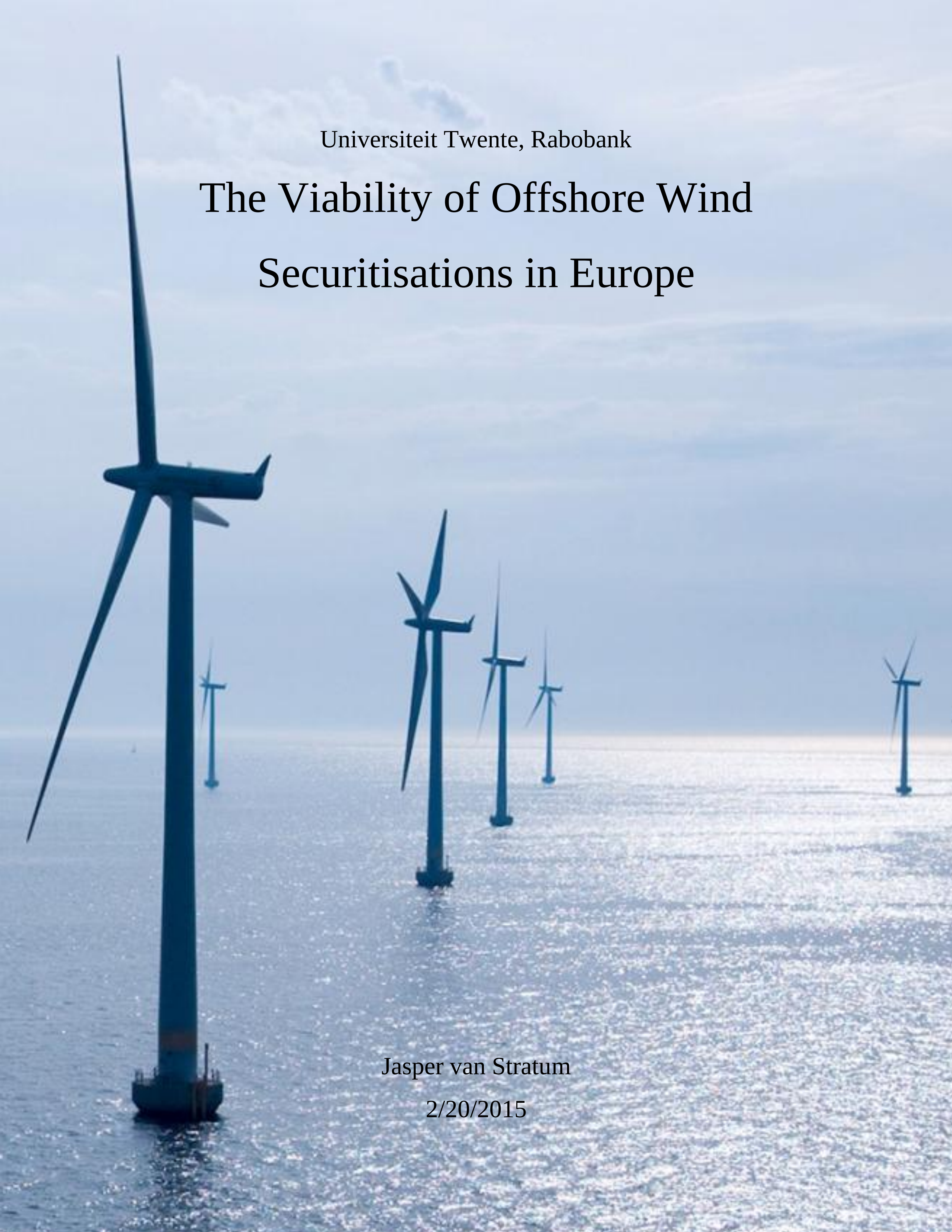

Universiteit Twente, Rabobank

The Viability of Offshore Wind Securitisations in Europe

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Document

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Management summary

In this research, an assessment of the possibilities for financing offshore wind projects using securitisation is made. The need for this research arises because of the desire for growth in the renewable energy market. This leads to big capital needs in the sector. Furthermore, the market for securitisations is shrinking which leads to market participants looking for new asset classes that can be securitised. The research uses a qualitative analysis as well as a quantitative analysis, based on the stressing of a cash flow model, to determine the opportunities for offshore wind securitisation.

The main determinants for offshore wind development are the initial capital costs, the presence of a support scheme provided by the government, and any associated counterparty risks. Usually, the initial capital is provided by a syndicate of banks. This is due to the large amount of necessary capital. Based on the size of the project, distance to shore, and water depth, the costs for these types of projects are in the range of EUR 300-3,000 mn. The subsidies provided by the government depend on the output that is created by the project. For every kWh that is produced, the government pays a predetermined amount to the project owner. These subsidies are important as they, currently, account for more than half of the project's revenue. The exposure to the government leads to the first significant counterparty risk. The other large counterparty is servicer of the offshore wind facility. The costs for servicing the wind farms are high, and the number of servicers is limited, which leads to a substantial exposure to these companies. Another issue for the ABS is the lack of granularity. As the loans are large, and few in number, only a few can be included in the securitisation. This omits any diversification effects that usually arise in ABS deals.

Based on a cash flow model of a portfolio of ten stylised offshore wind projects, an ABS structure is created. Using several stress scenarios, the economic viability of the structure is assessed. The analysis shows that the ABS structure performs well, even when stressed in multiple variables, unless the government stops providing the subsidies. Depending on the timing of this stop, the mezzanine tranche, and even the senior tranche, could be affected severely. However, the analysis does show that the senior A tranche remains unaffected, unless the support scheme is stopped within the first three years.

In this research several assumptions have been made regarding the development of offshore wind facilities. Future research could focus on these subjects. The most important factors are the presence of a proper grid connection for the offshore wind project and the developments of cost prices of renewable energy, as well as other energy generating technologies. The costs related to offshore wind are expected to decrease to nearly half of current costs, which should make these projects much less dependent on a subsiding government. Finally, possibly the most interesting feature of the proposed offshore wind ABS is the green characterisation of the ABS. This could offer additional, non-financial yield for investors.

Chapter 1 Core problem

At the start of December 2014, German's largest energy concern, EON, announced that their entire fossil fuel branch will be split off and that the company will focus solely on renewable energy (RNE) and in February of 2015, Apple announced a further investment of USD 850 mn in a large solar plant in California. These are signs that the renewable energy market is becoming increasingly relevant. More and more buildings are fitted with solar panels and the wind energy development is moving to large offshore locations to significantly increase its size.

Because of these developments, the renewable energy industry is searching for new capital to fund new investments (Alafita & Pearce, 2014; Fink, 2014; Jacobsson & Karltorp, 2013; Lowder & Mendelsohn, 2013; Mendelsohn & Feldman, 2013). In the US, the overwhelming part of available capital comes from a pool of highly sophisticated investors, who profit from complex investment structures that are eligible for federal tax incentives (Schwabe, Mendelsohn, Mormann, & Arent, 2012). When looking at the supply for capital in the solar-power-industry, this pool is made up out of 10-20 financial institutions. As of 2017, the amount of tax incentive, the percentage of investments that can be deducted from taxable income, through the American Recovery and Reinvestment Act will decrease from 30% to 10%, which will probably lead to a decrease of investors in the already small pool (Fink, 2014; Lowder & Mendelsohn, 2013; Miller, 2012).

Since the credit crisis, the European market for asset-backed securities (ABS) has shrunk severely (AFME, 2014; Van Leeuwen, 2013). According to the Association for Financial Markets in Europe (AFME), issuance of securitisations has dropped from EUR 478 bn in 2006 to EUR 52 bn over the first three quarters of 2014 (AFME, 2014). The investor base is shrinking, for a significant part because of the departure of structured investment vehicles (SIVs) from the market. Also regulation for asset-backed securities has become much tighter than before the financial downturn, triggered by the legacy issues ABS has faced since the crisis. These factors have lead to a widening of spreads, thus making ABS less interesting for issuers. However, securitisations still remain a very viable product for investors that want to find a well diversified product that matches their risk appetite. The recent decline in market size leaves investors scrambling for opportunities. In an effort to revive the European ABS market, the ECB started a purchase programme at the end of 2014. One of the goals of this programme is to drive down spreads, and thus, improving conditions for sellers of asset-backed securities.

Another way to increase the opportunities for investors in the ABS-market is to find new markets. This could create a match between the wishes of investors, and the needs of RNE-developers who are looking for additional financing sources for their projects (Fink, 2014; Hyde & Komor, 2014; Jacoby, 2012;

Lowder & Mendelsohn, 2013). As of now, we have witnessed a couple of ABS launches backed by renewable energy assets by a US based RNE-developer named SolarCity (Parkinson, 2013; Wiltermuth, 2014). Thus far the European market has not seen this type of ABS issues and therefore the question remains whether the ABS that are being issued in the US could serve as a launch point and template for the issuance of European securitisations backed by renewable energy.

In Europe, countries are dealing with the EU's '20-20-20' targets that, among others, prescribe countries to increase the renewable energy share in total energy production to 20% by 2020 (Ecofys, 2011; Ernst & Young, 2014; Eurostat, 2014b; EWEA, 2013; Rabobank International & Bloomberg New Energy Finance, 2011). Also, where in the US the focus in RNE development is mainly on solar-photovoltaic (PV) technologies, this might only be a viable option in peripheral countries like Spain, Italy and Portugal. In northern Europe the development of the RNE industry is mainly focussed on onshore- and offshore wind facilities (Creutzig et al., 2014; Ernst & Young, 2014; Jacobsson & Karltorp, 2013; Kaldellis & Kapsali, 2013). As this research is carried out in cooperation with Rabobank, a bank based in the Netherlands, the study will focus on the possibilities in the wind energy sector.

Looking at the development of wind technology, the most recent trend is that it has commenced expanding towards the creation of offshore wind farms. Because of better wind resources at sea, and less restrictions related to an opposing society, size is easier to achieve and is becoming more and more important (Couture & Gagnon, 2010). Looking at the Netherlands for example, the share of generated renewable energy as a percentage of total generated energy needs to more than triple from 2012 to 2020 (Eurostat, 2014b). The costs for developing offshore wind facilities are very high, however. According to a study of Prässler and Schächtele (2012) the initial capital costs are somewhere in the range of EUR 2-4 mn per MW of capacity, depending on factors such as water depth and distance to shore. Because of the desired size increase and the high capital costs, the need for financing in the offshore wind sector is significant. This research, therefore, will scope on the offshore wind technology and sets out to determine whether it is possible to create an economically viable model for securitisations backed by assets in the offshore wind industry. This goal leads to the main research question:

Is securitisation an economically viable option for offshore wind financing in Northern Europe?

To find a comprehensive answer to this question, several aspects of this problem have to be identified and researched. In the next chapter, I will list these topics and make a preliminary assessment of their impact on this research. The aspects will lead to sub-questions that need to be answered in order to find an answer for the main research question. These sub-questions will form the main storyline for this research and will be the themes of chapters three and four.

Chapter 2 Methodology

In order to answer the main research question of report several aspects need to be studied. In the main part of this methodology chapter, relevant themes of securitisation and offshore wind projects will be mentioned and their relation with this research will be discussed. Based on these discussions, I will create sub-questions that will help me answer my main research question. The nature of the sub-questions will reflect the fact that the main research question has both qualitative and quantitative aspects. At the end of this chapter I will outline the structure of the remainder of this research.

As the first pillar for this research, a brief overview of the concept of securitisation will be presented. This will be followed by a deeper look into the current renewable energy market in Europe and its targets for the future. What have been the main trends in both offshore wind development and also the renewable energy sector as a whole? And what are the current goals for the future and what kind of capital is needed to fund the developments towards these goals? Combining these topics into one research question:

I. *What is securitisation and what is the current state of offshore wind development?*

In an effort to further the development of the renewable energy market, the sector is looking into parties that might want to invest in green energy. Over the last few years, several institutions have looked into the possibilities to reach a new pool of investors. One of the leading US institutes in this field is the National Renewable Energy Laboratory (NREL). It has published several papers advocating the opportunities for ABS-like structures to finance renewable energy projects in the US. Furthermore, the US market has seen a few renewable energy ABS issues in the last couple of years. A study into the specific characteristics of these deals might reveal valuable information about future possibilities for this sector.

Looking at other types of ABS structures, that show similarities to the proposed offshore wind ABS structure, with respect to the nature of the underlying assets, the commercial mortgage backed securities (CMBS) come to mind. Here, the similarity appears to lie in the fact that the underlying assets of both structures are very few in number and large in size. This influences the granularity, the extent to which a system is broken down into small parts, of the asset pool. Higher granularity usually will lead to tighter spreads, because of the diversification effect it creates within the pool backing the ABS structure. Because of these similarities a short overview of CMBS will be given, in chapter 3, in order to learn more about the link between spreads and credit enhancement in this asset class.

A much cited barrier in literature for growth of the renewable energy industry is the lack of policy stability (Alafita & Pearce, 2014; Bazilian et al., 2014; Creutzig et al., 2014; Fink, 2014; Fouquet, 2013; Fouquet & Johansson, 2008; Hegedus, 2013; Jacobsson & Karltorp, 2013; Jacoby, 2012; Mani &

Dhingra, 2013; Negro, Alkemade, & Hekkert, 2012; Wieczorek et al., 2013). Based on this wealth of literature, an assessment will be made on how policies and regulations should be constructed, so that they will stimulate, and not interfere, with the development of renewable energy. As the financing of renewable energy initiatives is the most important aspect for the proposed model, I will mainly focus on the different types of support schemes used in Europe, and look for matches and mismatches with ABS structures.

Although governments play a vital role in the process of funding offshore wind developments, the support schemes mentioned above do not fund the initial capital expenditures of an offshore wind project. The financing for this stage of the development exclusively comes from the private sector. The ability to model cash flows is essential for ABS, and the RNE-stimulating policies will go a long way, both in time and size, in determining the size and the predictability of incoming cash flows.

Related to European and local regulation is the establishment of a proper grid infrastructure for renewable energy. Especially for offshore wind farms, this is very important, since the power generated from these installations needs to be transported to the mainland. For this research, however, the assessment of grid development is out of scope. Common practice within project finance is that there will be no loan from a bank for an offshore wind project, when there is no guarantee of a proper grid connection, and without the presence of a loan there will be no securitisation. What does remain is the assessment of government's policies, such as for instance regulation, that create a healthy environment for renewable energy investing. Obviously there is a lot of integration between government policies concerning offshore wind and the subsidising of offshore wind projects.

An important indicator of the potential of asset-backed securities is the credit rating it can obtain from an external credit rating agency such as S&P, Moody's, and Fitch. In order to determine what they consider important variables when determining the rating of renewable energy portfolios, I will look into methodologies for rating specific portfolios and will try to determine how portfolios like the one in the proposed model are assessed and what the consequences will be for the securitisation structure.

Traditionally, the senior tranches of ABS issues obtains very high ratings from rating agencies like S&P and Moody's. However, recent renewable energy ABS issues by SolarCity only obtained a BBB+ rating from S&P for the senior tranche (S&P, 2013, 2014a, 2014b). This is barely an investment grade rating. The main argument for these ratings is that there is, as of now, not enough information on how these ABS-transactions will perform based on lack of knowledge on performance of the underlying assets as well as the default tendencies of customers. Also the uncertainty concerning government policies played a role in the somewhat low rating of these issues. The NREL is currently working on establishing a database on performance of renewable energy systems, as well as on default tendencies of consumers. These uncertainties will play a vital role in the assessment of offshore wind technologies. While there certainly is a lot of performance data for onshore wind, studies show that these performances cannot simply be copied to estimate performance of offshore wind facilities as lots of different factors play a role in this process. For instance, uncertainties about operations and management (O&M) expenses and counterparty risks, play a large role in the cash flow modelling concerning offshore wind installations.

In the sections above several issues have been raised that demand an answer before the construction of the model can commence. The common denominator between these topics is that to a certain extent they are all able to influence the securitisation model for offshore wind projects. In order to complete the qualitative analysis of this research the sub-question below has to be answered:

II. *What are the specific characteristics of offshore wind projects and how do they influence the model for an offshore wind asset backed security?*

The main component of all securitisation models are cash flows. In order to create a successful ABS structure, the seller and investor need to be able to accurately model and assess the relevant cash flows within the structure. In current literature, very few of these cash flow models for renewable energy have been created (Alafita & Pearce, 2014; Prässler & Schächtele, 2012) and none so far have combined a relevant cash flow model for offshore wind farms with a securitisation model. The main objective of the quantitative analysis of this research is to determine how to create a model for offshore wind securitisation and what variables are able to influence the performance of such an ABS. This analysis will show whether it is possible to create an economically viable model for both the seller as well as the investor in the ABS, considering the current economic environment.

The model will be based on a wide range of variables which I will categorise into three different groups:

- Fixed variables; these are the variables that are based on specifications in contracts, but for modelling purposes and simplicity are assumed to remain fixed;
- Range variables; these are the variables that determine the characteristics of the individual offshore wind projects based on pre-determined ranges for these variables. Also for these variables, the specifications are given in the contracts for the offshore wind projects. The fact that not all offshore wind projects are identical will be reflected in the values of these variables;
- Stress variables; these are the variables that are used for the stress testing of the model. The variables included in this group are those that are able to, in my view, influence the performance or alter the dimensions of the project after closing of all the contracts.

In the sections regarding the quantitative analysis I will go deeper into the underlying assumptions of the model and what variables will be placed in which group and why. Also, I will determine the output variables, and the stress analysis will be constructed and carried out. The research question that has to be answered in the quantitative part of the analysis is:

III. *Is it possible to create an economically viable ABS structure backed by offshore wind loans and how will this ABS perform under stressed conditions?*

In the following chapters all the issues, highlighted in this chapter, will be discussed in the context of offshore wind securitisation. First, in chapter 3, a qualitative assessment of both offshore wind development and securitisation will be made, based on sub-question 1 and 2. Beside from finding an answer to these two question, this assessment will provide the foundation for the quantitative part of the research. This quantitative research will be executed in chapter 4. I will create a quantitative model that can be used to test the performance of an asset-backed security structure with offshore wind projects as underlying assets. Following the quantitative analysis in chapter 4, I will answer the main research question as presented at the end of the first chapter, based on the sub-questions presented in this chapter. This concluding chapter will be chapter 5. Following the conclusions, I will discuss the assumptions and limitations of this research and offer implications for further research, in chapter 6.

Chapter 3 Qualitative analysis

In this chapter, I will discuss the qualitative aspects related to this research as they were mentioned in the previous methodology chapter. First, I will provide some background on asset-backed securities in the first paragraph and on current and future renewable energy market conditions in the second paragraph. These two paragraphs will provide the answer to the first research question. Second, after the background analysis, I will discuss the financing of offshore wind projects, the spectrum of regulation and policies that influence offshore wind development projects, and some ABS structures that show similarities with the structure proposed in this research. These paragraphs lead to the answer to the second research question.

3.1 Asset-backed securities

An ABS is a security that is backed by a pool of underlying assets (Fabozzi, 2012). The underlying assets determine the income payments and thus the value of the security. These underlying assets take many forms; there are securities backed by pools of mortgages, auto loans, student loans, credit card debt, small & medium enterprises loans, and so on.

The origination of an ABS is executed through a *special purpose vehicle* (SPV). This is a bankruptcy remote entity that is legally independent of the originator of the underlying loans. Through the use of a SPV, the credit risk in the underlying asset pool is disjoint from the credit risk of the issuing party. In the process of securitisation the issuer of the ABS sells the underlying pool of assets, which were originally at the balance sheet of the issuer, to the SPV. The SPV raises funds for this transaction by selling notes to investors who are interested in obtaining a share of the underlying asset pool.

Typical for any asset-backed security is that there are multiple tranches, each with different risk and reward characteristics. The investor thus has the choice to match its specific risk and reward appetite to a certain tranche of the ABS. The risk of specific tranches is dependent on the waterfall principle that is present in ABS structures. According to the waterfall principle the available cash first flows into the tranche with the highest seniority until the obligations to this tranche are fully paid off. Then the cash flows fall to the next most senior tranche, and so on, until the SPV runs out of incoming cash flows. The cash that flows into the ABS, which is used to pay the note holders of all the tranches, comes from the underlying asset pool in the form of interest payments and principal repayments. These two types of payments flow into the corresponding interest and principal waterfalls. So within the SPV there are usually two waterfalls present.

In case any losses occur in the SPV, because of non-performing loans for instance, these losses are recorded in an opposite direction of the interest and principal waterfall; the most junior notes are the first to suffer losses. Only when these junior notes cannot absorb anymore losses, more senior notes will suffer losses as well. This structuring of cash flows leads to lower risk, and thus lower reward in the senior notes, and higher risks and rewards as the notes become less senior. Related to the risks of a tranche, an important concept of securitisation for this research is *credit enhancement* (CE). The CE of a note is the percentage of the total principal, plus any reserve accounts, of the ABS that is junior to this tranche and will thus bear losses before this specific tranche does.

3.2 Renewable energy: market overview

In the first chapter, the European Union's '20-20-20' targets were mentioned as one of the driving factors for the increased activity in renewable energy development. One of these targets is to increase the share of renewable energy in total generated energy across the EU to 20%. The figure below shows the gap between the amount of installed renewable energy capacity as a percentage of total energy generation capacity as of 2012 and the targets as set out by the European Union (Eurostat, 2014b).

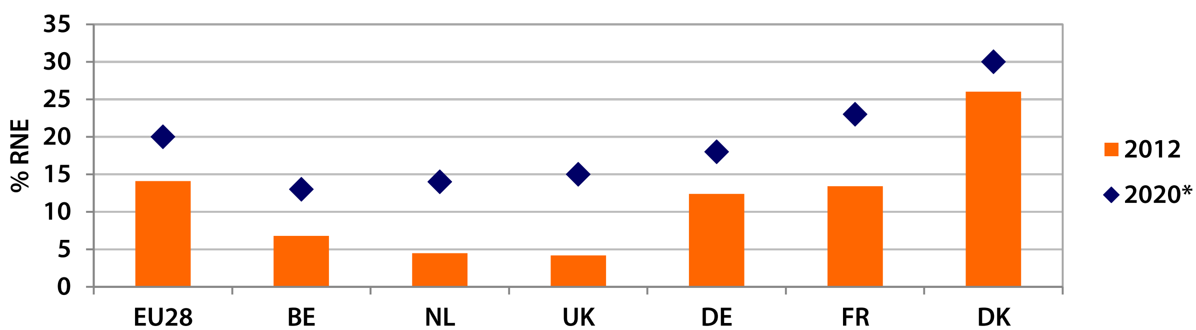


Figure 1: "20-20-20" targets, source: Eurostat (2014)

The countries mentioned in the graph all belong to the top 8 worldwide in offshore wind development, based on the attractiveness index of Ernst & Young (2014). The other two countries in the top 8 are China and the US. The targets for 2020 per country, as shown in the graph, differ among each other based on the economic climate and the potential for generation energy from renewable sources. The potential in a country like Denmark, for instance, is very high, based on its enormous amount of wind resources. From the graph it is clear that, especially in the Netherlands and the UK, there is still a relatively huge gap that has to be covered in order to reach the targets. Looking at the potential for different types of renewable energy sources, countries in the northern and western parts of Europe will mainly benefit from excellent wind resources contrary to southern Europe where solar resources are much higher. In Figure 2 below, derived from the research of Creutzig et al. (2014), this assessment is supported.

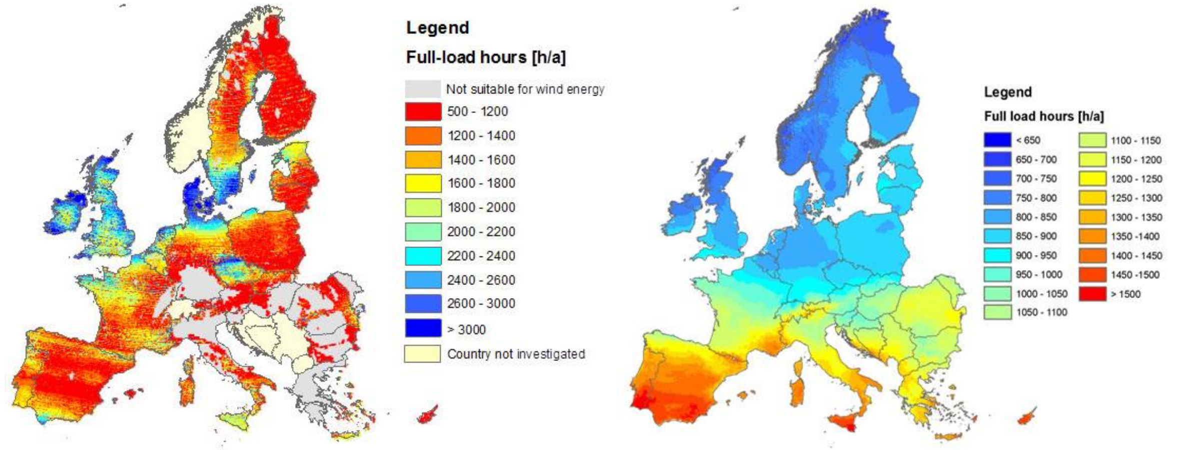


Figure 2: Wind resources (left) and solar resources (right) in full load hours in Europe (Creutzig et al., 2014)

Looking at the gap between current capacity and desired capacity, Ernst & Young (2014) estimate, in its yearly renewable energy assessment, that the UK alone will have to add around 90 TWh of renewable energy capacity between now and 2020. To put this in perspective, that is the same amount of energy necessary to let 1,285,000,000 8W LED lights burn year round, and more than 6.5x the production of the Gemini wind farm; a Dutch wind farm currently under construction, which will be the world's largest offshore wind farm, when it becomes fully operational in 2017.

Looking at the necessary funding for the desired capacity increase, a recent report by the European Wind Energy Association (EWEA) (2013) states that before 2020 the European offshore wind energy industry needs to attract between EUR 90 bn and 123 bn in order to reach its deployment target of 40 GW of capacity. Assuming an average availability factor of 0.4, this capacity will create around 140 TWh of energy. Mid 2013, the installed capacity of offshore wind facilities is still well below this target, at just 6 GW. Another stated target in publications for offshore wind capacity, is the National Renewable Energy Action Plans' (NREAP) target at 46 GW (Rabobank International & Bloomberg New Energy Finance, 2011). This target would lead to 4.1% of the EU's gross electricity generation being created by offshore wind.

According to the EWEA report published in November 2013 (EWEA, 2013), there was at that time 4.5 GW of offshore wind projects under construction. Nonetheless, even when adding an additional 18.4 GW of consented projects, that might be completed before 2020, there is still a sizeable gap of more than 10 GW in offshore wind capacity that has to be created.

3.3 Offshore wind loans

The underlying of every asset-backed security structure are loans originated by the seller of the securitisation. Whereas in most ABS structures loan conditions are pretty straightforward, this is not the case for loans to offshore wind development projects.

3.3.1 Size and recourse

The offshore wind projects usually have a capital expenditure (CAPEX) of several hundreds of millions and more, which makes these projects in general too big to be financed by a single party. Common practice is that the debt-equity ratio is around 70:30, with the equity provided by a group of project developers. The debt share is provided by a syndicate of, mainly, banks and possibly some other large financial institutions, such as insurers or pension funds. The number of participants in such a syndicate depends to some extent on the project's CAPEX, as well as on the ticket sizes of the investors. In general, ticket sizes are in the area of EUR 150 mn. The debt providers within the syndicate are usually all categorised as senior debt providers, and thus no differentiation between seniority among them is made. In some situations, there is an added mezzanine loan within the project financing structure. This mezzanine loan is then junior to the senior debt. All the loans provided by the debt-holders are written to a SPV, specially created for the purpose of financing the offshore wind project.

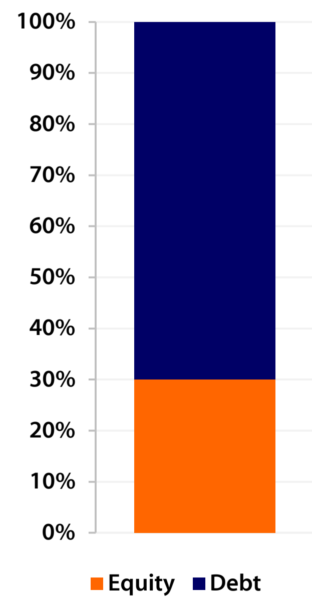


Figure 3: D/E shares project SPV

Because of the structure where the project is placed in a SPV, the debt holders have no recourse on the equity provider's assets outside of the SPV, should there be a default on the interest payments to the debt holders. The collateral that is available for the debt providers are the cash flows generated by the project, so in case of default the loan providing syndicate would become owner of the cash flows generated by the projects and are thus entitled to any profits made, but also run the risk of incurring losses. In order to prevent an event of default, the equity parties provide the SPV with a debt service fund large enough to facilitate 6 months of interest payments to the debt holders, should the cash flows coming from the project be too little.

3.3.2 Tenor

The tenor of a loan for an offshore wind development project is usually equal to the length of the project. The duration of an offshore wind project depends on several factors. First of all, the developers need to possess the appropriate licenses, which are usually provided for a certain amount of time; after the expiration of a license the wind farm has to be removed from the project site. Other factors are the availability of support schemes provided by the government, as well as the guarantee of a grid connection. These licenses usually go hand in hand with project licenses and the duration is in most countries around 15-20 years, counted from the start of energy production. The most important exception on this rule of thumb is Germany where the support scheme is guaranteed for eight years plus a period of a maximum of four years, depending on the project's distance to shore and the depth of water. Because of this, loan tenors in Germany will be somewhat shorter than in other countries. Should site licenses run for a longer period than the support scheme, this means that revenues will be low in the final years of the project and debt providers will not want to be exposed to these low revenue periods. The support schemes relevant for the offshore wind parks will be discussed in more detail in paragraph 3.4.

A final consideration for the tenor of the loan is the duration of the construction phase. In this period, which is usually around two years, the loan terms differ from the terms in the operational phase because of higher risks associated with the construction. Once the development is finished, performance estimates of the project are more accurate. So the loan is typically structured as a '2+x'-loan, where 2 is an estimate for the duration of the construction phase, and x is based on the length of the licenses.

3.3.3 Interest coupons

The difference between the risks in the construction and operational phase is translated into the coupons that are demanded by the debt holders in both phases. Where in the construction phase margins are around 300-350 bps, this drops by around 50 bps in the operational phase depending on project specific characteristics. The margin is on top of floating swap rates, but since the debt-holders usually do not want to be exposed to interest rate risks, they use interest rate swaps to swap these rates to fixed ones.

3.3.4 Amortisation

An interesting feature of the loan is the amortisation method. This is based on a so-called *sculp*-scheme. The target of a sculp-scheme amortisation is to optimise the stability of the *debt-service-coverage ratio* (DSCR). The DSCR is calculated in the following manner:

$$Debt\ service\ coverage\ ratio = \frac{Annual\ net\ operating\ income}{Total\ debt\ service}$$

The total debt service in this formula is the summation of interest- and principal payments. Based on a fixed target value for the DSCR, the principal repayments on the loan, according to a sculp-scheme become:

$$Principal\ repayment = \frac{Annual\ net\ operating\ income}{Debt\ service\ coverage\ ratio} - \ Interest\ payments$$

As the annual net operating income most probably is not going to be stable, this amortising scheme obviously means that principal repayments are neither stable. Depending on the project's cash flows, the principal repayments become either front-loaded, if revenues are high at the beginning of the project's operational phase, or end-loaded.

3.3.5 Reserves

In order to properly perform maintenance on the project's facilities, the SPV has an operations and maintenance (O&M) contract with the servicer of the wind farm. This is usually the company that installed the turbines. The contract covers the entire lifetime of the project and is structured in such fashion that there are a couple of points in time where there is a step-up for the servicing in the fee. Typically these moments are 5 and 10 years into the operational phase of a project with a lifetime of 15 years.

Depending on the record of the turbine facilitator, there could be a reserve within the SPV specifically created to deal with any problems concerning the O&M of the wind farm. For such a reserve facility it is common that it is gradually build up in the early stages of the operational phase. Should a company default on its servicing contract for whatever reason, this reserve can be used to mitigate some of this downside. Also, it should be noted that there is no cross-default clause within the O&M contract, meaning that should a company default on its contract in one offshore wind project, this does not mean that it automatically defaults on other projects as well. However, if a company would default on all its liabilities at once, this of course will be the case.

Other reserves present in the SPV are the debt reserve, I discussed in section 3.3.1, and possibly a dismantling reserve. The latter is specifically created to be used for the cost associated with the dismantling of the facility.

3.4 Risks and rating methodologies

Now that the financing of the offshore wind projects is covered, the main risks related to the projects have to be studied. First, a broad overview of risks related to project finance will be provided. As some of these risks will be more important than other, the second step in identifying the risks is an assessment of the rating methodologies of credit rating agencies. As the credit rating is an important determinant for the securitisation, knowing the factors that credit rating agencies deem important is useful when identifying the main risks related to the securitisation.

Based on literature, I have identified six main risk categories within project finance (Drake, 1994). These are political risks, market and revenue risks, operating risks, finance risks, legal risks, and construction risks. Political risks cover all topics related to the government, such as subsidies, grid connections, tax rules and exemptions, and changes in law regarding, for instance, the handling of oversupply of a wind farm. Market and revenue risks are related to the incoming cash flows of the project, while operating risks are mainly related to outgoing cash flows. For finance risks, for instance, changing interest rates are relevant. Legal risks are concerned with ownership issues of certain assets and what would happen when there is a breach in contracts. The construction risks, finally, are all risks involved in the construction of the project.

Now looking at securitisations and credit rating agencies, I have noted that it is common for securitisations to obtain high credit ratings for the most senior tranches of the structure. An important reason behind this is that the pool of loans backing the securitisation is usually granular. For the proposed offshore wind ABS this, most likely, will not be the case and therefore the assessment method of credit rating agencies changes. For granular pools, these agencies, like S&P, Moody’s and Fitch, assess the quality of the entire portfolio. However, for non-granular pools they will look at the credit quality of individual loans and will thus omit any diversification effects. These diversification effects are the main reason the granular pools are able to obtain the high credit ratings. For the ABS model in this research, the main driver for the credit rating of the pool of offshore wind loans will thus be the rating of the individual loans.

Looking at the rating for these individual loans there are four main factors on which the credit rating is based according to Moody’s (Moody's, 2012):

- Predictability of Cash Flows;
- Competitiveness/Regulatory Support;
- Technical and Operating Risks;
- Key Financial Metric(s).

Relating these bullets to the risk categories I defined earlier, the political risks, market and revenue risks, and the operating risks seem to be the most important. While I argued that political risks cover a wide range of risks, I will mainly focus on the one risk that also influences competitiveness and predictability of cash flows: the subsidies. This is also closely related to market and revenue risks. Together with operating risks, these three risks will be the primary focus of the remainder of this chapter. The legal risk, which in this context can be seen as risks related to the syndicate structure of the financing, is in my opinion of less importance in this research. The same goes for the construction and finance risks. The securitisation will not be influenced by the construction risks, as I assume that the ABS will not be issued based on projects that are still under construction. Both the risks and the coupons on the underlying loans are different in that situation. The impact of finance risks, which I see in the context of differences between incoming and outgoing interest payments, is negligible as well since both the incoming interest and the outgoing interest payments are based on a floating reference rate.

3.5 Support schemes

Currently most renewable energy (RNE) sources are still depending on subsidies to remain competitive in the market with traditional utilities. The two most used systems by European governments are *feed-in tariffs* (Alafita & Pearce; Couture & Gagnon, 2010) and *tradable green certificates* (Nielsen & Jeppesen, 2003). The former is encountered in countries like Denmark, Germany, the Netherlands and France, while the TGCs are the main subsidising tool used in the UK and Belgium. Looking at the differences between these policy alternatives, the compatibility with securitisations for each structure can be assessed.

3.5.1 Feed-in tariffs

According to several sources, feed-in tariffs (FiT) are the most successful policies for the stimulation of renewable energy development. They have consistently delivered more RNE supply at an effective rate, and at lower costs than other mechanisms (Butler & Neuhoff, 2008; Couture & Gagnon, 2010; Fouquet & Johansson, 2008; Klein, 2008; Mendonca, 2007). The principle behind FiT is that they offer some sort of guaranteed price to the suppliers of renewable energy for every kWh that is produced by the subsidised project. The FiT allows for differentiation according to renewable energy source, size of projects, quality of resources, location, and so on. In 2009, 63 countries already used some sort of feed-in tariff to stimulate the development of renewable energy (Couture & Gagnon, 2010; Fouquet & Johansson, 2008). Assigning a FiT to a RNE project will significantly reduce risks associated with the marketability of the generated power and therefore will make the project more attractive for potential investors. However, there is also differentiation between the exact structures of feed-in tariffs and these varying policy designs have different implications for the risks of the project.

The central difference between FiT policy designs is the choice whether the remuneration offered to renewable energy developers is *dependent* or *independent* of current and future actual market prices. With an independent policy, also known as fixed price policies, the RNE developer receives a fixed remuneration, independent of market prices, for the power that is produced. Essentially, the subsidising entity fills the gap between the actual market price and the predetermined price the developer will receive. In a dependent FiT mechanism, also referred to as feed-in premiums, the government offers a fixed amount to the RNE developer for every kWh that is produced on top of the amount that is earned by the developer in the marketplace.

In the two figures below, the basic structures for these two policies are shown. The dotted orange lines represent the market prices over time that can be obtained by the developer, the dotted blue lines represent the provided subsidy, and the solid blue lines show the total remuneration for the RNE developer.

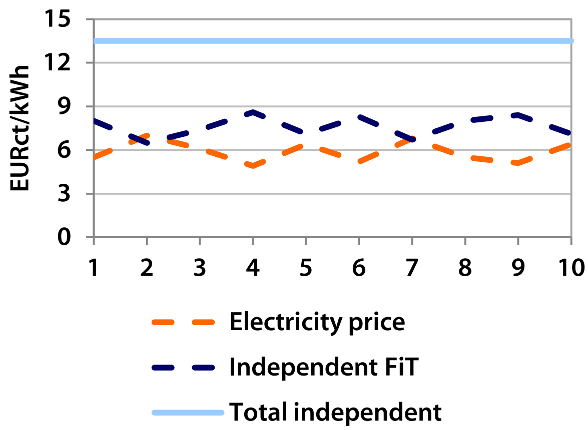


Figure 4: Independent feed-in tariff

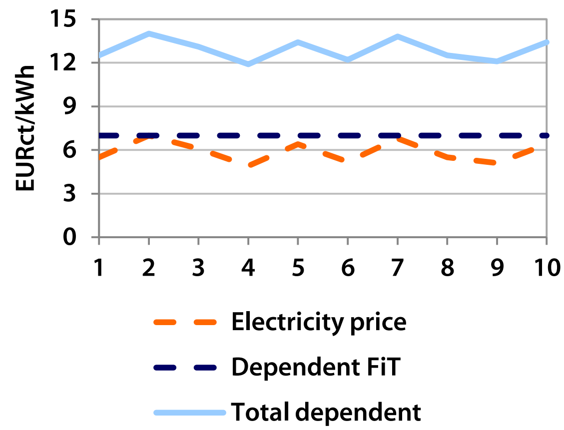


Figure 5: Dependent feed-in tariff

Within these two categories, there are again some different design options to choose from. For market-independent feed-in tariffs the benchmark structure is the fixed tariff over the entire lifetime of the project, as shown in Figure 4. Variations include policies with an inflation adjustment component, which will ensure tariff escalation based on the increase of price levels. Such a policy decreases predictability of incoming cash flows but RNE developers are better protected against a decline in the real value of project revenues. Another option is a front-end loaded feed-in tariff. This design creates higher revenue streams for developers in the early stages of the project, when it might be needed most as debt facilitators still have to be serviced, while not decreasing predictability of cash flows. Also, recall that the reserves in the project SPV are usually built up in the early stages of the project.

The standard market dependent policy, as shown in Figure 5, provides a fixed premium on top of market prices. Other possibilities include the provision of a premium that is a percentage of the market price and the inclusion of a floor and/or cap in the tariff's construction. The former increases exposure to market prices while the latter decreases this. In the figures below the standard independent and dependent feed-in tariffs are shown.

Looking at the benefits of both policy choices it can be said that independent feed-in tariffs are better suited to decrease investment risks because of the cash flow stability this policy creates. Premium price policies, on the other hand, create incentives to produce electricity during peak periods because, during these times, extra demand will push electricity prices up and since dependent tariffs follow market prices RNE developers will receive higher prices for their product. After an extensive study into different feed-in tariffs mechanisms, Couture and Gagnon (2010) conclude that independent policies, in general, are best suited to create relatively low-cost renewable energy deployment. This is mainly due to the lower risk investment associated with independent policies. Another benefit is that fixed prices impose a limit on the maximum amount RNE developers can obtain. Market dependent policies, unless constructed with a cap, are not able to impose such a limit as they track energy market trends. These market trends are typically driven by traditional utility prices and are therefore heavily dependent on fossil fuel prices, rather than on the generation costs trends for renewable energy. More often than not such a mechanism will lead to either over- or under-compensation for the RNE developer.

3.5.2 Tradable green certificates

The mechanism behind tradable green certificates (TGC) is less straightforward than that of feed-in tariffs. With a TGC policy the renewable energy developer is not provided with actual cash support but is rewarded a number of certificates based on the amount of energy that is produced. These TGC are tradable on the market so the developer can sell these to obtain additional funding. The demand for these products is created by the government. They force energy companies to possess a certain number of TGC based on the amount of energy they supply to households (Fouquet, 2013; Nielsen & Jeppesen, 2003).

This market-based approach obviously leads to more market exposure than FiT mechanisms (Fouquet, 2013; Prässler & Schächtele, 2012). Imagine a scenario where lots of RE projects are developed. This will lead to oversupply of certificates and therefore a significant decrease in market prices of the certificates. This will put pressure on the renewable energy projects as additional funding is vanishing, so they must now compete with traditional utilities on equal grounds. In Table 1, the support schemes per country are shown (3E, 2013; Prässler & Schächtele, 2012). Note that for the FiT schemes, which are all independent FiT schemes, the electricity price (approximately 5ct/kWh) is included. For the TGC schemes the presented remuneration is an addition to the electricity price.

Country	*Support scheme*	*Level of remuneration*	*Duration*
Belgium	TGC	1 certificate worth 10.7ct/kWh for first 216 MW of capacity; 9ct/kWh for additional MW	20 yrs
Denmark	FiT	According to project specific tender (project Anholt 14ct/kWh)	According to project specific tender (Anholt: 20 TWh of production)
France	FiT	Between 11.5ct/kWh and 20.0ct/kWh, based on location and specific tender.	20 yrs
Germany	FiT	19ct/kWh for first 8 years; 15ct/kWh for possible extension	8 yrs plus possible extension
Netherlands	FiT	According to project specific tender (project Gemini 17ct/kWh)	According to specific tender (Gemini max EUR 4.4 bn over 15 yrs)
UK	TGC	2 certificates worth ~6ct/kWh	20 yrs

Table 1: Support schemes in different countries

3.5.3 Compatibility with securitisations

The better the cash flows can be predicted the more success an ABS structure will have. Looking at the several policy options described in the previous paragraphs it is clear that feed-in tariff policies, especially the market independent ones, are best suited to support a strong renewable energy asset backed security. Predictability of cash flows is highest under these independent policies, as predetermined levels of cash flows are agreed upon in advance. Market dependent feed-in tariffs might also prove useful for securitisations as long as there are floor levels included in the FiT-policies. This will ensure RNE developers of a base level of cash flows on which the cash flows for the securitisation can be modelled.

Going back to the credit rating of both securitisations and individual projects, risks of this support scheme disappearing have a major influence on the credit rating as incoming cash flows are so heavily dependent on this support. Because of this severity, credit ratings for individual projects are usually not higher than BBB (Baa for Moody's). Based on information received from investors, their assessment of these risks is somewhat different. Since the discrepancy between the situations with and without a support scheme is so large, it was stated that you either have faith in prolonged support from the government or you do not. In the first case, the credit rating becomes much less driving for your investment decision, and in the latter case you do not have any business investing in the product what so ever, no matter what the credit rating is. Looking at the spreads of the individual offshore wind loans, this is exactly what happens; these spreads are very tight when seriously considering a government stopping its support of a project. Thus, for the assessment of the credit quality of an offshore wind portfolio, other factors will also be important.

3.6 Policies and counterparty risks

While the support scheme structuring is the main policy consideration for the model that I want to create in the next chapter, there are some other policy related remarks that have to be made that will either influence the model's construction process or influence the offshore wind development as a whole.

As is clear from the previous sections, there are a lot of different policies related to support schemes. This is, however, not the only dimension of offshore wind development that suffers from a lot of policy fragmentation. According to sources in the literature (Alafita & Pearce, 2014; Jacoby, 2012; Rabobank International & Bloomberg New Energy Finance, 2011; Wieczorek et al., 2013) this lack of stability leads to severe delays in the development of offshore wind facilities. Especially the lack of a long-term vision and the stubbornness of large market players hold up the innovation process. In a report by Rabobank International and Bloomberg New Energy Finance (2011), it is stated that changing governmental views on support policies in the Netherlands has severely impacted the development of offshore wind projects and Negro et al. (2012) state that when deciding on new policies more attention has to be given to new entrants in the market. Also the process to obtain all the necessary licenses related to offshore wind is very lengthy, which does not stimulate a fast development process.

Besides the availability of financing and the policy fragmentation, there is also a severe lack of skilled labour to construct and service the offshore wind farms (Wieczorek et al., 2013). This is most visible is the O&M service area. There are currently few companies with the capabilities to build and service the turbines used in the offshore wind industry. Combining this insight with the fact that there is quite some exposure to these O&M service companies because of the service contracts that are presents in the projects, there is a lot of counterparty risk to these companies. An example of the size of this risk can be found by looking at the company Vestas. This is one of the largest offshore wind turbine producers and servicers worldwide. In the figure below, derived from Bloomberg, the yield to maturity of a Vestas bond (VWSDC 4.625%, 2015) is presented.

Figure 6: Vestas (VWSDC 4.625%, 2015), source: Bloomberg

The actual numbers in this graph are of less importance. The main point of this figure is the obvious spike in yield. This reflects a severe credit risk related to the company Vestas in 2012 and it supports the suggestion that the companies servicing the offshore wind farms create counterparty risks for the projects and thus for a possible securitisation structure.

As mentioned in the previous paragraph, another source of counterparty risk is related to the governments providing the support schemes. As these funds are a large source for the revenues created by an offshore wind farm, it is important to value the risks of losing this support when modelling the cash flows of a project. Given current energy prices and specific terms of the support scheme contract, around 60% of the revenues of the offshore wind project come from these support schemes. A sudden stop of government's involvement in the project would therefore be very harmful for the ability of the project developer to make the debt payments. Obviously this has influence on the strength of the securitisation structure. In recent years we have witnessed the Spanish government retracting promised support to investors in solar systems, so this threat is definitely present in my view, and should not be underestimated.

3.7 Regulatory environment

For every ABS issue the regulatory environment is important. Depending on the type of investor, different regulatory standards are in place. For insurers, this standard is Solvency II. Especially for small insurers an offshore wind ABS could be interesting as the securitisation structure enables these smaller parties to participate in the market, because it becomes possible to acquire small parts of a deal. Under a whole loan transfer, i.e. when an entire loan is sold in one part, this is not an option.

Under Solvency II, which will come into effect after its entry date of 1 January 2016, the distinction is made between Type 1 and Type 2 ABS exposures. In order to be labelled as a Type 1 exposure, the ABS must apply, in general, to the following requirements:

- The collateral of the ABS must be classified as Prime;
- Only senior tranches;
- Credit rating of at least BBB-.

Based on either a Type 1 or Type 2 classification, a certain capital charge is applied. The value of this capital charge is based on the rating of the transaction and the effective duration of the exposure. In the table below, the capital charges per year of effective duration are presented.

Asset class	*AAA*	*AA*	*A*	*BBB*	*BB*
Type 1	2.1%	3.0%	3.0%	3.0%	-
Type 2	12.5%	13.4%	16.6%	19.7%	82.0%

Table 2: Capital charges under Solvency II

Using this table, the capital charge for an exposure can be calculated. For a Type 1, AA rated exposure with an effective duration of 4 years, the capital charge would be 12%. Should it be a Type 2 exposure, then the capital charge would move up to 53.6%. This shows the large impact of the characterisation of either Type 1 or Type 2.

As I argued in previous sections, the rating for the proposed offshore wind ABS will probably be around BBB. As the collateral of the ABS will not be classified as Prime, because of the lack of granularity, the capital charges for insurers investing in this ABS would be huge.

Looking at another type of investor, the main regulatory determinant for banks is the capital charge for securitisation exposures on the balance sheet as set out in the Basel framework. Currently the Basel II framework is still present, but from 2018 onwards the new Basel III Securitisation Framework will come into effect. The, for now, final version of this framework has been released in December 2014.

In the current framework the risk weights for securitisation exposures have a floor level of 7% for senior tranches. Under the new Basel III framework, which will come into effect in 2018, this risk floor will move up to 15%. While this is already a material increase, the difference for longer maturity and lower rated securitisation exposures is even bigger between these two frameworks. In Figure 7 the steep increase from the Basel II to Basel III framework is shown. The Basel III framework numbers are based on the External Rating Based Approach (ERBA). In the left panel the risk weights for 1-year maturity exposures are shown and in the right panel for 5-year maturities.

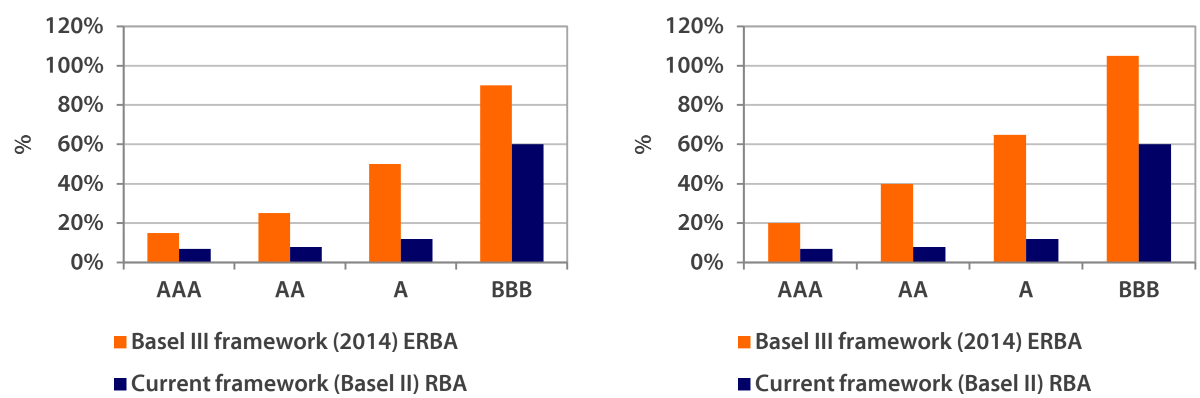


Figure 7: Capital charges for 1-year (left) and 5-year (right) ABS exposures

As can be observed in the above, risk weights are about to increase significantly under the new framework. This will obviously have a negative effect on the investor base for securitisations as bank investors will be more reluctant to invest in ABS because of the high risk weights. So for both insurers and banks, the capital charges for ABS exposures are unfavourable, which will make it harder for an issuer to find investors, who are subject to either of these regulations, for the offshore wind securitisation.

In a recent survey among investors, held by the Basel Committee itself, less regulatory restrictions was the most important factor for increasing investor participation in the securitisation market (BIS, 2014). This new Basel III framework, then, seems to be conflicting with another European activity, the relatively new ABS Purchase Program (ABSPP) by the ECB, that aims to revive the slacking securitisation market.

3.8 Similar structures

In this paragraph structures related to the proposed ABS structure will be reviewed. First, I will look into the trends in issuance of green financing products in recent years. Second, an assessment of a mature ABS class will be made.

3.8.1 Green financial products

Over the last couple of years we have witnessed a trend towards more issuance of financial products that carry a certain green label. A product that has seen sharp increase in volume over the last year are *Green Bonds* (Bloomberg New Energy Finance, 2014). A bond will be classified as a Green Bond when the proceeds are used to finance environmental and climate protection projects. Since 2008, these Green Bonds have been issued but, until recently, only on a very small scale. This changed in 2014. The current Euro-equivalent market size is around EUR 50 bn, of which EUR 36 bn has been issued in 2014 alone. About 23 bn of the issuance is denominated in EUR, and 22 bn in USD. The main players in the Green Bonds market have been, among others, the European Investment Bank (EIB), KfW and GDF SUEZ, a French multinational electric utility company (Bloomberg New Energy Finance, 2014).

Another development in the fall of 2014 has been the first thematic covered bond. The Münchener Hypothekenbank issued a EUR 300 mn *Pfandbrief* that could serve as a prototype for further thematic issuance of covered bonds. This 5-year AAA deal was 1.6x oversubscribed and was priced at 10 bps below mid swaps. While this deal was not a Green Bond by definition as its proceeds go to loans in cooperative housing schemes, the intention of the issuer was to create a green covered bond. It turned out that there was not enough data on building performances to comply with the definition of a Green Bond. The bond was ESG-labelled however, which is a slightly broader label for environmental investment instruments. All of these activities do show that there is an increasing interest from investors for all sorts of green financial products.

Also in asset-backed securities there have been some developments related to green products. Over the last two years we have witnessed a few ABS issues, and although all of them have been outside of Europe, it is another sign that the market for financial products backed by green assets is picking up.

Of these green ABS issues the bulk has come from SolarCity. Since 2013 the company has issued three securitisations backed by leases and power purchase agreements for solar photovoltaic (PV) systems to both residential and commercial customers. Founded in 2006, SolarCity currently is the largest solar power systems provider in the US, with more than 6,000 employees. Active in 15 US states, they service homeowners, schools, government agencies and corporate clients with their solar photovoltaic (PV) systems. In 2013, SolarCity became the first issuer of a renewable energy securitisation when they launched a USD 54.4 mn single tranche ABS (S&P, 2013).

Since this novelty, SolarCity has been successful in the launch of two more transactions, both in 2014. The second issue was again a single tranche with a total size of USD 70.2 mn and the latest issue was a dual tranche deal for a total of USD 201.5 mn with a senior tranche of USD 160 mn. In all three issues, the senior A tranche has been rated by S&P at BBB+. In the presale reports of S&P, the agency states as the main reason for the low-investment grade ratings of the SolarCity issues, the lack of performance history of the underlying contracts (S&P, 2014a, 2014b).

So far SolarCity is mostly using lease contracts and PPAs with residential customers as the underlying assets in their portfolios. SolarCity installs the systems for the customers without charging any upfront costs, while the customers pay for the generated energy according to predetermined pricing mechanisms. In order for a contract to be eligible for inclusion, the customer must have a sufficient credit score or an investment-grade credit rating. In the table below, some characteristics of SolarCity's ABS issues are presented.

Pool Characteristics	***2013-1***	***2014-1***	***2014-2***
No. of PV systems	5,033	6,596	15,915
Issue size (USD mn)	54.4	70.2	201.5
ADSAB* (USD mn)	88	106	276
Leverage (%)	62%	66%	73%
Aggregate PV system size (MW)	44	47	118
ADSAB* related to residential customers (%)	71	87	86

Table 3: SolarCity ABS characteristics ***ADSAB: Aggregate discounted solar asset balance.**

Even though S&P's ratings are not increasing, spreads on the SolarCity transactions are tightening. Where the 2013-1 note was priced with a 4.80% coupon, the 2014-1 and 2014-2 transactions were lower at 4.59% and a weighted 4.32% respectively. Although this case represents a very small sample, it does show that renewable energy securitisation in the US has passed the first test to viability.

A final interesting issue has been Toyota's first green Auto ABS issue. In March of 2014, the company brought a USD 1.75 bn deal to the market. This deal turned out to be a great success, as the high investor demand led to an upsizing of the deal from USD 1.25 bn. Even though this deal is not a renewable energy ABS, it is again a sign that there is demand for green securitisations.

3.8.2 CMBS

Looking at the possibilities for offshore wind securitisation, an analysis of another, similar ABS sub-asset class will prove valuable. A once large sub-asset class in European, and especially UK markets, are Commercial Mortgage Backed Securities (CMBS). The underlying of CMBS structures is very similar to the potential underlying of offshore wind ABS. Unlike some of the renewable energy ABS issues we have seen in the US, which are based on a quite granular pool of solar PV system leases, the loans to offshore wind facilities are few in number and large in size. The same can be said for the loans in CMBS transactions.

Another similarity of CMBS with the offshore wind-based ABS is the low note-to-value (NTV) level. In CMBS, it is common that only a part of the loans in securitised. With the offshore wind projects, we have already seen that there is, besides the debt part of the project, an equity share of about 30% in each project. This equity share serves as an extra layer of credit enhancement and will thus lower the note-to-value of the ABS.

Considering the comparisons between the loans underlying CMBS deals and the project finance loans for offshore wind development some information on spread levels for offshore wind securitisations lies in the spreads of CMBS deals. As the market for CMBS deals has been very small in recent years, and spreads move around quite a lot, I decided to look at one recent CMBS deal from the most active post-crisis shelf DECO. The DECO Bonn 2014 deal priced in December 2014. The structure of the deal is shown in the table below. The reference rate of this deal is the 3-months EURIBOR rate (3mE).

Class	***Amount***	***Rating Fitch***	***Rating S&P***	***NTV***	***Coupon***
A	*EUR 330 mn*	*AAA*	*AAA*	*33.5%*	*3mE +125 bps*
B	*EUR 50 mn*	*AA+*	*AA+*	*38.6%*	*3mE +165 bps*
C	*EUR 77 mn*	*AA-*	*AA*	*46.5%*	*3mE +190 bps*
D	*EUR 92 mn*	*A-*	*A*	*55.8%*	*3mE +235 bps*
E	*EUR 89 mn*	*BBB-*	*BBB*	*64.9%*	*3mE +345 bps*
F	*EUR 41.9 mn*	*BB*	*BB+*	*69.1%*	*3mE +450 bps*

Table 4: DECO-Bonn 2014, source: ConceptABS

For the estimate of the margins, I will not exclusively look at comparisons between credit ratings. As argued in paragraph 3.5, investors will be less reliant on these ratings and will look more at other characteristics of the structure. An important factor for the spread of the offshore wind ABS tranches, will be the NTV of the tranches. The NTV is the cumulative share of a loan-portfolio in a certain note. For every tranche this is the size of the tranche itself, plus the size of all tranches senior to it, divided by the total portfolio size. This NTV is also related to the CE as the NTV and CE always sum to 1.

3.9 Summary

In this chapter, I discussed the large need for capital in the offshore wind industry as well as some basic concepts in securitisation. Secondly, the offshore wind financing and revenue generating processes were mentioned. The financing of the projects is usually done through a syndicate of banks next to an equity share of a few companies. The revenues of the projects come from the sale of electricity and some sort of subsidy scheme provided by the government.

Looking more towards an ABS structure, I found that rating agencies stress the predictability of cash flows and any technical problems that can arise. As these factors are important, two critical counterparties were identified. One the one hand the government plays a vital role in providing the revenues, and secondly the O&M servicer is imperative to perform maintenance on the wind farm. Another issue lies with the regulatory environment. Under new Solvency and Basel regulation the capital charges for securitisations are higher, which is a negative for the investor base. Finally, when looking at the demanded coupon by the investors in the proposed ABS model, I drew a comparison with CMBS structures, as these deals are also based on non-granular portfolios.

Chapter 4 Quantitative analyses

In this chapter, I will execute the quantitative analyses of this research. The first step will be identifying and categorising the variables that influence the proposed ABS structure and the underlying projects. Subsequently, I will describe how I use these variables to create a cash flow model that is able to estimate performance of the proposed structure. In section 4.2, I will present all formulas used to describe the relationships that start with the wind breeze that powers the turbines and end with an interest and principal payment to a note holder of the securitisation. Next, in section 4.3 an overview of the relevant output variables will be provided. Then, in section 4.4, I will discuss the stress scenarios that will be used to test the performance of the proposed ABS structure. Finally in section 4.5 the scenarios will be put into the model to see what the influence is in terms of the output of paragraph 4.3. The results of these analyses in this final paragraph will be the main input, together with the insights that follow from chapter 3, for the answer to the research questions.

4.1 Variables

In this paragraph the variables underlying to the model will be discussed. After this first identification, I will group the variables into three categories:

- Fixed variables: these have a fixed value for all projects and situations over time. In reality, the values of these variables can vary, but for modelling purposes, and to decrease complexity of the analyses, these variables are chosen to remain fixed.
- Variable-range variables: these are the variables that determine the specific characteristics of the underlying projects. Usually these characteristics can be found in the contracts with debt holders, O&M service companies and so on. The values for these variables can be determined before the project commences.
- Stress variables. These are variables that could influence the performance of the offshore wind projects after all the contracts have been closed. Based on these variables the stress scenarios will be built in section 4.4.

The ranges for the ‘range’ variables are determined based on real life offshore wind projects. Obviously, using these ranges, this gives a lot of freedom when construction the fictional offshore wind projects that are the underlying projects in the ABS structure. The process of creating these fictional projects will therefore be structured in such a way that the created projects are representative for what is encountered in real life. For instance, a project close to shore will have relatively low capital expenditures, but probably also less beneficial wind resources.

The stress variables have a base value or range that is also determined based on an assessment of real life offshore wind projects. For the stressed ranges, per variable, an assumption is made on how much the value of the variable can differ from the base case scenario. Any correlation that might occur between the stress variables between different projects will be modelled using the stress scenarios.

I will now discuss all the variables used in the model. In order to improve overview, I will discuss the variables in groups using a similar table for all groups. In the first column of these tables the name of the variable is shown. If, for modelling purposes, this variable is assigned a symbol, this will be presented in the second column. Should this box be empty, then the variable can be found under its full name in the formulas in the next paragraph. In the third column, the group to which the variable belongs is shown. This can be either fixed, range, or stress. Based on this characterisation, the last four columns are filled: if the variable is fixed, then the value can be found in the fourth column. If the variable is a range variable, this is shown in the fifth column and when it is a stress variable the last two columns are used. The sixth column shows the base-case assumption for the value, and the final column shows the range in which the variable can be stressed.

The first group of variables that I will discuss are the variables that influence the size of the loans, the margins on those loans, their principal repayments, and the length of the project. In the table below these variables are presented:

Variable	*Symbol*	*Category*	*Fixed value*	*Variable range*	*Stress base value*	*Stress range*
# of turbines		Range		50-150		
Turbine size (MW)		Fixed	4			
CAPEX/MW		Range		2,800,000-4,500,000		
Project lifetime (years)		Fixed	15			
Debt share in project		Fixed	70%			
Margin on project debt		Range		~300 bps		
DSCR		Fixed	1.3			
Debt share ABS seller		Range		5%-25%		

Table 5: Project size and debt variables

The number of turbines can vary from project to project depending on several factors. The CAPEX/MW installed usually differs per project based on difference to shore, water depth, and whether the developer has to pay for the grid connection. Based on the description of the loan in the previous chapter the choice was made to fix the project lifetime at 15 years, mainly because it will make it easier to detect during what stage of a project problems arise, should these arise, if all the projects have the same length. Note that this assumption also means that all loans are originated at the same time. This is of course a pure hypothetical situation. An underlying portfolio usually has seasoned a bit, indicating that the loans have been originated a while back.

I also chose to fix the debt share in the project at 70% because this will be very close to the true size and the size of the loan will already be influenced by the number of turbines, the CAPEX/MW, and the debt share of the ABS issuer. I have chosen to keep the DSCR fixed, because this will improve comparability between projects when it comes to amortisation profiles. The effect of different stresses between projects will therefore be easier to determine. In summary, the main use of this group of variables is to determine the project size and the loan characteristics. As these two factors will be dependent on the assessment of real life project, these variables will be used to create of portfolio similar to the real life one.

The next set of variables influences the revenue generated by the offshore wind project.

Variable	*Symbol*	*Category*	*Fixed value*	*Variable range*	*Stress base value*	*Stress range*
Electricity price at t=0 (EUR/kWh)	p	Fixed	0.055			
Support scheme price (EUR/kWh)	q	Range		0.13-0.18		
Year support scheme stops		Stress			15	1-14
System degradation (p/a)	α	Stress			0.5%	0.5-2.5%

Table 6: Revenue variables

The choice for the fixed electricity price at t=0 is made because current electricity prices do not vary much per country (Eurostat, 2014a). The value of the support scheme price is based on an assessment in the article of Prässler and Schächtele (2012), where an overview of support schemes across different countries is presented. In the model the choice was made for a basic independent feed-in tariff. This assumption is made because earlier analysis in this research showed that this support scheme is best fitted for creating stability and predictability for incoming cash flows, which is favourable for asset-backed securities. The year when the support scheme stops is a stress variable. There could be a situation after the close of all contracts when a government decides, for whatever reason, that the support scheme payments will be stopped. In the previous chapter an example was given for the Spanish government that has reduced funding of solar initiatives. As the support scheme will always stop after the project is finished, a stop after year 15 is the base case value. This means that stresses can occur from year 1 up to year 14.

The system degradation value is also a stress variable. A base scenario of 0.5% is reasonable based on the article of Alafita and Pearce (2014), but because of lack of historical performance such a degradation rate could turn out to be higher. I chose to set the stress level at a maximum of 2.5%. This means that, even when O&M is done properly, the system degradation will be more than 30% over the lifetime of 15 years of the project.

The third group of variables determine the costs for the O&M servicing contract and the costs for the dismantling of the project.

Variable	Symbol	Category	Fixed value	Variable range	Stress base value	Stress range
O&M contract 1st period	θ	Fixed	1.5% of CAPEX			
O&M contract 2nd period	τ	Range		1.5x-2.5x		
O&M contract 3rd period	φ	Range		2.0x-3.5x		
O&M extreme value	ρ	Range		10%-15%		
O&M year of extreme value	ρ_t	Stress			-	1-12
Dismantling costs	π	Stress			25,000,000-75,000,000	75,000,000-125,000,000

Table 7: Costs variables

In general, the contract for the O&M servicing has predetermined costs for the first, second and third period. The three periods in the lifetime of the project are assumed to be year 1 through 5, year 6 through 10, and year 11 through 15. The step-up levels and initial costs can vary some however. I chose to fix the first period level and then have the 2nd and 3rd period levels fluctuate between projects. Since these contracts were not available to me, I assumed the ranges for these periods and chose quite wide ranges. These assumptions have been made based on literary assessments and information I gathered from several project finance sources (Prässler & Schächtele, 2012).

The O&M extreme value is put in the model in case of one of the following two events takes place: there will be a significant incident which requires large O&M costs that are not covered under the contract, or the O&M servicing company defaults on its contract. It is assumed that finding a new servicer for the project will involve big costs as urgency for the developer is very high and there are few companies with the capabilities to perform service on these complicated offshore projects. Whether an extreme O&M event takes place is a stress variable because it cannot be predicted beforehand. The range of this variable is 1-12, because of the assumption that after year 12 the costs made to correct the problems will be bigger than the potential earnings in the final stages of the project; why would anyone invest up to 15% of the initial CAPEX in the final year before the licenses expire? The final variable in this section is also a stress variable as it is hard to predict what the actual dismantling costs are going to be 15 years from now.

The next set of variables includes those that influence the reserves in the underlying projects. First of all, a dismantling reserve is included based on remarks made in literature (Prässler & Schächtele). The size of this reserve is variable because the developer will most probably determine the size based on an estimate for the actual costs which will be dependent on variables like distance to shore and water depth. These are determinants that will differ among projects. There is also a debt service reserve. In project finance it is common that the size is fixed at half a year of interest payments. Finally, there could be an O&M reserve within the project based on the reputation of the O&M servicer. The values for the build up paces of the reserves are assumed as no information on these figures can be found.

Variable	*Symbol*	*Category*	*Fixed value*	*Variable range*	*Stress base value*	*Stress range*
Dismantling reserve size		Range		25,000,000-75,000,000		
Dismantling build up pace	σ	Fixed	10			
Debt service size		Fixed	½ year			
O&M reserve size		Range		0-50,000,000		
O&M reserve build up pace	μ	Fixed	5			

Table 8: Reserve variables

The last group of variables for the underlying project are those that influence the underlying production model. In the model, the production function from the research of Prässler and Schächtele (2012) is used. The input variables of this function are the annual mean wind speed and the energy loss factor. In the next section, I will explain this function in greater detail. Both of these variables are classified as stress variables as the assumptions for these variables are quite fragile. Projected wind speeds at the project site could differ from the actual situation and the assumption for the energy loss factor, even though it is based on several surveys, is subject to limited performance history of offshore wind farms.

Variable	*Symbol*	*Category*	*Fixed value*	*Variable range*	*Stress base value*	*Stress range*
Annual mean wind speed	ω	Stress			~9.5	8.5-9.5
Energy loss factor	β	Stress			0.14	0.14-0.21

Table 9: Modelling variables

Now that all the variables influencing the projects underlying the asset-backed security have been identified and classified, the final step before moving on to the description of the relations between the variables is to define the variables influencing the ABS structure.

Variable	*Symbol*	*Category*	*Fixed value*	*Variable range*	*Stress base value*	*Stress range*
ABS lifetime		Fixed	15			
Size A tranche		Fixed	0.6			
Margin A tranche		Fixed	200 bps			
Size B tranche		Fixed	0.3			
Margin B tranche		Fixed	350 bps			

Table 10: ABS variables

The maturity of the ABS structure is 15 years. This makes the analysis of the structure much more insightful than an analysis with constantly changing lifetimes. By setting the maturity of the ABS at the same length as the projects’ lifetimes, the modelling of the ABS becomes less complex. In this scenario, there is no need to refinance the loans at a certain point and the modelling of a call structure in the ABS can be omitted. The tranche sizes and margins depend heavily on the desired credit rating the issuer wants to achieve, the necessary credit enhancement, and what the corresponding margin should be according to the investors. As there is no way of exactly knowing the demanded margins for certain combinations of tranche sizes, an estimate has been made. This estimate is based on a comparison with a recent CMBS deal, DECO-Bonn 2014, with respect to the NTVs. The characteristics of this deal were presented, in the previous chapter. The margins are added to a reference rate. In the next paragraph I will discuss this reference rate.

To compare the note-to-value of the tranches with the tranches of the DECO deal, I need to know the NTVs of the offshore wind ABS tranches. In the figure on the right, the debt portion of the offshore wind project financing is split up in an A, B and Equity tranche. I fixed the tranche sizes at respectively 60%, 30%, and 10% of the total debt in the portfolio.

Based on these tranche sizes, and the assumed fixed debt proportion of 70%, the note-to-value for the A tranche is 42% and for the B tranche 63%. Comparing the NTV of 42% for the A tranche with the DECO-Bonn deal, the estimated margin will be approximately 180 bps, as this is between the B and C tranche. As a conservative estimate I choose a margin of 200 bps for the A tranche. For the B tranche, with a NTV of 63%, the comparison is made with the E tranche of the DECO deal, which has a NTV of 64.9%. The margin for this tranche is 345 bps. My estimate is rounded to 350 bps.

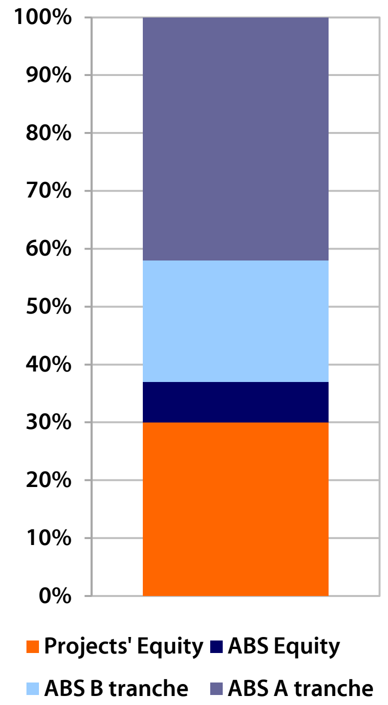


Figure 8: ABS tranches

4.2 Model

In this paragraph, I will describe the model and present the equations, based on the variables from the previous paragraph. This model will be used to test the performance of the offshore wind ABS structure that I propose. The stressing of the ABS structure will follow in succeeding paragraphs.

4.2.1 From ten to one

The model that is built to test the performance is based on loans to ten different offshore wind projects. Using ten loans with a common ticket size of an average around EUR 150 mn, will lead to a total size to be securitised in the area of EUR 1.5 bn, which is in the upper range of other typical transactions in the market. Using these ten loans will also create the opportunity to build a somewhat diversified portfolio of loans with different characteristics. The diversification will be created through the altering of the ranged variables as described in the previous paragraph.

The exact characterisation of the ten projects will be made based on an assessment of actual real-life offshore wind projects. While these projects all have different individual characteristics, there are several similarities. The portfolio of real-life European offshore wind projects will serve as a benchmark for the ten hypothetical projects in the securitisation model.

The ten loans will combine to form one asset-backed security structure. All the loans will be put in the securitisation in their entirety. Of course this is still just 70% of the size of total projects as these projects have an equity share in their financing structure. The coupons paid to the ABS structure will be the weighted average coupon of the underlying loans and the principal repayments will be made based on the principal repayments of the ten underlying loans. The payment streams from the loans to the ABS structure are depicted in the top part of the flow chart below. The top half of the figure shows the project finance part of the model, where the debt payments are made. The bottom half shows the ABS structure where the payments flow to the tranches. From now on, I will refer to these two parts as level 1 and level 2, respectively.

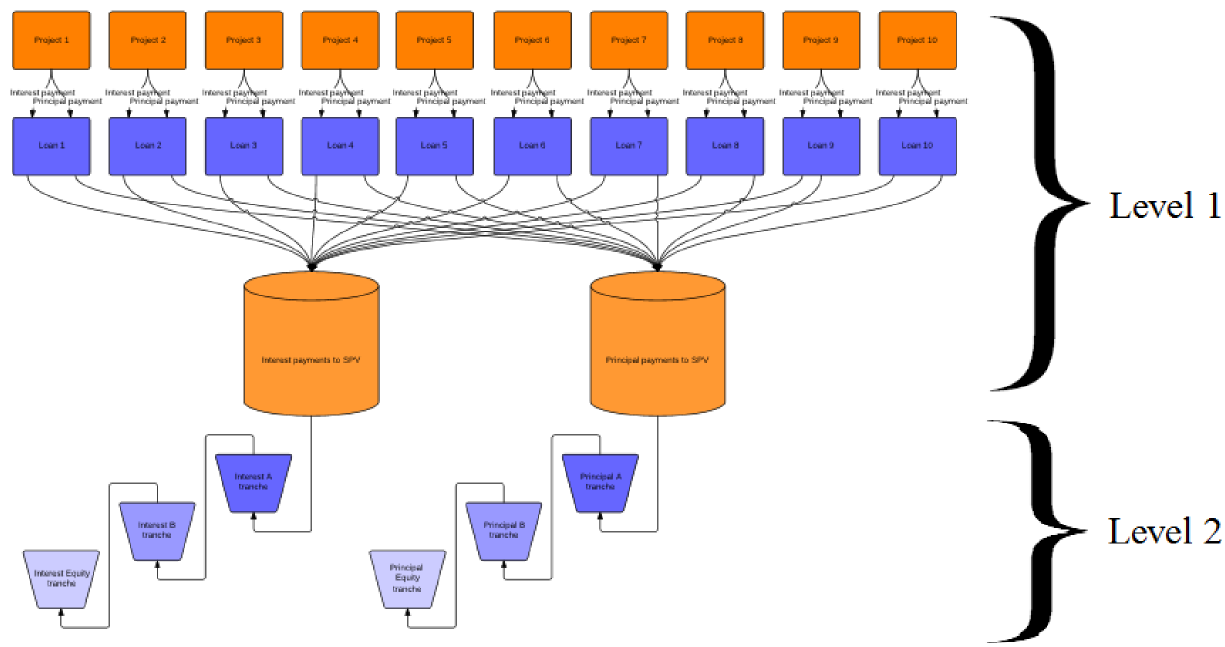


Figure 9: Cash flow streams

The ABS structure in the model has a senior A tranche, a mezzanine B tranche and an Equity tranche. The A and B tranches will have predetermined interest margins whereas the Equity notes will receive any residual interest payments. The most senior part of the structure, which is not shown in the figure, is the servicing fee. This fee is paid to the servicer of the ABS structure. For this model it is assumed that the servicing fee is 35 bps on top of the underlying interest reference rate.

4.2.2 Waterfall

In the bottom part of the figure, the waterfall principle of the ABS structure is shown for the situations where there has not yet been an event of default. Situations after an event of default will be discussed later. As is clear from the figure, there is a two-waterfall principle in this ABS structure. The interest and principal payments from the loans are separated into two buckets and then flow into the tranches of the securitisation. The A tranche, which has the highest seniority, will get its share first. For the interest waterfall this share is the outstanding principal multiplied with the pre-determined coupon of the A tranche. After the A tranche is filled, the remaining interest payments to the SPV will subsequently flow into the B tranche following the same concept as for the A tranche. Finally, any remaining interest payments will flow into the Equity tranche. The principal payments that are paid into the SPV will flow into the A tranche until the principal of the A tranche is fully paid back. Only then, the principal of the B tranche will start to redeem, and finally after this is completed, the Equity notes will be redeemed.

In the case of an event of default, the structure of the waterfall changes. Instead of using a two-waterfall concept the structure will change to a one-waterfall concept. All the incoming cash flows from the loans will flow into one bucket. First the interest on the A notes, based on the outstanding principal, will be paid. Second, the interest on the B notes will be paid. Following these interest payments all of the remaining cash flows will be used redeem the principal of, first the A, and then the B notes, as quickly as possible; there will be no payment to the Equity notes until the entire A and B tranches are redeemed. This process is called *acceleration*. Using such a structure optimally mitigates the risks for the senior note holders. At a later stage in this chapter I will describe how it is determined when there will be acceleration in the waterfall structure.

The next step in the modelling process of the securitisation structure is to model the cash flows of the underlying loans. These loan-related payments are, however, related to the performance of the projects themselves; when the projects generate little available cash flows this might influence the ability to pay the interest on the loans. As noted in the previous chapter, the principal repayments are also directly related to the available cash flows due to the sculp scheme that is used for the amortisation. So I will have to model all the relevant cash flows of the project in order to determine the actual predicted payments related to the loan. In the sections 4.2.3-4.2.7, the cash flows related to level 1 in the structure, the underlying projects, are presented. Then, in section 4.2.8, the cash flows in level 2, the SPV, are presented.

4.2.3 Level 1: Available cash flow

As shown in paragraph 1 of this chapter a lot of different variables play a role when modelling the cash flows of an offshore wind project. For the entire lifetime of the project the model creates on a yearly basis an estimate for the available cash flows based on the following formula, where the delta represents the positive change in reserves:

$$Available\ cash\ flow_t = Revenue_t - \ Costs_t - \delta\ Reserve_t$$

The three factors on the right hand side in the formula above are calculated based on the following three formulas.

$$Revenue_t = Market\ revenue_t + Support\ scheme\ revenue_t$$

$$Costs_t = Initial\ capital\ costs_t + O\&M\ costs_t + Dismantling\ costs_t$$

$$\delta\ Reserve_t = \ \delta\ Debt\ reserve_t + \delta\ O\&M\ reserve_t + \delta\ Dismantling\ reserve_t$$

The four formulas in this section are derived based on common economic reasoning and the assumption that all relevant factors are captured in these formulas.

4.2.4 Level 1: Revenue

As explained in earlier sections, the revenue of an offshore wind project comes from two sources. There is the market revenue and for most projects there will also be some sort of support scheme revenue. The main determining factor for the size of these two sources is the energy that the offshore wind project is able to produce. As the price of wind energy is quoted in kWh, I will model the annual electricity produced per year in kWh/year.

The formula used for determining this output is derived from the article of Prässler and Schächtele (2012). In the article it is stated that the output on a yearly basis can be calculated as:

$$Annual\ electricity\ produced\ \left(\frac{MWh}{year}\right) = (626.51 * \omega - 1901) * (1 - \beta) * installed\ capacity$$

In this formula they use power velocity curves and a *Weibull* distribution to convert the annual mean wind speed ω into gross full load hours. They correct this number using the energy loss factor β. The energy loss factor accounts for downtime losses as well as array losses. Array losses are the losses resulting from interference of turbines within an offshore wind project. For the model used in this research some slight alterations to the equation of Prässler and Schächtele (2012) have been made. First of all, I will calculate the annual electricity produced in kWh/year. Second, and most importantly, I will allow the model to decrease yearly production based on a system degradation variable α. This insight follows from the review of the article of Alafita and Pearce (2014). Also, instead of the fixed project size approach in the article of Prässler and Schächtele (2012), I will allow the model to use different sized offshore wind projects. The energy output in year t in kWh /year, e_t will follow from the following two formulas:

$$e_t = (1-\alpha)^t * e_0$$

$$e_0 = (626.51 * \omega - 1901) * (1-\beta) * project\ size * 1000$$

Using the previous equations, the market revenue mr_t and the support scheme revenue sr_t can be calculated. Additionally, for the support scheme revenue I need the price provided by the support scheme q_t. As discussed in the previous paragraph, the model uses an independent feed-in tariff which provides a fixed price for a predetermined number of years. The formulas for mr_t and sr_t are shown below, as well as the resulting formula for the revenue in year t r_t. The expression p_t gives the electricity market price in year t. The dynamics modelled below are based on common economic reasoning as well as well as my interpretation of the dynamics present in the support scheme payments.

$$mr_t = e_t * p_t = [(1-\alpha)^t * e_0] * p_t$$

$$sr_t = MAX\{(q_t - p_t), 0\} * e_t$$

$$r_t = mr_t + sr_t = e_t * p_t + MAX\{(q_t - p_t), 0\} * e_t$$

4.2.5 Level 1: Costs

I assume that the costs of an offshore wind project in this model come from three different sources. First, we have the initial capital costs, which are incurred before the project starts producing electricity. I made the assumption that all these costs are taken in a single year. This was mainly done for modelling purposes, as the construction phase is usually longer than a single year. Second, there are the O&M costs, which are incurred during the lifetime of the project and finally there are the dismantling costs for the removal of the project. The formulas for the initial capital costs i_t and the dismantling costs d_t are quite straightforward as they are only present in t=0 and t=15 respectively:

$$i_t = project\ size * \frac{CAPEX}{MW}, if\ t = 0, else\ 0$$

$$d_t = \pi, if\ t = 15, else\ 0$$

The O&M costs are somewhat more complex because of the step-up triggers in the O&M contract and the inclusion of the possibility of an extreme O&M event as discussed in paragraph 4.1. Because the assumption in the model is made that the maturity of each project is 15 years, the formulas below might not be representative for every real offshore wind project. However, based on this maturity assumption, I constructed these formulas, so they accurately reflect the dynamics of the O&M costs. The step-up triggers are modelled at the beginning of year 6 and 11 and the extreme O&M event takes place in year ρ_t, the costs for O&M in any given year $t \in \{1, \dots, 15\}$ are given by the three formulas below.

$$O\&M\ costs_t, if\ t \in \{1, \dots, 5\} = Initial\ capital\ costs_0 * \ MAX(\rho, \theta), \rho = 0\ if\ t \neq \rho_t$$

$$O\&M\ costs_t, if\ t \in \{6, \dots, 10\} = Initial\ capital\ costs_0 * \ MAX(\rho, \theta * \tau), \rho = 0\ if\ t \neq \rho_t$$

$$O\&M\ costs_t, if\ t \in \{11, \dots, 15\} = Initial\ capital\ costs_0 * \ MAX(\rho, \theta * \ \varphi), \rho = 0\ if\ t \neq \rho_t$$

4.2.6 Level 1: Reserves

Replenishments for reserves occur when the balance of a reserve increases. In this section the formulas that describe the filling and clearing of the balances of the three reserves in this model are presented. As there was very limited information on the use and filling of these reserves, the dynamics modelled in this section are based on my own assumptions and assessments. The first reserve I will discuss is the debt reserve. At the start of the project it is assumed, that the debt reserve fund is filled up to its target size, which is fixed at half of the interest payment that is due in year 1 of the project. In formula:

$$Debt\ reserve_0 = \delta Debt\ reserve_0 = Debt\ reserve\ target\ size = \frac{Interest\ due\ _1}{2}$$

The delta of the debt reserve in later years is a bit trickier. Obviously it follows the recursive formula below:

$$\delta Debt\ reserve_t = Debt\ reserve_t - Debt\ reserve_{t-1}$$

The debt reserve in year t is equal to the reserve in year t-1, if there are no interest payment shortages in year t and in year t-1. Should there be a shortage in year t, than the reserve decreases with the minimum of this amount and the size of the reserve in year t-1. If there was a shortage in year t-1, then the debt reserve will increase up to its original size by adding the funds used from the reserve in year t-1, which is the minimum of the interest payment shortages in year t-1 and the size of the reserve in year t-2. The following formula describes this relationship:

$$\begin{aligned} Debt\ reserve_t = Debt\ reserve_{t-1} + MIN\{Interest\ payment\ shortages_{t-1}, Size\ of\ reserve_{t-2}\} \\ - MIN\{Interest\ payment\ shortages_t, Size\ of\ reserve_{t-1}\}, t \in \{1, \dots, 14\} \end{aligned}$$

In the final year of the project, the modelling assumption is made that, any remaining funds in the debt reserve will be paid out according to the following formula:

$$\delta Debt\ reserve_{15} = -Debt\ reserve_{14}$$

The O&M reserve in the project is designed to create some security in the case of an extreme O&M event as described in paragraph 4.1. This means that the reserve will only be used in a year when there is an extreme O&M event. As a modelling assumption, the entire reserve will be used when there is a trigger event. Also at the end of the lifetime of the project the fund will be emptied, because it has no further use after the project is completed. This results in the following two equations:

$$\delta O\&M\ reserve_t = -O\&M\ reserve_{t-1}, if\ t = \rho_t$$

$$\delta O\&M\ reserve_t = -O\&M\ reserve_{t-1}, if\ t = 15$$

The filling of the reserve starts as soon as the project begins to produce output. This means that the following recursion will hold under all circumstances with $t \in \{1, \dots, 15\}$:

$$O\&M\ reserve_t = \delta O\&M\ reserve_t + O\&M\ reserve_{t-1}$$

$$O\&M\ reserve\ balance_0 = 0$$

The reserve fund will build up towards its target size until the target size has been reached. The build up pace is given by the variable μ, which represents the number of years before the O&M reserve should reach its target size. The two equations below represent this build up:

$$\delta O\&M\ reserve_t = 0, if\ t \neq \rho_t, t \neq 15\ and\ O\&M\ reserve_{t-1} \geq O\&M\ reserve\ target\ size$$

$$\delta O\&M\ reserve_t = \frac{O\&M\ reserve\ target\ size}{\mu}, if\ t \neq \rho_t, t \neq 15\ and\ O\&M\ reserve_{t-1} < O\&M\ reserve\ target\ size$$

The final building block for modelling the available cash flow is the dismantling reserve. The structure for this reserve is very similar to the O&M reserve as it empties in year 15, after which the dismantling takes place, and it is filled based on a predetermined target size and a number of years σ after which the target size must be reached. While the presence of a dismantling reserve is based on findings in the literature (Prässler & Schächtele, 2012), the modelling of this concept is based on my own assessment of the dynamics of such a reserve. The set of equations below describe the relationships for the reserve:

$$Dismantling\ reserve_t = \delta Dismantling\ reserve_t + Dismantling\ reserve_{t-1}$$

$$Dismantling\ reserve\ balance_0 = 0$$

$$\delta Dismantling\ reserve_t = -Dismantling\ reserve_{t-1}, if\ t = 15$$

$$\delta Dismantling\ reserve_t = 0, if\ \sigma < t < 15$$

$$\delta Dismantling\ reserve_t = \frac{Dismantling\ reserve\ target\ size}{\sigma}, if\ t \leq \sigma$$

4.2.7 Level 1: Debt payments in the underlying projects

As soon as the project is operational, it will generate cash flows that can be used to service the debt holders. The modelling of these available cash flows has been covered in the previous sections. In this section, I will turn to the modelling of the payments made to the debt holders. The important components of this section will be the interest and principal payments, as well as the event of default of the project, and any corresponding deferred interest payments.

The interest payments on the loan are quite straightforward. In the debt-contract an agreement has been made on the coupon that will be paid to the debt holders. This coupon will be paid on the amount of outstanding principal in any given year. Based on information obtained about the sort of coupons that are paid I can conclude that these are floating coupons. While some debt providers will use interest rate swaps to swap this floating rate for to a fixed one, the assumption in the model is made that this does not happen. The reason behind this assumption is that it would create another level of complexity to the model because the value of the swap has to be determined.

The underlying interest rate used in this model is the 12-months EURIBOR rate and the model uses the implied spot curve bootstrapped from the forward curve for this interest rate as estimate for the interest rate in the coming 15 years. In the model, this implied spot rate is represented as s_t. The 12-months EURIBOR is chosen as underlying since the assumption is made that the interest on the loan is paid once every year. Also, the interest payment to the debt holders cannot be higher than the available cash flow. Thus the interest paid in year t is:

$$Interest\ payment_t = MIN\{Available\ cash\ flow_t, Outstanding\ principal_t * (s_t + coupon)\}, t \in \{1, \dots, 15\}$$

As argued in the previous chapter the principal payments on the loan are made according to a *sculp*-scheme, which means that the DSCR is constant. The formulas used to determine the principal payment made in year t is:

$$Principal\ repayment_t = MIN\{Outstanding\ principal_{15}, \frac{Available\ cash\ flow_t}{DSCR} - \ Interest\ payment_t, t \in \{1, \dots, 14\}$$

$$Outstanding\ principal_t = Outstanding\ principal_{t-1} - Principal\ repayment_{t-1}$$

$$Outstanding\ principal_0 = \frac{CAPEX}{MW} * project\ size * debt\ share\ in\ project$$

Should it happen that in the final year of the project the debt has not yet been fully paid back, then the assumption in the model is made that the entire available cash flow in that year will be used to repay any outstanding principal:

$$Principal\ repayment_{15} = \ MIN\{Outstanding\ principal_{15}, Available\ cash\ flow_{15}\}$$

Under some adverse circumstances the project developer could default on its debt payment obligations. In that situation the assumption is made that the equity share in the project is immediately wiped away and all future earnings of the project directly flow to the debt holders. Because a clear cut point is necessary for the model to determine when the project is in default, I assume in the model that this happens as soon as the actual debt payment is lower than the debt payment that is supposed to be made based on the contractual agreements between the project developer and the debt holders. In formula:

$$Default_t = 1, if\ Interest\ payment_t < Outstanding\ principal_t * (s_t + coupon), t \in \{1, \dots, 15\}$$

Should there be such an event of default, there obviously would be an amount of interest payments that was not made in the year that the event of default occurred. This amount is what is called the deferred interest payment. These deferred payments should be redeemed as soon as possible. In year t, also the deferred interest payments accrue. So after an event of default the interest payments to the debt-holders change to:

$$Interest\ payment_t = MIN\{Av.cash\ flow_t, (Outst.prin._t + deferred\ payments_{t-1}) * (s_t + coupon)\}, t \in \{1, \dots, 15\}$$

Besides the interest payments, also the principal repayments change after an event of default. In the model the assumption is made that the debt holders would have their principal paid back as soon as possible after such an event because this is the optimal way to mitigate any further risks as this amortisation scheme will lead to the shortage of time exposure. All available cash flows will therefore be used to service the debt and thus repay the outstanding principal. In formula this looks like:

$$Principal\ repayment_t = \ Available\ cash\ flow_t - \ Interest\ payment_t$$

Now the final step in the project model to consider is the fact that the entire debt share in the project is usually funded by a syndicate instead of a single party. As discussed in the previous chapter, the debt-holders within such a syndicate all have the same seniority and thus will receive their share of interest payments and principal repayments simultaneously. The payments to a single debt-holder i are given by the following equations:

$$Interest\ payments_t^i = Interest\ payment_t * Debt\ share^i, t \in \{1, \dots, 15\}, i \in [0,1]$$

$$Principal\ repayments_t^i = Principal\ repayment_t * Debt\ share^i\ t \in \{1, \dots, 15\}, i \in [0,1]$$

In the following section I will discuss how these payments influence the ABS structure based on the waterfall principle that was discussed in section 4.2.2.

4.2.8 Level 2: ABS-model

The payments made on the outstanding debt as discussed in the previous section are the core of the ABS structure. Out of these payments the SPV can service its note holders. The set of equations below describe how the debt payments flow into the SPV, where j is the number of the related project. These flows are based on the two-waterfall assumption I described in a previous section:

$$Interest\ to\ SPV_t = \sum_j Interest\ payments_t^i\ , t \in \{1, \dots, 15\}, i \in [0,1], j \in \{1, \dots, 10\}$$

$$Principal\ to\ SPV_t = \sum_j Principal\ repayments_t^i\ , t \in \{1, \dots, 15\}, i \in [0,1], j \in \{1, \dots, 10\}$$

Now the cash flows into the SPV are known, I can describe how these cash flows are distributed among the investors in the A, B and Equity tranches. Like the underlying projects, the ABS structure has a default trigger that influences the waterfall principle. First I will discuss the payments before acceleration and, after the definition of the default trigger of the SPV in this model is presented, the payments after acceleration will be considered.

As noted in section 4.2.2, the interest payments before acceleration are made based on the availability of cash flows and the coupons of the corresponding tranches. First, the interest to the A notes will be paid, then to the B tranche and, finally, the remainder goes to the equity notes. However, before any interest payments are made, the service fee for the servicer of the SPV is paid. Subtracting this servicing fee from the interest that flows to the SPV leads to the interest available for the note holders. The implied spot rate s_t in the equations below is again derived from the 12-months EURIBOR curve:

$$Available\ interest_t = Interest\ to\ SPV_t * (s_t + servicing\ fee)\}, t \in \{1, \dots, 15\}$$

$$Interest\ A_t = MIN\{Available\ interest_t, Outstanding\ principal\ A_t * (s_t + coupon\ A)\}, t \in \{1, \dots, 15\}$$

$$Interest\ B_t = MIN\{Available\ interest_t - Interest\ A_t, Outstanding\ principal\ B_t * (s_t + coupon\ B)\}, t \in \{1, \dots, 15\}$$

$$Interest\ Equity_t = Available\ interest_t - Interest\ A_t - Interest\ B_t, t \in \{1, \dots, 15\}$$

The outstanding principal of all tranches is determined by the following set of equations, which show that first the principal of the A notes will be redeemed, then the B notes', and finally the Equity notes' principal:

$$Outstanding\ principal\ A_t = Outstanding\ principal\ A_{t-1} - Repayment\ principal\ A_{t-1}, t \in \{1, \dots, 15\}$$

$$Outstanding\ principal\ B_t = Outstanding\ principal\ B_{t-1} - Repayment\ principal\ B_{t-1}, t \in \{1, \dots, 15\}$$

$$Outstanding\ principal\ Equity_t = Outstanding\ principal\ Equity_{t-1} - Repayment\ principal\ Equity_{t-1}, t \in \{1, \dots, 15\}$$

$$Repayment\ principal\ A_t = MIN\{Outstanding\ principal\ A_t, Principal\ to\ SPV_t\}, t \in \{1, \dots, 15\}$$

$$Repayment\ principal\ B_t = MIN\{Outstanding\ principal\ B_t, Principal\ to\ SPV_t - Repayment\ principal\ A_t\}, t \in \{1, \dots, 15\}$$

$$Repay.prin.Equity_t = MIN\{Outst.prin.Equity_t, Prin.to\ SPV_t - Repay.prin.A_t - Repay.prin.B_t\}, t \in \{1, \dots, 15\}$$

Now that the situation without a default of the SPV has been completed, I can continue describing the trigger for the acceleration process. For this model I assumed that the SPV will default when at a certain time the interest to the A and B notes cannot be fully paid. This choice has been made because it is in line with other ABS structures in which the equity tranche functions as a means of credit enhancement through subordination.

Because the interest to the A notes will always be paid before the interest to the B notes, the default trigger for the proposed ABS structure is:

$$Default = 1, if\ Interest\ B_t < Outstanding\ principal_t * (s_t + coupon\ B), t \in \{1, \dots, 15\}$$

Should this happen then the SPV will be in default and for the remaining lifetime, and the structure will follow the one-waterfall principle, with the acceleration process, as described in section 4.2.2. Under this principle the following set of equations will determine the interest payments and principal repayments to all tranches:

$$Cash\ flow\ to\ SPV_t = Interest\ to\ SPV_t + Principal\ to\ SPV_t$$

$$Interest\ A_t = MIN\{Cash\ flow\ to\ SPV_t, (Outs.prin.A_t + deferred\ interest\ A_{t-1}) * (s_t + coupon\ A)\}, t \in \{1, \dots, 15\}$$

$$Interest\ B_t = MIN\{Cash\ flow\ to\ SPV_t - Int.A_t, (Out.prin.B_t + def.interest\ B_{t-1}) * (s_t + coupon\ B)\}, t \in \{1, \dots, 15\}$$

$$Prin.repayment\ A_t = MIN\{Cash\ flow\ to\ SPV_t - Interest\ A_t - Interest\ B_t, Outstanding\ prin.A_t\}, t \in \{1, \dots, 15\}$$

$$Prin.repay.B_t = MIN\{Cash\ flow\ to\ SPV_t - Interest\ A_t - Interest\ B_t - Prin.repay.A_t, Outs.prin.B_t\}, t \in \{1, \dots, 15\}$$

$$Payments\ to\ Equity = Cash\ flow\ to\ SPV_t - Interest\ A_t - Interest\ B_t - Prin.repay.A_t - Prin.repay.B_t, t \in \{1, \dots, 15\}$$

$$Outstanding\ principal\ A_t = Outstanding\ principal\ A_{t-1} - Repayment\ principal\ A_{t-1}, t \in \{1, \dots, 15\}$$

$$Outstanding\ principal\ B_t = Outstanding\ principal\ B_{t-1} - Repayment\ principal\ B_{t-1}, t \in \{1, \dots, 15\}$$

As can be seen in the equations above, the Equity tranche's principal is essentially wiped away and will only receive payments when the entire A and B tranche's principal have been redeemed. Furthermore, just like the interest payments in the underlying projects, the ABS part of the model incorporates deferred payments.

The formulas described in paragraph 4.2 have been translated to an Excel scheme. Using this scheme, the model will be tested using the output measures and stress scenarios described in the following sections.

4.3 Output

For the analysis of the model, it is necessary to identify what characteristics of the ABS structure will be reviewed. First and foremost it is important to know whether the ABS structure has experienced an event of default. Recall from section 4.2 that a default in the ABS structure occurs when the interest to the A and/or B notes cannot be paid in its totality.

Secondly, it is important for the seller to know what the return is on the Equity notes. As these notes are usually retained, in a funding transaction, by the seller, it will have to determine whether it is beneficial to securitise the portfolio instead of retaining all the loans and simply collect the coupons that the project loans pay. The measure used to monitor the return on the Equity notes is the *internal rate of return (IRR)*. The internal rate of return is the hypothetical interest rate that makes the net present value (NPV) of a series of cash flows equal to zero. The IRR is a measure often used in literature to measure the value of a series of cash flows and is therefore very much suited to value the performance of the cash flows related to the Equity notes in the ABS structure. The initial expense will be the be the amount of cash in present in the Equity tranche and the incoming cash flows are the interest and principal payments that are reserved for the Equity note holders. The IRR of the Equity notes' cash flows will be compared with the cash flows that flow into the SPV and would otherwise flow directly to the seller of the securitisation.

Another measure used in the analysis of an asset-backed security is the *weighted average life (WAL)* of a note. The longer the WAL, the higher the demanded coupon by investors usually is because of the increased exposure to risks. Also, looking back at the Solvency and Basel regulation, the longer the maturity of the exposure, the higher the capital requirements are. The WAL is determined based on the following formula:

$$WAL_i = \sum_t Expected\ principal\ repayment\ year_t * t, i \in \{A, B\}\ and\ t \in \{1, \dots, 15\}$$

Since the default of the ABS structure is only influenced by the interest payments made, it is also important to monitor the repayment of principal. Therefore the principal losses in the three tranches of the model will be analysed. These principal losses are calculated by subtracting the principal repayments from the outstanding principal in the final year of the lifetime:

$$Principal\ losses_i = Outstanding\ principal_i^{15} - Principal\ repayment_i^{15}, i \in \{A, B, Equity\}$$

If there are any principal losses in the structure, it will obviously be interesting to check what projects are at the foundation of these losses. Such an inquiry might lead to additional valuable information as to what combination of stress factors is particularly troublesome for the ABS' and project's structures. Also, there could be a situation in which a certain individual underlying project defaults but is still able to repay the entire principal. These defaults are also interesting as they might discourage future projects from launching because of the higher risks, implicated by a worser history.

4.4 Stress scenarios

Based on the 6 stress variables defined in paragraph 4.1, I will construct stress scenarios that will be used to test the performance of the proposed ABS structure. For these stress scenarios it is important to know whether I should expect correlation between these variables (external) or within the variables itself (internal). The former will happen when there is correlation between two variables within the same project and the latter will be encountered when there is correlation between the underlying projects in a single variable. In Table 11, the stress variables are shown as well as their internal and external correlation assumptions.

Nr.	*Variable*	*Internal correlation*	*External correlation (with variable)*
1	*Year support scheme stops*	Yes	No
2	*System degradation*	Yes	Yes, (3)
3	*O&M year of extreme value*	Yes	Yes, (2)
4	*Dismantling costs*	Yes	No
5	*Annual mean wind speed*	Yes	Yes, (6)
6	*Energy loss factor*	Yes	Yes, (5)

Table 11: Stress variables

Looking at the first variable, the internal correlation is quite straightforward. Should a government stop the funding of offshore wind projects through the support schemes, then this will probably affect multiple projects as most projects are developed in only a few countries. Furthermore, the driver behind this decision of the government in one country might very well be a driver for a similar decision in another country. Think for instance about a declining oil price, like in late 2014. This could result in decreasing energy market prices which will create a larger gap between the fixed support scheme price and the energy price. This on its turn could make governments reluctant to keep on funding offshore wind projects. As far as external correlation, there is no clear link with other stress variables, and it is therefore assumed that this correlation does not need explicit modelling.

The second and third variables also have internal correlation based on a similar reasoning as the support scheme stop. Should an offshore wind service company default, or should one producer have built quickly degrading turbines, this will affect multiple projects as the number of producers/servicers is small. Because the companies who produce and service the turbines are usually the same, I assume that there also is external correlation between these two variables.

The dismantling costs are correlated internally; if the costs to dismantle a plant 15 years from now is higher for one offshore farm, this will probably also be the case for another, similar farm. A clear correlation with other variables is not present in my view and is therefore omitted from consideration.

The final two variables are related to the modelling of the output from the offshore wind project. Both of these variables are subject to modelling risks as the assumptions are based on models for wind speed and estimations of array losses and downtime of the wind farms. If these models are incorrect this will have impact on the output of the project and will most likely influence multiple projects.

Based on these variables and assumed correlations stress scenarios have been created. When there is external correlation between two variables within a certain scenario, then the stresses in the scenario will occur in the same projects. For the internal correlation, it is hard to determine in how many projects a stress will actually occur. The projects are probably placed in different countries and subject to different O&M counterparties. I therefore chose to stress 7 out of 10 projects in the portfolio on the particular variables when a stress occurs. In the table below the stress scenarios are presented:

Nr.	***Scenario***
1a	• *In year 10, 7 out of 10 projects will have stop of the support scheme.*
1b	• *In year 5, 7 out of 10 projects will have stop of the support scheme.*
2	• *System degradation +2% in 7 out of 10 projects;* • *O&M extreme value in year 7 in 7 out of 10 projects;* • *Dismantling costs +50,000,000 in all projects.*
3	• *Energy loss factor +50% in 7 out of 10 projects;* • *Annual mean wind speed -1 m/s in 7 out of 10 projects.*
4	• *Support scheme stop in year 8 in 7 out of 10 projects;* • *System degradation +1% in 7 out of 10 projects;* • *O&M extreme value in year 7 in 7 out of 10 projects;* • *Energy loss factor +50% in 7 out of 10 projects;* • *Wind speed -1 m/s in 7 out of 10 projects.*

Table 12: Stress scenarios

Scenarios 1a and 1b are used to test the sensitivity of the model to a stop of the support scheme. I created two separate scenarios so I can also observe the timing effect of a support scheme stop. This could be very important as the loans amortise constantly and the exposure of different tranches could be very different at different moments in time.

In scenario 2, the system performance is severely lacking due to a much higher than normal degradation factor and an extreme O&M event in several projects. Also in this scenario, the developer has incorrectly estimated the costs for the dismantling of the project, which results in a discrepancy between the reserve and the actual costs. Scenario 3 captures model-errors related to wind speed estimates and the energy loss factor.

Finally, scenario 4 combines elements from the other scenarios. The reasoning behind this set-up is that such an adverse scenario will allow me to identify the elements that are the main driver for a defaulting SPV, as this scenario in constructed for the purpose that it will almost certainly create defaults in individual projects and possibly the SPV.

4.5 Stress analysis

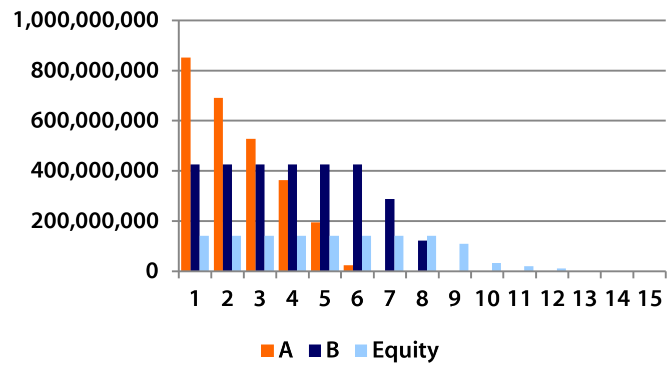
In this section the stress scenarios will put the ABS structure to the test. As argued, the hypothetical portfolio of offshore wind project loans will be created based on an assessment of actual offshore wind projects. After conducting five stress scenarios, I will also determine under what investor conditions, the demanded margins, the base-case scenario will be economically viable.

The ten hypothetical projects all have ten range variables and six stress variables. In Appendix A, the values for the base-case scenario, so before any stress is applied, are shown for sixteen variables. First, this base-case scenario is used to set a performance benchmark for the portfolio. Later on, the stress scenarios can be measured versus this benchmark. The results on this base scenario analysis are shown in Table 13:

Default in ABS structure?	***Principal losses in A***	***Principal losses in B***	***Principal losses in Equity***	***Equity tranche IRR***	***Debt payments IRR***	***WAL A tranche (years)***	***WAL B tranche (years)***
No	0	0	0	5.13%	3.87%	3.12	6.96

Table 13: Base-case scenario output

As can be seen in the table, under base-case assumptions, the ABS structure does not default nor experience any principal losses. Also of importance, the IRR of the ABS structure's Equity tranche has a higher internal rate of return than the debt payments as a whole. This fact makes it an economically sensible decision to securitise the portfolio of loans for the seller of the ABS. Looking at the WAL for the A and B tranches under the base-case assumption, these show relatively short principal exposures. As this WAL figure only shows the average expected life, it is interesting to see what the outstanding principal will be over time and how this effects the credit enhancement (CE) in the structure. The outstanding principal of all tranches, both in absolute and relative numbers, is shown in the two graphs below:



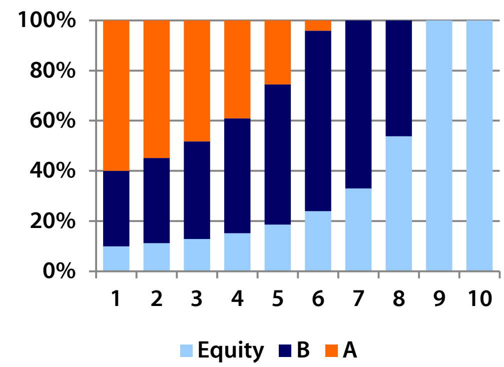


Figure 10: Outstanding principal base-case absolute

Figure 11: Outstanding principal base-case relative

In the panel on the left it is shown that the A tranche is fully redeemed after year 6; in year 7 no principal payments are made to these notes. The redeeming of the B notes starts in year 6 and finishes in year 8. Thus, in the final 7 years of the ABS' lifetime, the A and B note holders are paid off; all the interest payments have been made and the principal is paid back entirely. The Equity notes will also be fully redeemed, but not until the end of year 13. Looking at the underlying projects to find a reason for this, it can be noticed that only the loan to project 8 has not fully redeemed at the end of year 10, while the nine other notes have redeemed. The slower amortisation of this specific loan is mainly due to a very modest support scheme price of EUR 0.13/kWh, which results in relatively low incoming cash flows, and thus less available cash flows for amortisation.

4.5.1 Stress scenario 1

In both stress scenario 1a and 1b, the support scheme vanishes after a certain year in 7 projects. As these two scenarios are related, I will discuss them simultaneously in this section. In the two tables below, I present in which projects stresses are applied for scenario 1a and 1b and what the influences are for the individual projects.

Project	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stress variable										
Support scheme stop	✓	✓	✓	✓		✓	✓	✓		
System degradation										
Extreme O&M event										
Annual mean wind speed										
Energy loss factor										
Default?	No	No	No	No	No	No	No	No	No	No
Principal losses (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.1%	0.0%	0.0%

Table 14: Stress in scenario 1a

Project	1	2	3	4	5	6	7	8	9	10
Stress variable										
Support scheme stop		✓	✓	✓		✓	✓	✓	✓	
System degradation										
Extreme O&M event										
Annual mean wind speed										
Energy loss factor										
Default?	No	Yes	No	Yes	No	Yes	No	Yes	Yes	No
Principal losses (%)	0.0%	37.7%	34.7%	34.8%	0.0%	44.9%	21.9%	58.7%	43.3%	0.0%

Table 15: Stress in scenario 1b

Now that I presented the results for the individual projects, the translation to the ABS structure can be made. These results are presented in the table below.

Scenario	*Default in ABS structure?*	*Principal losses in A*	*Principal losses in B*	*Principal losses in Equity*	*Equity tranche IRR*	*Debt payments IRR*	*WAL A tranche (yr)*	*WAL B tranche (yr)*
1a	No	0	0	11,845,129	4.56%	3.77%	3.12	6.96
1b	Yes	0	247,592,531	141,933,400	-13,87%	0.13%	3.12	-

Table 16: Stress scenario 1 output

As could be expected from the base-case scenario analysis, the disappearing of the support scheme in year 10, as in scenario 1a, does not influence the performance of the ABS a lot. The A and B notes are already redeemed at that point, so there were no principal losses, nor changes in WAL expected. The IRR of the debt payments drops slightly, by 0.1%, because of the decreasing incoming cash flows in the final 5 years of several of the projects. Because of the leveraging in the ABS, the influence on the Equity tranche's IRR is a bit bigger. In this case, the IRR drops more than 0.5%. Furthermore, the Equity notes suffer a small principal loss of approximately 8% of the total principal. Principal losses in the Equity tranche are, however, common practice in mature ABS classes as well. The losses are quite small, as the equity notes had already redeemed to just over 20 million by the end of year 10.

The situation becomes much more dire when we consider the 1b scenario. In this scenario the support schemes also vanishes in 7 out of 10 projects, but already after year 5. The ABS structure experiences a default in year 12 because it is at that point not able to fully pay the interest to the B notes. The timing of this default might seem quite odd since the stress is applied from year 6 onwards, but it is not. The costs in year 6-10 are still lower than the revenues. In year 11, there is a new step up level in the O&M costs. As this is a structural increase on the costs side, which is not compensated by any revenue increases, the interest reserve account is only able to cover up these deficiencies for one year. So, where in year 11 the interest in the stressed projects can be paid out of the reserve, this reserve is close to empty in year 12.

This reasoning holds for five of the seven stressed projects. For the other two, the default occurs one or two years earlier. These earlier defaults are in two projects with relatively high CAPEX and a high O&M step-up for years 6-10. More than the other five, these projects need high incoming cash flows in order to service the debt. In the SPV there are sufficient cash flows to pay interest payments until year 11. In the profile of outstanding principal as shown in Figure 13, you can see that there is still a little bit of room for redemptions from year 6-11, but from year 12 onwards the outstanding principal in the B and Equity is stable.

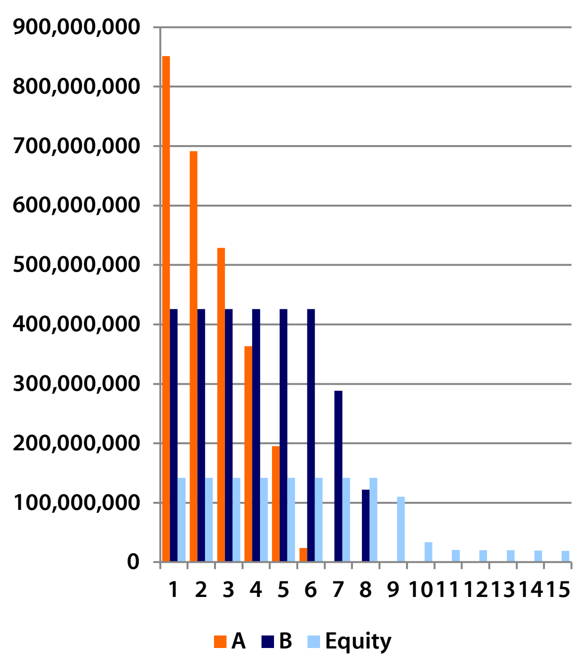


Figure 12: Outstanding principal scenario 1a

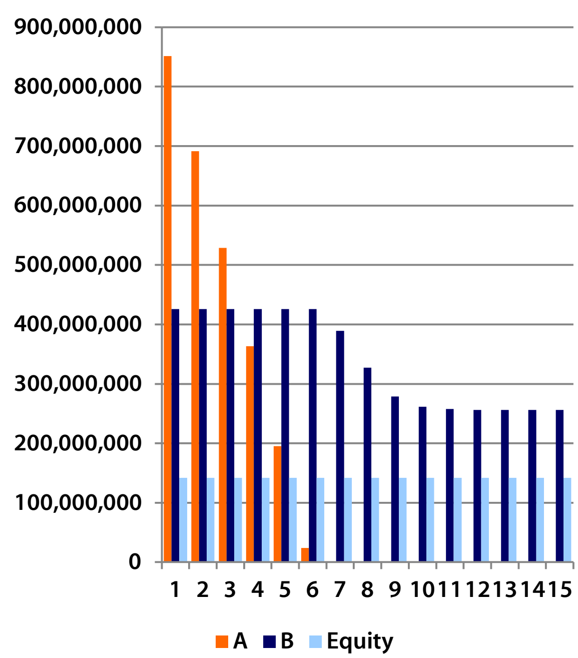


Figure 13: Outstanding principal scenario 1b

Looking at principal losses, 58% of the principal of the B notes is not redeemed. This obviously also means that the entire Equity tranche's principal is not paid back and, even though there are interest payments to the Equity notes in the first 11 years, the IRR of the Equity tranche is negative. So the difference between a support scheme stop after year 5 or after year 10 is very significant under the current project assumptions. Should, for instance, the amortisation pace drop, with more principal exposure towards the end of the structure's lifetime, then it could very well be that also in the 1a stress scenario the losses would be more significant. Another important conclusion is that in both scenarios there are no losses in the senior A tranche.

4.5.2 Stress scenario 2

In the second scenario the stress effect is more clustered in one specific year through the presence of an extreme O&M event and the higher than expected dismantling costs in year 15. In the tables below the stress scenario input, the results for the underlying projects and the output for the ABS structure of the second stress scenario are shown.

Project	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stress variable										
Support scheme stop										
System degradation	✓	✓			✓	✓	✓		✓	✓
Extreme O&M event	✓	✓			✓	✓	✓		✓	✓
Annual mean wind speed										
Energy loss factor										
Default?	No	No	No	No	No	Yes	No	No	No	No
Principal losses (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 17: Stress in scenario 2

Default in ABS structure?	***Principal losses in A***	***Principal losses in B***	***Principal losses in Equity***	***Equity tranche IRR***	***Debt payments IRR***	***WAL A tranche (yr)***	***WAL B tranche (yr)***
No	0	0	0	5.06%	4.01%	3.38	8.63

Table 18: Stress scenario 2 output

Compared to the base-case scenario, the effects of this stress scenario are really minor; there are no principal losses, the Equity tranche IRR drops only a few basis points and the WAL of the A notes is just a few months longer. The WAL of the B tranche is almost 2 years longer, though. This makes sense since the extreme O&M event is in year 7 in seven of the projects and this will delay the repayment of the B notes' principal. To see how close the ABS structure was to a default, we can look at the interest payments over time and look for years where the interest to the Equity notes was really small.

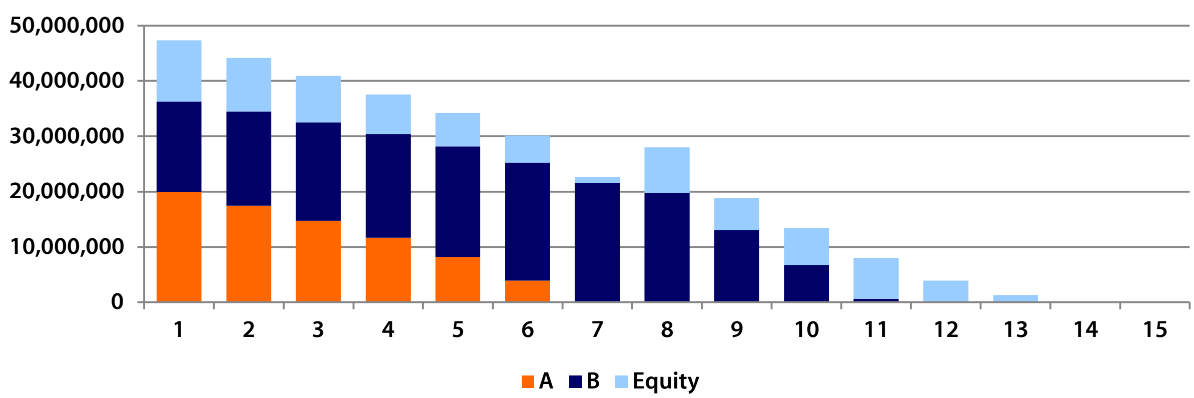


Figure 14: Cumulative interest scenario 2

In Figure 14, the interest paid to the Equity tranche in year 7 is very low. This is obviously related to the extreme O&M event. However, the credit enhancement in the structure, and the reserves in the projects, were sufficient to prevent a default of the ABS. The margin was very slim however, as the interest paid to the equity notes was only 1 million while the interest to the B notes was 21 million. So had the total interest paid by the underlying loans been 5% lower, the structure would have defaulted. Looking, then, at the underlying projects, only one project experienced an event of default because of the extreme O&M event. Not surprisingly, this was one of the two projects with the highest factor (15%) for the extreme O&M event, and it had one of the lowest O&M reserves, at just 15 million. The project did manage to fulfil all its debt obligations by the end of the lifetime of the ABS.

Finally, the high dismantling costs did not influence the ABS structure whatsoever. By the time these became a factor, all of the loans have been redeemed in total; in this scenario, higher than expected dismantling costs only influence the equity share of the project.

4.5.3 Stress scenario 3

In the third scenario, stress is applied to the modelling variables, which are related to performance of the offshore wind projects. This will result in lower incoming cash flows in 7 of the projects. The input and the output of this scenario are shown in the tables below.

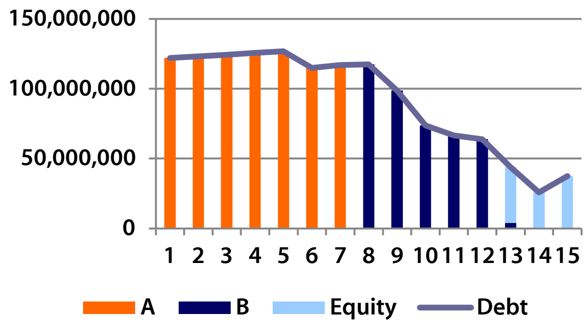
Project	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stress variable										
Support scheme stop										
System degradation										
Extreme O&M event										
Annual mean wind speed		✓	✓		✓	✓	✓	✓		✓
Energy loss factor		✓	✓		✓	✓	✓	✓		✓
Default?	No	No	No	No	No	Yes	No	No	No	No
Principal losses (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	32.7%	0.0%	0.0%

Table 19: Stress in scenario 3

Default in ABS structure?	***Principal losses in A***	***Principal losses in B***	***Principal losses in Equity***	***Equity tranche IRR***	***Debt payments IRR***	***WAL A tranche (yr)***	***WAL B tranche (yr)***
No	0	0	38,429,099	3.73%	3.84%	3.96	9.69

Table 20: Stress scenario 3 output

Again, the most important conclusions from this table are that there is no default of the structure, nor any principal losses in the A and B tranches. What is noteworthy, though, is that the IRR of the Equity tranche drops slightly below the Debt IRR; under this scenario it would not be economically sensible to securitise the portfolio. Also interesting is the slower amortisation of all three tranches. This is again due to the lower incoming cash flows in the projects and thus lower available cash flows for principal repayment. In the two figures below the evolvement of the principal- and the interest payments is shown.



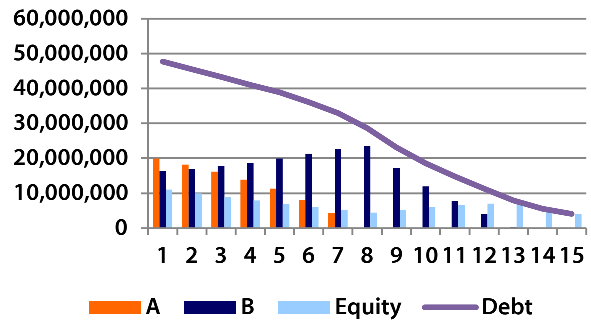


Figure 15: Principal payments scenario 3

Figure 36: Interest payments scenario 3

Striking in these figures is that it takes until year 13 to fully redeem the B notes. The uptick in principal redemptions in the final year, is due to the assumption in the model that any remaining redemptions take place, if possible, in the final year. Before year 15, the sculp scheme is still in place and this automatically puts a limit on repayments. The reason behind the principal losses in the Equity tranche, are losses in project 8. The combination of stressed wind speed and energy loss factor, a low support scheme price of EUR 0.13 per kWh, and high step-up values for O&M costs, created insufficient available cash flows. The result is that nearly 33% of the EUR 117.6 million loan was not redeemed. Even though this was the only loan actually suffering principal losses, there were several others that struggled to fully redeem the principal before the end of year 15. This is, of course, also the reason that it took until year 13 to fully redeem the B notes' principal.

4.5.4 Stress scenario 4

The final scenario combines stress factors from all previous stress scenarios. As the target of this scenario is to identify the main drivers behind defaulting projects and a defaulting SPV, the adverse output in the table below is not surprising.

Default in ABS structure?	*Principal losses in A*	*Principal losses in B*	*Principal losses in Equity*	*Equity tranche IRR*	*Debt payments IRR*	*WAL A tranche (yr)*	*WAL B tranche (yr)*
Yes	0	251,430,113	141,933,400	-	0.78%	4.22	-

Table 21: Stress scenario 4 output

Just as in scenario 1b, there are severe principal losses in the Equity and the B tranche. The losses in the B tranche amount to 59% this time, which is just 1% (or 4 million) more than in scenario 1b. So, under the model's assumptions, moving the support scheme stop year from year 5 to year 8 has about an equal effect as the additional four effects combined. The default of the SPV does occur sooner, however. Already in year 7, the SPV is no longer able to fulfil its interest obligations. This is obviously related to the extreme O&M event in that year. While there was no default in scenario 2, because of this event, this time it does lead to a default. This is due to the combination of the extreme O&M event, and the higher energy loss factor and lower wind speed in several projects. So, while the stop of the support scheme after year 8 does not directly influence the default, it does influence the pace of the amortisation afterwards. Since incoming cash flows are stressed due to this stop, as well as due to the lower wind speed and the high energy loss factor, there is very little room to redeem principal.

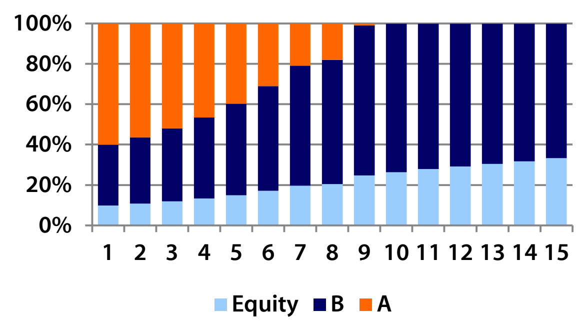


Figure 4: Outstanding principal scenario 4

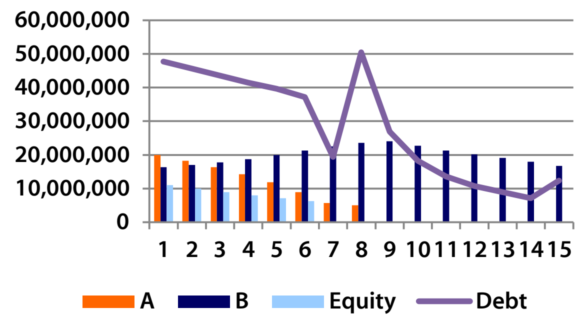


Figure 58: Interest payments scenario 4

On the positive side, however, the A notes fully redeem with the final payments in year 9 and a WAL of 4.22 years. Also, there are no deferred interest payments related to the A notes. While the WAL is 1 year longer than in the base-case scenario, the fact that these notes' principal and interest payments are made in full and for the most part on time, shows the strength of the structure. Obviously one could argue the strength of the underlying assumptions and the severity of this particular stress scenario, but in my opinion both are sufficient underlying assumptions for these observations.

Noteworthy, in Figure 18, is the spike in debt payments in year 8, and the quick decline afterwards. This is due to the project defaults in year 7 and the support scheme stop after year 8. Because of the default in year 7, many projects have deferred interest payments to make in year 8. Since the SPV also defaults in year 7, the *acceleration* process in the ABS starts. This means that when all interest obligations to the A and the B notes are met, the SPV starts redeeming principal. In year 9, the A note is redeemed, and there is also a little bit of money available for the B tranche. For year 10 on out, however, the interest payment to payments coming from the underlying projects are lower than the interest obligations of the SPV. This means that, combined with the low principal payments coming from the underlying loans, there is little room to redeem the B notes further, as can be seen in the figure above with the outstanding principal.

Of the 10 loans to the underlying projects, eight have defaulted and nine suffered principal losses. In the table below the projects, and the corresponding stresses that were put on them, are shown. Also the defaults and the principal losses are presented. The latter are presented as a total of the loan's principal. Looking at this table, the combinations of variables that cause defaults and principal losses can be identified.

Project	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stress variable										
Support scheme stop		✓		✓		✓	✓	✓	✓	✓
System degradation	✓	✓	✓		✓		✓	✓		✓
Extreme O&M event	✓	✓	✓		✓		✓	✓		✓
Annual mean wind speed	✓		✓	✓	✓	✓	✓		✓	
Energy loss factor	✓		✓	✓	✓	✓	✓		✓	
Default?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Principal losses (%)	2.7	17.6	8.7	32.3	0.0	46.6	51.5	47.1	44.3	11.5

Table 22: Underlying projects scenario 4

By combining the randomised variables, there are several patterns to be observed in the table. In project 1, 3, and 5, all variables are stressed, except for the support scheme stop. In the first two cases, this combination has led to a default in year 7, when the extreme O&M event occurs. In the case of project 5, this did not lead to a default. In my view, this is due to the low value for the extreme O&M event of only 10%. Because of this, the incoming cash flows combined with the O&M reserve, were able to prevent a default. After year 7, the stressed incoming cash flows result in amortisation of the loan until the end of year 15. The other two projects, even though incoming cash remained on the low end after the default, were almost able to repay the entire principal as losses were just 2.7% and 8.7%, respectively. To put this in terms of the ABS structure: both of these losses would have been absorbed by the Equity tranche in the ABS, as this tranche's size is 10% of the total ABS.

The second pattern, observed in project 2, 8 and 10, contains the stress of the support scheme, system degradation, and the extreme O&M event. In project 2, the default actually does not occur until year 12. Because incoming cash flows are quite strong in this very large project, the O&M event did not cause a default. Even the stop of the support scheme did not immediately cause this, but the combination of increasing normal O&M costs in year 11, the lack of a support scheme, and the continuing degradation of the wind park, led to a default in year 12. The default would have occurred, without a debt reserve account, in year 11. Project 8, on the other hand, did not survive the extreme O&M event. Even more, when the support scheme vanished, the project generated far too less cash to repay any principal. Also interest payments could not be paid totally and all of this led to 47.1% of unredeemed principal and nearly

13 million of deferred interest payments. Finally, project 10 did not default at all. But just like in project 2, the incoming cash flows got so weak after year 10, that all available funds were needed to fulfil the interest obligations, with next to nothing available for principal redemption.

In the third pattern three stress variables influencing incoming cash flows are stressed. This occurs in projects 4, 6, and 9. In all three projects, this leads to default and severe principal losses of 32.3% 46.6% and 47.1% respectively. Furthermore, in all three projects, interest payments have been deferred which adds to the losses. The default in project 4 occurs directly after the support scheme stops, while in the other two projects the debt reserve account in sufficient to cover expenses for one more year; the default in those projects occurs in year 10.

The final pattern to be discussed, is the pattern of project 7. In this project all stress variables have been stressed in this scenario. Just as with some projects in following the second pattern, the project did not survive the extreme O&M expense. In year 8, then, the deferred interest could be paid, as well as some principal redemption. After the support scheme stops the cash flows almost completely dry up. This finally leads to nearly 80 million of unpaid principal and interest.

4.5.5 Break-even scenarios

Now that the defaulting tendencies under various scenarios have been considered, this final section of chapter 4 will be used to describe some break-even points for the ABS structure. First, I will discuss the sensitivity of an increase or decrease of the margin of the A and B tranches on the IRR of the Equity notes. Second, I will increase the stress level in the support scheme stop variable to see when the A notes will suffer principal losses as well.

For the first break-even analysis, I use the base case scenario setting from the previous section. In this scenario the IRR for the Equity tranche is 5.13%. Lowering the margin of A notes by 10 basis points, from 2% to 1.9%, leads to an increase in IRR to 5.37%, or 24 basis points. This number is a good indication of the sensitivity of the IRR, as lowering the margin for the A notes by 100 bps, leads to an increase in IRR of 251 bps, from 5.13% to 7,64%. Looking at the B notes, a similar pattern is observed. When lowering the margin for the B notes by 10 basis points, the IRR for the Equity notes increases by approximately 25 basis points.

While it appears to be surprising that the sensitivity to both the A and B notes is similar, because of the larger size of the A tranche than the B tranche (60% vs. 30% of the ABS structure), it is actually not. Recall that the principal of the A notes is redeemed prior to the principal of the B notes. Because of the longer exposure of the B notes this size effect is diminished. It is, however, simply coincidence that the sensitivity is this similar in this setting. Testing for other combinations of tranche sizes showed vastly different sensitivities. The larger the tranche size compared to the Equity tranche, the higher the sensitivity.

For the second break-even analysis, I use a scenario similar to the stress scenarios 1a and 1b. I will gradually force the support scheme stop at an earlier moment. In scenario 1b, it was noted that the A notes were unaffected when the support scheme stops after year 5. So the first step of this analysis will be to lower this figure to a stop after year 4. In the tables below the scenario is presented.

Project	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stress variable										
Support scheme stop		✓	✓	✓		✓	✓	✓	✓	
System degradation										
Extreme O&M event										
Annual mean wind speed										
Energy loss factor										
Default?	No	Yes	No	Yes	No	Yes	No	Yes	Yes	No
Principal losses (%)	0.0%	49.5%	49.0%	47.2%	0.0%	55.3%	40.1%	66.7%	54.5%	0.0%

Table 23: Support scheme stop after year 4

Default in ABS structure?	***Principal losses in A***	***Principal losses in B***	***Principal losses in Equity***	***Equity tranche IRR***	***Debt payments IRR***	***WAL A tranche (yr)***	***WAL B tranche (yr)***
Yes	0	368,626,946	141,933,400	-	-	3.32	-

Table 24: Support scheme stop after year 4

As Table 24 shows, the A tranche still does not suffer any principal losses. The WAL is longer than in the base scenario, mainly because it needs until the end of year 8 to fully redeem the principal, but this effect is minimal. Stressing the support scheme further, gives another result, however. In the tables below the situation is shown for a stop after year 3, with all other variables being equal to the base scenario:

Project	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stress variable										
Support scheme stop		✓	✓	✓		✓	✓	✓	✓	
System degradation										
Extreme O&M event										
Annual mean wind speed										
Energy loss factor										
Default?	No	Yes	No	Yes	No	Yes	No	Yes	Yes	No
Principal losses (%)	0.0%	61.9%	64.2%	60.1%	0.0%	66.2%	56.2%	75.1%	66.2%	0.0%

Table 25: Support scheme stop after year 3

Default in ABS structure?	*Principal losses in A*	*Principal losses in B*	*Principal losses in Equity*	*Equity tranche IRR*	*Debt payments IRR*	*WAL A tranche (yr)*	*WAL B tranche (yr)*
Yes	66,844,120	425,800,200	141,933,400	-	-	-	-

Table 26: Support scheme stop after year 3

As can be seen in the tables, more than 60% of the principal in several loans is not redeemed and this creates a principal loss of EUR 67 million in the A tranche. This is nearly 8% of the total principal in this tranche. Further increasing the stress in this variable, or combining it with other types of stress like I showed in stress scenario 4, would obviously only further increase losses in the A tranche.

Chapter 5 Conclusions

In this chapter, I will answer the main question of this research. This will be done based on the analyses in the previous two chapters. As the quantitative analysis is based on a significant set of modelling assumptions, I will focus on the general observed trends instead of on the specific values resulting from the analysis. The most important and impactful assumptions, as well as their presumed impact, are discussed in the next chapter. The main research question that has to be answered is:

Is securitisation an economically viable option for offshore wind financing in Northern Europe?

In order to answer this question, three sub-questions have been constructed. The first question was used to create a backbone for this research with respect to both securitisation and offshore wind development:

I. *What is securitisation and what is the current state of offshore wind development?*

The most important point, learned from answering this first sub-question, is that the need for capital in the offshore wind industry is very large. In Europe, the gap between the desired renewable energy capacity and the current capacity is huge. Looking at the offshore wind sector in specific, it is estimated that around EUR 100 bn op new capital is necessary to fund the desired expansion up to 2020. This estimate takes costs reductions, expected for the still developing technology, into account.

The second sub-question was created to identify the relevant variables for the securitisation model as well as any important factors that could influence the securitisation outside of the modelling terms:

II. *What are the specific characteristics of offshore wind projects and how do they influence the model for an offshore wind asset backed security?*

For the modelling, the main inputs were the underlying loan characteristics, the estimates for the parameters of the ABS structure and, last but not least, the two crucial counterparties involved in every offshore wind project: the subsidising government and the O&M service provider.

The government is a very important party for the generation of revenue in the offshore wind projects; currently, around 60% of a project's revenues come from support schemes provided by the government. Usually these schemes are in the form of some type of feed-in tariff. The knowledge that a government can default on these payments creates an significant counterparty risk. On the other hand, the O&M counterparty is responsible for the maintenance of the wind farm. The costs concerned with this service are substantial and are therefore a crucial factor in the cash flow model. Also for this type of counterparty, there is a risk that a counterparty default will occur.

Other important factors for the assessment of the viability of the proposed offshore wind securitisation model are the high policy fragmentation, the assessment of credit rating agencies, and the regulation that the offshore wind ABS would be subject to. While many countries in Europe are stimulating the development of renewable energy, a lot of different policies are used. To ensure a rapid development, a stable, coherent and comprehensive set of innovation policies should be in place across Europe (Alafita & Pearce, 2014; Wieczorek et al., 2013). These policies should comprise not only the subsidising scheme, but many more factors such as grid connections, innovation of the technology, and the creation of skilled labour force.

For the credit rating of the offshore wind ABS, an important factor will be the granularity of the underlying loan portfolio. As the loans to the offshore wind projects are usually very large in size and few in number, the portfolio will most probably not be very granular. This will, at best, lead to a low investment grade rating (BBB) for the ABS in the foreseeable future, as rating agencies will likely not account for any diversification effects in such a concentrated portfolio. This relatively low rating will also have an effect on the regulation the ABS is subject to. Under the new Basel and Solvency regulation, the risk weights for securitisations are much higher than before, especially for the non-"high-quality" ABS. This makes the securitisation much less attractive for banks and insurers. Possibly funds that do not have to comply with Basel and Solvency regulation could fill this gap.

The final sub-question aimed to answer any questions regarding, whether it is possible to create an ABS model backed by offshore wind loans and how this model would respond under stressed scenarios:

III. Is it possible to create an economically viable ABS structure backed by offshore wind loans and how will this ABS perform under stressed conditions?

Based on the quantitative analysis in chapter 4, there are several conclusions. First of all, in my opinion, it is possible to create an economically viable model for both the seller and the investor of the ABS under the base-case assumptions I made. The analysis of the base-case scenario shows that the seller would benefit from a higher return after securitising the portfolio, and the investor would be able to receive their estimated demanded return.

However, when stressing several variables in the underlying projects, this conclusion becomes harder to defend. While it is was expected that all stressed variables have some influence on the performance of the structure, there is one variable that is absolutely vital for success of the structure; the presence of a support scheme, in this model in the form of an independent feed-in tariff, is crucial for prolonged success. Without government support, incoming cash flows would be insufficient to service the project's debt and thus the SPV would be unable to service its note holders.

Nevertheless, the timing effect of the disappearance of government support is important as well. Under current assumptions, the amortisation of the SPV's A notes happens rather quickly; the WAL of the A notes is just above 3 years in the base-case scenario, and even in the most severely stressed scenario, just above 4 years. Even though these numbers represent an average, it shows that the exposure of the most senior notes ends rather quickly. This short exposure can be considered as a good sign for the viability of the structure. Back-end principal exposure is quite risky for note holders, as the cash flows become weaker as time goes on. This is due to the higher O&M costs in the final years of the project, the possibility of escalating dismantling costs, as well as the constantly degrading system.

However, it should be noted that there is also a drawback related to a short WAL. No more exposure also means no more rewards. Investing in a product gives to right to the interest payments and this is the interesting component for investors and the reason they invest in the product. A quick repayment of the principal means that the investor will have to reinvestment its capital sooner, which could be present a problem if no desirable alternatives are present.

A good sign for the structure is that, under the scenarios in which the presence of a support scheme is not stressed, it performs well. The ABS does not default in these scenarios, and only small principal losses are incurred, only in the Equity tranche. Due to the reserve accounts in the underlying projects, the equity shares in these project, do not even necessarily default when the project experiences an extreme O&M event. This does, however, depend to some extent on the severity of the extreme O&M event and the size of the reserve accounts in the corresponding project.

The fact that the model performs well under the stresses is, in my opinion, to some extent due to diversification effects in the ten-loan portfolio. While credit rating agencies, are likely not accounting for this effect, it can be observed in the analyses. Under several scenarios, one or a few projects defaulted, without causing severe damage to the ABS structure. It must be noted, however, that a part of the diversification was created by my own modelling of the stress scenarios, because of the assumption that stresses would only be applied to 7 out of 10 projects. This obviously influenced the severity of the stresses.

Looking at all these factors described above, it is impossible to answer the main research question with a simple yes or no. Based on quantitative reasoning, it is, in my opinion, possible to use securitisation as a financing means for offshore wind development. The model shows that even under severe stresses, besides from the break-even analysis, the A tranche is untouched, and when excluding stresses related to the government support scheme, the securitisation is an economically sensible transaction for the seller, as well. Considering the second break-even analysis in section 4.5.5, it is, however, possible that the principal of the A notes is affected, when the subsidy stops after year 3 or sooner. While this might seem early, this risk cannot be excluded from consideration.

However, there are various issues related to the model that could cause severe problems. The government still plays as vital a role as any other party in the transaction, and, as we have already seen the Spanish government stop its support of the solar industry, it remains to be seen what happens to the government support, should the renewable energy industry expand quickly. Also there is still limited history on the performance of the projects and loans. This, for now, leads to low credit ratings and it might thus lead to higher demanded yield by investors, than anticipated in the analysis in this research. Also the regulatory pressure will, most likely, cause bank investors to neglect this market. So while I definitely feel that securitisation could work for offshore wind loans, and could even stimulate the growth in this market by providing a possibility for balance sheet relief for the project financiers, there are still some severe kinks to be worked out before I see this market taking off.

Chapter 6 Discussion and future research

Now that the conclusion section is completed, I will discuss how the conclusions of the previous chapter might have been impacted by assumptions I have made. Also, a preview on future developments and the impact of these developments on the model will be discussed. Finally, several of these topics might be relevant for research in the future.

Before any reflections regarding the outcomes of this research, I will reflect on the model that I created. The purpose of the model was to give insight in the dynamics that would occur when creating an asset-backed security based on loans to offshore wind projects. In my view the model was very well suited for this purpose. All of the main dynamics that I observed when studying the offshore wind projects where captured in the model. Also, for the ABS model, the model could handle important dynamics related to a defaulting structure and the related deferred interest payments.

While in this research the created model was only used to assess a portfolio of offshore wind projects, it is also very much suited for other types of renewable energy backed securitisations. Possibly the model should be expanded to include more projects, but no changes in the structure would be needed to incorporate this. Obviously the values of several variables will have to be altered, based on the type of projects included in the model. An onshore wind project, for instance, will have much smaller turbines and very different annual mean wind speeds. Also O&M contracts are different as costs are lower at the moment, but, again, this would not change the structure. For solar projects a new dynamic should be created to incorporate the replacing of the inverter. This is a part of the system that deteriorates much faster than the solar panels and will thus have to be replaced halfway into the project. Such a dynamic could be structured similar to the extreme O&M event in the offshore wind model. Except for making this event a stress event it could be included as a fixed variable in a the year when you plan to replace the inverter.

For other types of securitisations this model would be less suited as it is constructed to incorporate cash flows coming from energy generating projects. Traditional generating technologies might be used, but I do not have enough insight in this industry to find this argument convincing. Also, as I will discuss in the following paragraphs of this chapter, some of the assumption I made could be of interest to other researchers and might therefore be included or substituted into my model.

For the modelling of the offshore wind ABS structure many assumptions have been made. First of all, the grid connection of any offshore wind development project is of vital importance for the success of the project. In the early stages of this research it was concluded, however, that the costs and development for the grid connection were out of scope for this research. The handling of the costs of these connections, however, varies quite a bit among different countries; in some countries the project developer is responsible, where in other countries the transmission service operator (TSO) pays these expenses. In this research, a wide range of capital costs per MW has been used, based on a portfolio of real-life European offshore wind projects. These real-life projects, however, do feature both varieties of grid connection reimbursement. As it was hard to distinguish the actual costs for the grid connection in these projects, I chose to keep the range of capital costs intact. This means that, for now, the grid connection costs are to some extent present in this research's model, but I am not able to fully capture the effect it has on the outcomes of the analysis. In future research, it might, thus, be interesting to create a model that is able to capture these costs as an individual variable as well.

While the grid connection creates some additional complexity for this research, it does create opportunities in the ABS market, as well. In early February 2015, a securitisation of the grid connection of the Gwynt y Mor offshore wind farm was sold. The senior notes of the deal were rated A3, aided by a letter of credit provided by the European Investment Bank (EIB), by Moody's, which is a promising sign for the asset class. The assets included in this securitisation comprise all assets related to the grid connection, such as the transmission cable, the offshore transmission stations and the onshore transmission station. As the costs associated with the grid connection are significant, securitisation of the assets could be a useful tool to create balance sheet relief for the parties investing in the connection. Possibly, this would also improve conditions for offshore wind development.

Important estimations have been made regarding the annual mean wind speed the projects achieve. These variables directly influence the incoming cash flows. In this research a model based on the annual mean wind speed and the energy loss factor was used to estimate the produced electricity. Another, often used, measure for a wind farms productivity is the capacity factor. This capacity factor measures the percentage of equivalent full-load hours relative to the hours in a year. An equivalent full-load hour is the amount of power generated, if the wind turbine were to produce for one hour under its full capacity. A good test for my wind speed estimations is then whether the portfolio I created is in line with a portfolio of real-life projects and average reported capacity factors in literature. The real-life portfolio I used has an average capacity factor of just over 40%. This is also a value often mentioned in offshore wind assessment reports. The portfolio I created for this research has an average capacity factor of 39.7% with outliers at 35.5% and 45.3%. This seems to be very much in line with actual data. It should be noted, however, that annual mean wind speed might not be the best measure for estimating output of a wind farm. Combining very high peaks with long durations of low wind speed could also lead to a high mean wind speed, but during should these peaks be too high, the wind turbines must be switched off, as they have a maximum wind speed they can deal with.

Another assumption that heavily influences the cash flows in the model, concerns the expenses for operations and maintenance (O&M). Based on literature findings (Prässler & Schächtele, 2012), these costs are directly linked to the initial capital expenditure of the project. Also, the step-up levels in these values for later stages of the project are varying quite a lot. Because I was not able to assess the actual contracts between O&M servicers and project developers, because of confidentiality reasons, these step-up values are hard to predict accurately. Based on the information I was allowed to use, I created quite wide ranges for the second and third period step-up values. Because of this, there probably will be some unwanted deviation in the calculations. Using actual data could therefore improve the analysis of this research.

Since the renewable energy sector, and the offshore wind sector in particular, is still in an early lifecycle stage, the costs for developing renewable energy capacity are expected to decrease in the coming decades. This will obviously have a huge impact on the outcomes of this research. In the graphs below, the expected electricity price, as well as the expected future investment- and O&M-costs are shown for both the offshore- and onshore wind technology. These figures are based on a report from the European Renewable Energy Council (2012).

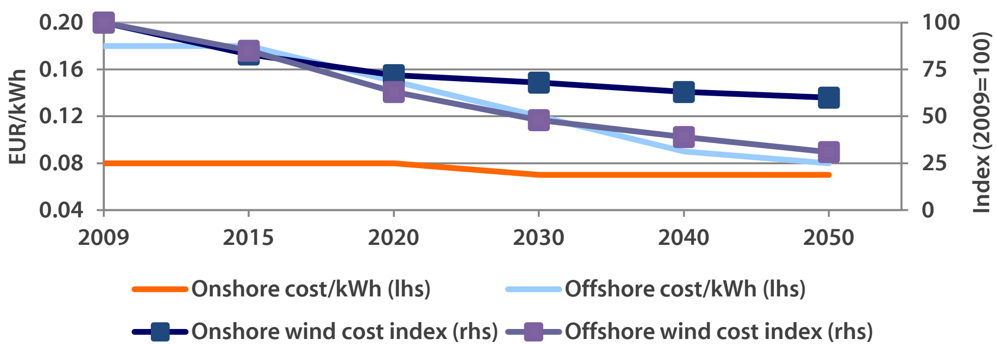


Figure 20: Wind development costs

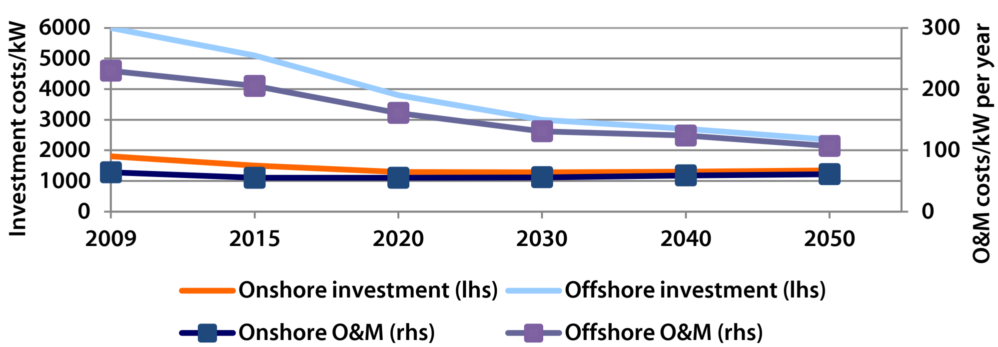


Figure 6: Investment and O&M costs for wind technologies

Both figures show that it is expected, that in the coming decades the costs for offshore wind development are going to decrease significantly. For 2030, the costs for both initial investments, as well as O&M, should have nearly halved. This trend brings me directly to one of the most important points in this discussion.

As shown in the quantitative analysis of the securitisation model, the presence of a support scheme is, at the moment, of vital importance for the success of the ABS structure. It is, however, hard to imagine a government will continue to subsidise projects that are becoming more and more competitive. What this retraction of the subsidising body will eventually look like, is very interesting when we want to estimate the cash flows in an ABS structure. To create and maintain successful origination of securitisations backed by offshore wind assets, the technology should, in my opinion, eventually become competitive with other exhaustive energy generating technologies. Current expectations for the development costs of offshore wind show that this could be possible within the coming decades.

In order to mitigate the risks of a subsidy stop in the near future, governments and offshore wind developers might look at other types of subsidy structures to make the guarantee of this subsidy more explicit. One structure that could be used, are the so called Export Credit Agencies (ECA). ECAs are usually quasi-governmental institutions that provide credits and/or guarantees. The primary objective of most ECAs is to mitigate risks for parties when investing outside of their native country. In developing countries, ECA funds are often used in project finance, as they underwrite commercial and political risks of investments.

Another means to improve the credit quality for debt providers is to use a letter of credit provided by a party such as the EIB, like the one used in the Gwynt y Mor offshore wind grid connection securitisation. A letter of credit is a document provided by a bank to guarantee that a seller of a product will receive payments in full from the buyer. This letter of credit can be used to mitigate risks, related to a defaulting government, for the equity providers of an offshore wind project, but it could also be used to improve credit quality for the debt providers of the projects, as the counterparty risks related to the equity providers can be diminished with such a bank guarantee.

When assessing the competitiveness of offshore wind with other technologies, one should keep in mind, that also traditional fossil fuel based energy generating technologies have received, and still receive, subsidies from governments. The subsidies to fossil fuel projects are usually less direct than their renewable energy counterparts, and are less noticed in the public eye. Most of the benefits for fossil fuel initiatives are achieved through some sort of tax exemption. The actual size and impact of these fossil fuel subsidies is hard to estimate. Multiple reports, from very different sources, circulate and state numbers that differ quite a lot among each other. What is certain, however, is that, globally, on a nominal basis, the subsidies to fossil fuel are much larger than the subsidies to renewable energy, while on a per project basis, the subsidies to renewable energy are larger.

Also concerning the support schemes, it was assumed in the modelling of the revenues that all projects would benefit from an independent feed-in tariff. This assumption was made for modelling purposes, but in reality a lot of different schemes are being used in Europe, and this might have influenced the modelling of these specific cash flows. I do, however, think that this influence is minimal. The contracts for these support schemes usually have very clear and stable terms for the entire lifetime of a project. Even under a market-dependent scheme, a slight increase or decrease in the underlying energy price would still have limited influence in my view. The large impact arises when a government stops the subsiding of a project. This variable is modelled independently of the choice of support scheme, so it is not influenced by the assumption of the presence of an independent feed-in tariff.

For the modelling of the cash flows in the project SPV, several important assumptions have been made. First of all, the DSCR of the underlying loans was fixed at 1.3. This assumption was made so I could compare amortisation profiles between different projects on an similar basis. And while this value is in fact fixed for the underlying loans, it could very well differ somewhat from the assumed value in some projects. Looking at the impact of the DSCR, the main consequence of a higher DSCR is that it will lead to slower amortisation and, thus, more principal exposure towards the end of the project.

The opposite could also happen. When cash flows are sufficient, the project developer might choose, if possible under the loan terms, to repay principal at a faster rate than expected. These prepayments could lead to shorter time exposure for the noteholders, and thus diminishing opportunities for investors to gather interest payments on their investment.

Besides the DSCR, the modelling of the loan also features some important assumptions. First of all, the maturity of the project, and thus the loan, is fixed at 15 years. After this point, no more cash can flow to the SPV. Therefore, the assumption was made that the maturity of the SPV is also fixed at 15 years. In practice, however, the legal lifetime of an SPV could be longer than this. So if for some reason, a project is able to generate cash flows after year 15, these cash flows could be used to pay any deferred interest or principal to the loan. These payments would then flow to the SPV, where the proceeds can be used to service the note holders.

What could make this entire process more difficult, especially when a project is in default, is the presence of the syndicate-structure in the project financing section of the model. In the model, it is assumed that, when the underlying project goes into default, the SPV (partially) becomes owner of the project. The fact that the loan is usually provided by a syndicate consisting of many parties, might make this quite tricky. Some parties in the syndicate might want to exploit the underlying project in different way, which could harm the ability of the project to recover any incurred losses. The question therefore remains, whether it is possible to optimally access the recourse on the loan in the most desirable way, for the SPV. Future research could focus on the strength and depth of the recourse in these project loans, and determine what factors play a role in syndicate structure, like the one we usually see in offshore wind financing.

Other assumptions regarding the SPV's cash flows are related to the tranche sizes and the corresponding margins. For the tranche sizes and margins, a link with CMBS issues was made. The question remains how strong this link is, however. The CMBS market has been quite small in recent years, and is obviously exposed to very different market and credit risks than the offshore wind industry. The estimation for the margins, based on the chosen tranche sizes, might therefore differ when the product would be marketed.

Looking at the data in Chapter 4, I can make some general observations about the effect of tranche sizes on the losses in the respective tranches. Assessing the worst proposed stress scenario, the fourth one, it is noted that 59% of the mezzanine B tranche's principal is not redeemed. So assuming that, when changing tranche sizes, margins remain the same, about 40% of this B tranche could be moved to the A tranche without having any effect on principal losses in the A tranche. While this assumption is quite weak, it does give an indication that there is some room to increase the size of the senior A tranche, which would lead to a lower cost of funding and a higher IRR for the Equity notes. This line of reasoning obviously would need to be altered when a stress scenario is considered where the support scheme stops at an earlier point in time, like in the second break-even analysis.

In Chapter 3, I argued that recent developments in the world of regulation would impact the investor base for ABS issuance as a whole, and in particular for non-'high-quality' ABS. As the Solvency and Basel regulation is only applicable for insurers and banks, the ABS issuers might start to look at other types of investors, such as funds that are not restricted by the higher capital charges under the European Commission's regulation. Also, in my model, the effect of the capital charges is not taken into account. As is it very hard to predict how severe the effect is on investors, and how this translates to the spreads demanded by these investors, it was not used to estimate the hypothetical spreads on the A and B tranche.

Looking at eligible investors for an offshore, the European Central Bank might be an interesting party. Under the current ABS purchase programme they participate in all sorts of ABS transactions in order to revive the ABS market, with actual yield pickup of less concern. While the offshore wind ABS would not be eligible at the moment, because of it being classified as non-"high-quality", this might change in the future should the ECB decide to expand its efforts. Green or renewable energy securitisations, that can offer a AAA rated senior tranche, would greatly benefit from aggressive ECB buying, in my opinion. With lower coupons on the senior tranche, there is more room to provide a strong coupon for the mezzanine tranche. This tranche could then be bought by all sorts of funds.

From an issuer perspective there is also an issue. If the issuer wants to use an offshore wind securitisations for balance sheet relief, it must be able to achieve a so-called *significant risk transfer* of the risky assets. If the seller manages to sell all three tranches this transfer has taken place. The approach chosen in this research is that the seller sells the A and B notes and retains the Equity notes. The question then is, whether a retention of 10% is small enough to achieve significant risk transfer. If this transfer does not take place, the risks of the assets are still (partially) on the balance sheet of the seller. Because of this, it is required to keep capital on its balance sheet, which makes the securitisation economically less sensible.

Finally, a very interesting aspect of these offshore wind ABS structures is the fact that they can be labelled as a *"green"* investment. With the green bond market severely picking up in size in 2014 and the fact that many institutions pride themselves on their investments in green industries, this characterisation might offer an additional, different kind of, non-financial yield pickup for investors. For now, the presence of such an effect has not been proven and might therefore be a very interesting field of research in the future and not just for securitisations, but for the whole spectrum of financial instruments.

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Appendix A Underlying project base-case characteristics

Project nr.	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
# of turbines	100	120	75	150	80	100	60	100	110	90
CAPEX/MW (millions)	3.6	3.9	3.0	4.3	3.1	3.7	2.9	3.5	3.9	3.3
*Margin on project debt (bps)**	-	-	-	-	-	-	-	-	-	-
Debt share ABS seller (%)	15	10	25	7.5	20	15	25	12	12	20
Support scheme price (EUR)	0.15	0.17	0.14	0.18	0.16	0.16	0.15	0.13	0.17	0.16
Year support scheme stop	15	15	15	15	15	15	15	15	15	15
System degradation (%)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
O&M contract 2nd period	1.8	2.2	1.5	2.4	1.5	1.9	1.5	1.8	2.0	1.7
O&M contract 3rd period	2.6	3.0	2.2	3.5	2.7	2.6	2.1	2.7	3.0	2.7
O&M extreme value (% of CAPEX)	11	13	14	11	10	15	12	14	13	15
O&M extreme year	-	-	-	-	-	-	-	-	-	-
Dismantling costs (millions)	50	60	30	75	35	45	25	45	40	35
Dismantling reserve size (millions)	50	60	30	75	35	45	25	45	40	35
O&M reserve size (millions)	10	35	25	40	25	15	10	40	35	15
Annual mean wind speed (m/s)	9.8	10.0	9.0	10.4	9.1	9.4	8.8	9.5	9.6	9.3
Energy loss factor	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

* Omitted because of confidentiality issues.

Appendix B Rating matrix

S&P	*Moody's*	*Fitch*	*Risk Characteristics*
AAA	Aaa	AAA	Prime
AA+	Aa1	AA+	High grade
AA	Aa2	AA	High grade
AA-	Aa3	AA-	High grade
A+	A1	A+	Upper medium grade
A	A2	A	Upper medium grade
A-	A3	A-	Upper medium grade
BBB+	Baa1	BBB+	Lower medium grade
BBB	Baa2	BBB	Lower medium grade
BBB-	Baa3	BBB-	Lower medium grade
BB+	Ba1	BB+	Non-investment grade
BB	Ba2	BB	Non-investment grade
BB-	Ba3	BB-	Non-investment grade
B+	B1	B+	Non-investment grade
B	B2	B	Non-investment grade
B-	B3	B-	Non-investment grade
CCC+	Caa1	CCC	Non-investment grade
CCC	Caa2	CC	Non-investment grade
CCC-	Caa3	C	Non-investment grade
CC	Ca	DDD	Non-investment grade
C	C	DD	Non-investment grade
D	D	D	Non-investment grade