-grade corporates ran into a default over the period 2005-2019 (120). The timespan 2005-2019 has been chosen since this is as long as a potential loan period of 15 years. To check if this period diminishes an uplift in the more recent timespan, the default rate for 2015-2019 is also taken into account separately. According to S&P Global this is 0.02%. The difference between the two default rates is mainly caused by a high peak of defaults during the 2007-2008 financial crisis. Multiplying the average cost at risk for the guarantee by the default rates would give two indications of potential governmental costs over time. Retrieving the cost at risk from Figure 14, this gives a potential cost of respectively €9m and €30m for a 0.018% and 0.060% default rate, for a 700MW wind park. This is still significantly lower than the PPA subsidy, which has an average cost of around €360m.

10. Conclusion

The conclusion of this thesis is structured around the main research objective and the sub research questions. Furthermore, the conclusion will also reflect on the discussion. The main research question answered in this thesis is:

"Identification and cost calculation of WACC stabilizing support mechanisms for new Dutch offshore wind parks, which are funded with PPA based project financing facilities, in a non-SDE and electricity price volatile market"

Reflecting on the discussion and the performed research, it can be concluded that the governmental guarantee is the most suitable mechanism to support PPA based project financed wind parks. This mechanism both eases the credit risk of the Corporate PPA and can be free of governmental expenses. Although the public subordinated loan would be less costly in case of a default, it could be considered that merchant behaviour of a government should be limited as much as possible in a free market. For a 700MW wind park, the governmental costs are estimated to be €515m when a target LCOE of €42.6/MWh is effectuated. This LCOE is the mean of the SDE+ reference scenario, which is used to benchmark the support mechanisms in this thesis. However, it could be considered that the SDE+ reference LCOE would have to be higher to sustain subsidy free renewables over the long term. This would however not change the preference for the governmental guarantee since the benefits, relative to the other mechanisms, still hold.

Below, the main conclusion of this thesis is broken down in sub conclusions which build up to the form the main conclusion. This is done by providing sub conclusions per sub research question. These sub research questions can be found in Chapter 1. Sub research question 2 and 3 are discussed together.

10.1. Sub research question 1

"Do the Dutch renewable energy market characteristics fulfil the requirements for the use of project financing facilities?"

To create a framework for the assessment of the Dutch renewable energy market, the global renewable energy market drivers are firstly identified. This is subdivided into the predominant investors and their investment behaviour. From the research it is identified that offshore wind is often targeted as a subset of infrastructure investments, this sector mainly sees the interest of institutional investors. These investors are specifically attracted to the infrastructure sector because of the long term fixed returns against a low risk profile, which matches their liquidity preferences. Their preferred financing mechanism is often a project financing facility, but the use of (a combination with) project bonds are also increasing. However, project financing facilities are still dominating the market. The main reason for the use of a project financing facility is the opportunity to attract tailored debt with a long repayment schedule.

When assessing the Dutch renewable energy market is concluded that the risks applicable to offshore wind are for a lesser extent applicable to the onshore sector. The onshore sector can also vary in its composition by changing the ratio between onshore wind and solar PV subsectors, which could mitigate the risk of underdevelopment. This is already shown by the changing forecasts of PBL. The onshore sector also sees significantly smaller development investments than the offshore wind sector. The investors in the onshore subsectors are also much smaller and differ from the ones present in the offshore wind sector. The onshore projects are also often supported by local collectives, which co-invest in the park and consume the electricity. Furthermore, relative to offshore wind, it can be concluded that the Dutch government already started to facilitate the onshore market with additional support mechanisms.

Project financing is extensively used in the Dutch offshore wind sector and the onshore sector. When assessing the sectors on the investment criteria, it is concluded that the Dutch market is still very well suited for the application of project financing facilities. Apart from the project financing similarity, it is concluded that offshore wind has little connection to the onshore subsector and that the latter does not face the same problems (yet).

The semi-structured yielded the conclusion that the view generated by the industry assessment is also recognized by market players.

10.2. Sub research questions 2&3

- *"What kind of support mechanisms could act as drivers for the application of project financing to Dutch offshore wind parks?"*
- *"What kind of support mechanisms can best support PPA based wind parks, taking into accounts the risks and uses of PPAs?"*

To answer this sub research question a dataset, comprising financing parameters per offshore wind park, is set up. The analyses performed on the dataset are used to create support mechanisms, which are later evaluated in semi-structured interviews with industry participants.

The offshore wind parks are mainly located in the North Sea or neighbouring areas, to secure the largest comparability between the parks. The dataset is analysed in both a qualitative and quantitative way. From the assessment of the dataset it is concluded that there is little corporate PPA activity going on. Furthermore, the quantitative analysis did not yield any significant effects from PPAs to leverage and financial shareholder presence. This is caused by the fact that little information about the PPA is publicly available, due to its business sensitivity. Furthermore, the corporate PPA industry is still immature and does not provide enough datapoints to facilitate a quantitative analysis.

When evaluating the success factors behind project financed offshore wind parks it can be concluded that leverage positively influences the presence of financial investors. Leverage on itself has a negative effect on the presence of public financing institutes such as the EIB. However, it should be concluded that the presence of such public institutes actually brought about the feasibility of the projects, where they were deemed to be too risky by private institutes. By bridging the financing gap the public institutes made it possible to close the financing of the wind parks. Subsequently, this did not yield the financial structuring with a high leverage, due to the low appetite from the market. Taking this into account, it can be concluded that public loans have had a positive influence on setting up project financing facilities when market risks are deemed to be high.

Furthermore, it can be concluded that a lack of government-backed revenue security negatively influences leverage. The UK namely shows an overall negative effect on leverage. When qualitatively evaluating the data one can see that most of the UK wind parks with a low leverage are supported via the Renewable Obligation scheme. Over time both the leverage and financial investor interest has increased. This can however not solely be explained by the introduction of the Contract-for-Difference system, since the industry has matured significantly over time as well. Furthermore, the UK government has also made use of governmental equity investments through the GIB.

The semi-structured interviews yielded the conclusion that the qualitative and quantitative analysis are validated by the respondents. Furthermore, new factors have been identified which influence the shareholding of financial investors and leverage. These factors have also been assessed during the qualitative analysis and have shown the same positive/negative relation, but did not pass the significance threshold.

Furthermore, the semi-structured interviews yielded the conclusion that a governmental offtake guarantee, a subordinated public loan and a PPA subsidy would best be suited to support offshore wind parks in the Netherlands. However, the respondents have indicated that they don't think only one support mechanism will solve the problem. Most of them indicated that a combination of the evaluated support mechanism should be enforced. Also, the respondents are also in favour of systematic improvements like the creation of hydrogen and battery storage plants. Often, the respondents mentioned that such improvements should be enforced regardless of the current lack of revenue security. Also, multiple respondents have stated that they think the SDE+ tender mechanism would still work best for offshore wind.

10.3. Sub research question 4

"What are the governmental costs of the identified support mechanisms, which are applied to PPA based project financed wind parks?"

To compare the costs of the mechanisms, the cost for maintaining an average SDE+ electricity price of €42.6/MWh is assessed. The costs are evaluated for a 700MW wind park. The PPA subsidy in concluded to yield a governmental expense between €328 - 398m, depending on the mismatch between the strike prices of the CfDs. In the case of a default of a wind park, a governmental loan ranging between €123m - €368m can be lost. A materialized governmental guarantee would lead to governmental costs in the range of €438 - 591m, depending on the guarantee period. However, these costs only materialize if the PPA runs into a default. Over the last 15 years, 0.06% of PPA candidate firms have been found defaulting. Scaling the cost at risk for the guarantee with the default rate yields a total cost which is significantly lower than the PPA subsidy. The governmental subordinated loan is scalable against the same default rate and would yield an even lower governmental cost, based on the lowest cost at risk. However, it is though that the merchant activity of the government should be as little as possible in a free market.

Appendix

A.1. Offshore wind parks

Table 9: Offshore wind parks used for assessment against private investment criteria (Utility owned = no PPA information available, but utility owned, PF = project financing, BF = balance sheet financing)

Wind park	Capacity (MW)	Status	Current owners	PPA	Construction costs (€m)	Financing structure (PPP/PF/BF)
Borssele I&II	752	Development	Ørsted	Alliander	1,500	BF, 30% loan from EIB under review
Borssele III&IV	732	Development	Blauwwind[20]	Eneco (Microsoft), Shell	1,505	PF
Hollandse Kust Zuid I&II	700	Development	Vattenfall	Utility owned	*1,400*	-
Hollandse Kust Zuid III&IV	700	Development	Vattenfall	Utility owned	*1,520*	-
Gemini	600	Operational	Consortium[21]	Delta, HVC	2,839	PF
Luchterduinen	129	Operational	Eneco, Mitsubishi	NS, Utility owned	450	BF
Prinses Amalia	120	Operational	Eneco, Mitsubishi, ING	Utility owned	383	PF
Egmond aan Zee	108	Operational	Vattenfall, Shell	Nuon (Vattenfall)	218	BF

A.2. Onshore wind parks

Table 10: Onshore wind parks used for assessment against private investment criteria (Utility owned = no PPA information available, but utility owned, PF = project financing, BF = balance sheet financing, Consortium = local shareholders)

Wind park	Capacity (MW)	Status	Current owners	PPA	Construction costs (€m)	Financing structure (PPP/PF/BF)
Fryslân	383	Development	Consortium	Eneco	850	PPP and PF
Noordoostpolder	429	Production	See below	See below	See below	See below
NOP Agrowind	*195*	*Production*	*Consortium*	*Eneco*	*420*	*PF*
Westermeerwind	*144*	*Production*	*Consortium*	*Eneco*	*400*	*PF*
Zuidwester	*90*	*Production*	*innogy*	*Utility owned*	*150*[22]	*BF*[22]
Zeewolde	320	Development	Consortium	Vattenfall[23]	500[24]	PF under negotiation
Wieringermeer	300	Development	Vattenfall	Microsoft[25]	396[26]	BF
Windplanblauw	250	Reconstruction	Vattenfall	Utility owned	*375*	BF
Eemshaven	213	Development	Engie, innogy, Consortium	Utility owned, Consortium	*350*	BF
Westereems	168	Production	innogy	Utility owned	*240*	BF
Strekdammen	14	Development	YARD Energy	Utility owned	*21*	PF
Drentse Monden	175	Development	Consortium	Locals	200[27]	PF

[20] Consortium consists of: Partners Group (45%), Shell (20%), DGE (Mitsubishi) (15%), Van Oord (10%), Eneco (10%)
[21] Consortium consists of: Northland Power (60%), Siemens (20%), ALH (10%) (sold by Van Oord), HVC (10%)
[22] innogy mentions its investment, but does not mention the attraction of bank debt (117). The investment figure is however broadly in line with the Westermeerwind and NOP Agrowind total investment figures. Considering innogy is a utility, BF is assumed.
[23] Vattenfall will consume about 90% of the generated energy (124).
[24] The total equity investment in the wind park is €500m (118). Project financing facility is not yet agreed upon. Financial close was however expected end of 2019 (119).
[25] Microsoft will consume 50% of the generated electricity (125).
[26] Pro rata to Vattenfall's €200m investment to start construction of the first 50 wind turbines, out of the 99. Vattenfall does not mention any bank debt or financial close (120).
[27] €200m project financing facility, equity investment information is not available (121).

Prinses Alexia	122	Production	Vattenfall	Locals	*180*	BF
Krammer	102	Production	Consortium	Consortium, Google, Philips, DSM, Akzo Nobel	200	PF
Oostpolder	100	Development	See below	See below	See below	See below
innogy	*32*	*Development*	*innogy*	*Essent (innogy)*	*45*	*BF*
N33	100 - 150	Development	See below	See below	See below	See below
Eekerpolder	*45 - 60*	*Development*	*innogy*	*Essent (innogy)*	*75*	*BF*
Vermeer	*45 - 60*	*Development*	*YARD Energy, Eurus Energy*[30]	*Eneco*	*75*	*PF*
Maasvlakte 2	100	Development	Eneco	Rijkswaterstaat	*150*	n.a.[28]
A16	100	Development	Vattenfall	Utility owned	*150*	-
Kroningswind	80	Development	Partly TINC	-	*120*	-
Delfzijl Noord	63	Production	Eneco	Google	90	BF[29]
Slufterdam	c. 50	Reconstruction	Eneco, Vattenfall	GVB, Schiphol	*75*	-
Kreekraksluis	40	Production	Partly TINC	DELTA	*60*	PF
Mondriaan	39	Development	YARD Energy, Eurus Energy[30]	Eneco	*60*	PF
Nij Hiddum Houw	36	Reconstruction	Vattenfall	Utility Owned	*55*	-
Kubbeweg	34	Production	Consortium	Vandebron (innogy)	*50*	-
Haringvliet	32	Development	Partly APG	-	*45*	-
Mauve	30	Development	YARD Energy, Eurus Energy[30]	Eneco	*45*	PF
Bouwdokken	29	Production	Consortium, E-connection	DELTA	*40*	-
Moerdijk	27	Development	Consortium, Vattenfall	Utility owned	38	BF
Landtong Rozenburg	27	Reconstruction	Eneco, Port of Rotterdam	Heerema Marine Contractors	*40*	-
Jaap Rodenburg	24	Reconstruction	Vattenfall	Utility owned	*35*	-
Deil	21	Development	YARD Energy, Eurus Energy[30]	Eneco	*30*	PF
Nieuwe Waterweg	21	Production	Eneco	Locals	*30*	-
Spui	21	Production	Eurus Energy[30]	Eneco	51.5	PF
Karolinapolder	20	Reconstruction	innogy	Utility owned	*30*	-
Haringvliet Zuid	18	Development	Vattenfall	Utility owned	26	BF
Irene Vorrink	17	Production	Vattenfall	Utility owned	*25*	-
Eemmeerdijk	17	Production	Vattenfall	Utility owned	*25*	-
Amer	15	Development	innogy	Utility owned	*23*	-
WO-ZU-XIX Wind	15	Production	Consortium	-	*23*	PF
De Veenwieken	14	Development	ABN Amro ETF, Greenchoice, Windunie	Utility owned (Greenchoice)	*21*	PF
Netterden	14	Production	Eurus Energy[30]	-	17.1	PF
Van Gogh	12	Production	Eurus Energy[30]	-	*18*	PF
Neeltje Jans	12	Production	E-connection	-	*18*	PF
Roompotsluis	12	Production	E-connection	-	*18*	PF
Rembrandt	11	Production	Eurus Energy[30]	Scholt Energy Control	16.9	PF
Reusel-De Mierden	10	Production	Eneco	Utility owned	*15*	-
Nieuwegein	10	Production	Eneco	Utility owned	*15*	-
Kattenberg-Reedijk	10	Production	innogy	Utility owned	*15*	-
Oosterpolderdijk	10	Development	innogy	Utility owned	*15*	-
Tolhuis	10	Production	Eurus Energy[30]	-	*15*	PF

[28] Permit is awarded 3 February 2020 (123). If Eneco would want to attract financing, it would be likely to be still under negotiation.
[29] Eneco mentioned its investment, but does not mention the attraction of bank debt (122).
[30] Owned by the Japanese conglomerate Toyota Susho and the Japanese Utility Tokyo Electric Power Company

Dalfsen	10	Development	Eurus Energy[30]	-	*15*	PF
Roggeplaat	9	Production	E-connection	-	*15*	PF
Jacobahaven	9	Productin	E-connection	-	*15*	PF
Volkerak	9	Production	innogy	Utility owned	*15*	-
Sabina-Henrica	9	Production	Eneco	Utility owned	*15*	PF
Autena	9	Production	Eneco	Utility owned	*15*	-
Zoetermeer	9	Production	YARD Energy, Consortium	-	*15*	PF
Boerderijweg	9	Production	Eurus Energy[30]	-	*15*	PF
Noordpolder	9	Production	Zeeuwind, Consortium	-	*15*	PF
Buren	8	Production	Eurus Energy[30]	-	*12*	PF
Duiven	8	Production	Eurus Energy[30]	Scholt Energy Control	11.8	PF
Echteld	8	Production	Vattenfall	Utility owned	*12*	-
Greenport Venlo	7	Development	ABN Amro ETF, Greenchoice, Windunie	Utility owned (Greenchoice)	*11*	PF
Sabinapolder	7	Production	innogy	Utility owned	*11*	-
Halsteren	7	Production	innogy	Utility owned	*11*	-
Vlaardingen	6	Production	Eurus Energy[30]	Scholt Energy Control	8.6	PF
De Bjirmen	6	Production	Vattenfall	Utility owned	*9*	-
Lely	5	Production	Eurus Energy[30]	-	*8*	PF
Oesterdam	5	Production	Eurus Energy[30]	-	*8*	PF
Notos Wind	4	Production	Consortium	Vandebron (innogy)	*6*	PF
Boreas Wind	4	Production	Consortium	Vandebron (innogy)	*6*	PF
Haringvlietdam	4	Production	E-connection	-	*6*	PF
IJslandweg	2	Production	Eurus Energy[30]	-	*3*	PF
Houten	2	Production	Eneco	Utility owned	*3*	-
Karolinapolder	2	Production	innogy	Utility owned	*3*	-
De Beitel	1	Production	innogy	Utility owned	*2*	-
Spijk	1	Production	innogy	Utility owned	*2*	-

A.3. Solar PV parks

Table 11: Solar PV parks used for assessment against private investment criteria (Utility owned = no PPA information available, but utility owned, PF = project financing, BF = balance sheet financing, Consortium = local shareholders)

Solar PV park	Capacity (MW)	Status	Current owners	PPA	Construction costs (€m)	Financing structure (PPP/PF/BF)
Vlagtwedde	110	Development	Impax	-	95	PF
Midden-Groningen	103	Production	Blue Elephant Energy	undisclosed[31]	90	PF
Stadskanaal	101	Development	Blue Elephant Energy	undisclosed[31]	90	PF[32]
Borger	70	Development	Solarfields	-	60	-
Scaldia	55	Production	SUSI Partners	Engie	*50*	PF
Buinerveen	45	Development	Blue Elephant Energy	undisclosed[31]	45	PF[32]
Budel	44	Production	Encavis, Solarcentury	Eneco	44	PF

[31] Blue Elephant Energy invests under the conditions of either a PPA or FiT (85). However in this case the specific offtake entity is not mentioned.
[32] Blue Elephant Energy acquired two greenfield projects in the province of Groningen, with a total capacity of 146 MWp (126). From the portfolio of Blue Elephant Energy it can be concluded that these are the only two greenfield projects in Groningen which accumulate to a 146 MWp capacity.

Molenwaard	40	Development	Solarfields	Engie	*40*	PF
Almelo	39	Production	Obton	Vattenfall	35	PF
Lelystad	39	Development	Solarvation	Engie	32[36]	PF
Haringvliet Zuid	38	Development	Vattenfall	Utility owned	35	-
Ooltgensplaat	38	Production	Encavis	undisclosed[33]	35[34]	PF
Bavelse Berg	37	Development	Rooftop Energy	-	35	PF
Hoogeveen	30	Production	Blue Elephant Energy	undisclosed[31]	-	PF
Sunport Delfzijl	30	Production	Wirsol, Eneco, Groningen Seaports	Google (via Eneco)	40	-
Shell Moerdijk	27	Production	Shell	Shell	30	-
Flevokust Haven	17	Development	Engie	Utility owned	20	-
Borssele	21	Development	EPZ	Utility owned	20	-
Veendam	16	Production	Blue Elephant Energy	undisclosed[31]	30	PF
Groene Hoek	15	Production	Blue Elephant Energy	Eneco	30	PF
Andijk	15	Production	Blue Elephant Energy	undisclosed[31]	20	PF
Stadskanaal	14	Production	Obton	-	20	PF
Lange Runde	14	Production	Blue Elephant Energy, Statkraft	undisclosed[31]	-	PF
Middelburg	14	Production	Obton	Vattenfall	20	-
Zierikzee	14	Production	Encavis	undisclosed[35]	11	PF
Uden	12	Production	Obton	Vattenfall	16[36]	PF
Emmeloord	12	Production	Obton	Vattenfall	14	-
Zonneakker De Watering	12	Development	Solarfields	Engie	12[36]	PF
Sinnegreide	12	Production	SUSI partners	Engie	12[36]	PF
Melissant	10	Production	Encavis	Undisclosed[33]	10[34]	PF
De Kie	10	Production	SUSI partners	Engie	10[36]	PF
De Vaandel	9	Production	Eco Invest	-	10	PF
Marum	9	Production	Solarfields	Engie	10[36]	PF
Avri Solar	9	Production	Avri	Vandebron (innogy)	10	PF
Coevorden	7	Development	Vattenfall	Utility owned	8	-
Ameland	6	Production	Eneco	Utility owned	8	PF
Eemshaven	6	Production	Vattenfall	Utility owned	3	BF
Emmen - Pottendijk	5	Development	PowerField	E-Circuit	5	-
De Zwette	4	Development	Eco Invest	Greenchoice	4[37]	PF
Koudekerke	4	Development	Zeeuwind	Vandebron (innogy)	3	PF
Jutterszon	3	Development	shareNRG	Greenchoice	3[36]	PF
Hemweg	2	Production	Vattenfall	Utility owned	2	BF
Velsen-Noord	2	Production	Vattenfall	Utility owned	2	BF
Azewijn	2	Production	Pfixx Solar	Wienerberger	-	-
Hemriksein	0.4	Development	Eco Invest	Greenchoice	0.4[37]	PF

[33] Encavis mentions a 15 year fixed electricity price, but does not disclose the name of the offtake entity (129).
[34] Encavis mentions a €44.5m investment for Ooltgensplaat (38MW) and Melissant (10MW) (129). The construction costs are estimated pro rata to the capacities.
[35] Encavis mentions a 15 year PPA, but does not disclose the name of the offtake entity (128).
[36] Figures were stated excluding Dutch VAT. The construction costs are estimated by adding 20% and rounding the result.
[37] Ecorus reports an investment of €4.1m for the portfolio which combines De Zwette and Hemriksein (127). The investment costs are estimated pro rata to the project capacities.

A.4. Offshore wind parks included in the dataset used for the qualitative assessment

Table 12: List of offshore wind parks included in the dataset

Wind park name	Country
C-Power Phase 1	Belgium
Belwind I	Belgium
C-Power Phase 2&3	Belgium
Northwind	Belgium
Nobelwind	Belgium
Rentel	Belgium
Norther	Belgium
Seastar	Belgium
Mermaid	Belgium
Northwester	Belgium
Horns Rev 1	Denmark
Ronland	Denmark
Nysted	Denmark
Horns Rev 2	Denmark
Rodsand II	Denmark
Sprogo	Denmark
Anholt	Denmark
Horns Rev 3	Denmark
Kriegers Flak	Denmark
Le Treport	France
Noirmoutier	France
Saint Nazaire	France
Courselles	France
Fecamp	France
St-Brieuc	France
Alpha Ventus	Germany
Baltic 1	Germany
BARD1	Germany
Global Tech 1	Germany
Meerwind Sud-Ost	Germany
DanTysk	Germany
Borkum Riffgat	Germany
Trianel Borkum Phase 1	Germany
Borkum Riffgrund 1	Germany
Butendiek	Germany
Nordsee Ost	Germany
Baltic 2	Germany
Wikinger	Germany
Gode Wind I	Germany
Gode Wind II	Germany
Veja Mate	Germany
Nordsee One	Germany
Sandbank	Germany
Nordergrunde	Germany
Deutsche Bucht	Germany
Merkur	Germany
Trianel Borkum Phase 2	Germany
Borkum Riffgrund 2	Germany
Arkona	Germany
Hohe See & Albatros	Germany

Kaskasi	Germany
Egmond aan Zee	Netherlands
Prinses Amalia	Netherlands
Luchterduinen	Netherlands
Gemini	Netherlands
Borssele I&II	Netherlands
Borssele III&IV	Netherlands
Hollandse Kust Zuid I&II	Netherlands
Hollandse Kust Zuid III&IV	Netherlands
North Hoyle	United Kingdom
Scroby Sands	United Kingdom
Kentish Flats Phase 1	United Kingdom
Barrow	United Kingdom
Burbo Bank	United Kingdom
Gunfleet Sands Phase 1	United Kingdom
Gunfleet Sands Phase 2	United Kingdom
Lynn&Inner Dowsing	United Kingdom
Rhyl Flats	United Kingdom
Thanet	United Kingdom
Walney Phase 1	United Kingdom
Walney Phase 2	United Kingdom
Sheringham Shoal	United Kingdom
Ormonde	United Kingdom
Greater Gabbard	United Kingdom
Robin Rigg West	United Kingdom
Robin Rigg East	United Kingdom
Humber Gateway	United Kingdom
London Array	United Kingdom
Lincs	United Kingdom
West of Duddon Sands	United Kingdom
Gwynt y Môr	United Kingdom
Westermost Rough	United Kingdom
Kentish Flats Extension	United Kingdom
Dudgeon	United Kingdom
Burbo Bank Extension	United Kingdom
Rampion	United Kingdom
Walney Extension	United Kingdom
Galloper	United Kingdom
Race Bank	United Kingdom
Beatrice	United Kingdom
East Anglia One	United Kingdom
Kincardine	United Kingdom
Hornsea One	United Kingdom
Moray East	United Kingdom
Triton Knoll	United Kingdom
Neart Na Gaoithe	United Kingdom

B.1. Regression results

Table 13: Regression results - presence of financial investors in project financed wind parks

Dependent Variable: INVESTORS_PRESENT
Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)
Date: 05/24/20 Time: 12:59
Sample: 1 96 IF CURRENT___FINANCING_METHOD="PF" AND
COUNTRY<>"France"
Included observations: 55
Convergence achieved after 4 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.904207	0.551417	-1.639790	0.1010
CURRENT DEBT PORTION	1.972074	0.793559	2.485101	0.0130

McFadden R-squared	0.089660	Mean dependent var	0.654545
S.D. dependent var	0.479899	S.E. of regression	0.454436
Akaike info criterion	1.246315	Sum squared resid	10.94513
Schwarz criterion	1.319309	Log likelihood	-32.27367
Hannan-Quinn criter.	1.274542	Deviance	64.54733
Restr. deviance	70.90461	Restr. log likelihood	-35.45230
LR statistic	6.357274	Avg. log likelihood	-0.586794
Prob(LR statistic)	0.011690		
Obs with Dep=0	19	Total obs	55
Obs with Dep=1	36		

Table 14: Regression results - leverage drivers

Dependent Variable: CURRENT__DEBT_PORTION
Method: ML - Censored Normal (TOBIT) (Newton-Raphson / Marquardt
steps)
Date: 05/08/20 Time: 19:49
Sample: 1 96 IF CURRENT___FINANCING_METHOD="PF"
Included observations: 56
Left censoring (value) series: 0
Right censoring (value) series: 1
Convergence achieved after 2 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.864879	0.042799	20.20803	0.0000
CURRENT___NB_EIB____OF_PF_	-0.262402	0.083580	-3.139519	0.0017
COUNTRY="Denmark"	-0.325688	0.120939	-2.692993	0.0071
COUNTRY="United Kingdom"	-0.215663	0.051337	-4.200958	0.0000
Error Distribution				
SCALE:C(5)	0.175909	0.017151	10.25624	0.0000

Mean dependent var	0.680308	S.D. dependent var	0.225352
S.E. of regression	0.177556	Akaike info criterion	-0.320223
Sum squared resid	1.607835	Schwarz criterion	-0.139388
Log likelihood	13.96623	Hannan-Quinn criter.	-0.250113
Avg. log likelihood	0.249397		
Left censored obs	1	Right censored obs	1
Uncensored obs	54	Total obs	56

C.1. Semi-structured interviews

Table 15: List of respondents

Company type	Company coverage	Team	Function of respondent
Financial advisory	North West Europe	Renewable energy advisory	Managing Director
Financial advisory	North West Europe	Renewable energy advisory	Vice-President
Financial advisory	Global	-	Senior Consultant
Bank	Global	Renewable energy financing	Global Head
Bank	Global	Renewable energy financing	Global Head
Bank	Global	Renewable energy financing	Global Head
Bank	Global	Renewable energy financing	Director
Bank	Global	Renewable energy financing	Vice-President
Bank	Europe	Renewable energy financing	Director
Bank	Europe	Renewable energy financing	Chief Economist
Bank	Europe	Offshore energy financing	Director
Utility	Europe	Offshore wind	Global Head
Utility	Global	Europe	CFO
Energy company	Global	Wind energy	Director

C.2. Semi-structured interview questions Chapter 5

Below the questions are stated as they are asked to the respondents.

Financiers and financial advisors

1. What is your view on the general developments in the offshore wind financing industry?
2. What would be your evaluation of the industry, using the following criteria:
   - Opportunity to invest >€100m of equity per project
   - Maximum debt and equity investment sizes, is there an upper limit?
   - Availability of project financing facilities for the projects
   - Availability of PPA opportunities
   - Revenue stability over loan- and project lifetime
   - Stability of regulatory framework and mainly the support schemes
3. What is your view on Dutch/North West European offshore wind farms, are they at least performing at their 'base case' scenario?
   - What are the success factors? (e.g. EIB loans, ECA guarantees, PPA production coverage)
4. In general, would banks still be interested in providing a project financing facility to a subsidy-free offshore wind park?

Power generators and energy companies

1. What is your view on the general developments in the offshore wind financing industry?
2. What would be your evaluation of the industry, using the following criteria:
   - Opportunity to invest >€100m of equity per project
   - Maximum debt and equity investment sizes, is there an upper limit?
   - Availability of project financing facilities for the projects

- ➢ Availability of PPA opportunities
- ➢ Revenue stability over loan- and project lifetime
- ➢ Stability of regulatory framework and mainly the support schemes

3. What is your view on Dutch/North West European offshore wind farms, are they at least performing at their ‘base case’ scenario?
4. What are the success factors? (e.g. EIB loans, ECA guarantees, PPA production coverage)
5. In general, would banks still be interested in providing a project financing facility to a subsidy-free offshore wind park?
6. Would you / power companies still be willing to operate subsidy free offshore wind parks – looking at Vattenfall pulling out of the Hollandse Kust Noord tender?
7. Would you / a power company be willing to operate the future offshore wind parks without a subsidy and a project financing facility?
8. Would you / a power company be willing to operate a project financed wind farm with a subsidy which only covers the debt costs, thus leaving the full risk at the address of the equity holders?
9. If you’re developing a project in the Netherlands, do you apply route-to-market PPAs or do you for instance agree on a minimum fixed price (on which a loan can be based)?
10. Does this also hold for other countries?
11. Do you have a preference for certain PPA types?
12. Do you see a preference for certain PPA types at the address of both equity investors and banks?
13. Under what conditions would you be willing to agree on longer PPAs (>15 years) with a wind farm you invested in, to stretch the project financing facility lifetime?
14. Would you be willing to operate a fully merchant, subsidy free, wind park?

C.3. Semi-structured interview questions Chapter 7

Below the questions are stated as they are asked to the respondents.

Financiers and financial advisors

1. Would a loosening in regulated coverage ratios for banks result in the application of larger loans for offshore wind parks?

2. Would such a loosening open up possibilities for project financing of subsidy-free wind parks, resulting from an increase in risk taking possibilities?

3. What are the financing consequences for a subsidy-free offshore wind farm, which only relies on PPAs, looking at for example:

   - Debt ratios
   - Interest rates
   - Bank guarantees at the address of the offtaker

4. Per listed support mechanism:

   - Would such a mechanism be feasible in the Dutch offshore wind industry?
   - Would this increase the project financing opportunities?
   - What other consequences would such a structure have to a project financing facility?

5. Could you please provide a top-3, from (a combination of) the listed support mechanisms?

6. Could there be any other PPA support mechanism, other than the ones covered?

7. Which current European support mechanism would be best suited to cover merchant/PPA risk against minimized governmental expenses?

8. Considering the rise in construction costs per wind farm and that institutional investors would fill the investment gap; is a subsidy-free system still feasible looking at the risk appetite of the institutional investors?

   - Or would this require companies to hold larger shares in the wind park construction costs, and thus reduce their farming-down opportunities?

Power generators and energy companies

1. Per listed support mechanism:

   - Would such a mechanism be feasible in the Dutch offshore wind industry?
   - Would this increase the project financing opportunities?
   - What other consequences would such a structure have to a project financing facility?

2. Could you please provide a top-3, from (a combination of) the listed support mechanisms?

3. Could there be any other PPA support mechanism, other than the ones covered?

4. Which current European support mechanism would be best suited to cover merchant/PPA risk against minimized governmental expenses?

5. Considering the rise in construction costs per wind farm and that institutional investors would fill the investment gap; is a subsidy-free system still feasible looking at the risk appetite of the institutional investors?

- Or would this require companies to hold larger shares in the wind park construction costs, and thus reduce their farming-down opportunities?

C.4. Full list of all the support mechanisms and their scores

This list shows the total amount of point each support mechanism received in the process of identifying the top three support mechanisms.

Table 16: List of all the scores per support mechanism

Rank	Support mechanism	Score
1	Governmental guarantee	22
2	Governmental loans	17
3	PPA subsidy	14
4	Subsidized H2 PPA	8
5	Governmental equity investment	9
6	Subsidized batteries	6
7	Pooled inter European PPAs	5
8	Standardized tradable PPAs	4
9	Equity investment incentive	0

D.1. Inputs for cost calculations

Table 17: Project metrics which are held constant

Parameter	Lower limit	Upper limit	Average
Project lifetime (yrs)	25	25	25
Loan lifetime (yrs)	12	15	13.5
Project capacity (MW)	700	700	700
CAPEX (€m/MW)	1.6	1.9	1.75
OPEX (€k/MW/yr)	41	61	51
AEP factor (%)	50	55	52.5
Tax rate (%)	25	25	25

Table 18: Financial metrics for the SDE+ scenario

Parameter	Lower limit	Upper limit
Commercial debt (%)	80	85
Return on equity (%)	12	12
Cost of debt (bps)	200	250

Table 19: Financial metrics for the Corporate PPA scenario

Parameter	Lower limit	Upper limit
Commercial debt (%)	55	70
Return on equity (%)	12	12
Cost of debt (bps)	300	350

Table 20: Pricing limits per parameter used to calculate the governmental costs

Parameter	Lower limit (€/MWh)	Upper limit (€/MWh)
LCOE	38.1	43.3
Corporate PPA	26.1	29.0
Mismatch	12.0	15.7

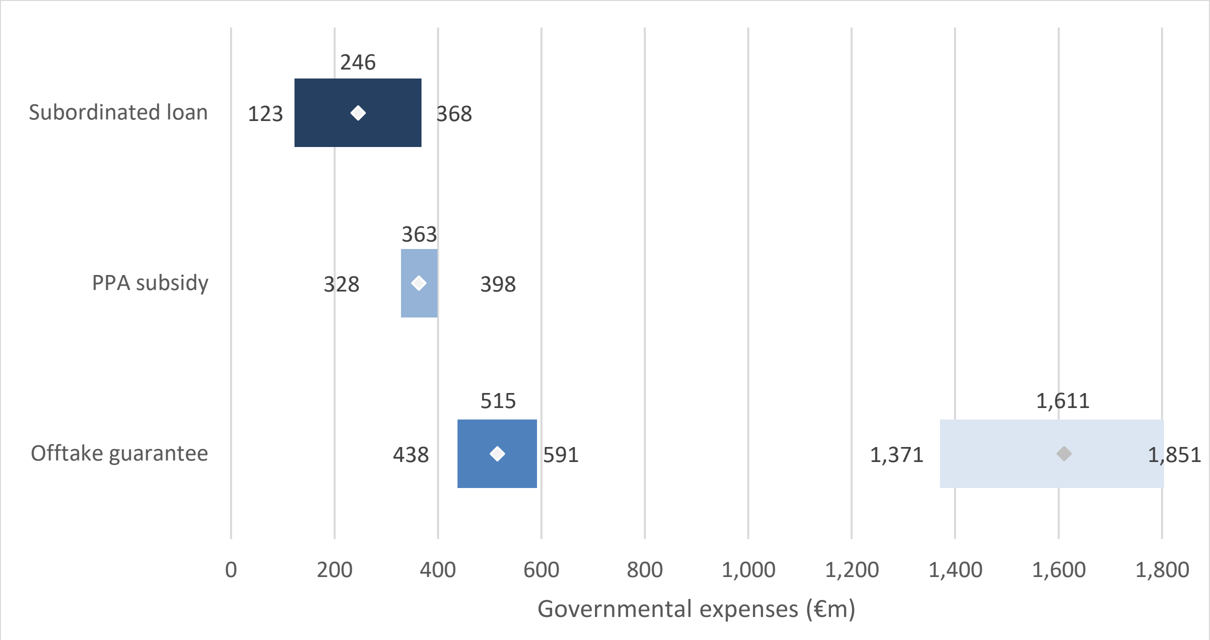

Figure 14: Governmental expenses per support mechanisms, including the remuneration range of the offtake guarantee (shown in the lower right corner).

E.1. Onshore sector research

PBL has provided an estimation of the likely renewable energy mix by 2030 (121). However, this estimation changed over time for onshore production. The new estimation predicts a larger role for the steadily growing solar PV sector and a smaller role for onshore wind (31). The drivers behind this change will be discussed in this section.

The Climate Agreement states that all onshore projects will have applied for the SDE+ subsidy by 2025, after which the subsidy program will be terminated (1). This subsidy is the common factor for both onshore wind and solar PV development. The onshore SDE+ subsidy also follows a Feed-in-Premium structure, but provides the same subsidy for every project within the same subsector. The remuneration is based on the difference between the so-called base price and a correction price. The correction price is subtracted from the base price and results in the eventual subsidy. The correction and base prices are determined per year and differ per installation type (122).

Onshore wind and solar PV will be assessed on the following sequence of factors: required development pathway, regulatory framework, support mechanisms, national developments in the industry, and global development. This will be supplemented by assessment of the current projects, against the private investment criteria from Chapter 2.

E.1. Onshore wind

E.1.1. Development analysis

The current onshore wind production (2018) in The Netherlands is 6.9TWh (123). To reach a target production of 17.6TWh an additional production of around 11TWh is needed. In an earlier energy agreement, the 'Energy Agreement for Sustainable Growth', the Dutch government agreed on a target capacity of 6GW by 2020 (124). However, the development pathway to this target is rather stalling. This is underscored by a growth of only 400MW over 2015-2018, from 3.0GW to 3.4GW. The realised energy production subsequently increased from 6.4 to 6.9TWh (123). However, the efficiency of the wind farms is deemed to increase to 3237 full load hours per year in 2030 (1). This results in a target capacity of approximately 6.5GW by 2030. The 2018 capacity almost has to double in 2030 to reach this goal. Development has to speed up significantly to reach the 2030 target production.

At first sight, it would not seem entirely fair to compare the onshore wind targets with the past development trend. For instance, the development in the offshore wind energy sector could be analysed in the same way. However, the offshore sector enjoys a clear development pathway with abundant governmental support. On the contrary, the onshore development has to be planned and executed per local government. Furthermore, the onshore development takes place around the built environment and not on sea. This leads to a lot of public participation in approving wind farm locations.

E.1.2. Regulatory framework and development implications

The development of onshore wind parks can be subject to different governmental bodies, dependent on the planned wind park size. This could either be the municipality (<5 MW), provincial government (5-100MW), or national government (>100MW) (125). Apart from the exposure to a variety in public governmental bodies, the developer is also personally responsible for obtaining additional permits. It can be concluded that onshore wind development takes place in a rather decentralized regulatory framework which isn't as streamlined as the offshore equivalent. This has also been noted by the government, which issued a small tender pilot to assess streamlining possibilities. The Streepland tender covers 3 wind turbines alongside a highway (126).

E.1.3. Support mechanisms

Next to the SDE+ support mechanism another way of support is a co-investment structure of a local government in an onshore wind park. An example of this co-investment structure is the near shore Fryslân wind park, with 89 turbines this park will deliver electricity to around 500,000 households. The provincial government invested for a total of €100m to accelerate the development process of the wind park (127). The early stages of the project development namely already started in 2008 (128). This co-investment points in the direction of a lack of investor appetite and subsequent investment gap, which is filled by the government. The investment consists of a €20m equity investment for 15% of the shares, and a €80m subordinated loan. This subordinated loan covers for around 10% of the total construction costs (127). Due to its shareholding the provincial government will also appoint commissioners to safeguard public interest during the development and operation of the wind park (127).

E.1.4. Current developments in The Netherlands

The current state of wind development is likely to not reach the 2020 target. Of the 6GW target about 4.7GW is estimated to be developed by the end of 2020, within reasonable uncertainties (129). The Dutch onshore wind potential is estimated yearly in the so-called 'Monitor wind op land'. What strikes most is that 2017 estimation of the 2020 potential is higher than the most recent 2018 estimation. Although the total onshore wind potential is estimated to be higher, this mostly occurs due to an increase in potential with a lower development certainty. This is mostly caused by technical and safety circumstances which lead to the termination of projects.

E.1.5. Current global development

This decrease in confidence is also visible in the realised global onshore wind investments. Over the period 2015-2017 the global investments in the total wind sector decreased by about $40bn, even while the offshore wind investments were rising. This is mainly caused by a decrease in onshore investments of 15% in 2017 (42). However, it should also be noted that the overall costs per MW decreased over time since the market is maturing. This offshore preference is visible in The Netherlands, were 2018 investments in offshore wind outnumbered onshore investments (130). However, offshore wind project generally requires a higher total construction investment. Therefore, the issuance of offshore tenders can easily lead to a higher offshore wind investment in the year the construction of the tendered offshore wind park starts. The decrease in onshore wind appetite is predominantly caused by unexpected lower deployment rates of wind turbines (42). This targets one of the other risks of onshore wind: wind speed variance. Compared to offshore wind, onshore wind parks have a higher inter-year production variability (131). The variability in wind speed over time and per location makes the production less predictable. This production risk would negatively impact the financing costs of onshore wind parks.

E.1.6. Assessment against private investment criteria

Onshore wind parks in the Netherlands differ significantly in size. Furthermore, there are also a lot of small sized wind parks present. These wind parks are listed in Table 10 in Appendix A.2.

The private investment criteria are established in Chapter 2, and are listed below:

1. Minimum investment opportunity of €100m
2. Application of project financing
3. Revenue is partly secured through PPA
4. Stable production and revenue over project lifetime
5. Minimization of regulatory risks by clear and stable support schemes for operations

The investments in the onshore wind industry differ widely in ticket size. There are already a few large projects, as for instance Windpark Fryslan, and medium sized parks such as the previously mentioned Windpark Kreekraksluis (78MW) or the wind A16 Streepland (100MW) project. However, these projects are still outnumbered by the amount of wind parks with a capacity in the range of 1-20MW. This can be seen in Table 10 of Appendix A.2. The most notable wind parks, with available financial information, are analysed below.

Windpark Fryslân

This 383MW wind park is going to be developed in the IJsselmeer, 6km off the coast (132).The government invested €20m for 15% of the equity, which values the equity of the project at about €130m. Since there is no information available about any premiums or discounts in the acquisition projects, the equity value is taken pro rata to the share package price. The total construction costs of the project are €850m (133). This leads to an estimated debt facility of €670m, leading to a debt to equity ratio of 5:1. The project financing facility is financed by a large group of (inter)national banks, and the PPA is secured with Eneco (127). Looking at the equity investments made for this project, it is concluded that this project could be suitable for institutional investors.

Windpark Noordoostpolder

This 429MW wind park is developed in Flevoland and consists of nearshore and onshore turbine groups. The total wind park can be divided into three smaller wind parks, owned by the following enterprises:

- NOP Agrowind (195MW): owned by about 100 farmers which made their land available for development
- Westermeerwind (144MW): co-funded by surrounding citizens for a total of about €9m, through debt and equity construction funds. The remaining financing consists of a project financing facility and equity of the consortium.
- Zuidwester (90MW): wind park of innogy.

It is important to note that this project reached its scale due to the accumulation of smaller development opportunities in NOP Agrowind. Westermeerwind is initialized by a consortium of local farmers, the management of the wind park is later transfered to Ventolines, a renowned wind park manager.

Westermeerwind has attracted a €254 debt facility through project financing and a €5m debt facility through their local-participation debt fund (134). This is complemented by a €4.3m local-participation equity investment (135). Furthermore, it also attracted a €92m complementary investment subsidy from the Dutch Government (136). Further equity investment details are not available. However, the total construction costs are said to be about €400m for the 144MW wind park (137). Subtracting the above mentioned costs lead to an equity remainder of about €45m. These figures are broadly in line with the capital structure of Windpark Fryslân, which has 5.15 times as much debt as equity. Combining all debt and equity funds, Westermeerwind has 5.25 times as much debt as equity.

NOP Agrowind has attracted a €350m debt facility through project financing to partly fund the about €420m construction costs (138). From this information an equity ticket of about €70m can be concluded. The resulting debt to equity ratio of 5:1 is also broadly in line with the above mentioned wind parks.

Information about the capital structure behind the wind turbines of innogy is not as abundant as for NOP Agrowind and Westermeerwind. Moreover, the only information which is publicly available notes construction investment costs of over €150m. The cost ratio of €1.7m per MW would then be broadly in line with the costs faced by Westermeerwind and NOP Agrowind. Both NOP Agrowind and Westermeerwind have agreed upon a PPA with Eneco (139).

Looking at the above presented capital structures it can be concluded that none of the three wind parks would meet the equity ticket size criteria. However, combining all the wind turbines in Windpark Noordoostpolder, and keeping the subsidy of Westermeerwind, would result in an equity ticket of about €145m. For this assumption a debt to equity ratio of 5:1 is assumed for the innogy wind turbines, following the ratio of Westermeerwind and NOP Agrowind. It can thus be concluded that Windpark Noordoostpolder would meet the equity ticket size criteria, when the wind parks are combined.

Windpark Maasvlakte 2

This 100MW wind park is subsidy-free and tendered by the Dutch government (140). The tender is won by Eneco, who also has agreed upon a 25-year PPA with the Dutch government. There is no publicly available information about the financing of the wind park (yet). Given the fact that the wind park is awarded in February 2020, it is assumed that potential negotiations would still be underway. The PPA could be regarded as a subsidy, since it has such a long tenor and a remuneration from the government. The credit risk on Rijkswaterstaat is also considered to be significantly lower than any corporate, since it is part of the Dutch government. Therefore, it is still to be seen to what extent new subsidy-free onshore wind parks will be developed in the near future.

This wind park is part of the project ‘Hernieuwbare energie op rijksgrond’. This project aims to tender solar and onshore wind project which are situated on governmental estates (141). Similar to the Maasvlakte 2 tender, a PPA with the Dutch government can be applied where possible.

Other wind parks

Wind parks in The Netherlands predominantly have smaller capacities than the previously analysed projects. Furthermore, most of these projects do not publicly present their financial details. In order to still assess the market, the assumption is made that the investment costs per MW can be taken pro rata to Windpark Fryslân and Noordoostpolder. By doing so it can be concluded that most of the listed projects do not yield a large enough equity ticket size. To be conservative in assessing projects on this basis, a high investment cost ratio of €2m/MW is combined with a low debt to equity ratio of 4:1. Even with these relatively light parameters most of the projects do not make the cut. A €100m equity investment would namely result in projects with a minimum capacity of 250MW, which is not widely available in The Netherlands.

For smaller wind parks it is assumed that the same investment conditions hold as for the larger wind parks. By doing so, it can be concluded that all of the wind parks, listed in Table 10 (Appendix A.2.), would not meet the €100m equity investment criteria. However, some wind parks could fulfil this equity investment criteria if they were not financed through debt. This assessment is however based upon the assumption that the projects are financed through debt.

This list does not include all the 'smaller' wind parks in The Netherlands. Listing and researching all the smaller wind parks is deemed to be an inefficient use of time, given the limited timeframe for this thesis. The main purpose of this list is to show the broad variety in capacities from Dutch wind parks. There are numerous small wind parks in The Netherlands with capacities smaller than for instance 20MW, which contribute to a large cumulative capacity.

When analyzing the wind parks one of the striking conclusions which can be made is that private investors invest in these parks as well. For instance, Eurus Energy invests in smaller wind parks such as Mauve (30MW), Deil (21MW) and IJslandweg (2MW). Eurus is a consortium of the Japanese conglomerate Toyota Susho (80%) and the Japanese utility TEPCO (20%) (142). Although this consortium has a utility-shareholder, the main shareholder is an industrial financial investor.

Eurus Energy entered the Dutch market by buying a portfolio of wind parks from YARD Energy (143). YARD Energy is an onshore wind developer which, in the Netherlands, mainly focuses on the smaller wind parks. After or during construction most of the wind parks are sold, predominantly to Eurus Energy. This follows the previously discussed farm-down principle, where a developer or utility sells (part of) its shares to free up capital, to initiate new projects. YARD Energy predominantly finances its projects through small scale project financing facilities with local bank offices. An example of this principle is the wind park Dalfsen (10MW), which is financed by a local Rabobank office. However, more recently Eurus Energy bought a greenfield portfolio of larger wind parks from YARD Energy. These wind parks are financed through international project financing facilities of Rabobank and the Japanese SMBC, and ABN Amro and BNG Bank. PPAs are secured with Eneco (144). This shows the moving interest of international banks into smaller scale onshore wind projects as well.

Furthermore, the Belgian private equity investor TINC also invests in Dutch small-scale onshore wind parks. Their portfolio consists of Windpark Kreekraksluis (40MW) and Windpark Kroningswind (80MW). Windpark Kreekraksluis is originally constructed by Delta, which now holds a PPA for the wind park. Delta reports to have sold the wind park since it does not primarily want to own wind parks of which it consumes the electricity. This is a clear example of the previously discussed farm-down model, where power generators sell their stake after construction is finished to free up capital for new projects. TINC reports that the park is bought for a sum of about €65m. The acquisition is bank financed by ASN Bank, which leads to a total equity investment of €12m at the address of TINC (145). Although this is a brownfield project, this acquisition signals the interest of financial investors in onshore wind projects. This signal is strengthened by the acquisition of the majority share in greenfield wind park Kroningswind. TINC is reported to have reserved funding up to €40m for full construction of the wind park (146). TINC, on itself, is however not a large-scale institutional investor. Its main shareholders are however the Belgian Belfius Bank and the private equity Gimv (147). It could be concluded that institutional investors invest in smaller projects via specialized investors as TINC.

Another example of this institutional investment strategy is the onshore wind investment portfolio of ABN Amro Energy Transition Fund. This portfolio covers the wind parks Greenport Venlo (about7MW) and De Veenwieken (14MW). Both wind parks are project financed and have a PPA with Greenchoice, the utility partner in the new shareholder consortium (148) (149).

Furthermore, as of 20 December 2019, the Dutch institutional investor APG invested in a wind park which is significantly smaller than the wind park size which is assumed to be feasible as a result of the investment criteria. The investment is made in Windpark Goerree-Overflakkee, which has a capacity of only 32MW. APG states that its investors increasingly demand investments in decarbonizing initiatives (150). It can thus be concluded that this investment need drives APG to assess investment opportunities in small scale energy projects, which are significantly smaller than their predominant energy investments.

Stable production over project lifetime

For most of the wind parks it is not specifically available what their production figures are, since this is treated as confidential information. However, Westermeerwind has disclosed its production details in light of their assumptions in its prospectus. Westermeerwind produced 15% less than its P50 production assumed for the first year, and 5% less than the P50 assumption for the second year. The most important factor for the disappointing results is the deviation of the 2016 and 2017 wind volumes compared to the long-term average (134). It can be concluded that these conditions are applicable for all wind parks in The Netherlands since the wind deviation is not extremely large within the country. To mitigate deviations the wind parks are financed at risk-weighted production assumptions, as can be seen from Westermeerwind.

Minimization of political risk

The Netherlands is a stable country, but still has its fluctuations in support mechanisms. This can for instance be seen at Windpark Noordoostpolder (Westermeerwind, NOP Agrowind, innogy). This wind park had to delay the local debt and equity participation mechanisms due to a recalculation of the SDE+ subsidy, while the wind park was already operating (151). Since the wind park applied for multiple subsidies, it had to be investigated at the level of the European Commission if this caused a state-aid scenario. This leads to the decrease of the SDE+ subsidy, which is estimated to yield a cut of €68m (152). This decrease is caused by a shortening of the SDE+ period to 13 years, from the conventional 15 year period. However, Windpark Westermeerwind has stated that NEA has estimated an electricity price which is likely not to be realised over the upcoming years, which leads to a lower subsidy. Furthermore, according to the wind park management board, the operational costs are not fully included in the calculations of NEA, which leads to a too high estimation of the project cash flow. The capital cost assumptions of NEA would also deviate from the allowable costs of the project (134).

All in all, this causes an unfavourable uncertainty in cash flows over the longer term, against the investment strategy of institutional investors. However, this recalculation of the SDE+ subsidy is caused by the fact that multiple subsidies were assigned to Windpark Westermeerwind. This is not commonly happening, since the applicable 'innovation'-subsidy is only assigned once in The Netherlands (153). Assuming that such a subsidy is thus not frequently assigned, the risk of significant changes in SDE+ subsidies during the production phase is deemed unlikely. Further research did not result in similar cases.

Conclusion

The assessment yields to results which show an extension of the traditional investment environment into smaller scale onshore projects. Most of the onshore wind parks in the Netherlands have equity tickets which are too small to be primarily of interest for direct traditional institutional investments. Nearshore wind parks with a substantial capacity could become interesting for the traditional institutional investor due to its high construction costs. Some of the wind parks in the Netherlands have seen equity investments which would be large enough for the institutional investors. Overall, investors are putting their money in small-scale projects via the investment in smaller specialized infrastructure funds like TINC or ABN Energy Transition Fund. Their capital thus still finds its way towards these projects. Furthermore, APG has also recently invested in the small-scale wind park Haringvliet. Continuance of such investments however still has to be proven.

The financing of onshore wind parks is also widely available for both large scale and small-scale wind parks. Looking at for instance Greenport Venlo or the wind parks of Eurus Energy, it is visible that local banks as well as (inter)national banks are interested in financing smaller wind parks as well. Most of these small-scale projects are initiated by power generators or developers, and are later 'farmed-down' to financial investors.

From the data set it can be concluded that 51% of the projects applied project financing. However, this increases to 89% if we only use the projects from which the financing mechanism is known.

In case of a utility the PPA still remains in hands of the initiating utility. An example would be the PPA of Delta for Windpark Kreekraksluis. Furthermore, without the investments of power generators most of the wind parks still find their way towards a PPA with Dutch power generators, as can be concluded from Table 10 in Appendix A.2.

E.1.1.7. Overall conclusion

From the above it can be concluded that onshore wind development in The Netherlands is stalling and is very likely to not reach the 2020 development target. The troubles of the Dutch onshore sector are also visible on a global scale, with onshore investments decreasing by 15% in 2017. The sector's slow development is caused by a number of factors such as public acceptance, long development procedures, safety measurements and production risk.

However, when looking at the assessment against private investment criteria it is visible that the sector enjoys a broad spectrum of support from financial institutions. (Inter)national financial investors are either starting to invest in small scale projects or are investing via a secondary structure, by investing in funds which target smaller projects. For institutional investors this would decrease their direct exposure to the onshore wind project risks. Project financing is also proven to be widely available, with interest from national as well as international banks for both small-scale as large-scale projects. The presence of project financing has also solidified and PPAs are often concluded with power generators. However, the nature of the PPAs is not publicly available. All in all, it can be concluded that it is likely that the onshore wind subsector can adapt to the changing electricity price market due to its smaller scale, abundance of investors and more mature PPA market.

E.2. Solar PV

E.2.1. Development analysis

The Climate Agreement states that it expects the production of solar PV farms to increase, leading to 854 full load hours per year in 2030 (1). A 24.4TWh target production would therefore lead to a 2030 target capacity of about 28.6GW. The current solar PV capacity, including all capacity sizes, in The Netherlands is 4.4GW as of 2018 (154).

Above the 15kW capacity the installation can apply for the SDE+ subsidy. The current capacity of realised solar PV projects in The Netherlands, which are managed under SDE+ and thus have a capacity larger than 15 kW, is however only 1.5GW as of November 2019 (155). On the other hand, CertiQ, which certifies the SDE+ approved projects on their renewable nature, already noted 2.7GW as of October 2019 (156). However, the Climate Agreement also states that smaller installations could be included in Regional Energy Strategy too, while safeguarding the 35TWh target production for the total onshore sector (1).

The appetite for solar PV investments is rapidly growing in The Netherlands. From the three discussed renewable energy sources, solar PV energy consumption is growing the fastest. Over 2015-2018 solar PV energy consumption grew from 1.4 to 3.5TWh, which more than triples the increase in onshore wind energy consumption (157). The installed capacity increased with 1.5GW to 4.4GW in 2018, which is more than 1.5 times the capacity growth of 2017. Most of the growth came from enterprises, which increased their total capacity with 71% in 2018. The total installed capacity of households grew with 31% in this period (158). Residential solar PV with a capacity lower than 15 kW accounts for the largest part of the total installed capacity.

However, the interest in the larger installations is also rapidly increasing. This can be seen from the application volume for the SDE+ subsidy. The total amount of approved SDE+ applications for solar PV in 2018 accumulated to a capacity of 4.7GW (159) (160). The SDE+ applications which were received in the first half of 2019, and are approved, accumulated to a total capacity of 2.5GW (161). This is even topped by the, not yet approved, SDE+ applications received in the second half of 2019, which accumulated to 4.6GW (162). Looking at the recently approved capacities it could be concluded that the capacity gap is likely to be filled by 2030.

E.2.2. Regulatory framework and development implications

However, the approval of the SDE+ subsidy does not directly lead to the development of the approved capacity. The approved capacities will therefore have to be regarded with a certain amount of conservatism. In an attempt to mitigate the non-realisation in these time frames, a feasibility study is required as part of the SDE+ application, starting at a minimum capacity of 0.5MW (163).

In addition to the realisation terms and the feasibility study there are more requirements which need to be fulfilled before a SDE+ subsidy can be issued. The requirements are mainly dependent on the location and subsequent network connection of the installation, which could either be rooftop mounted or ground mounted. Ground mounted (and floating) installations can namely also apply for an 'energy-investment tax reduction', this reduction is meant to partly repay the network connection costs. The SDE+ subsidy is only issued when the installations are connected to the network with a so-called 'wholesale consumer' network connection ('grootgebruikersaansluiting'). The connection is established by the local network operator, the costs will however be incurred on the developer. Furthermore, starting in the second half of 2019, a transport capacity declaration of the local network operator is needed when applying for a SDE+ subsidy. This obligation is set up so that potential non-realisation, due to an apparent lack of network capacity, is decreased (163).

E.2.3. Support mechanisms

Unlike onshore wind, the SDE+ base price is not dependent on the location. The base prices and correction prices however differ for the installation type and the amount of network supply (163). The correction price per kWh is higher for non-network supplied energy since the consumer benefits from the low-cost electricity. This subsequently results in a lower SDE+ subsidy. In the second half of 2019 the base prices were also higher for smaller and rooftop mounted installations (163). Larger parks are more efficient due to their scale and therefore have lower costs. Furthermore, the smaller installations have a significant share of household installations which do not have the commercial character of the larger installations.

Next to the SDE+ subsidy the so-called 'postcoderoos'-arrangement also supports large-scale solar PV. This mechanism targets cooperatives of smaller energy consumers, with a 'small consumer' network connection, which use renewable energy sources. These cooperatives are taxed with a lower rate on their total electricity consumption. The cooperative members do not have to pay taxes on their share of the renewably generated electricity, which is subsequently subtracted from the electricity in the first electricity tax box (164). The first electricity tax box taxes the first 10MWh of consumed electricity (165). Originally, the location of the renewable installations had to be located within the same zip-code area as the consumers from the cooperative. However, this has been expanded to installations in neighbouring zip-codes as well. Furthermore, it is noted that the 'postcoderoos'-arrangement will be assessed for a potential inclusion in the new 'feed-in-subsidy' mechanism. Larger buildings, as schools or office locations, would also be assessed on a potential inclusion (166).

E.2.4. Current developments in The Netherlands

According to IRENA, the Netherlands is a significant market for solar PV systems, which have a capacity lower than 1MW. Looking forward, the solar PV capacity in The Netherlands is estimated to reach 11.4GW in 2022 according to a medium scenario estimation of SolarPower Europe. This would be the result of an estimated development of 8.8GW over 2018-2022, which boils down to a CAGR of 34% (167).

E.2.5. Current global development

The increasing costs mostly hinder the development of new solar PV installations. On the other hand, operating solar PV installations have seen a record year of energy production in 2018. The average amount of energy generated relative to the installed capacity (kWh/kWp) increased by 11% to 0,98 (168). This upwards trend in profitability is also visible in the global investment environment. Over the period 2015-2017 solar PV investments increased with about 40% globally, with the investment costs declining on nearly 15% on average (42). Global solar PV investments are estimated to further increase with a CAGR[38] of 8.9% over 2019-2050 (169).

E.2.6. Assessment against private investment criteria

In this section the solar PV section is assessed against the private investment criteria. Solar PV parks in the Netherlands differ significantly in size. Furthermore, there are also a lot of small sized residential installations present. This assessment targets the solar PV investment opportunities for large scale investors and therefore only addresses the larger solar PV parks. These parks can be found in Table 11 in Appendix A.3.

The private investment criteria are established in Chapter 2, and are listed below:

1. Minimum investment opportunity of €100m
2. Application of project financing
3. Revenue is partly secured through PPA
4. Stable production and revenue over project lifetime
5. Minimization of regulatory risks by clear and stable support schemes for operations

For most of the listed solar parks financial figures were unfortunately not publicly available. However, looking at the solar parks, it can be concluded that none of the solar parks would yield a €100m equity investment opportunity. The global debt portion in the projects was situated between 60-70% in 2017 (170). Assuming the lower bound debt ratio, 60%, an equity stake of €100m would yield a total construction cost of €250m. None of the Dutch solar parks fulfils this requirement. The assessed Dutch solar PV parks are listed in Table 11 in Appendix A.3.

It is important to note that there are numerous smaller projects with capacities far below Solarpark Azewijn, the current amount of SDE(+)-managed projects is namely around 32,000 as of January 2020 (171). This underscores the abundance of smaller projects.

However, institutional financial investors are still active in the Dutch solar PV industry. These investors find their way to the market via secondary investment in smaller specialized funds. However, there are only a few funds active in the Netherlands and all the analyzed funds are foreign. These funds follow the earlier discussed 'farm-down' principle by buying greenfield as well as brownfield solar parks from solar park developers. From Table 11, Appendix A.3., it can also be seen that they cover larger as well as smaller solar parks. Examples of such funds are Impax, Blue Elephant Energy, Obton, Encavis and SUSI partners. For instance Blue Elephant Energy and Encavis are partly owned by respectively the German insurance companies Gothaer Group and Versicherungskamer Bayern (172) (173).

Application of project financing

Project financing is widely applied in the Dutch solar PV industry and covers the larger as well as the smaller solar parks. These project financing facilities are provided by a variety of (inter)national smaller and larger banks. The most active Dutch banks are Rabobank, ING, Triodos and ASN Bank. However, German banks as Hamburg Commercial Bank (HCoB) and Landesbank Badem-Württemberg (LBBW) are also active in this sector. Examples of HCoB its project financing facilities are the solar parks Vlagtwedde (110MW), Scaldia (55MW), but also Marum (9MW) (174) (175) (176). LBBW provides the project financing facility for solar park Stadskanaal (103MW).

[38] Compound Annual Growth Rate

From the data set it can be concluded that 67% of the projects applied project financing. However, this increases to 91% if we only use the projects from which the financing mechanism is known.

Revenue is partly secured via PPA

Not every solar park has reported the negotiation of a PPA. However, for most of the solar parks it can be concluded that they have negotiated a PPA. The nature of the PPA is however not always published, since this is sensitive financial information. The financial investors present in the solar PV market are all using project financing, but do not require a fixed price PPA to be present since the SDE+ subsidy is still available. For instance the German investor Blue Elephant Energy notes that it only invests under the condition of either a PPA or a Feed-in-Tariff (172).

Stable production over project lifetime

For most of the solar parks it is not specifically available what their production figures are, since this is treated as confidential information. However, relying on the solar PV analysis performed earlier in this section, it could be concluded that solar PV production is rather exceeding the expectations.

Minimization of political risk

There are no significant cases known which show political decisions which disadvantage operational solar PV projects. The main political risk at this moment would be the ongoing review of support mechanisms. Minister Wiebes has already shown that a reformation of the system could result in the proposal to change support mechanisms retroactively, which could affect the cash flows of operational projects.

Conclusion

All of the solar parks in the Netherlands have equity tickets which are too small to be primarily of interest for direct traditional institutional investments. However, investors are putting their money in the Dutch projects via the investment in smaller specialized infrastructure funds like Obton or Blue Elephant. Their capital thus still finds its way towards these projects. Furthermore, these financial investors are currently responsible for the equity in the largest solar parks in the Netherlands. This covers operational as well as developing projects.

The financing of solar parks is also widely available for both large-scale and small-scale solar parks. Most of these small-scale projects are initiated by developers and are later 'farmed-down' to financial investors. Project financing and PPAs are also widely used, the nature of the latter is however often undisclosed. The combination of supportive financing facilities and secured offtake is enhanced with stable production results and a solid governmental support mechanism. Looking at the solar parks in the Netherlands it can be concluded that financial investors and power generators find their way towards solar PV, predominantly via project financing facilities.

E.2.7. Overall conclusion

From the above it can be concluded that the Dutch solar PV market has seen promising growth in the past years. This is mainly caused by the stable support schemes from the Dutch government and the wide use of project financing. These conditions have drawn the interest of (inter)national financial investors and power generators, looking to invest equity, as well as banks which are supplying project financing facilities. However, the support mechanisms are planned to be decreased over time as well. The SDE+ applications will be closed by 2025, which marks the end of the main subsidy for larger solar PV installations. However, the Climate Agreement states that it targets to have all the necessary projects 'SDE+ approved' by 2025. These projects would then still rely on the stable subsidy cash flows. Looking at the current usage of project financing, and the increasing portfolio of financial investors, it is thought that project financing plays an important role in reaching the 2030 production target of the Climate Agreement. Furthermore, the current support mechanisms and rate of development give comfort when assessing the likelihood that the 2030 production target will be reached.

E.3. Conclusion of the onshore market assessment, relative to offshore wind

The market assessment is conducted to place offshore wind in perspective in the Dutch renewable energy market, relative to the onshore sector and its solar PV and onshore wind subsector. This is done by looking at the investors, the use of PPAs and the use of project financing. Furthermore, the nature of the current support mechanism in the markets and the influence of the subsectors to the Climate Agreement 2030 production target is assessed.

The market assessment yielded to the conclusion that the risks applicable to offshore wind are for a lesser extent applicable to the onshore sector. The onshore sector can also vary in its composition by changing the ratio between onshore wind and solar PV subsectors, which could mitigate the risk of underdevelopment. This is already shown by the changing estimates of PBL. The onshore sector also sees significantly smaller development investments than the offshore wind sector. The investors in the onshore subsectors are also much smaller and differ from the ones present in the offshore wind sector. The onshore projects are also often supported by local cooperatives, which co-invest in the park and consume the electricity.

Furthermore, the PPAs and project financing are used extensively throughout the onshore subsectors. However, the nature of all the PPAs are not known due to the financial sensitivity of such information. The 'Energie op rijksgronden' project enables developers to take part in tenders from the Dutch government. This also includes a long-term PPA, where possible, similar to Maasvlakte 2. The latter is tendered by the Dutch government and will be operated without a subsidy. Opposite to the offshore wind sector, the subsidy schemes are also still available for the onshore subsectors. The absence of these schemes forms the basis for the offshore wind sector. Compared to the offshore sector the onshore sector is more decentralized. The previously described tenders are not (yet) a standard. This is predominantly not the case for the onshore sector. Thus, it could be considered that it is not particularly easy for these tenders to become the norm for the onshore sector. This makes it harder to assess the impact of market development, since the interest in the tenders can act as a measuring point. The upcoming government tenders will therefore have to be closely monitored to assess the success of this mechanism. However, relative to offshore wind, it can be concluded that the Dutch government already started to facilitate the onshore market with other support mechanisms than the SDE+.

Project financing is extensively used in the Dutch offshore wind sector and the onshore sector. When assessing the sectors on the investment criteria, it is concluded that the Dutch market is still very well suited for the application of project financing facilities. Apart from the project financing similarity, it is concluded that offshore wind has little connection to the onshore subsector and that the latter does not face the same problems (yet). The offshore wind sector also accounts for a significant part of the Climate Agreement target capacity, which outweighs either solar PV or onshore wind.

However, it is deemed to be fruitful to research the behavior of the onshore subsector under conditions similar to those of the offshore wind industry. The urgency of this research is however deemed to be smaller for the onshore sector than for the offshore equivalent. However, it would be an advantage if this problem is already more extensively researched before it (potentially) hits the onshore subsectors. This is not the case for offshore wind. The first subsidy free onshore wind farm has already been agreed upon. It should however be noted that this wind park is tendered by the Dutch government, and that a 25-year PPA is negotiated with the government itself. The nature of such a PPA comes close to the SDE+ subsidy. Nevertheless, this underscores the importance of the PPAs in a subsidy free market.

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