The business case and supporting interventions for Dutch offshore wind

A REPORT TO THE MINISTRY OF ECONOMIC AFFAIRS AND CLIMATE POLICY

MARCH 2020

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Key Messages

The viability of the business case

1. Under the assumptions of our Reference Scenario our modelling suggests that 'typical' offshore wind projects deployed in the near future would fail to make the returns ordinarily required for a merchant investment in the electricity sector. However, projects may still go ahead due to differences in:
   a. project costs;
   b. assumed future revenues; or
   c. investors willing to accept relatively low hurdle rates for strategic reasons (e.g. offshore wind developers looking for market position).
2. The development of offshore wind across Europe and decarbonisation more widely requires a huge investment in infrastructure, and Dutch offshore wind will have to compete with other countries and technologies for finance.
3. Once cheaper capital and the best project sites are exhausted it may be difficult to attain the required levels of investment in the longer term without a reduction in financing risk or higher returns.
4. **Therefore under the Reference Scenario the 2030 offshore wind target would only be met at zero subsidy without further intervention if the required return on investment does not rise materially.**
5. There are factors that could strengthen the business case beyond the Reference Scenario, in particular a higher than expected fall in project costs (e.g. a larger fall than the 14% fall in capex assumed from 2020 to 2030 in the Reference Scenario). However, there appear to be more downside risks to the business case[1] including lower baseload prices, lower capture rates, and higher costs.
6. **This means there is a material risk the Netherlands does not meet its 11GW offshore wind 2030 target at zero-subsidy under the current market environment. Whilst it is conceivable that targets could be met in 2030 without further intervention, the potential for the business case to become unviable as a result of changes in market conditions should be taken seriously.**

[1] This is because some of the Reference Scenario assumptions are materially in excess of a 'business as usual' level and assume significant structural and behavioural change (most notably those related to future demand growth and carbon prices), and the downsides are therefore reflective of failing to achieve these levels of ambition.

How the business case could be improved

7. The business case for offshore wind could be made more robust to change by addressing the following areas:
    a. **supporting baseload wholesale electricity prices** by maintaining a balance between supply and demand – for example, through the use of roadmaps to provide clear objectives regarding electricity demand trajectories and intervening where differences occur would help;
    b. **avoiding low capture rates by incentivising time-shifting flexibility** to complement wind generation patterns – for example, by encouraging the deployment of time- shifting flexibility; and
    c. **keeping project costs down**, including avoiding increases in the cost of financing whilst still attracting capital into the sector – for example, strategic planning of future grid requirements to optimise the use of infrastructure and avoid curtailment, improving allocation of risk and developing hedging markets.
8. **Whilst these measures should *reduce* the need for regulatory intervention, it may not ultimately *remove* the need for regulatory intervention if market conditions prove more challenging than anticipated.**
9. In addition to specific measures, given the changing environment, the success of offshore wind is more likely in the Netherlands if the Dutch Ministry Of Economic Affairs and Climate Policy and industry continue to work together proactively to find ways to ensure that as the market adapts to the continual growth of offshore wind and how that's viewed by investors

Offshore wind as a part of decarbonising the energy system

10. This study is focussed on interventions that could improve the business case for merchant offshore wind. It has not considered the energy system as a whole, and what would be the lowest cost decarbonisation solution. In practice, any interventions impact on other technologies, as interventions for them impacts on offshore wind.
11. Any consideration of interventions to support the business case for offshore wind will need to be viewed in the context of the Netherlands strategy for a low carbon energy system.
12. Equally, any change in strategy on technologies that impact on the offshore wind business case should account for the impact on the offshore wind business case present and future (e.g. a change in desire to decarbonise heat via electrification to hydrogen is likely to change the economics for offshore wind).

Executive Summary

As part of the Draft Klimaatakkoord, the Dutch Government and offshore wind sector agreed to investigate whether systematic changes are required to ensure that the business case for offshore wind is viable in the long term. AFRY Management Consulting (AFRY) has been engaged to carry out analysis to provide a fact base to support this investigation, under the leadership of a Steering Committee comprised of the Ministry of Economic Affairs and Climate Policy, InvestNL, PBL (Netherlands Environmental Assessment Agency) and representatives from the Dutch wind industry.

This report presents and explains our main findings from the study.

All market modelling presented in this report has been designed specifically for this study in discussion with this project's Steering Committee. Market scenarios therefore differ, in some aspects significantly, from AFRY's independent views of the market. The reasons for this are explained further in Chapter 1.

The purpose of the study

The Dutch Government has set out a 49% emissions reduction target for 2030[2]; and 95% emissions reduction by 2050[3,4]. To reach the 2030 goals, there are over 600 measures to be implemented across the sectors of Built Environment, Mobility, Industry, Agriculture and Electricity. Offshore wind has been identified as one of the main pillars of the energy transition required to reach these decarbonisation targets.

The Government's Offshore Wind Energy Road Map 2030, sets out plans to expand on the existing target of 4.5 Gigawatts (GW) of offshore wind capacity installed by 2023, with a build rate of 1GW per year over the period 2024-2030 intended to deliver a total target capacity of 11.5GW (generating around 49TWh) of offshore wind by 2030. This is a significant undertaking as the target is almost five times the 2.5GW in operation or under construction in the Netherlands at the end of 2019. Beyond this, offshore wind is expected to play a major role in meeting the 95% 2050 decarbonisation targets.

Currently the pre-development of offshore wind projects is undertaken by the Government. For the Borssele sites (I-IV), the Government ran competitive tenders whereby permits were awarded through a procedure involving the allocation of subsidies based on the SDE+. For the Hollandse Kust sites (I-IV) permits were granted through a different procedure: using a Comparative Assessment (CA) without financial support for non-subsidy tenders based on the current Offshore Wind Energy Act. As part of the decision process, applications were ranked according to the points they had scored out of a total of 100 according to a set of criterion predefined by the Dutch Government. The winner of the development rights thereby operates the project on a subsidy-free basis.

Whilst a similar procedure will be followed for Hollandse Kust Noord in 2020, albeit with some different emphasis on the points awarded to certain criteria, there is currently a backstop that means if there is insufficient interest a floor price can be awarded using a competitive tender. However, the Government has stated[5] its desire to remove this backstop from 2025 onwards. This raises the question of whether future offshore wind projects in the Netherlands will be viable in a merchant environment (i.e. without regulatory intervention to reduce exposure to revenue risk), and whether targets for 2030 and beyond can be realised.

[2] In its Klimaatakkoord (Climate Agreement), June 2019.
[3] In its KlimaatWet (Climate Act), May 2019.
[4] Compared to 1990 levels. Includes 100% CO2-neutral electricity generation in 2050.
[5] In the Klimaatakkoord.

The key questions we were asked to address in the study and our broad approach to answering them are explained in Figure 1.

FIGURE 1 – SUMMARY OF KEY QUESTIONS AND APPROACH TO THE STUDY

Question	Approach
1 How are electricity prices likely to evolve, specifically the capture price for offshore wind projects in the Netherlands?	Develop projections of future electricity prices under a Reference Scenario for future market development
2 Which developments in the offshore wind market and the broader electricity market/energy system as a whole have a significant impact on these future prices and therefore the business case for offshore wind projects?	Undertake sensitivity analysis on the Reference Scenario to assess the importance of individual market and non-market drivers
3 Is a successful business case for offshore wind projects in the current framework still possible in the long term?	Assess business case quantitatively by comparing investor returns in the Reference Scenario and sensitivities to those typically required by investors in subsidy-free generation, and qualitatively though discussions in the Steering Committee
4 How can uncertainties and risks related to these developments be mitigated (if necessary) in order to make sure a successful business case for offshore wind projects still exists in the long term?	Identify, together with Steering Committee, the range of options for intervention beyond those identified in the Klimaatakkoord, then qualitatively assess benefits, costs and wider impacts.

In undertaking this study, we considered the potential returns for 'typical projects' and did not account for the particular technical or economic characteristics of individual projects. Our findings on each of these questions are addressed below, with the viability of the Reference Scenario separated from the impacts of the sensitivities.

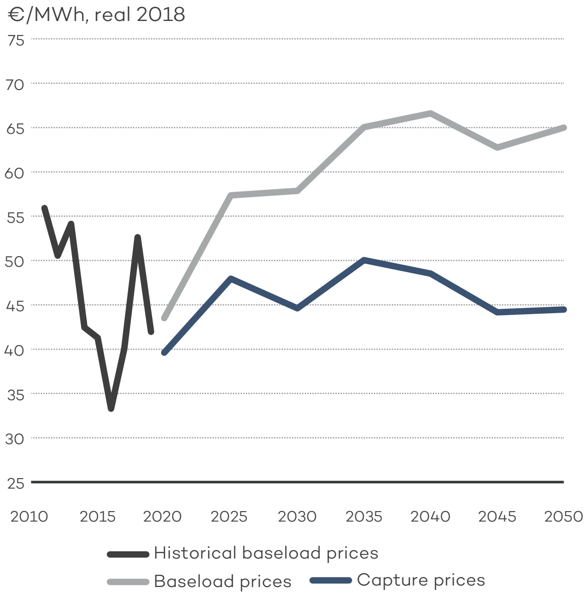
This study outlines potential measures that could be implemented; it does not offer recommendations on what should be implemented.

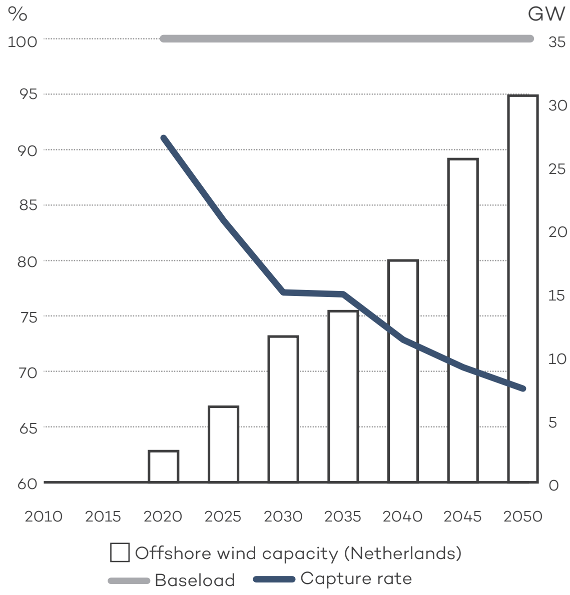
Whilst offshore wind is the focus of this study, in practice it sits among a range of low carbon technologies, many of which will be required to meet decarbonisation targets. In this study we have considered these in so far as they impact on the offshore wind business case, but not in their own right as decarbonisation options. **This means the options for intervention presented are based on what could support the offshore wind business case but do not assess the extent to which they offer the lowest cost decarbonisation solution for the electricity or energy sector.**

Cannibalisation offsets benefit of increased baseload wholesale prices

Figure 2 shows our wholesale electricity price projections under the Reference Scenario. The assumptions for which were agreed with the Steering Committee. Baseload wholesale electricity prices are projected to rise, but the revenue from the wholesale market that can be realised by offshore wind (the capture prices) is relatively stable. This is due to the 'cannibalisation effect' of increasing wind capacity in the Netherlands and elsewhere generating at the same time. The extent of this 'cannibalisation effect' is shown by the falling proportion of the baseload price realised by offshore wind (capture rate) over the modelling period.

FIGURE 2 – OFFSHORE WIND CAPTURE PRICES (€/MWH), CAPTURE RATES (%) AND INSTALLED CAPACITY (GW) FOR THE NETHERLANDS IN THE REFERENCE SCENARIO





The business case for offshore wind in the Reference Scenario is marginal today

Whilst wholesale electricity prices make up the majority of the revenues to offshore wind, the viability of the offshore wind business case is also dependent on a number of other factors.

The business case itself depends both on the:

- **hurdle rate:** the return at which investors are willing to go ahead with the project; and
- **expected return on investment:** the anticipated return based on revenue and cost expectations.

Where the expected return on investment is higher than the hurdle rate then the investment is considered to be viable.

Many factors influence both the hurdle rate and expected return on investment. For the hurdle rate this depends on the different elements that influence investors' perception of, and appetite for, risk as well as the availability and cost of capital. For the expected returns on investment this includes revenues – primarily from the wholesale electricity market, but also potentially other revenues – and project capital, operating and financing costs.

Under the assumptions of the Reference Scenario our modelling suggests that a typical offshore wind project deployed in the Dutch North Sea in the near future would fall just short of making the returns ordinarily required for an investment in the electricity sector fully exposed to merchant risk. The level of such returns are highly uncertain and changeable over time, however, returns below 7% (on a real, pre-tax, unleveraged basis) are unlikely to be sustainable, with many investors likely to require significantly higher returns. However, projects may still go ahead because auction participants:

- take a more optimistic view of future project revenues;
- project costs are expected to be lower than those assumed in the modelling; and/or
- investors use a lower hurdle rate than is typical for a merchant investment (e.g. because strategic factors such as competing for market position influence their behaviour).

We do not consider the Reference Scenario offers a particularly pessimistic view of future revenues; however, individual project costs, load factors and market risk mitigation strategies will vary and be better known to developers so could result in a divergence in views on expected returns. There will also be some investors that are willing to go ahead at relatively low returns, this is explored further below.

Over time our modelling suggests that project returns are likely to improve as a result of falling capex costs. Whilst this could be interpreted to mean future projects are more likely to go ahead, in practice, account also needs to be taken of the increased capital requirement meaning investors with higher hurdle rates are likely to be required in future.

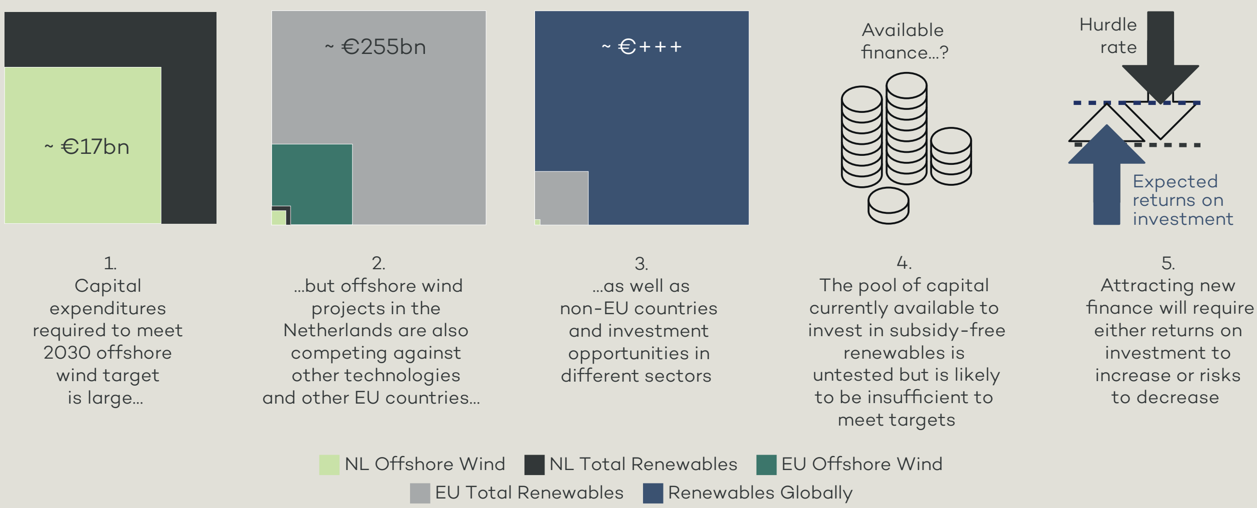
The financing challenge – how hurdle rates could change in future

Looking forward, the amount of capital required for NL offshore wind is high, with the Reference Scenario projecting around €17bn will be required over the next 10 years. This is only part of a much higher amount of capital likely to be required for investments in other renewables technologies and in other countries – the Reference Scenario has over £250bn of renewables across the EU in the next 10 years.

The size of the pool of capital able to invest projects with market risk is unknown; although there have been large inflows into renewables in the past decade; almost all of these have been into subsidised projects with limited market exposure.

Given increased future capital requirements, there is a good chance that there will be insufficient funds available from current investors and, if targeted levels of renewables are to be built, new types of investors will need to enter into the sector. This could be achieved by ensuring appropriate allocation of risk and returns within financing structures, or by reducing risk exposure through hedging or policy support.

FIGURE 3 – THE FINANCING CHALLENGE



Note: Capex requirements taken from Reference Scenario, and include onshore and offshore wind and solar PV capacity

To understand financing costs of new offshore wind projects, it is helpful to consider how new investors might think about their risks in entering the sector. At low levels of expected returns, few investors will be interested. These investors are likely to be strategic in nature and will deploy limited amounts of capital in order to help build material market shares and to gain experience in the technology or have access to market risk mitigation strategies that are not widely available. As market conditions improve greater investment will enter the sector until such a point is reached where financial (non-strategic) investors can enter the sector because returns for a given level of risk are comparable to other competing sectors.

If 2030 offshore wind targets are to be met, then it seems likely that either returns will have to rise or risks will have to reduce so that lower returns can be accepted.

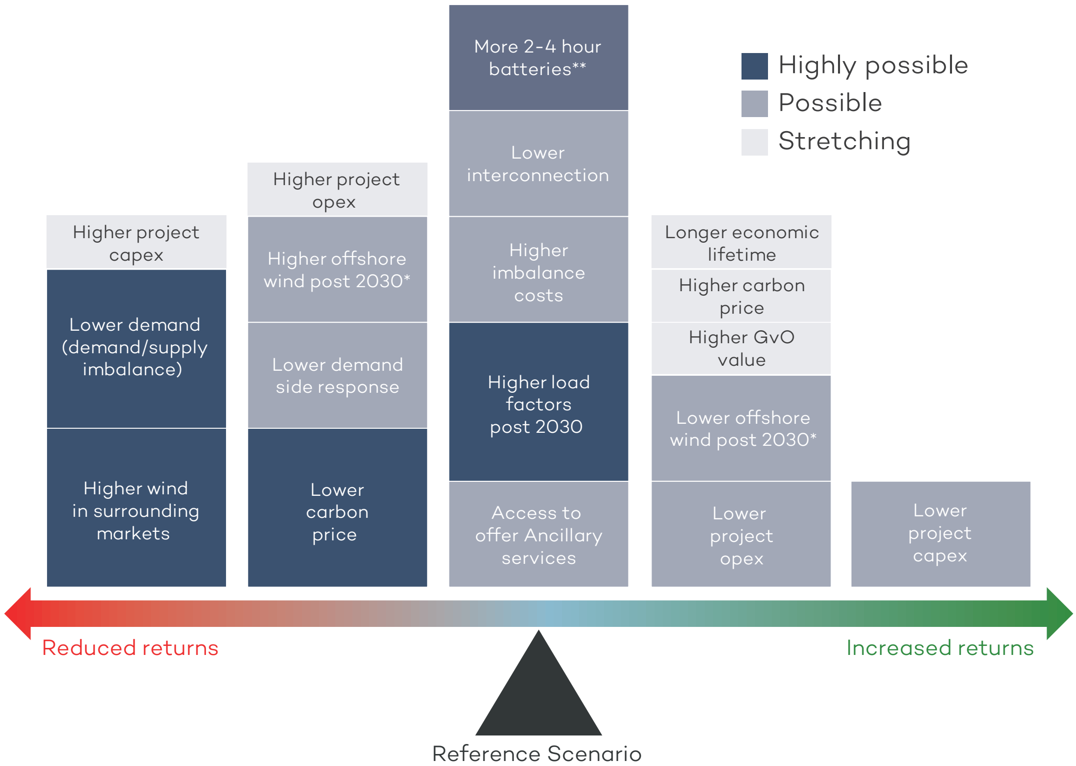
Therefore under the Reference Scenario the 2030 offshore wind target would only be met at zero subsidy without further intervention if the required return on investment does not rise materially.

Various market and regulatory uncertainties could further weaken the business case

Figure 4 shows the factors that could strengthen or weaken the business case for offshore wind based on our sensitivity analysis. Those further from the centre showed the greatest change in equity returns compared to the Reference Scenario, with those in the outer most columns changing pre-tax, real equity returns by at least 3 percentage points (pp), those in 2nd and 4th columns changing equity returns by at least 1pp and those in the middle changing equity returns by less than 1pp. This should only be used as an indication of the impact of a particular driver. Sensitivities allow for individual drivers to be tested in isolation, which means any change is not balanced by the adjustments to other drivers which might normally be expected. Consequently, the sensitivities show a system out of balance for the duration of the modelled period when in reality it may be out of balance for parts but not the whole modelled period (e.g. a demand/supply imbalance may be corrected over time by a reduction in new build capacity).

The likelihood of each factor occurring is also important in understanding the risk. These are shown by the colour and size of the boxes.

FIGURE 4 – IMPACT OF DIFFERENT DRIVERS ON THE REFERENCE SCENARIO (BASED ON SENSITIVITIES RUN)



** The higher/lower wind in this sensitivity was brought about by the an increase/decrease in assume capex costs*
*** The greater number of batteries in this sensitivity was brought about by a decrease in assumed capex costs*

Whilst the number of downside risks is only one greater than those on the upside, as a whole the likelihood of downside to the Reference Scenario occurring appears greater than the likelihood of upside[6].

Broadly speaking, the risks to the offshore wind business case fall into the following areas:

- wholesale market revenues – either baseload prices or capture rates for offshore wind are lower than expected;
- other revenue streams do not materialise or are lower value than expected;
- capital, operating or financing costs are higher than expected; or
- required hurdle rates increase (as discussed above).

The single most important factor that could strengthen the business case for offshore wind is a fall in project costs beyond the 14% drop assumed between 2020 and 2030[7]. The greatest risks to the business case appear to be slower than expected electrification of heat and transport depressing electricity demand and hence prices, and stronger than expected wind build out not just domestically but also in surrounding markets leading to more cannibalisation of offshore wind revenues. Lower than anticipated carbon prices are also a significant factor.

With the Reference Scenario vulnerable to market variations and the balance of risks more strongly weighted towards the downside **there is a material risk the Netherlands does not meet its 11GW offshore wind 2030 target at zero-subsidy without intervention. So, whilst it is conceivable that targets could be met in 2030 without further intervention, the potential for the business case to become unviable as a result of changes in market conditions should be taken seriously.**

[6] The chart itself only shows the sensitivities run as part of the study, it cannot be considered a full analysis of all the impacts that could influence the viability of the offshore wind business case. For example, concession payments by a developer ensuing from a competitive auction are excluded. However, the sensitivities were agreed by the Steering Committee and consideration was given to which were more likely to occur, have the greatest impact and most viable to model given the Reference Scenario assumptions.

[7] There are subtleties around the extent to which this could have an impact, for example if future project costs are also lower than assumed costs then the impact will be dampened.

A range of intervention options should be considered

The problem of low returns for offshore wind could manifest itself as failure to secure capacity in tenders, as tendered capacity not being built or as capacity commissioning but the prospect of low returns discouraging future investment. The current backstop to enable non-zero bids via the SDE+ would address the first of these issues (at least to 2025). But, perhaps the greater challenge lies in the instances that capacity is secured but not built[8] or it commissions but makes low returns. In these situations the problem will be identified at a later stage, making intervention in time more difficult, so increasing the potential for targets to be missed or confidence to fall (and perceptions of risk rise) within the offshore wind industry.

This is why understanding the dynamics that influence future offshore wind investment decisions is important, as it allows such risks to be taken into account in future policymaking. Particularly as these are risks that may not be immediately obvious from observation of the merchant offshore wind market today.

A continued dialogue between the Dutch Ministry of Economic Affairs and Climate Policy (Ministerie EZK) and the Dutch offshore wind industry should also help identify any issues early and how these can be best mitigated.

Figure 5 provides a summary of the short list of potential measures to support the business case that were agreed with the Steering Committee for consideration within this report.

The focus was on measures that did not require direct regulatory intervention to support offshore wind but looked to support the business case through different means. The measures are split into three broad categories:

- maintaining wholesale market revenues (light blue).
- supporting other revenue streams (light grey); and
- keeping costs down (dark grey).

Given the uncertainty around the business case, whilst these measures should reduce the need for regulatory intervention they may not ultimately remove the need for regulatory intervention if market conditions prove more challenging than anticipated. For this reason Measure 11 does consider direct regulatory intervention.

The short list was based on options that addressed the risks identified as part of the modelling analysis. The options were chosen based on their potential effectiveness in meeting offshore wind objectives and any practical implications. They are not necessarily the least cost options for decarbonising the Dutch energy system.

- Many of these measures are either overlapping or interlinked. To have an impact several measures are likely to be required simultaneously. Measures could be combined or substituted broadly around the impacts they are intended to address. The interaction between measures is discussed further in the main body of this report.

[8] The experience of offshore wind auctions internationally is still very limited. However, there are several examples of capacity being secured in auctions for other technologies, which later fails to commission. One example of a large project failing to commission is Trafford CCGT in Great Britain. In 2014 Carlton Power won a contract in the GB capacity market to develop the project, but later had the contract cancelled after failing to meet milestones for financial commitment.

FIGURE 5 – SUMMARY OF OPTIONS FOR INTERVENTION

Measure	Explanation
1 Roadmaps for electric heat, industrial processes and transport, hydrogen and flexibility	• Publication of roadmaps for the roll-out of electric heat, industrial processes & transport, hydrogen and flexibility over the next 20-30 years • Providing more detail and longer timeframes than the Klimaatakkoord including annual volumes (for earlier years) and demand expectations • A clear process for re-evaluation will be required
2 Link roadmaps to action on demand stimulation and offshore wind tende volumes	• Regular monitoring of demand and flexibility growth against Measure 1 targets and take corrective action as required • Adjust the offshore wind tender volumes up or down (post 2030) according to the latest demand expectations
3 Provide additional boost for electrification solutions that include flexibility	• Support provided for the electrification of heat and transport could include an incentive for vehicles or heating to be operated in a flexible manner • This could include emphasising existing price signals to use wind output when it is windy and the electricity price is low, and vice versa • Ongoing monitoring would be required to ensure flexibility is operating to support intermittent generation
4 Investigate potential for products that value time-shifting flexibility[9]	• Undertake a review of potential products offering value to for time-shifting flexibility with input from stakeholders • The options for consideration range from extending time-shifting arbitrage opportunities beyond the day ahead market to bilateral agreements (e.g. tolling contracts)
5 Run joint tenders for offshore wind and time-shifting flexibility	• For every GW of offshore capacity tendered an associated amount of time-shifting capacity is also tendered to (at least partially) mitigate the cannibalisation effects • This could work through the operation of either two separate tenders but run in parallel, or integrated tenders for offshore wind projects and time-shifting flexibility together
6 Revenue support for time-shifting flexibility	• Offer support to time-shifting flexibility technologies e.g. hydrogen to enable learning and reduce costs • Design of support would need to be carefully structured to incentivise the types of time-shifting flexibility that complement intermittent renewables generation patterns

[9] In this report, 'time-shifting flexibility' is defined as storage or demand side response that can consume electricity when there is a surplus of generation, and generate (or not consume) when there is little spare generation. For a full discussion, see Box B in Chapter 2.

FIGURE 5 – CONTINUED

Measure	Explanation
7 Require supported electric heat, industrial processes and transport to use low carbon electricity	• Require that any support provided for electric heating, transport or industrial processes is only provided if the electricity it consumes is from low carbon sources • This would directly link electricity demand growth from the electrification of heat, industrial processes and transport to low carbon sources • Proof that the electricity has come from a low carbon source will be necessary, Guarantees of Origin (GoOs) could be used for renewables
8 Optimise onshore grid use	• Ensure that connections and grid charging and reinforcement policy considers complementarity between offshore wind connections and new large electricity users sharing network resource (e.g. connecting large demand centres in ports to export cables) • Identify the areas of network that are favourable for connection of demand and offshore wind e.g. publication of network 'heat maps'
9 Co-ordinated discussion on innovative financing structures	• Coordinated discussions between current industry participants and potential future providers of equity and debt to accelerate the widening of the pool of capital able to invest in the merchant renewables sector and efficient financing structures • Could include allocation of risk, securitisation of debt, possible role for a 'green investment bank', role of insurance companies, etc.
10 Investigate the potential for and barriers to longer term hedging products	• Identify what, if any, agreements or products could emerge or be facilitated which provide a long term hedge to both baseload wholesale electricity prices and/or offshore wind capture rates • This would need to include discussions with relevant stakeholders • The options could range from bilateral contracts to financial products enabling hedges
11 Use a regulatory measure to reduce financing risk	• Reduce financing risk through regulation, such as capital support, a regulatory asset base or price or revenue stability mechanism

1. Project objectives and methodology

As part of the Draft Klimaatakkoord, the Dutch Government and offshore wind sector agreed to investigate whether systematic changes are required to ensure that the business case for offshore wind is viable in the long term. AFRY Management Consulting (AFRY) has been engaged to carry out analysis to provide a fact base to support this investigation, under the leadership of a Steering Committee comprised of the Ministry of Economic Affairs and Climate Policy, InvestNL, PBL (Netherlands Environmental Assessment Agency) and representatives from the wind industry. This report explains our main findings from the study.

All market modelling presented in this report has been designed specifically for this study in discussion with the project's Steering Committee. Market scenarios therefore differ, in some aspects significantly, from AFRY's independent views of the market. The purpose of this was to enable a balance between Klimaatakkoord goals and investors views. All assumptions were taken from independent sources such as PBL (Klimaatakkoord effects) and IEA (commodity prices). However, some of the assumptions used in the Reference Scenario in this study are materially in excess of a 'business as usual' level and assume significant structural and behavioural change (most notably those related to future demand growth and carbon pricing). Such differences however, do not invalidate the results of the study as the view on the viability of the business case, combines the modelling results of the Reference Scenario and the likelihood of different events occurring whereby such ambitions are not met. More detail is given in Section 1.4.1.

In this introductory chapter we provide some context to the project, its objectives, the approach to meeting those objectives and the structure of the report.

1.1 The background to the study

The focus of the study is offshore wind, which over the coming years and decades is expected to make a significant contribution to the wider decarbonisation agenda. Currently the pre-development of offshore wind projects is undertaken by the Government with the project development rights then allocated via non-subsidy tenders using a Comparative Assessment (CA) based on the current Offshore Wind Energy Act.

There is currently a backstop that means if there is insufficient interest a floor price can be awarded using a competitive tender. However, the Government has stated[10] its desire to remove this backstop from 2025 onwards. This raises the question of whether future offshore wind projects in the Netherlands will be viable in a merchant environment (i.e. without regulatory intervention to reduce exposure to revenue risk), and whether targets for 2030 and beyond can be realised.

1.1.1 The role of offshore wind in meeting the Netherlands' decarbonisation objectives

The Netherlands is striving to reduce its carbon emissions, to reduce its impact on climate change and meet its commitments under the Paris Agreement. To this end, the Dutch Government has set out a 49% emissions reduction target for 2030 under the Klimaatakkoord, June 2019[11]; and 95% emissions reduction by 2050[12] within the KlimaatWet, May 2019[13]. To reach the 2030 goals, there are over 600 measures to be implemented across the sectors of the Built Environment, Mobility, Industry, Agriculture and Electricity.

[10] In the Klimaatakkoord.
[11] Sometimes referred to as the Climate Agreement in English.
[12] Compared to 1990 levels. Includes 100% CO2-neutral electricity generation in 2050.
[13] Sometimes referred to as the Climate Act in English.

Offshore wind energy has been identified in the Klimaatakkoord as one of the main pillars under the energy transition. As set out in the Offshore Wind Energy Road Map 2030, there are plans to expand on the existing target of 4.5 Gigawatts (GW) of offshore wind capacity installed by 2023, with a build rate of 1GW per year over the period 2024-2030 intended to deliver a total target capacity of 11.5GW (generating around 49TWh) of offshore wind by 2030. This is a significant undertaking as the target is almost five times the 2.5GW (in operation or under construction) in the Netherlands at the end of 2019. Beyond this, offshore wind is expected to play a major role in meeting the 95% 2050 decarbonisation targets.

Within the 600+ measures in the Klimaatakkoord, there are already several which could support the offshore wind business case and progression towards the 2030 target. These include measures to encourage the development of green hydrogen production, regulation to ensure all passenger cars sold in 2030 are 100% emission-free and the CO2 levy on industry. Hydrogen could offer an alternative use for offshore generation in windy periods, and potentially store electricity for use in tight periods. If emission-free vehicles are electric or hydrogen this could increase the demand for electricity from offshore wind. The CO2 levy on industry should help encourage electrification of industrial energy demand and incentivise the increase in flexibility of that demand. In this report, we propose measures that either extend or are in addition to those already outlined in the Klimaatakkoord.

1.1.2 The current offshore wind tender system

A cornerstone of the Dutch Offshore Wind Energy Act has been the requirement that an offshore windfarm can only be built after a permit has been issued. For the Borssele Wind Farm Sites I-V tender rounds (held during 2015-2017), permits were awarded through auctions based on the SDE+ arrangements. With these permits, the winning bidders received a connection to the electricity transmission network of TenneT, whereby the cost of the grid connection has been socialised. In addition they gained a guaranteed floor price (strike price) for their electricity at the value they bid.

There have been many interested parties within the SDE+ tender rounds and strike prices have partly fallen through cost reductions achieved by the offshore wind industry[14]. So much so, those for the Hollandse Kust sites (I-IV) permits were granted through a different procedure: using a Comparative Assessment (CA) without financial support for non- subsidy tenders based on the current Offshore Wind Energy Act. As part of the decision process, applications were ranked according to the points they had scored out of a total of 100 according to a set of criterion predefined by the Dutch Government. The winner of the development rights thereby operates the project on a subsidy-free basis.

Whilst a similar procedure will be followed for Hollandse Kust Noord in 2020, albeit with some different emphasis on the points awarded to certain criterion, there is currently a backstop that means if there is insufficient interest a floor price can be awarded using a competitive tender. However, the Government has stated (in the Klimaatakkoord) its desire to remove this backstop from 2025 onwards. This raises the question of whether future offshore wind projects in the Netherlands will be viable in a merchant environment (i.e. without regulatory intervention to reduce revenue risk), and whether targets for 2030 and beyond can be realised.

This could occur through the following routes:

- a point is reached where developers **no longer bid into zero subsidy tenders** meaning prior to 2025 the backstop is used, post 2025 insufficient capacity is secured though the auctions;
- **capacity is secured** in auctions but no longer looks viable at the time of the investment decision and so there is a risk it is not built; and/or
- capacity is secured and commissioned but **fails to make anticipated returns,** discouraging future investors.

1.1.3 The impact of wholesale electricity market revenues on the business case for merchant offshore wind.

Whether offshore wind can continue to be developed in a merchant environment depends on the viability of its business case into the future. As the primary revenue steam for offshore wind projects is revenues from the wholesale electricity market, the level of these revenues has a significant influence on its viability.

Revenue from wholesale electricity prices in the future is uncertain. In the coming years, many potential changes are envisaged in the electricity system, such as rising demand with greater electrification of heat and transport, greater potential for demand side flexibility, and storage options becoming more viable. Meanwhile, there also continues to be uncertainty around commodity and carbon prices. All of these factors will affect the future level of wholesale electricity prices.

[14] The strike price Borssele I&II was €72.7/MWh and for Borssele III&IV was €54.5/MWL.

An additional concern is that as levels of wind penetration rise, wholesale prices will tend to be driven lower at times when wind output is highest, leading to prices captured by wind farms falling below the baseload price. This has the effect of 'cannibalising' revenues for wind generators and making their business case more challenging.

In considering the offshore wind business case, it is therefore important to understand the relative strength of individual drivers, as well as the outcome from the interplay of different factors.

1.2 The objective of the study

The purpose of the study is to provide a factual basis for discussion on industry efforts, policy measures, market design and market instruments necessary to meet the offshore wind rollout targets.

In this study, AFRY was asked to investigate a number of questions, which are set out below alongside our approach to answering them:

Our methodology for the project is explained in Section 1.3.

In undertaking this study, we considered the potential returns for 'typical projects' and did not account for the particular technical or economic characteristics of individual projects.

We discuss the viability of different options for intervention at a high level, highlighting clear benefits and challenges. The next stage of analysis would be to understand which of these should be taken forward and acted upon.

Whilst offshore wind is the focus of this study, in practice it sits among a range of low carbon technologies, many of which will be required to meet decarbonisation targets. The interrelationships between these technologies are complex. In this study we have considered these in so far as they impact on the offshore wind business case. This means **the options for intervention presented are based on what could support the offshore wind business case but do not assess the extent to which they offer the lowest cost decarbonisation solution for the electricity or energy sector.**

FIGURE 6 – SUMMARY OF KEY QUESTIONS AND APPROACH TO THE STUDY

Question	Approach
1 How are electricity prices likely to evolve, specifically the capture price for offshore wind projects in the Netherlands?	Develop projections of future electricity prices under a Reference Scenario for future market development
2 Which developments in the offshore wind market and the broader electricity market/energy system as a whole have a significant impact on these future prices and therefore the business case for offshore wind projects?	Undertake sensitivity analysis on the Reference Scenario to assess the importance of individual market and non-market drivers
3 Is a successful business case for offshore wind projects in the current framework still possible in the long term?	Assess business case quantitatively by comparing investor returns in the Reference Scenario and sensitivities to those typically required by investors in subsidy-free generation, and qualitatively though discussions in the Steering Committee
4 How can uncertainties and risks related to these developments be mitigated (if necessary) in order to make sure a successful business case for offshore wind projects still exists in the long term?	Identify, together with Steering Committee, the range of options for intervention beyond those identified in the Klimaatakkoord, then qualitatively assess benefits, costs and wider impacts.

1.3 The approach taken to meet the objectives

This study has comprised two main elements: the quantitative modelling of the electricity market and a typical project investment decision; and the qualitative evaluation of potential options for mitigating risks to the offshore wind business case. There are several ways to design the quantitative and qualitative analysis to better understand the dynamics of the offshore wind business case, and how it is designed depends on the end goal. As the results of the analysis are ultimately for the Dutch Ministry of Economic Affairs and Climate Policy (Ministerie EZK) and representatives from the wind industry to take forward, this has been a collaborative study between all parties.

1.3.1 Collaboration with Ministerie EZK and the offshore wind industry

To create a common knowledge base and establish points of agreement on priorities including whether and what intervention is required, there was continual discussion throughout the project between Ministerie EZK, representatives of the offshore wind industry, InvestNL, PBL (Netherlands Environmental Assessment Agency) and AFRY. This included discussion around both the overall direction of the project and the results.

The offshore wind industry provided input into the project through a number of routes:

- A **Steering Committee** which was responsible for detailed input into the modelling assumptions used, sensitivities run and intervention options considered. This was arranged by Ministerie EZK and comprised of several offshore wind developers, a representative of the Netherlands Wind Energy Association, InvestNL, PBL and representatives of Ministerie EZK.
- A **Sounding Board** open to all interested stakeholders to keep them briefed on the progress of the project and provide their views.
- Wider input was also provided via the **Netherlands Wind Energy Association (NWEA)** who attended both the steering committee and sounding board meetings and responded to various documents explaining the proposals at each stage of the project.
- The Steering Committee held eight meetings throughout the project, four of which were facilitated by AFRY. The Sounding Board met twice, both times facilitated by AFRY. In advance of all eight Steering Committee meetings AFRY provided material for discussion and feedback.

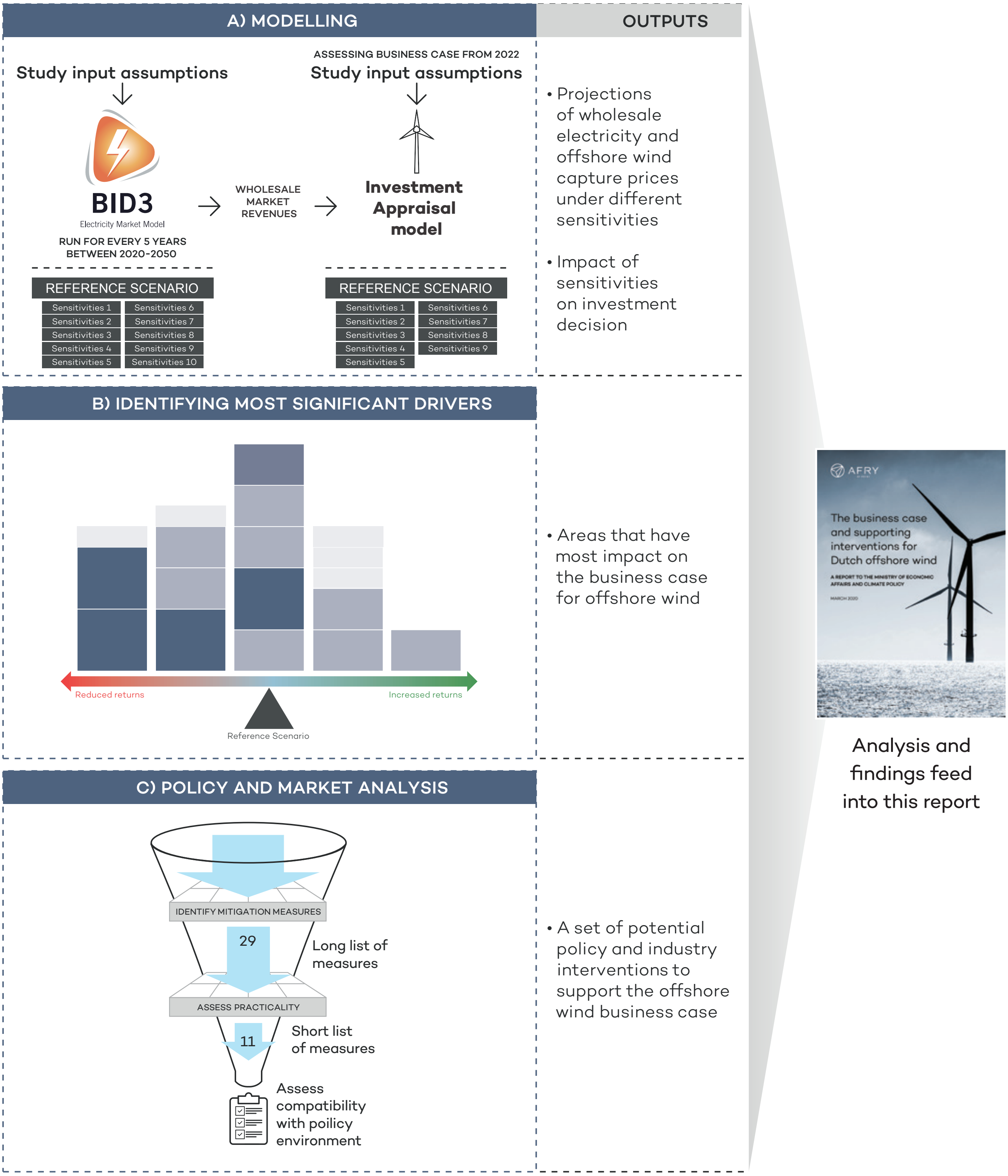
1.4 The methodology for the analysis

To meet the objectives discussed in Section 2.2, we used the methodology summarised in Figure 7. Overall the approach was divided into two parts:

- investigating the viability of the offshore wind business case using models to simulate the future revenues under a Reference Scenario and a range of sensitivities; and
- policy and market analysis to identify and assess potential interventions to support the offshore wind business case.

To understand if the business case for offshore wind is sustainable in the long term, and the significant factors influencing it, we modelled an 'expected return on investment' for a typical offshore wind project using an investment appraisal model. We combined this with modelling of the wholesale electricity market using our BID3 model to determine the electricity market revenues to feed into the investment appraisal model. In addition to wholesale electricity market revenues the investment appraisal model used assumptions on other market revenues and project costs to determine their impact on equity returns.

FIGURE 7 – OVERVIEW OF THE PROJECT METHODOLOGY



Note: When assessing the business case, the focus was wind farms commissioning 2022 onwards

The current and future viability of the offshore wind business case was considered using an internally consistent Reference Scenario. The relative risks presented by different drivers of the investment case were then assessed using a set of single variable sensitivities covering alternative wholesale electricity market conditions, other market revenues and project costs. These sensitivities are not necessarily internally consistent views of the future but are useful to identify those drivers causing material risks. The assumptions of the Reference Scenario and the sensitivities modelled were agreed in discussion with the Steering Committee.

Focusing on the most significant of these risks we developed a long list of policy and market interventions to help mitigate these risks and/or boost the business case for offshore wind. This included suggestions by NWEA, Ministerie EZK and AFRY. These suggestions were then reduced down to a short list based on their potential effectiveness, expected ability to help meet offshore wind objectives and the practical and cost implications. A final short list was then agreed by the Steering Committee taking account of their view of the practicality of these options. We then considered the implications of each option on the current offshore wind tender scheme, the offshore wind 2030 target and the wider electricity market as well as any cost or practical implications.

1.4.1 The approach to the Reference Scenario

All market modelling presented in this report has been designed specifically for this study in discussion with the project's Steering Committee.

The wholesale market Reference Scenario is used as the starting point to understand the sustainability of the business case under a feasible vison of the future. Sensitivities to understand the impacts of particular drivers of wholesale electricity prices were then run off this scenario (such as carbon prices or electricity demand).

There was considerable discussion over the form of the wholesale electricity market Reference Scenario, including the extent to which it should reflect an investor's view of the future or existing policy ambitions. The approach agreed by the Steering Committee was a mix of the two with all the main inputs taken from independent sources. Inputs consistent with the 95% emissions reduction study by PBL (Netherlands Environmental Assessment Agency)[15] were used for demand, carbon prices to 2030 and offshore wind load factors; it was also assumed that the 11.5GW target by 2030 would be achieved. For all other aspects a 'business as usual' approach was taken so it was assumed only current policy measures applied.

In the Reference Scenario 28TWh of onshore wind and solar PV generation is reached in 2030. Whilst this was the outcome of the modelling, this was not the focus of the study and so it would not be appropriate to draw conclusions on the circumstances under which these targets would or would not be met.

There is also a question over whether if these targets were met it would change the outcome of our modelling of this project. We do not consider this to be the case. Of the difference, around 4TWh is expected to come from less onshore wind generation with the remaining difference to reach 35TWh coming from solar PV (which has a lesser impact on wind revenues). The target is reached in 2035 so the impact lasts 5 years. To put this into context the *Higher wind in surrounding markets* sensitivity presented in this study tests an increase in wind generation of 25TWh by 2035 increasing to over 100TWh by 2050 across the Netherlands and neighbouring countries.

In addition, the 2050 carbon emissions reduction target was not enforced. Had the 2050 target been enforced, a likely outcome would be a restriction on new build CCGTs, particularly in later years. This would mean that instead of CCGT, CCGT with CCUS or Biomass with CCUS would have been built. Again we do not consider this would have a material impact, as it is likely to bite later in the modelled period, the Netherlands is highly interconnected and there will be higher variable costs attached to CCS in place of carbon costs.

The key assumptions used in the Reference Scenario are provided in Annex B.

[15] Total demand up to 2030 uses 'Effecten Ontwerp Klimaatakkoord', PBL , 2019; and total demand post-2030 uses 'Verkenning van Klimaatdoelen', PBL 2017.

1.4.2 The approach to the sensitivities

Similar to the Reference Scenario, the sensitivities tested (in this study) were designed specifically for this study. The intention was to identify the most important drivers to help inform a discussion on the measures that could be introduced to aide the offshore wind business case. To allow for a better understanding of the impacts of individual drivers, they are (intentionally) not representative of a market in equilibrium, and as such do not represent alternative full scenarios such as a typical 'downside scenario' that might be used by investors. In addition, as the sensitivities take account for the likelihood of different events occurring to help focus on the problem areas, the sensitivities used were not all mirrored on the upside and downside.

1.4.3 The approach to the measures

Finally, the measures outlined in this report represent a range of possible directions that could be taken for the future of the industry. Beyond assessing the benefits and costs as outlined in this report, AFRY does not advocate one particular approach over another; it is now for the Ministerie EZK and the offshore wind industry to decide how to take this analysis forward.

1.5 Structure of this report

This report is structured as follows:

- Part 1: The purpose and findings of the study are introduced in Chapter 1, the viability of the offshore wind business case based on our analysis is discussed in Chapter 2 and the options available to support the business case in Chapter 3.
- Part 2: This part provides the results of our modelling. In Chapter 4 we present the Reference Scenario and discuss the impact of different market drivers on wholesale electricity market revenues for an offshore wind farm. In Chapter 5, we dscuss the impact of other non-wholesale market drivers on the investment decision.
- Part 3: In the final part, we present the potential measures that could be implemented, including those associated with wholesale electricity market revenues (Chapter 6), other revenue streams (Chapter 7) and an offshore wind farm's project costs. We then put our findings into context in the Conclusions chapter.

Further information on the modelling methodology, inputs and outputs are in Annex A, Annex B and Annex C respectively.

1.6 Conventions

The following conventions are observed throughout this report:

- all monetary values quoted in this report are in euro in real 2018 prices, unless otherwise stated; and
- annual data relates to calendar years running from 1 January to 31 December, unless otherwise identified.

1.7 Sources

Unless otherwise attributed the source for all tables, figures and charts is AFRY Management Consulting.

2. The viability of the future offshore wind business case

This Chapter brings together the key findings from our analysis to address the question of whether intervention is likely to be required to meet 2030 targets. The more detailed evidence to support these findings is contained in Parts 2 and 3.

We first describe the important factors in an investment decision for an offshore wind project, we then use this to explain the results of our analysis into the robustness of the current business case for offshore wind under a Reference Scenario. We look both at what the business case looks like now and how it might evolve in the future to influence investment decisions required to meet the 2030 targets. This includes the extent to which different factors could influence the viability of the business case in the future. In the final section of this chapter we provide our conclusions on the need for intervention.

2.1 Factors influencing the future offshore wind business case

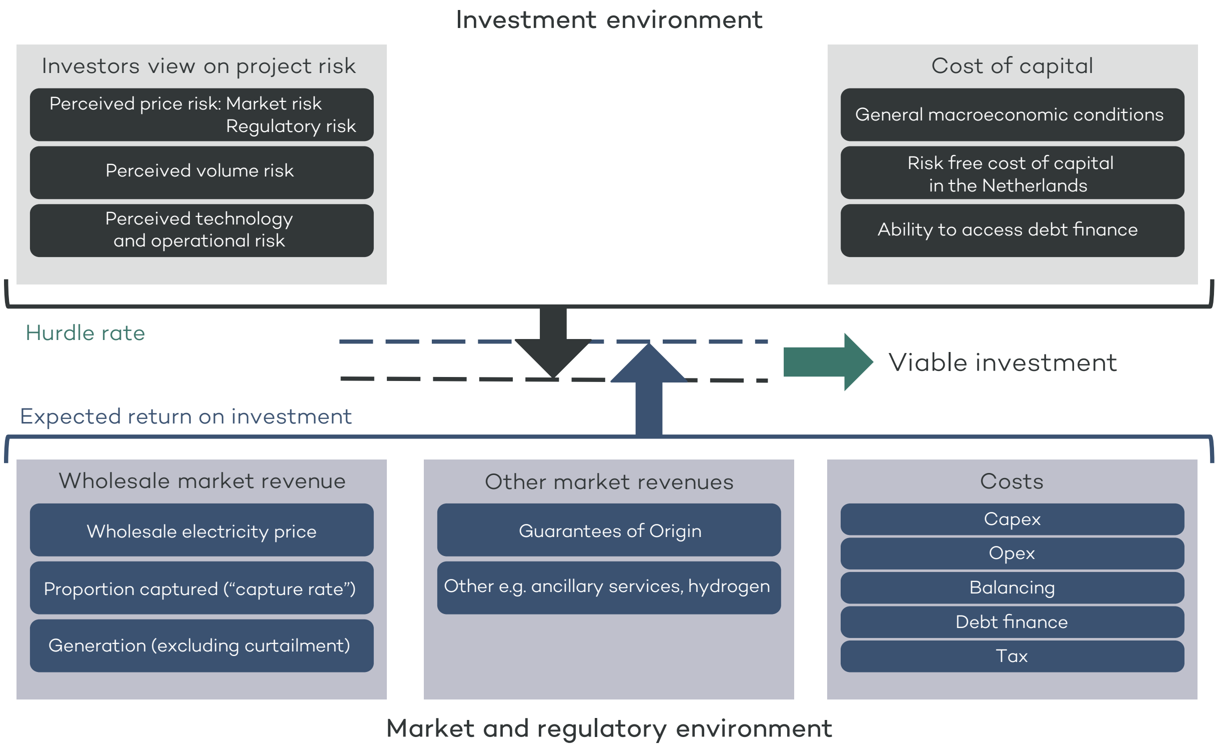
Figure 8 shows the two main elements influencing an offshore wind project investment decision:

- the hurdle rate: the return at which investors are willing to go ahead with the project; and
- the expected return on investment: the anticipated return based on revenue and cost expectations.

Where the expected return on investment is higher than the hurdle rate then the investment is considered to be viable.

Many factors influence both the hurdle rate and expected return on investment. For the expected returns on investment this includes revenues – primarily from the wholesale electricity market, but also potentially other revenues – and project capital, operating and financing costs. For the hurdle rate this depends on the different elements that influence investors' perception of and appetite for risk as well as the availability and cost of capital.

FIGURE 8 – FACTORS INFLUENCING AN INDIVIDUAL OFFSHORE WIND PROJECT INVESTMENT DECISION



2.2 The offshore wind business case under the Reference Scenario

Meeting the 2030 offshore wind targets requires not just a single project investment decision to be made but a number of project investment decisions between now and 2030. Whether these projects are considered viable depends on how the appetite for investment and expected returns on investment evolve in the future.

2.2.1 The current appetite for investment in Dutch offshore wind

Ordinarily returns from merchant investments in electricity generation assets where there is a high degree of revenue risk might be expected to be in the order of 7-10% (on a real, pre-tax, unleveraged basis). Under the assumptions of the Reference Scenario our modelling suggests that a typical offshore wind project deployed in the Dutch North Sea in the near future would fall just short of making the returns ordinarily required for an investment in the electricity sector fully exposed to merchant risk. However, projects may still go ahead because auction participants:

- take a more optimistic view of future project revenues;
- project costs are lower than those assumed in the modelling; and/or
- investors use a lower hurdle rate than is typical for a merchant investment (e.g. because strategic factors such as competing for market position influence their behaviour).

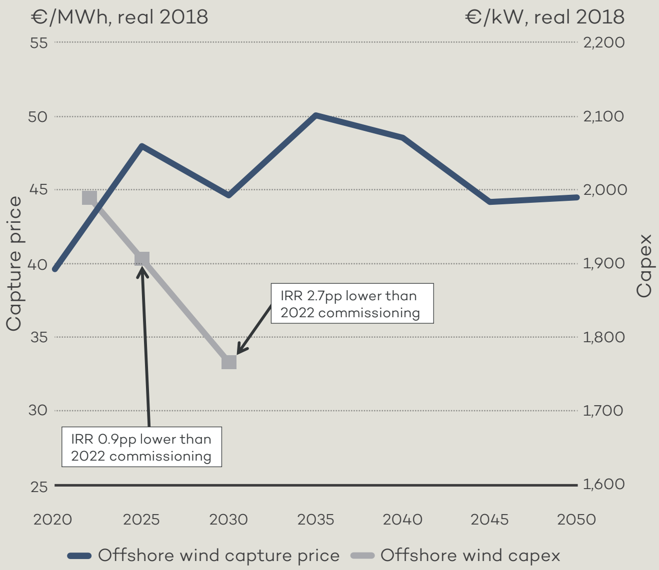
We do not consider the Reference Scenario offers a particularly pessimistic view of future revenues; however, individual project costs, load factors and market risk mitigation strategies will vary and be better known to developers so could result in a divergence in views on expected returns. There will also be some investors that are willing to go ahead at relatively low returns; this is explored further in the following sections.

2.2.2 How the projected returns on investment under the Reference Scenario compare

If the market were to evolve as anticipated under the Reference Scenario the return on investment for future projects would improve as shown in Figure 9. The challenge is the anticipated roll out is gradual over the period to 2020; it is clearly not desirably or even viable to build all the offshore wind in 2029/2030.

This improvement in outlook is because whilst revenues are projected to be relatively stable over time, it is assumed that the cost of offshore wind projects will continue to fall. The revenues shown for offshore wind are the projected offshore wind capture price under the Reference Scenario. These prices differ from baseload wholesale prices as they take account of the wind cannibalisation effect, which is explained in Box A.

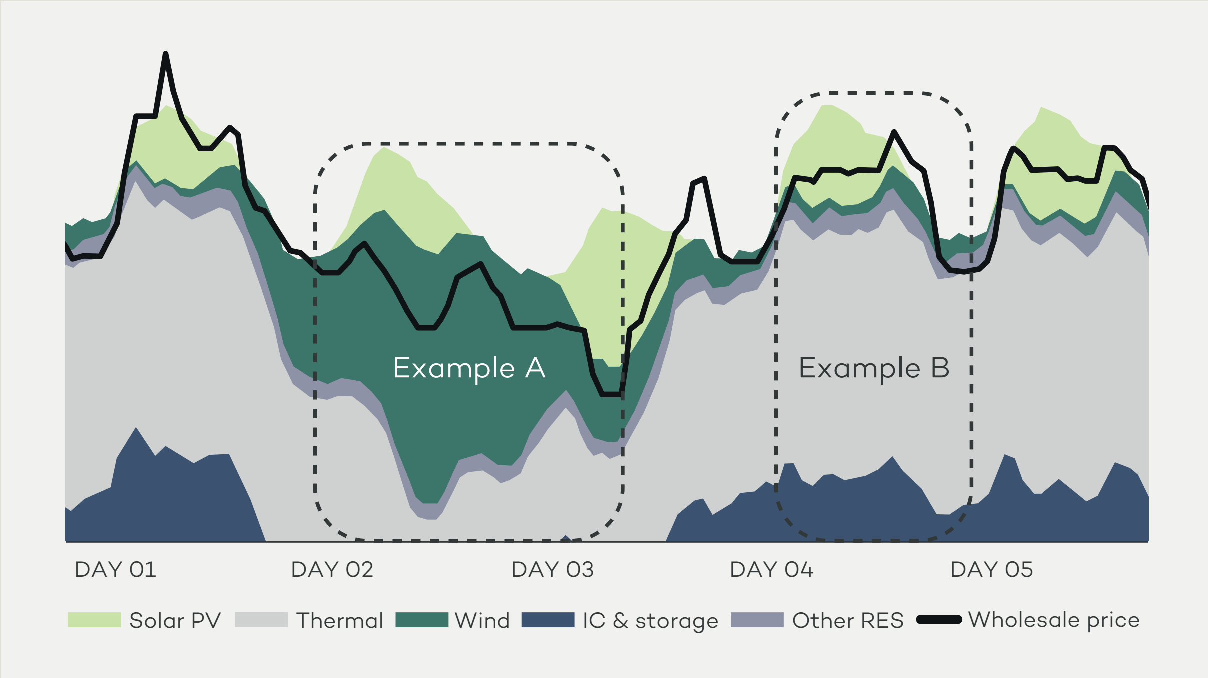
FIGURE 9 – REFERENCE SCENARIO



BOX A: THE IMPACTS OF INTERMITTENCY ON ELECTRICITY MARKETS AND CAPTURE PRICES

Intermittent renewable technologies generate when resources are available throughout the day and across seasons. Depending on the relationship between the generation profile and the underlying market price, renewable generators could capture income streams above, at, or below the baseload price.

The figure below shows an illustration of the hourly generation mix for a North-West European market over a five-day period. It also shows the corresponding wholesale electricity price (black line). Prices tend to be lower when wind and/or solar output are higher.



The growth of renewable capacity means that wind and solar generation has a significant influence on the wholesale price. This is because:

- during periods of high renewable generation there would be downward pressure on wholesale electricity prices, as renewable generation displaces higher-cost generation sources (example A); and
- during periods of low renewable generation there would be upward pressure on wholesale electricity prices, as higher-cost generation sources would be forced to operate (example B).

This is sometimes referred to as the 'cannibalisation effect'. It effectively means that the proportion of the baseload price that a wind or solar generator captures (i.e. the capture rate) is likely to be below 100%. Capture rates will vary by market, by technology, by modelled weather pattern, by scenario, and over time.

2.2.3 The future appetite for investment in Dutch merchant offshore wind

Looking forward, the amount of capital required for Dutch offshore wind is high, with the Reference Scenario projecting around €17bn will be required over the next 10 years. This is only part of a much higher amount of capital likely to be required for investments in other renewables technologies and in other countries – the Reference Scenario has over €250bn of renewables across the EU in the next 10 years.

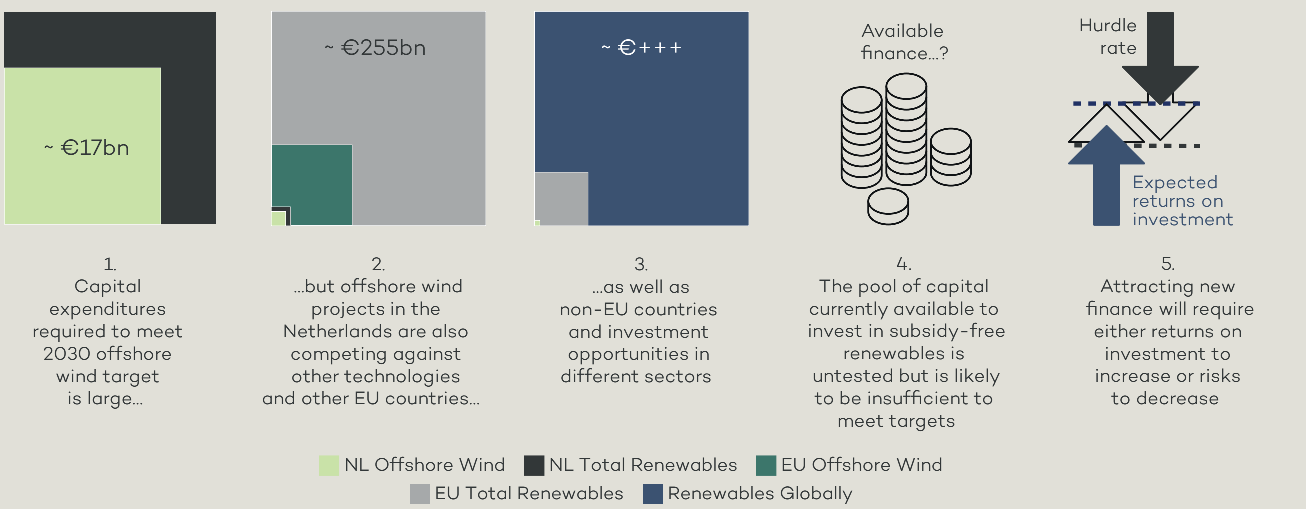
The size of the pool of capital able to invest in projects with market risk is unknown; although there have been large inflows into renewables in the past decade; almost all of these have been into subsidised projects with limited market exposure.

Given increased future capital requirements, there is a good chance that there will be insufficient funds available from current investors and, if targeted levels of renewables are to be built, new types of investors will need to enter into the sector. This could be achieved by ensuring appropriate allocation of risk and returns within financing structures, or by reducing risk exposure through hedging or policy support.

To understand financing costs of new offshore wind projects, it is helpful to consider how new investors might think about their risks in entering the sector:

- At low levels of expected returns, few investors will be interested.
- As market conditions improve, some investment will enter the sector. These early investors are likely to be strategic in nature and will deploy limited amounts of capital in order to help build material market shares and to gain experience in the technology.
- Eventually, cheaper 'strategic' sources of capital are exhausted and returns must rise to a point where financial (non-strategic) investors can enter the sector because returns for a given level of risk are comparable to other competing sectors. .
- Finally, as the sector becomes mature, good project opportunities decline as bottle necks appear. At this point, the potential for further investment begins to dry up as risks rise more rapidly than returns.

FIGURE 10 – THE FINANCING CHALLENGE



Note: Capex requirements taken from Reference Scenario, and include onshore and offshore wind and solar PV capacity

The implication for capacity build out under the assumptions of the Reference Scenario is that it is likely some capacity will be built:

- because they are particularly good sites which have more favourable returns; or
- with capital available to invest at lower levels of return.

Once these sites and capital are exhausted, higher returns or lower risks will be required to access greater capacity. This could come from greater than anticipated falls in project costs, and improvement in the outlook for revenues or policy interventions to reduce risk.

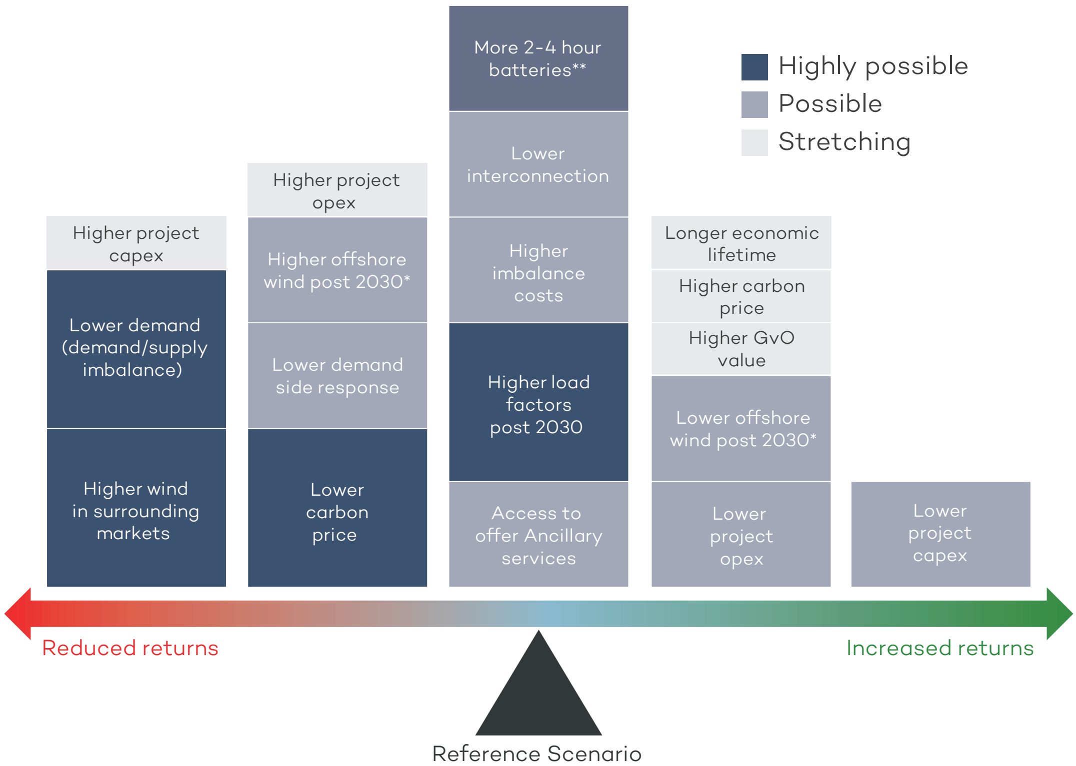
If 2030 offshore wind targets are to be met, then it seems likely that either returns will have to rise or risks will have to reduce so that lower returns can be accepted.

Therefore under the Reference Scenario the 2030 offshore wind target would only be met at zero subsidy without further intervention if the required return on investment does not rise materially.

2.3 Changes in the electricity market that could impact the offshore wind business case

Figure 11 shows the factors that could strengthen or weaken the business case for offshore wind based on our sensitivity analysis. Those further from the centre showed the greatest change in equity returns compared to the Reference Scenario, with those in the outer most columns changing pre-tax, real equity returns by at least 3 percentage points (pp), those in 2nd and 4th columns changing equity returns by at least 1pp and those in the middle changing equity returns by less than 1pp. This should only be used as an indication of the impact of a particular driver. Sensitivities allow for individual drivers to be tested in isolation, enabling this means any change is not balanced by adjustments to other drivers so they show a system out of balance for the duration of the modelled period. In reality it may be out of balance for parts but not the whole modelled period e.g. a demand/supply imbalance may be corrected over time by a reduction in new build capacity.

FIGURE 11 – IMPACT OF DIFFERENT DRIVERS ON THE REFERENCE SCENARIO (BASED ON SENSITIVITIES RUN)



** The higher/lower wind in this sensitivity was brought about by the an increase/decrease in assume capex costs*
*** The greater number of batteries in this sensitivity was brought about by a decrease in assumed capex costs*

The likelihood of each factor occurring is also important in understanding the risk. These are shown by the colour and size of the boxes.

This likelihood of occurring is defined as:

- **Stretching** – the level used in the sensitivity is at the edge of the upper or lower boundary of values we consider feasible under current market conditions within the timeframe considered;
- **Possible** – the level used in the sensitivity fits comfortably within the boundary of values what we consider feasible under current market conditions within the timeframe considered; and
- **Highly possible** – there is a high degree of uncertainty around future trajectories, with many plausible outcomes; the level used in the sensitivity is at least similar in likelihood to the Reference Scenario under current market conditions within the timeframe considered.

Whilst the number of downside risks is only one greater than those on the upside, as a whole the likelihood of downside to the Reference Scenario occurring appears greater than the likelihood of upside[16].

The option to introduce concession payments[17] is excluded from the list of sensitivities[18]. If implemented, concession payments would re-introduce price based auctions for offshore wind, with the concession payments being the price bidders are willing to pay for the opportunity to develop a project. Concession payments offer the option of developing offshore wind at lower cost to consumers. However, a policy change such as this can also influence developers' perceptions of risk and strategic behaviour in auctions (see Section 2.4). So, although not included in the modelling, any implications of concession payments on the viability of the business case and, depending on the timing of their introduction, progress towards 2030 targets, should be considered prior to implementation.

2.3.1 Factors that strengthen the future offshore business case

The evolution of **project costs is the single most important factor** that could strengthen the offshore wind business case. In the last decade the costs of offshore wind have fallen dramatically. Our Reference Scenario assumes a fall in capex costs of 14% over the period from 2020 to 2030, but it is conceivable that falls in capex costs could be considerably faster. When we performed the sensitivity which considered a 20% lower project capex, this improved the equity returns by greater than 3pp. Combined with the potential for lower opex which also have a moderate impact on rates of return, the outlook was improved futher still.

The extent of the impact project costs have an impact on equity returns will also depend on the costs of future projects. If costs for projects commissioned up to 2030 are lower, but so are those for future projects commissioned after 2030, then the impact may be tempered by a corresponding reduction in wholesale market revenue due to higher levels of wind capacity post 2030. This is shown by the *Higher offshore wind (lower offshore capex)* sensitivity discussed in Section 2.3.2. The extent to which the impact is dampened will depend on a number of factors including whether there is additional scope for project costs to fall. Consequently the potential impact of lower costs should not be dismissed on this basis.

Other factors that have a notable impact on the business case are a stable value for Guarantees of Origin (GoOs), higher carbon prices and lower wind post 2030 (resulting from higher capex costs of future projects).

We consider the potential for interventions to support the value of GoOs and carbon prices as well as reductions in capex costs as part of this study – though it is difficult to identify potential interventions on these aspects beyond measures already in place. As a result most potential measures discussed in this study are intended to mitigate risks. The pursuit of lower wind and higher future capex costs is clearly an undesirable, and so no potential measures are considered to encourage this.

[16] Figure 11 itself only shows the sensitivities run as part of the study, it cannot be considered a full analysis of all the impacts that could influence the viability of the offshore wind business case. For example, concession payments by a developer ensuing from a competitive auction are excluded. However, the sensitivities were agreed by the Steering Committee and consideration was given to which were more likely to occur, have the greatest impact and most viable to model given the Reference Scenario assumptions.

[17] The potential to introduce concession payments for offshore wind tenders was introduced as an amendment to the Wet Windenergie op zee (Offshore Wind Energy Act).

[18] The sensitivities were modelled using an investment appraisal model to show the change in the level of returns on investment. The questions arising from concession payments relate more to perceptions of risk and strategic behaviour which cannot be modelled through an investment appraisal model.

2.3.2 Factors that weaken the future business case

The greatest downside risks to the business case come from:

- **A demand/supply imbalance** which may be the result of lower demand growth than anticipated. This is unlikely to be sustained for the modelled period, however, if policy objectives around electrification of heat, industrial process and transport perpetually fall short of targets there could be considerable lengths of time when there is excess capacity on the system, dampening prices.
- **Higher levels of wind capacity** than anticipated particularly in surrounding markets. In the Reference Scenario offshore wind capacity expands more rapidly than in surrounding markets. If in reality this level of growth is matched by growth in surrounding markets, it is quite feasible that the competition to generate could be higher at windy periods of the day.

Other notable risks to the business case include lower carbon prices, and lower demand side response, both of which are plausible market outcomes[19]. Further non-market risks associated with the ability of capital to flow into the sector are also important, as discussed in Section 2.2.3.

As a result most of the potential measures in this study focus on ensuring demand and supply are balanced, mitigating against the 'cannibalisation effect', for example through time-shifting flexibility such as demand side response and reducing the cost of financing.

The role of flexibility, including time-shifting flexibility is discussed in Box B.

2.4 The need for intervention to support the offshore wind business case

The current offshore wind business case appears to be fragile and vulnerable to changes in the market. Under the assumptions of our Reference Scenario, a typical offshore wind project in the Netherlands would achieve a rate of return which could be unsustainably low for investments exposed to merchant risk. There are two main reasons this could occur, either returns are expected to be higher than our modelling suggests e.g. different project costs or wider strategic reasons as organisations build market shares. The number of projects to which this applies may be limited, and so as the demand for capital increases over the next decade such investments are unlikely to continue.

However, over time the investment case becomes more robust to change as project capex and opex costs are expected to fall. The challenge is whether future competition for finance will result in a requirement for higher returns for projects with merchant risk than might typically be expected today.

Furthermore, the potential for alternative market outlooks appears high, with the likelihood of a downside to the Reference Scenario higher than the upside. In particular the risks of slower than expected electrification of heat and electricity depressing prices and/or stronger than expected wind build out in surrounding markets. As a consequence **there is a material risk the Netherlands will not meet its 11GW offshore wind 2030 target at zero-subsidy without intervention. So, whilst it is conceivable that targets could be met in 2030 without further intervention, the potential for the business case to become unviable as a result of changes in market conditions should be taken seriously.**

Beyond the outcomes of the modelling it is worth considering the point at which any problem with the viability of the business case would be identified. The current backstop to enable non-zero bids via the SDE+ would address an absence of bidders into a zero price tender (at least to 2025) if returns looked low.

However, there is also the potential for capacity to be secured under a tender but not built[20] as a result of 'winners curse[21], the market outlook deteriorating or costs failing to fall as anticipated between securing the project and the final investment decision. In an emerging market with the global growth prospects of offshore wind and uncertainty around future costs and revenues, it is not unreasonable to envisage such an event occurring. In this situation the problem would be identified at a later stage than an absence of bidders, making intervention to ensure targets are met more challenging.

For similar reasons it is feasible to envisage projects being commissioned but then earning relatively low returns. This could reduce the confidence of investors in offshore wind in the future, impacting either on 2030 offshore wind targets if problems arose earlier, or if not, decarbonisation targets to 2050.

This is why understanding the dynamics that influence future offshore wind investment decisions is important, allowing risks to be taken into account in future policy making. Particularly as these are risks that may not be immediately obvious from observation of the merchant offshore wind market today.

A continued dialogue between Ministerie EZK and the offshore wind industry should help identify any issues early and how these can be best mitigated.

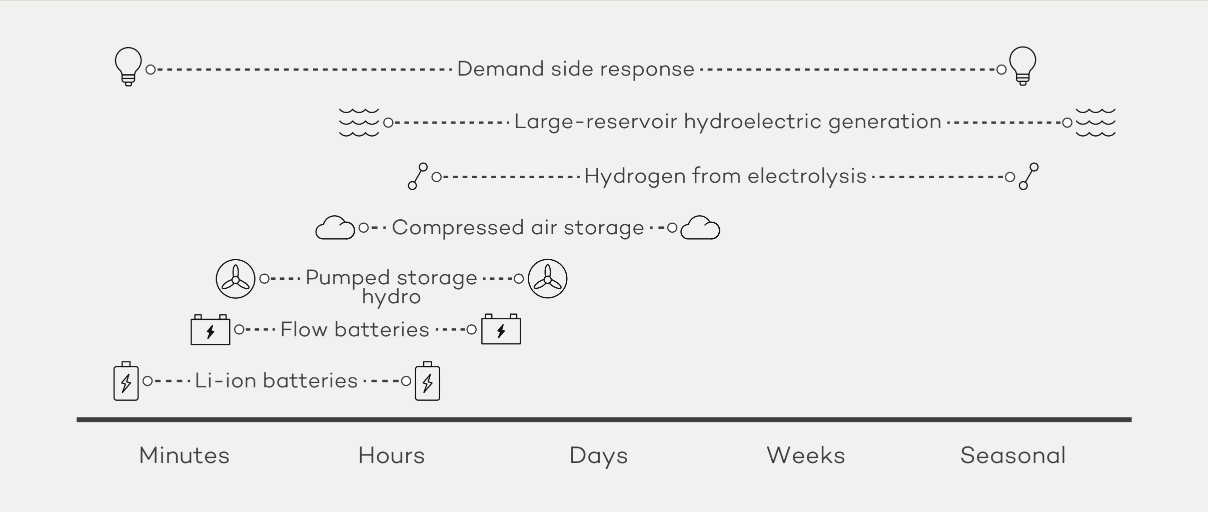
BOX B: THE ROLE OF FLEXIBILITY IN ELECTRICITY MARKETS

With the expected rapid increase of intermittent generation, the challenge of balancing supply and demand is growing. In addition to the traditional solution of adjusting centrally-dispatched thermal generation to match demand, new sources of flexibility will become cost effective. Broadly speaking, there are three alternative types of flexibility that can be used to balance the system. In this report, we refer to them as follows:

- **Fast-acting flexibility** – generation, storage or demand that can react rapidly (normally within seconds or minutes) to mismatches in the supply demand balance caused by (for example) forecasting errors or unexpected loss of generation or demand. Often, this takes place in balancing or ancillary services markets.
- **Peaking flexibility** – generation that can turn on (or demand that can turn off) for relatively short time periods to cover peaks in demand or shortfalls in renewable output. As these periods can often be foreseen in advance, it is often not necessary for the flexibility providers to respond rapidly.
- **Time-shifting flexibility** – storage or demand side response that can consume electricity when there is a surplus of generation, and generate (or not consume) when there is little spare generation. For industrial demand side response this could involve (for example) flexible production schedules; for electric vehicles it could be charging in lower-demand periods, or even putting power back onto the grid.

Some technologies may be able to provide more than one type of flexibility; for example, lithium-ion batteries can not only perform time-shifting, but can also respond rapidly allowing them to provide fast-acting flexibility in balancing and ancillary services markets.

Time-shifting flexibility can be sub-divided depending on the volume of time-shifting it provides. For example, a lithium-ion battery can cost effectively only store up to 2-4 hours of generation (maybe up to 6 hours in future as costs reduce), whilst hydrogen electrolysis can (subject to storage considerations) store days' or weeks' worth or even longer. The figure below shows the approximate time-shifting ability of different technologies.



Longer duration time-shifting has the ability to shift at least several days-worth of generation from one period to a later one. Given that offshore wind potentially has periods of high output lasting days followed by low output also lasting days, longer duration time-shifting will tend to have a greater impact on the offshore wind business case than shorter duration time-shifting.

[19] The impact of congestion curtailment was also considered but given in practice this is compensated for under extant market arrangements, it is not likely to have an material impact on revenues and so is not presented here.

[20] The experience of offshore wind auctions internationally is still very limited. However, there are several examples of capacity being secured in auctions for other technologies, which later fails to commission. One example of a large project failing to commission is Trafford CCGT in Great Britain. In 2014 Carlton Power won a contract in the GB capacity market to develop the project, but later had the contract cancelled after failing to meet milestones for financial commitment.

[21] Where bidders are too optimistic in the viability of a project and bid too low in order to be successful. In the context of the Dutch offshore wind tenders, it is not that the price would be bid too low as competition is not price based. However, it may still apply where investors are too optimistic in the viability of a project at zero subsidy.

3. Options to support the offshore wind business case

In this chapter we provide an overview of the short listed options for intervention to support the offshore wind business case, including co-dependencies and other interactions between the measures. In Chapters 6, 7 and 8 we provide our more detailed analysis of each individual measure, alongside a summary of some other measures discussed as part of the long list.

The short list of options was agreed with the Steering Committee for consideration within this report. The short list was based on options that addressed the risks identified as part of the modelling analysis. The options were chosen based on their potential effectiveness in meeting offshore wind objectives and any practical implications.

The measures focus purely on the potential benefit to the offshore wind business case. We have made no assessment of what mix of measures would offer the lowest cost regulatory framework for decarbonising the electricity or wider energy sector. In particular, many of the interventions advocate the advance of time-shifting flexibility and the electrification of heat and transport. It is beyond the scope of this study to consider whether other low carbon options such as generating capacity with carbon capture and storage offer a better solution even if they do not necessarily help the offshore wind business case.

Figure 12 provides a summary of the short list of potential measures to support the business case. The measures are split into three broad categories:

- maintaining wholesale market revenues (light blue).
- supporting other revenue streams (light grey); and
- keeping costs down (dark grey)

FIGURE 12 – SUMMARY OF OPTIONS FOR INTERVENTION

Measure	Explanation
1 Roadmaps for • electric heat, industrial processes and transport, hydrogen and flexibility	• Publication of roadmaps for the roll-out of electric heat, industrial processes & transport, hydrogen and flexibility over the next 20-30 years • Providing more detail and longer timeframes than the Klimaatakkoord including annual volumes (for earlier years) and demand expectations • A clear process for re-evaluation will be required
2 Link roadmaps to action on demand stimulation and offshore wind tender volumes	• Regular monitoring of demand and flexibility growth against measure 1 targets and take corrective action as required • Adjust the offshore wind tender volumes up or down (post 2030) according to the latest demand expectations
3 Provide additional boost for electrification solutions that include flexibility	• Support provided for the electrification of heat and transport could include an incentive for vehicles or heating to be operated in a flexible manner • This could include emphasising existing price signals to use wind output when it is windy and the electricity price is low, and vice versa • Ongoing monitoring would be required to ensure flexibility is operating to support intermittent generation
4 Investigate potential for products that value time-shifting flexibility[22]	• Undertake a review of potential products offering value to for time-shifting flexibility with input from stakeholders • The options for consideration range from extending time-shifting arbitrage opportunities beyond the day ahead market to bilateral agreements (e.g. tolling contracts)
5 Run joint tenders for offshore wind and time-shifting flexibility	• Offer support to time-shifting flexibility technologies e.g. hydrogen to enable learning and reduce costs • Design of support would need to be carefully structured to incentivise the types of time-shifting flexibility that complement intermittent renewables generation patterns
6 Revenue support for time-shifting flexibility	• Reduce financing risk through regulation, such as capital support, a regulatory asset base or price or revenue stability mechanism
7 Require supported electric heat, industrial processes	• Require that any support provided for electric heating, transport or industrial processes is only provided if the electricity it consumes is from low carbon sources
8 Optimise onshore grid use	• Ensure that connections and grid charging and reinforcement policy considers complementarity between offshore wind connections and new large electricity users sharing network resource (e.g. connecting large demand centres in ports to export cables). • Identify the areas of network that are favourable for connection of demand and offshore wind e.g. publication of network 'heat maps'.
9 Co-ordinated discussion on innovative financing structures	• Coordinated discussions between current industry participants and potential future providers of equity and debt to accelerate the widening of the pool of capital able to invest in the merchant renewables sector and efficient financing structures. • Could include allocation of risk, securitisation of debt, possible role for a 'green investment bank', role of insurance companies, etc.
10 Investigate the potential for andbarriers to longer term hedging products	• Identify what, if any, agreements or products could emerge or be facilitated which provide a long term hedge to both baseload wholesale electricity prices and/or offshore wind capture rates • This would need to include discussions with relevant stakeholders • The options could range from bilateral contracts to financial products enabling hedges
11 Use a regulatory measure to reduce financing risk	• Reduce financing risk through regulation, such as capital support, a regulatory asset base or price or revenue stability mechanism

[22] In this report, 'time-shifting flexibility' is defined as storage or demand side response that can consume electricity when there is a surplus of generation, and generate (or not consume) when there is little spare generation. For a full discussion, see Box B in Chapter 2.

3.1 How the measures could be combined

Figure 13 shows an overview of the short listed measures. These are a mix of strategic, market based and support based measures. The focus of the measures is to address the primary risks identified in the modelling, namely:

- imbalance between demand and supply;
- the cannibalisation effect; and
- an increase in the cost of financing.

As such, six of the eleven measures address wholesale electricity revenue risk and a further three focus on addressing the risk of increased financing costs. A coherent set of interventions to support the offshore wind business case might seek to address these three primary risks identified by our analysis.

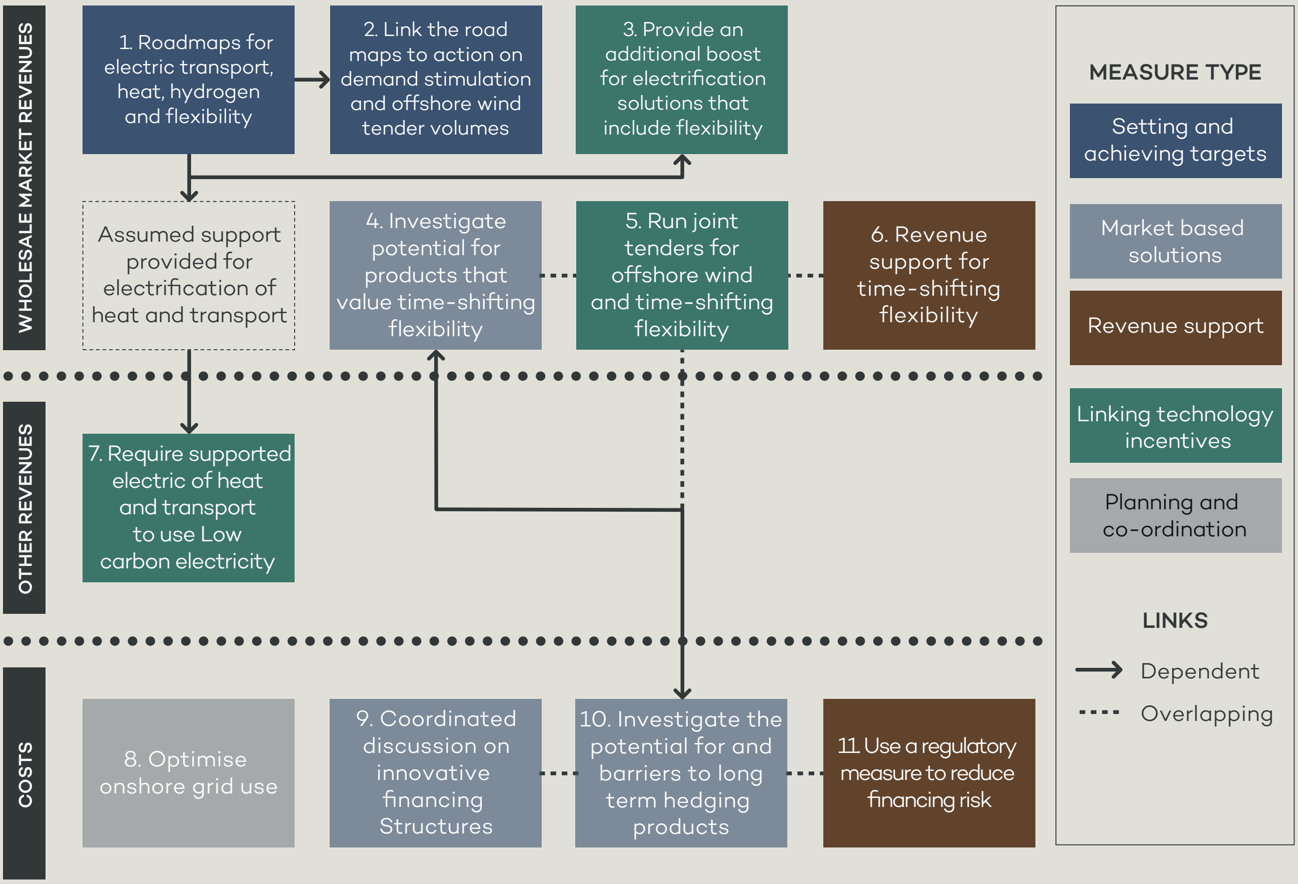
Many of these measures are either overlapping or interlinked. To have an impact several measures are likely to be required simultaneously. Measures could be combined or substituted broadly around the impacts they are intended to address.

3.1.1 Avoiding supply/demand imbalance

Measures 1 and 2 provide options to reduce the potential for demand/supply imbalance. The roadmaps under Measure 1 provide clarity on the Government's intentions on the electrification of heat, industrial processes and transport, while Measure 2 ensures those ambitions are met or, if not, that auctioned volumes are kept in check after 2030.

The link to tendered volumes of offshore wind serves two purposes. Whilst the most obvious is to dampen the cannibalisation effect, it is the avoidance of too much of any type of low marginal cost generating capacity that will affect the overall supply/demand imbalance. The risk around offshore wind tender volumes is that the Government has direct control over this new capacity and so has the potential to over allocate capacity.

FIGURE 13 – OVERVIEW OF THE SHORT LISTED MEASURES



3.1.2 Avoiding high levels of cannibalisation

Measures 3 to 6 offer action to help address the cannibalisation of offshore wind revenues by incentivising greater levels of time-shifting flexibility, including hydrogen which can act across seasons.

Roadmaps for hydrogen and flexibility, with associated actions to meet these goals, would encourage uptake and learning. Measures 3 and 4 could be part of the actions to meet these goals. In the short term support is likely to be required, at least for some of the less mature time-shifting technologies to increase uptake and accelerate cost reductions. However, in the medium term, or in the case of hydrogen more likely longer term, a market based solution may be possible.

Investigating the potential for market based solutions alongside regulation could help ensure that the design of any support interferes as little as possible with the emergence of products valuing time-shifting flexibility.

Any review of potential products valuing time-shifting flexibility would also need to consider how much value they provide to offshore wind in hedging capture price risk which is part of Measure 10. In theory time-shifting flexibility could offer offshore wind the service of accessing value in times of day that wouldn't otherwise be possible. In doing so, it reduces the cannibalisation effect. Time-shifting flexibility also benefits by retaining some of this value.

Measure 5 offers a regulatory alternative to considering Measures 3 and 10 and so an early decision on which is preferable would help with the design of any regulatory support.

Measure 6 provides a specific solution to ensure that where heat or transport sectors use electricity it is used in a flexible way that supports offshore wind. It therefore provides an option, but not the only option, to incentivise consumer behaviour that benefits offshore wind.

3.1.3 Avoiding higher financing costs

The pursuit of optimising financing (Measure 9) and identifying market solutions to allow better management of revenue risk (Measure 10) offer attractive alternatives to regulatory intervention. However, ultimately they may not be sufficient to avoid the need or even desire (as it could have the capacity to reduce costs for consumers) for regulatory intervention (Measure 11).

Even in this circumstance, optimising financing and developing a hedging market could reduce the level of regulatory intervention required. So investigating if regulatory intervention were considered necessary could still be beneficial, and help inform the design of regulatory intervention suppressing the development of new financing and risk management arrangements.

3.1.4 Other measures

Requiring electricity used for newly electrified heat, industrial processes and transport to be low carbon (Measure 7) offers an option to boost other revenues alongside the high level measures on Guarantees of Origin (GoOs) and ancillary services discussed in Chapter 7. Pursuit of this measure could be considered in isolation to the other options discussed.

Whichever other interventions are pursued, optimising onshore grid use (Measure 8) should support these interventions by keeping down system costs.

4. Drivers of wholesale electricity market revenues

Wholesale market revenues comprise almost all of the available revenues to an offshore wind project under the Reference Scenario, and as a result are critical to the viability of the business case. To understand the drivers behind the viability of the business case it is necessary to understand what drives wholesale electricity market revenues for offshore wind.

In this Chapter we discuss our Reference Scenario wholesale electricity price projections. We then explain the impact of different electricity market drivers on wholesale electricity market revenues based on the results of 10 sensitivities run against the Reference Scenario.

Wholesale electricity market revenues for offshore wind are dependent on three factors:

- Baseload wholesale electricity prices: the annual average wholesale electricity price across all periods within the year.
- The 'capture rate': the proportion of the baseload wholesale electricity price realised by offshore wind projects.
  - As prices tend to be lower when wind generates, this accounts for the amount of value that exists only in the periods when wind is generating.
  - The average over these periods is termed the 'capture price'. The capture rate is then the annual average capture price as a proportion of the baseload price.
- The amount of electricity that is curtailed: this can be the result of economic curtailment due to an oversupply of generation causing prices to fall sharply. Or grid congestion, where projects are ordered to shut down – however, in practice this currently does not reduce revenues as the shutdown will be compensated for though balancing arrangements. The first of these is an output to our electricity market modelling; the second is run as a sensitivity through our investment appraisal model.

In our analysis we discuss these three elements separately to understand which element each driver impacts upon[23]. This can then be used to identify where to target intervention to mitigate risks or support positive market developments.

Box A in Chapter 2 explains in more detail why baseload wholesale electricity prices and captured wholesale electricity prices differ as a result of the 'cannibalisation effect'. Box B in the same chapter explains the differences between flexible technologies, and in particular what we mean by time-shifting flexibility.

4.1 The Reference Scenario

Below we explain the approach taken to modelling the Reference Scenario (as agreed with the Steering Committee), followed by projections of baseload wholesale electricity prices and offshore wind capture prices under this scenario.

4.1.1 Approach to modelling the wholesale market

The approach agreed for the Reference Scenario by the Steering Committee was a mix of an investors' view of the future and existing policy ambitions. This is explained further in Section 1.4.1.

Main inputs were taken from independent sources. Demand, carbon prices to 2030 and offshore wind load factors were consistent with the 95% emissions reduction study by PBL (Netherlands Environmental Assessment Agency)[24]. For offshore wind capacity build it was assumed that build out under the Dutch Offshore Wind Roadmap would be achieved with the 11.5GW target met in 2030. After this date an economic test was used to determine new capacity build. For all other aspects a 'business as usual' approach was taken, assuming only current policy measures applied. The key assumptions used in the Reference Scenario are provided in Annex B.

[23] Please note that changing a modelling parameter will normally impact to some degree on both baseload prices and capture rates, as well as possibly affecting curtailment. In the discussion, the drivers are therefore discussed under the element(s) upon which they have the most significant impact.

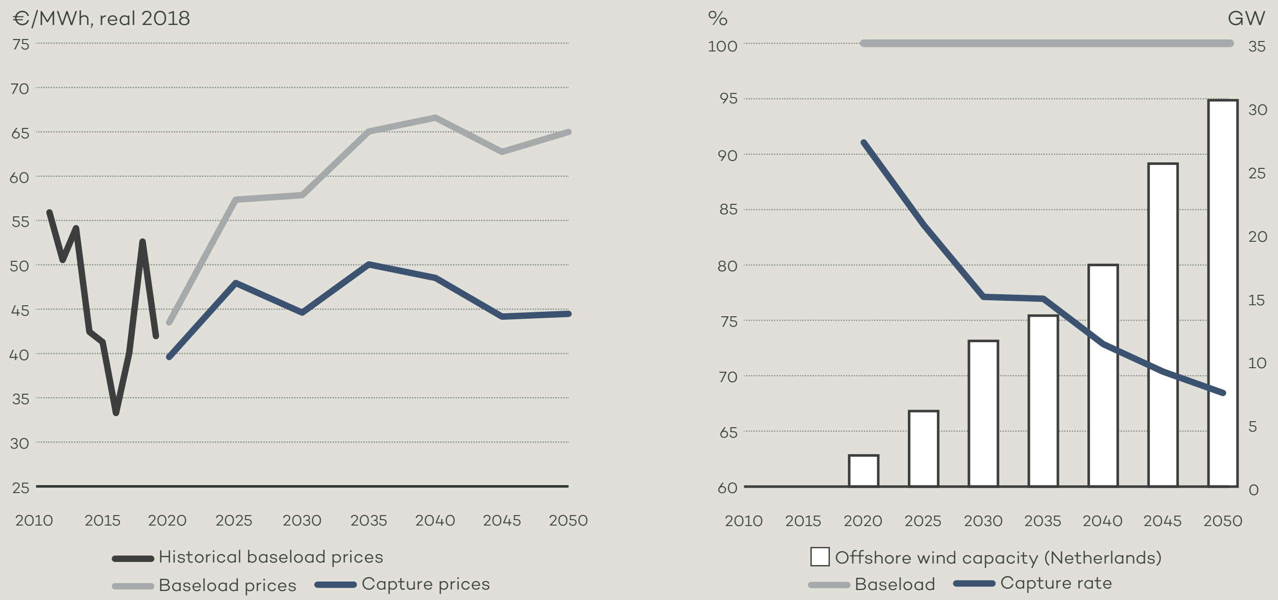
[24] Total demand up to 2030 uses 'Effecten Ontwerp Klimaatakkoord', PBL , 2019; and total demand post-2030 uses 'Verkenning van Klimaatdoelen', PBL 2017.

4.1.2 Wholesale electricity price projections

Figure 14 shows baseload electricity prices, offshore wind capture prices and offshore wind capture rates (capture prices as a percentage of the baseload price) projected to 2050 under the Reference Scenario.

Overall, baseload prices are expected to be significantly higher than they have been over the last 10 years. The majority of this increase comes in the period to 2035 where wholesale electricity prices rise from around €44/MWh to €65/MWh. This is the result of capacity margins across the region tightening from their currently loosened state, as well as increasing gas and carbon prices.

FIGURE 14 – OFFSHORE WIND CAPTURE PRICES (€/MWH), CAPTURE RATES (%) AND INSTALLED CAPACITY (GW) FOR THE NETHERLANDS IN THE REFERENCE SCENARIO



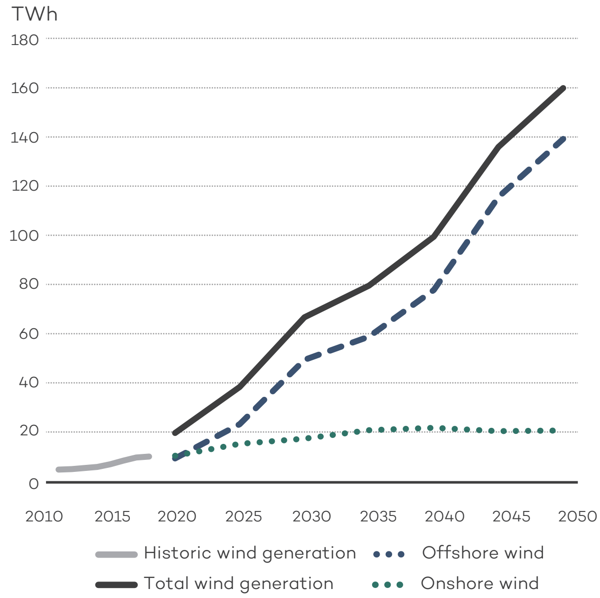
At present the Dutch market is generally oversupplied, but with growing demand and some plant retirals reducing supply, capacity margins are liable to tighten. Post 2035, baseload prices flatten off as a result of the interplay between rising commodity prices having an upward effect, and increasing offshore wind capacity exerting downward pressure on prices.

2030 bucks the upwards trend to 2035 with a dip in prices. Whilst wind capacity is assumed to increase to 11.5GW in line with the Dutch Offshore Wind Roadmap, demand growth is insufficient to retain capacity margins, resulting in a looser system and drop in both baseload and capture prices.

Demand post 2030 is assumed to rise much more rapidly than pre-2030 reflecting a higher uptake of electric heating, industrial processes and transport. Consequently, even with increasing amounts of flexible demand in the system, capacity margins tighten and baseload prices rise again to 2035.

Capture prices for offshore wind in the Netherlands remain at a more similar level to historic prices. The reason these do not increase in the same way (as baseload prices) is rapidly falling capture rates, which decrease from 91% to 68% over the modelled timeframe. The impact of which is to erode virtually all the value from the projected increase in wholesale electricity prices. The sharp decline in capture rates is due to increased levels of projected wind generation in the Netherlands rising from around 20 TWh in 2020 to almost 160 TWh in 2050 (see Figure 15). Generation from these installations will occur at similar times, depressing prices i.e. wind cannibalisation effects.

FIGURE 15 – WIND OUTPUT IN THE NETHERLANDS TO 2050 FOR THE REFERENCE SCENARIO



Curtailment in the Reference Scenario remains at relatively low levels at less than 2% across the modelled period with the exception of 2030. In 2030 it reaches around 2.75% as the roll out of offshore wind continues, but growth in electricity demand has not kept pace with the increase in capacity.

4.2 The impact of different market drivers on the wholesale electricity market

To assess the relative impacts of different market drivers we ran 10 sensitivities on the Reference Scenario.

4.2.1 The sensitivities selected

Taking the Reference Scenario as a foundation, the aim of the sensitivities was to test the effect of individual drivers on the captured revenues and the investment case for offshore wind projects. For a summary of the sensitivities run, see Figure 16, the colours represent the colour of the lines in future charts explaining the results.

The sensitivities were agreed with the Steering Committee and were chosen based on the following criteria:

- if they have the potential to materially impact the economics of offshore wind commissioned 2020-30; and
- whether they will be useful to inform a discussion on potential policy or industry actions.

As a consequence, not all sensitivities were performed on the both the upside and the downside.

Overall a change of 20% was used where possible in order to maintain a consistent approach across sensitivities. This change was chosen to bring about enough of a shift to demonstrate the impact of the driver, whilst avoiding over tipping the balance to an extreme. In some cases where this did not make sense, the approach was deviated, e.g. for demand side flexibility a 50% reduction was used, which translates into a similar change in the proportion of battery capacity available in the *Lower cost of batteries* sensitivity.

Many of the sensitivities were applied to neighbouring countries (e.g. carbon prices under the EU ETS). This is because these market variations are likely to occur across a number of markets, and not solely the Netherlands.

It should be noted that these are sensitivities demonstrating the relative impact of individual variables and in doing so may well represent the results of a system out of equilibrium. This contrasts from alternative internally consistent scenarios in which a change to one variable is followed by consideration of its impact on other variables and the system is re-optimised so that it is brought back into equilibrium. This means that although the relative impact of drivers can be compared in sensitivities, the absolute differences to the Reference Scenario do not necessarily represent the absolute difference that may be expected to persist over an extended period of time.

FIGURE 16 – SENSITIVITIES MODELLED

	Sensitivity name	Description	Markets where change in made
1	Higher carbon price	+20% on carbon prices	All EU ETS markets
2	Lower carbon price	- 20% on carbon prices	All EU ETS markets
3	Lower demand	- 20% demand	Netherlands only
4	Lower offshore wind (higher offshore capex)	+20% offshore wind capex post 2030 (offshore capacity adjusted for change in offshore IRR, CCGT capacity adjusted to maintain capacity margin)	Netherlands, Belgium, Denmark, France, Germany, Great Britain
5	Higher offshore wind (lower offshore capex)	-20% offshore wind capex post 2030 (offshore capacity adjusted for change in offshore IRR, CCGT capacity adjusted to maintain capacity margin)	Netherlands, Belgium, Denmark, France, Germany, Great Britain
6	Higher load factors	60% offshore load factors post 2030	Netherlands, Belgium, Denmark, France, Germany, Great Britain
7	Higher wind in surrounding markets	+20% of all new build onshore and offshore wind from 2020 onwards	Belgium, Denmark, France, Germany, Great Britain, Norway
8	Reduced demand flexibility	50% reduction in demand side flexibility	Netherlands, Belgium, Denmark, France, Germany, Great Britain, Norway
9	Lower cost of batteries	-20% cost of batteries (batteries capacity adjusted for change in IRR)	Netherlands, Belgium, Denmark, France, Germany, Great Britain
10	Reduced interconnection capacity	Removed interconnectors (CCGT capacity added to avoid loss of load)	Only interconnections to Netherlands

4.2.2 The impact on baseload wholesale electricity prices

The sensitivities that had a demonstrable impact on baseload prices were lower demand[25], changes to carbon prices and changes to offshore wind capex (see Figure 17, Figure 18 and Figure 19).

When demand is reduced by 20%, but capacity is kept the same, prices fall on average by 13% over the period (see Figure 17). This is because less generation capacity is required to be utilised to meet demand at any given time, meaning that the marginal plant required to meet demand will (on average) be able to generate for a lower price.

Figure 18 shows the impact of higher and lower carbon prices in the EU Emissions Trading Scheme (ETS) on wholesale electricity prices. If carbon prices are higher than assumed in the Reference Scenario, wholesale electricity prices in the Netherlands are projected to be higher by around €3/MWh. This is because the increase in variable costs is likely to affect the marginal plant, (whether in the Netherlands or elsewhere through interconnection imports), and therefore be passed through to the wholesale price. Conversely, when the carbon price is lowered across all years, this feeds through as a reduction of an almost equivalent value in wholesale prices.

The Reference Scenario assumes that there is no change in current policy for existing or new gas-fired generation in the Netherlands, as explained in Section 4.1.1. This means it remains influential even into future decades as CCGTs are often the marginal plant setting wholesale prices (especially post 2030 once coal-fired generation is either retired or replaced by biomass). However, carbon emission reduction goals could conceivably result in regulation to restrict the development and/or operation of CCGT without carbon abatement, particularly towards the end of the modelled period. Even with such a change, carbon prices would likely have a notable impact if this regulation was not mirrored across Europe as the Netherlands is a highly interconnection country.

If regulation against new CCGT was implemented in key interconnected countries (e.g. Germany and the UK) the sensitivities on carbon prices could be interpreted differently. CCGT with Carbon Capture and Storage (CCS) is the next most cost effective technology in the long-term, and so would be the most likely alternative technology to be deployed in later years of the Reference Scenario.

Note that although we have modelled a change in carbon prices, a similar effect could be expected if there was a rise/fall in gas prices, or higher or lower than the anticipated variable cost of abating carbon from a CCGT in the instance such regulation were to be implemented.

FIGURE 17 – IMPACT OF LOWER DEMAND ON WHOLESALE ELECTRICITY PRICES

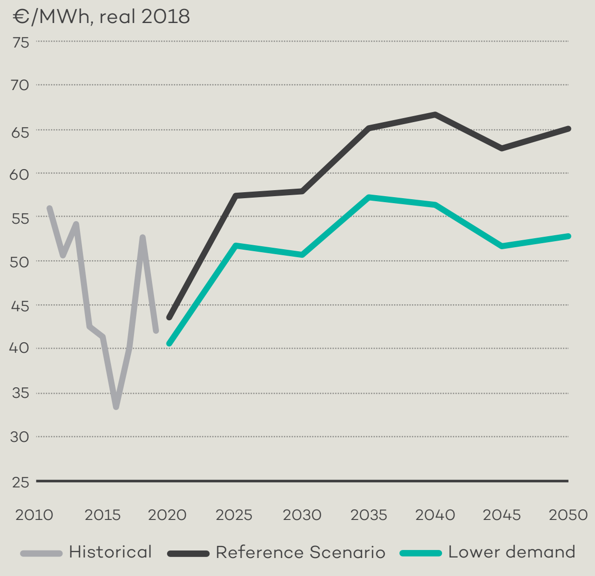
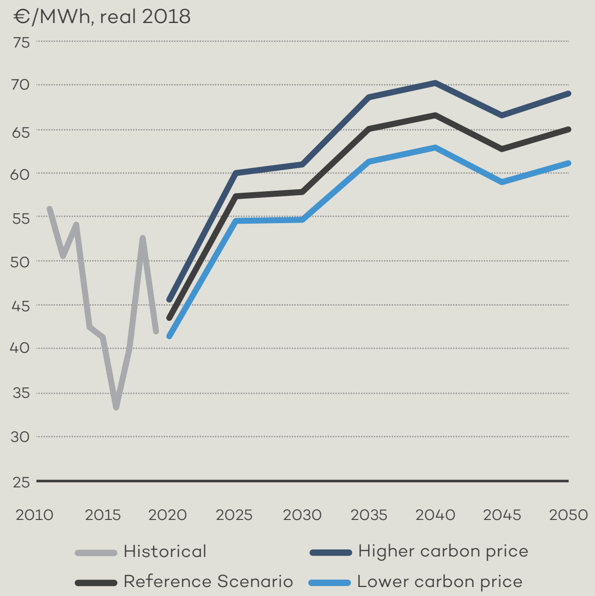


FIGURE 18 – IMPACT OF A CHANGE IN CARBON PRICES ON WHOLESALE ELECTRICITY PRICES

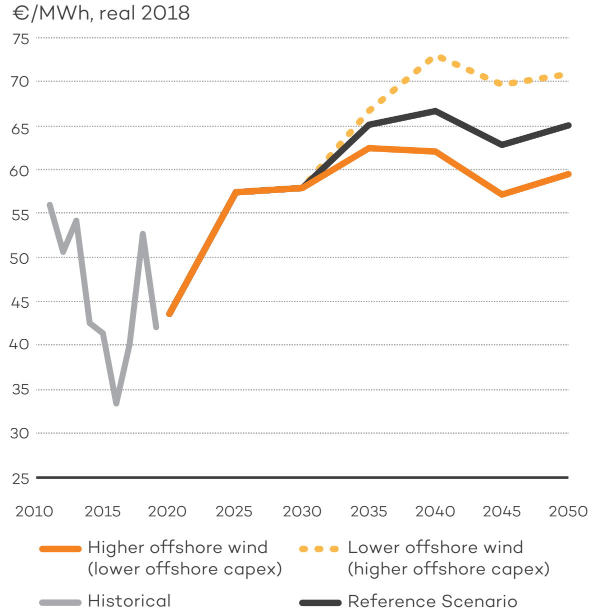


[25] *Higher load factors* also had an impact on baseload prices similar to the *Lower demand* sensitivity there was a mismatch between demand and supply. The impact however, was lower, and the likelihood of returning to equilibrium more quickly is higher, so it is considered that it is demand growth that presents the greater risk.

It is not only the variable cost of price setting plant that affects wholesale electricity prices, it is also the cost of constructing new capacity i.e. capex costs. Figure 19 shows the results of two sensitivities, one increasing, one reducing the assumed level of offshore wind capex by 20% from 2030 onwards. With higher assumed offshore wind capex, less offshore wind capacity is built meaning more expensive plants are required to meet demand and the projected wholesale price rises by around €6/MWh. Conversely, with *Lower offshore wind (higher offshore capex)*, more capacity can be built at lower cost, and lower cost plants are able to meet demand.

The impact of offshore wind capex costs demonstrates a paradox: that higher offshore wind costs in the long term, which would generally be considered undesirable, the better returns for earlier projects.

FIGURE 19 – IMPACT OF DIFFERENT CAPEX SENSITIVITIES ON WHOLESALE ELECTRICITY PRICES



4.2.3 *The factors influencing offshore wind capture rates*

Figure 20 shows the impact of greater or lesser wind generation on offshore wind revenues for three sensitivities: *Higher offshore wind (lower offshore capex)*, *Lower offshore wind (higher offshore capex)* and *Higher wind in surrounding markets*. Figure 21 shows the corresponding installed capacities of offshore wind under these sesitivities.

FIGURE 20 – DUTCH OFFSHORE WIND CAPTURE RATES (%) FOR HIGH WIND SENSITIVITIES

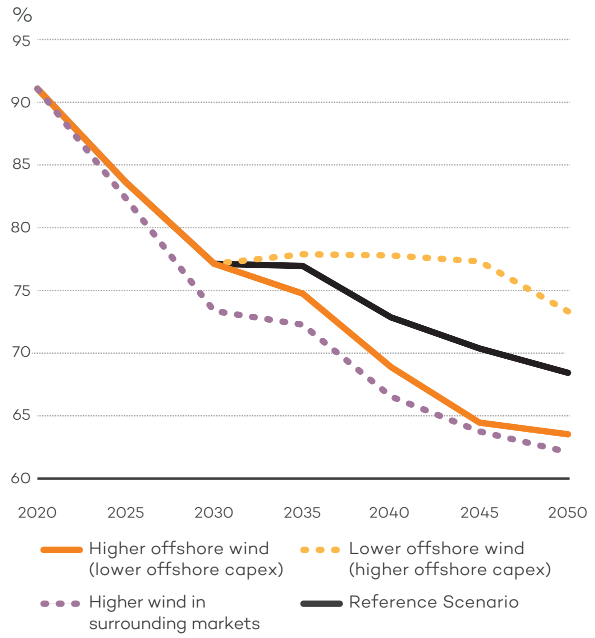
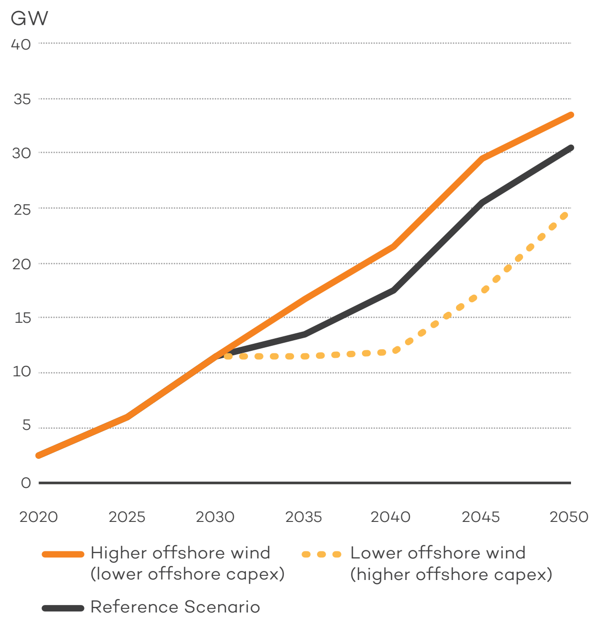


FIGURE 21 – INSTALLED CAPACITIES OF OFFSHORE WIND (GW) IN THE NETHERLANDS FOR HIGH WIND SENSITIVITIES



Changing capex assumptions influences the capacity of offshore wind through economic viability of new build. With higher levels of offshore capex, the capacity of offshore wind installed in the Netherlands is almost 6 GW lower by 2050 than in the Reference Scenario as fewer projects meet their required hurdle rate. In the *Lower offshore wind (higher offshore capex)*, an additional 14GW is built across the wider region by 2050 (including 3GW in the Netherlands).

Capture rates tend to be pushed down as a result of higher amounts of wind generation available on the system as all the wind tends to generate at roughly the same time (correlated generation) and so the effect is cannibalisation of revenues. For the lower capex sensitivity, the resulting drop in capture rates is up to 7% points (pp) with a fall of around 4pp on average. A similar opposing effect is seen in the higher capex sensitivity.

Wind cannibalisation effects not only result from increased wind generation indigenously but also from surrounding markets. There is no change in domestic installed capacity in the *Higher wind in surrounding markets* sensitivity, yet a combined increase in onshore and offshore wind generating capacity of 55GW in surrounding markets pushes down prices in periods of high wind, reducing the capture rates of wind plants in the Netherlands by almost 7pp.

In order to explore how the impacts introduced by higher wind might be mitigated, we modelled sensitivities on different technologies offering flexibility including:

- a reduction in the cost of lithium-ion 2 and 4 hour batteries, leading to increased deployment of these batteries;
- reduced interconnection capacity; and
- reduced demand side flexibility

The results of these sensitivities are shown in Figure 22.

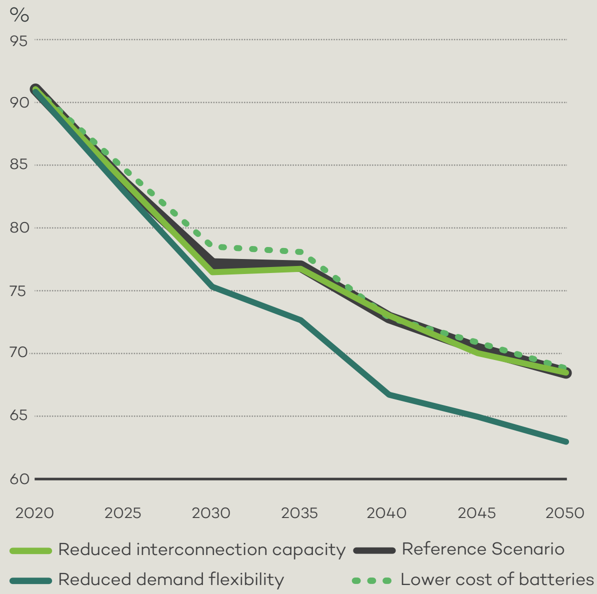
Increased deployment of lithium ion batteries had little impact on capture rates, with a small effect in 2030 when there are high levels of offshore wind capacity. The likely reason for this is that high wind periods often last longer than 2-4 hours. This means the period of time-shifting offered by these batteries is generally not sufficient to move generation into a significantly tighter period.

Lithium-ion batteries are still a complementary technology to intermittent generation, in particular solar PV which tends to benefit more from short time-shifting periods. However, arguably, their most valuable purpose for offshore wind is enabling real time balancing of the system rather than to shift generation from high wind periods to low wind periods.

Similarly, reduced interconnection showed little impact. This may be because a large amount of interconnection exists in the Netherlands and even with the reduction of two interconnections a significant amount more, 7GW is still assumed to be built. A more significant reduction in interconnection capacity would more likely have a greater impact (although the impact of interconnection on prices is complex and depends on the market situation in the connected country). The consequence of this for policy interventions is that interconnection capacity should not be ignored, although as it was the most near term interconnectors that we assumed not to be built, this is unlikely to be an issue until beyond 2030.

Reducing demand side flexibility did have a notable impact on capture prices reducing them by almost €4/MWh from 2040 onwards.

FIGURE 22 – COMPARISON OF DUTCH OFFSHORE WIND CAPTURE RATES UNDER SENSITIVITIES FOCUSSED ON BATTERIES, INTERCONNECTION AND DEMAND SIDE FLEXIBILITY



Higher levels of demand flexibility allow wind generation to be used at the time it is produced, rather than according to a fixed schedule. Depending on the amount and nature of demand flexibility, this can lead to significant consumption of generation in high wind periods, thereby reducing consumption in later, lower wind periods. For some types of demand, this 'time-shifting' effect can be utilised over many hours, or even days, making it much more valuable in increasing offshore wind capture rates than that offered by (say) 2-4 hour lithium-ion batteries.

Future levels of demand flexibility are highly uncertain, as it requires not only on the deployment of potentially flexible technologies in heating and transport sectors, but also on the willingness of consumers to allow their heating systems or vehicles to be used flexibly. Even if consumers are willing to allow this, it is not clear over what time periods and frequency they would offer flexibility. The *Reduced demand flexibility* sensitivity therefore represents a feasible outcome, and one which would have a material negative effect on wind capture rates.

The results of this sensitivity combined with the results of the 2-4 hour batteries sensitivities could be interpreted more widely to demonstrate the advantages of longer duration time-shifting technologies. As a result our interventions not only include encouraging the development of demand side flexibility but also longer duration storage solutions including hydrogen.

Different types of time-shifting technologies are discussed in Box B in Chapter 2, the specific roll of hydrogen is discussed in Box C in Chapter 5.

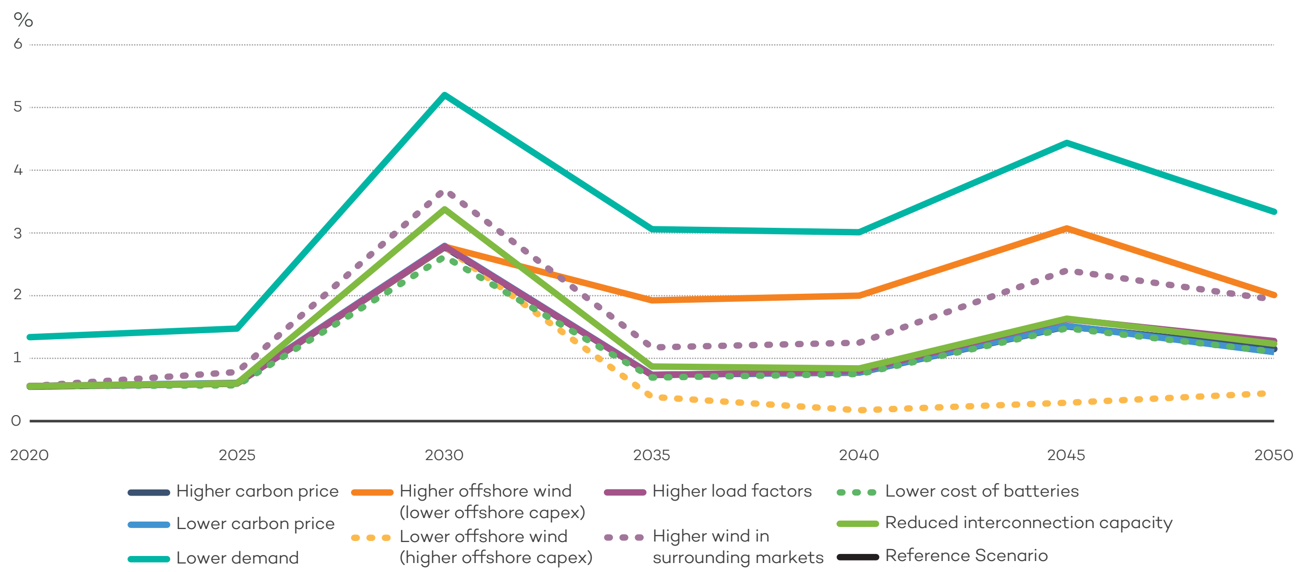
4.2.4 The potential for economic curtailment of offshore wind

Economic curtailment represents unused wind generation at times when revenues would either be negative or below acceptable levels for the generator.

There are different levels of curtailment across the sensitivities as shown in Figure 23. Most pronounced is in the *Lower demand* sensitivity where capacity margins are loosened as a result of a demand reduction[26]. In cases of higher installed wind capacity, such as the *Higher offshore wind (lower offshore capex)* and *Higher wind in surrounding markets* sensitivities higher levels of wind curtailment occur than in the Reference Scenario; conversely the opposite occurs in the *Lower offshore wind (higher offshore capex)* sensitivity.

There is minimal change in curtailment seen in the *Lower cost of batteries* and *Reduced interconnection capacity* sensitivities. Similar to the reasons discussed previously, these sensitivities have shown minimal effect on offshore wind development, but this is likely to be because technologies with greater time-shifting capacity would need to be explored and/or a more significant reduction in interconnection capacity to see a clearer effect.

FIGURE 23 – LEVELS OF WIND CURTAILMENT (AS % OF GENERATION) FOR SENSITIVITIES



[26] This has been applied as a sensitivity without re-balancing of the capacity margin, which may occur in some years if demand reduction is potentially unexpected.

5. Other factors impacting the project investment decision

Whilst wholesale market revenues comprise almost all of the available revenues to an offshore wind project, they are not the only factor affecting the business case. A range of non-wholesale market factors are also important in determining whether positive investment decisions can be made, including:

- other revenue streams available for offshore wind, such as:
  - Guarantees of Origin (GoOs or Garanties van Oorsprong in Dutch), the certificates which provide proof of generation from a sustainable source (solar, wind, hydro and biomass) ;
  - revenues from provision of ancillary services;
  - the production of green hydrogen through electrolysis;
- capital costs of an individual project
- operating costs of an individual project;
- balancing costs for offshore wind;
- financing costs, including:
  - amount and cost of debt; and
  - economic lifetime of the project.

For each of these non-market factors (except hydrogen production), we have made an assumption (agreed with the Steering Committee) to use in the Reference Scenario, and have then also tested the sensitivity of the business case to changes to the Reference Scenario parameters.

Hydrogen production through electrolysis has the potential to benefit the offshore wind business case by offering an additional revenue stream as well as offering time shifting flexibility. However, although the costs of hydrogen production are expected to fall significantly over time, there is significant uncertainty over how fast these cost reductions can occur. Under the assumptions used in the Reference Scenario, electrolysis is not economically viable within the modelling timeframe (see Box C) and so will need support. Given the uncertainty over hydrogen costs we have not considered quantitatively the additional revenues that could be realised from hydrogen production. However, its potential benefits mean encouraging the acceleration of hydrogen production features heavily in the various intervention measures proposed in this study, even though it is absent from scenario modelling.

5.1 Modelling investment decisions

For the purposes of this study, we have used a simplified investment appraisal model to assess the performance of investments in offshore wind. This takes the form of a stylised project finance model that replicates the high-level assessment that a project developer would undertake at the point of making a Final Investment Decision. Equity returns for the investor have been calculated based on an assumed fixed level of gearing and cost of debt.

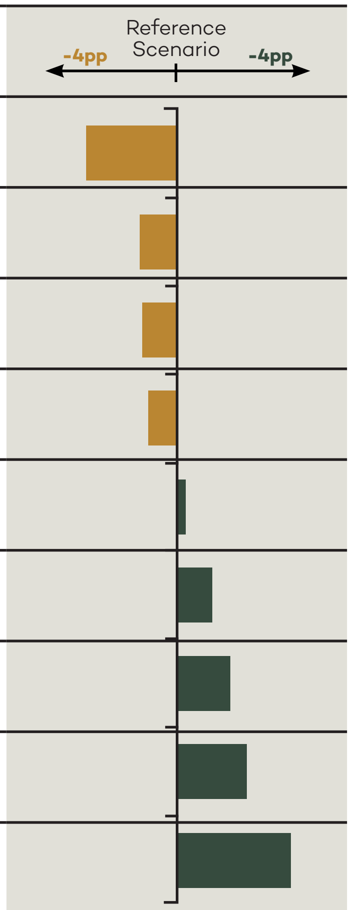
The investment appraisal model has then been used to assess the viability of the business case for the Reference Scenario and how this is impacted by variation in the aforementioned non-market factors. Figure 24 shows the non-market assumptions used in the Reference Scenario and the sensitivities we have considered around these, together with the relative impact of each sensitivity.

Offshore wind capital (capex) and operating (opex) cost assumptions used in the investment appraisal model are provided in Figure 25. This includes sensitivities with capex and opex increased and decreased by 20% relative to the Reference Scenario for a project commissioning in the Netherlands between 2022 and 2030.

The results from the wholesale electricity market were also run through the investment appraisal model, the results of all sensitivities are shown in Figure 11.

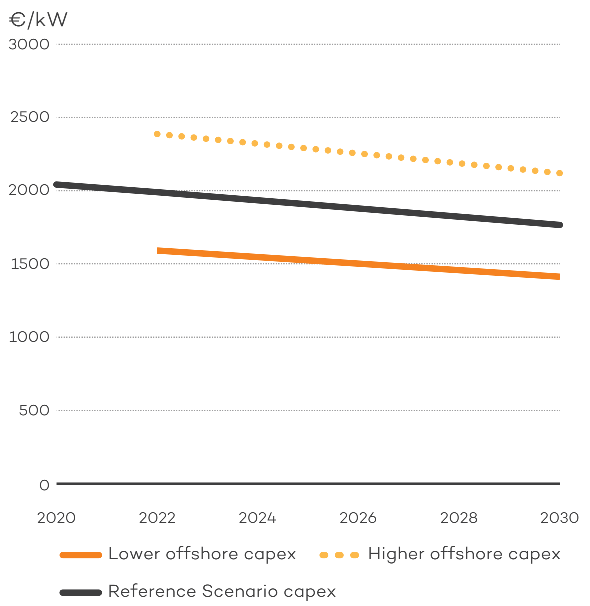
FIGURE 24 – REFERENCE SCENARIO NON-MARKET ASSUMPTIONS AND IMPACT OF POTENTIAL VARIATIONS

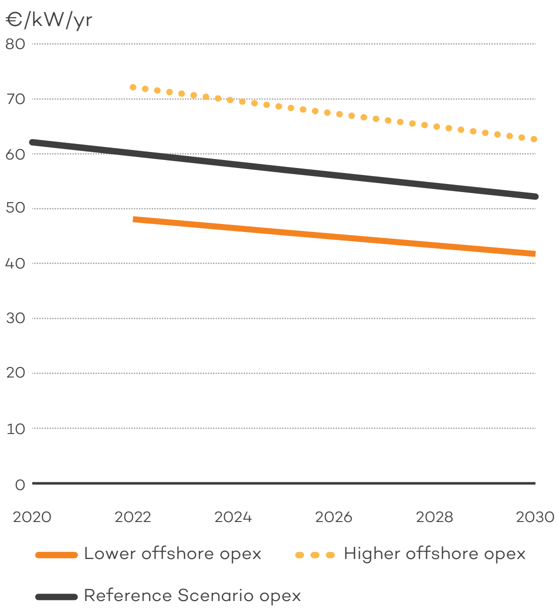
	Reference Scenario assumption	Sensitivity assumption	Impact on equity return*
Higher project capex	Varies by year (see Figure 25)	+20%	
Higher project opex	Varies by year (see Figure 25)	+20%	
Higher structural curtailment	0%	5%	
Higher imbalance cost	€1/MWh in 2020 rising to €2/MWh in 2030, then flat	Double	
Ancillary services revenue	€0/kW/year	€3/kW/year	
Extended economic lifetime	25 years	35 years	
Lower project opex	Varies by year (see Figure 25)	-20%	
Higher GoO value	Decline from €5/MWh in 2020 to zero by 2025	€5/MWh flat	
Lower project capex	Varies by year (see Figure 25)	-20%	



**for projects commissioning 2025*

FIGURE 25 – OFFSHORE WIND CAPEX AND OPEX ASSUMPTIONS FOR THE NETHERLANDS (€ REAL 2018)





5.2 Viability of the offshore wind business case

In the Reference Scenario (for both market and non-market factors), implied equity returns for a typical project commissioning in 2022 falls just short of the lower end of the feasible level at which investments would be deemed viable (we assume 7-10% equity returns would be required). This indicates that the investment decision for a typical project is likely to be a marginal one, and could well be negative, depending on the project's individual characteristics and a particular investor's return aspirations and strategic intentions.

Furthermore, as seen in Figure 24 and our discussion in 2.2.3, the business case is highly sensitive to both upside and downside variations in the capital and financing costs, whilst variations in operating costs also have a moderate impact. Assuming a higher future value from GoOs can have a materially positive impact on the business case though, as discussed elsewhere in this report, this would come with a high degree of risk. Meanwhile, reasonable alternative assumptions on the imbalance costs and the value of ancillary service revenues make only a small impact on the overall business case. Conversely, hydrogen has the potential to help the offshore wind business case, and as such its acceleration is included in several of the interventions considered as part of this study. The role of hydrogen is discussed separately in Box C.

These variations serve to highlight the risks associated with the parameters of individual projects and have been used to inform discussions of potential measures that could be used to support the business case.

BOX C: THE ROLE OF HYDROGEN IN SUPPORTING THE OFFSHORE WIND BUSINESS CASE

Hydrogen is an energy carrier which can be used directly in transport, heat and industrial processes, and for generating electricity in fuel cells or in turbines similar to current natural gas-fired CCGTs. Advantages of hydrogen include the absence of local emissions, its ability to provide flexibility through storage, and its high specific energy (energy per unit of weight).

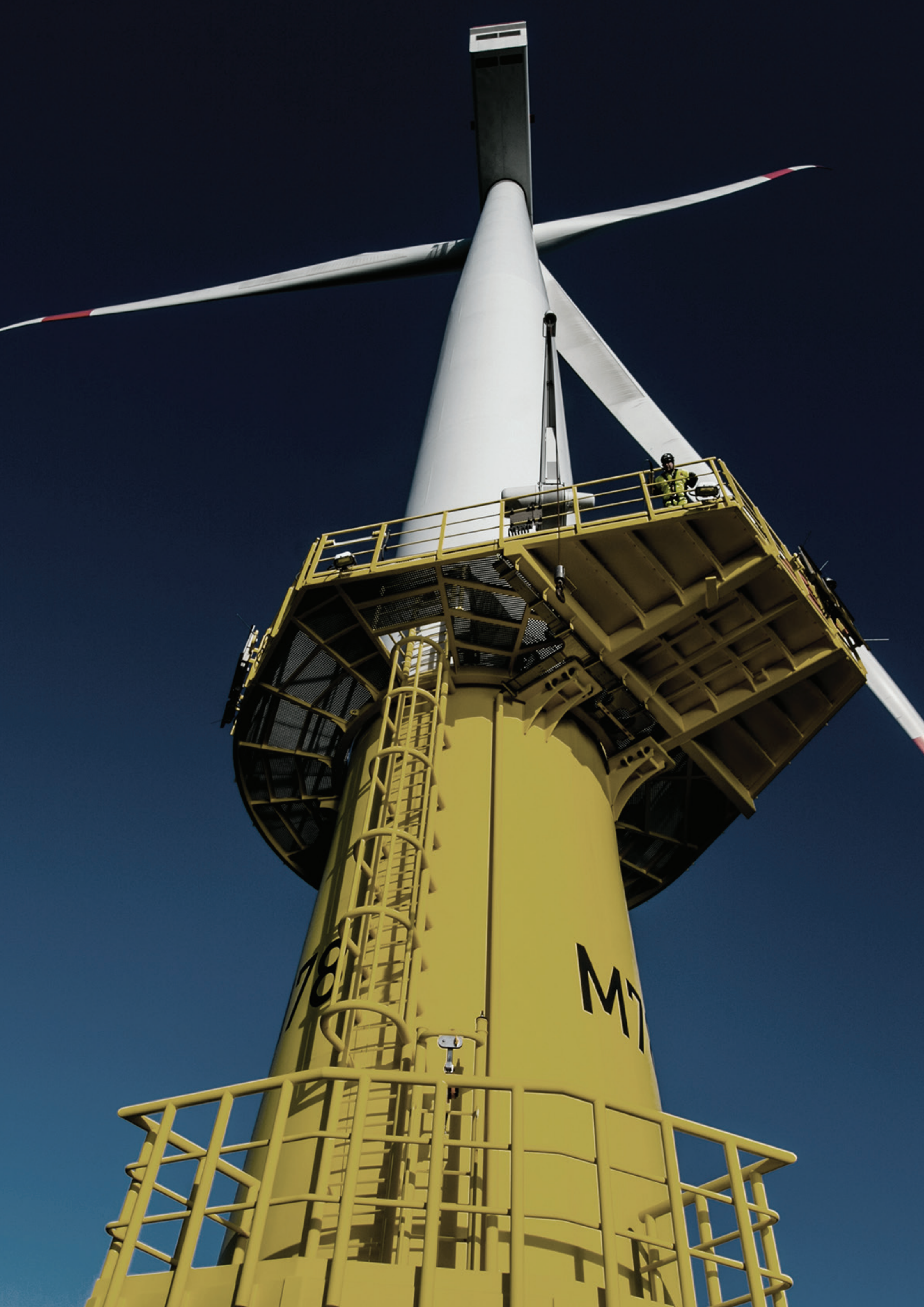
Depending on how hydrogen is produced, it can contribute towards decarbonisation targets. The two main methods for low-carbon hydrogen production are electrolysis and steam-methane reforming with carbon capture and storage (SMR with CCS):

- Electrolysis uses electricity to split water into oxygen and hydrogen. The most widely known technologies include the proton exchange membrane (PEM) electrolysers, alkaline electrolysers, and solid oxide electrolysers. Through electrolysis, electricity from renewables can be used for the low-carbon production of hydrogen. The cost of hydrogen production using electrolysis depends on the cost of electricity used. Hydrogen produced by electrolysis is commonly referred to as 'green hydrogen'
- Steam-methane reforming (SMR) uses a methane source (e.g. natural gas) together with steam at high temperature to produce hydrogen. Besides hydrogen, carbon emissions are also a product of this process. Therefore, CCS in combination with SMR has been considered as a solution for low-carbon hydrogen production using this technology. CCS together with the necessary CO2 transport and storage infrastructure, however, is a less mature technology which adds to the cost of production from this method. Hydrogen produced by SMR with CCS is commonly referred to as 'blue hydrogen'

The relative attractiveness of each of these technologies is highly dependent on not only capital and fixed operating costs, but also the variable cost of production. In the case of electrolysis this is largely electricity prices and in the case of SMR, this is largely natural gas prices. With a low electricity and high gas price scenario, electrolysis would be more economic, whereas low gas prices and high electricity prices would lead to SMR being the favourable technology.

Although the costs for both electrolysis and SMR with CCS are expected to fall significantly over time, under the assumptions used in the Reference Scenario, neither technology is economically viable within the modelling timeframe. It is also worth bearing in mind that suitable transportation and storage infrastructure would need to be developed, alongside demand for hydrogen in heat and transport sectors.

On the other hand, it is possible that hydrogen deployment could be accelerated through subsidies or some other form of intervention, coupled with rapid development of hydrogen transport infrastructure and demand. In this case, if significant volumes are commissioned in the 2030s and 40s, the resulting additional time-shifting flexibility could provide material reduction in the cannibalisation effect leading to an improvement in the business case for offshore wind. The potential for accelerating deployment of hydrogen production therefore features heavily in the various intervention measures proposed in this study, even though it is absent from scenario modelling.



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6. Interventions to mitigate wholesale electricity revenue risk

In this study we have separated the risks to revenues from the wholesale electricity market into: i) the risks impacting on baseload wholesale electricity prices; and ii) risks impacting on the proportion of the baseload price offshore wind can capture – the cannibalisation effect.

The main risks identified in Chapter 4 impacting on baseload wholesale electricity prices are a demand/supply imbalance and carbon prices. In this Chapter we discuss the potential for clear objectives around demand growth through the use of roadmaps, with an associated commitment to act where demand falls short of expectations. Following that we consider the potential to strengthen carbon prices through various means.

Cannibalisation risk comes from increased wind capacity; as reducing wind capacity is contrary to decarbonisation objectives, we do not generally consider measures to bring this about[27]. Instead we focus on measures that help enable the electricity system to accommodate a greater proportion of wind generation, this includes the hydrogen and flexibility roadmaps in Measures 1 and 2. With the exception of carbon prices, all other measures discussed in this chapter are aimed at reducing cannibalisation risk and incentivising long duration time-shifting flexibility.

For some of the measures considered as part of this study (Measures 1-11) red flags are used to signify issues we have identified with that measure. These are not definitive, further analysis of the detail behind implementing a particular measure may uncover further red flags.

6.1 Roadmaps to clarify the Government's vision for the future

The Dutch Government has put great effort into defining actions under the Klimaatakkoord with the aim of meeting its 2030 decarbonisation targets. The Klimaatakkoord also includes targets that provide some clarity on the type of technology mix that might be expected in the future, for example, the Governments ambition for 3-4GW of green hydrogen production capacity by 2030 and all new cars to be 100% CO2-free by 2030.

The roadmaps build on the Klimaatakkoord providing more detail, such as how 100% CO2-free vehicles is expected to translated into growth in electricity demand, as well as extending the time period beyond 2030. For the offshore wind business case particular areas of importance are electric transport, heat, industrial processes, hydrogen and flexibility more widely. However, for the purposes of co-ordinated policy making such roadmaps may sit better as part of a wider decarbonisation strategy linked to the overall emissions objectives set out in the KlimaatWet (including achievement of carbon neutral electricity production by 2050)[28].

Measure 1 is about implementing the roadmaps, Measure 2 is about acting upon differences between actual and desired deployment rates.

[27] The exception to this is under measure 2 where, in the event that the levels of demand and flexibility on the system are not sufficient to support additional offshore wind, the adjustment of tendered offshore wind volumes post-2030 are discussed.
[28] The UK includes a structure similar to this where a series of 'carbon budgets' are defined for 5 yearly periods around 15 years into the future and progress is evaluated regularly.

6.1.1 Measure 1 – Roadmaps for electric transport, heat, industrial processes, hydrogen and flexibility

For this measure we would anticipate the Dutch Government publish a clear vision for the level and nature of Dutch electricity demand over the next 20-30 years, including the anticipated degree of flexibility from transport, heat, industrial processes, hydrogen production and other sources. The purpose of this would be to provide a clear message on the Government's ambitions for areas that are uncertain and offer signals when further action is needed in future.

The critical elements for the offshore wind business case will be to set out how the future roll out of electric transport, heat and green hydrogen is expected to evolve, including:

- anticipated annual volumes, and implications for electricity demand;
- expected participation of flexible storage and demand; and
- sufficient information on how targets would be met.

In addition, the roadmaps would need to identify and address the risks and challenges to the roll out of these technologies and outline provisions to mitigate challenges to deployment such as grid capacity, public acceptance, industrial and commercial utilisation.

The level of detail in the roadmaps is likely to be greater for earlier years e.g. annual expected volumes, but less for later years e.g. 5 yearly ambitions.

Ongoing re-evaluation of the roadmaps and monitoring of progress against interim targets will be essential. This should identify the need for a change in existing measures or additional measures (where necessary). Any process of re-evaluation would need to be set out in advance, to provide confidence that changes will only be made (where necessary).

Implications for offshore wind tenders and the 2030 offshore target

The long term roadmap with interim targets will provide clarity to the offshore wind industry over the Government's objectives. This should give developers and investors confidence that the Dutch government is committed to large scale electrification and the development of flexible solutions that time-shift generation. These two elements both have a significant impact on offshore wind revenues and are highly uncertain.

Whilst in itself this measure may not directly impact on the volume of offshore wind deployed to 2030, it would act as a framework to support other measures that do[29].

Implications for the wider electricity/energy market (where relevant)

Long term roadmaps including the electrification of transport, heat, industrial processes and hydrogen should enable more deployment of these technologies. This in turn makes the Netherlands carbon reduction targets for 2030 and 2050 more likely to be met.

Interactions with other possible measures

Aside from the confidence it can provide to investors, perhaps the most important roll of roadmaps is to act as a framework to support the necessary measures to enable electrification and flexibility to evolve in the way the Government desires. This measure therefore acts as a first stage for Measure 2 which requires action to be taken if anticipated roll out is not met. For this to be possible it first needs to be clear what the anticipated roll out should be.

Cost and other practical implications

The costs of putting in place a roadmap are administrative. The practical implications of doing so are:

- finding a balance between retaining flexibility to change over time in response to changes in the market and providing sufficient certainty for investors; and
- the complexity (particularly if part of a decarbonisation roadmap) of considering such a wide range of technologies and markets.

[29] Having definitive evidence of the effectiveness of roadmaps is difficult as the impact cannot be separated from the policies to reach the ambitions. However, the 2009 Renewable Energy Directive and associated National Renewable Energy Action Plans provide examples of where a roadmap type structure has demonstrated some success. They provide transparency over interim targets and actions to reach them with regular evaluation which almost certainly resulted in higher levels of renewables in most European countries than would otherwise be the case. However, the Dutch experience does demonstrate that roadmaps in themselves do not guarantee success if there are other barriers in the way.

6.1.2 Measure 2 – Link the roadmaps to action on demand stimulation and offshore wind tender volumes

This measure follows on directly from Measure 1. The monitoring of actual demand and flexibility growth against the roadmap expectations will, where necessary, result in regularly revised demand growth projections. This measure would entail a commitment that when deployment differs from expectations action will be taken. This could be in the form of:

- further action to stimulate demand[30] and flexibility to avoid over supply and to mitigate the cannibalisation effect; or
- after 2030, adjusting offshore wind tender volumes up or down.

Establishing a relationship between demand stimulation, flexibility and offshore wind tender volumes reduces the potential for greater offshore wind output than the system is ready for, which depresses both baseload electricity prices, the offshore wind capture rate, and impacts the offshore wind business case.

The circumstances in which offshore wind tendered volumes could be changed would need to be clear. The expectation is that focus would be on ensuring demand growth is in line with carbon reduction targets for 2050. Reasons for adjusting offshore wind volumes may be if there was a higher or lower demand due to other reasons, or if carbon reduction through other means was later considered to be more desirable.

Implications for offshore wind tenders and the 2030 offshore target

In the period to 2030 we do not anticipate any direct implications for offshore wind tenders unless demand growth is particularly strong and there is a desire to increase the 49TWh 2030 target. The action taken would be demand stimulation in the event of low growth.

The direct implication of this measure for offshore wind tenders comes after 2030 when tendered volumes are adjusted according to demand projections.

Indirectly, this action should improve the chances of the target being met. Linking demand and flexibility growth to offshore wind tender volumes in future will provide confidence to developers and investors that capacity will only be tendered post 2030 when it can be accommodated by the market without unduly depressing wholesale electricity prices or capture rates and in turn returns on investment.

Implications for the wider electricity/energy market (where relevant)

Acting on barriers to the deployment of electric heating or electric vehicles should help remain on course to achieve the 2030 target for a 49% reduction of greenhouse gas emissions (versus 1990 levels) as set out in the KlimaatWet.

Beyond 2030 there may be a delay or acceleration of offshore wind tendered volumes impacting of the speed of decarbonisation of the Dutch energy sector.

Interactions with other possible measures

This measure follows on from the framework provided by the roadmaps established in Measure 1 to provide additional confidence to investors that action will be taken to ensure targets are met.

Cost and other practical implications

Monitoring and reviewing progress will be administrative, however, steps which may be necessary to overcome barriers to the electrification of heat and transport may require support from electricity consumers or incur system costs.

[30] We have not included any downward adjustment should demand exceed expectations as we assume this is a positive change for meeting the Government objectives and the offshore wind business case

6.2 The potential to strengthen carbon pricing

Carbon pricing is attractive because it directly addresses the problem - that the cost of carbon is undervalued, advantaging higher carbon technologies and disadvantaging lower carbon technologies. It also does not discriminate between low carbon technologies in the way technology specific support can. However, there are various implementation hurdles when applying it nationally or internationally, including getting political consensus and overcoming competition issues.

We discuss two possible measures briefly below.

6.2.1 Higher carbon price floor

Applying a higher carbon price can have the effect of elevating wholesale electricity prices, however it is important to consider the geographical and sector extent of implementation. A floor could be applied nationally (within the Netherlands only), regionally (e.g. including Germany and Belgium) or across all the countries currently within the EU ETS. The floor element would mean a lower limit on the rate (€/tCO2) payable for the amount of carbon emitted.

Currently, the Netherlands as part of the EU ETS is part of an EU-wide carbon market which applies to other sectors as well as electricity. Under the Regeerakkoord (2017), a carbon price floor was proposed, to apply to electricity only, starting at €18/tCO2 in 2020 and increasing to €43/tCO2 by 2030. However, following various studies[31] and discussions within the Klimaatakkoord sector tables, the level of this was revised down to €12.3/tCO2 – €31.9/tCO2 and has been submitted for review to Dutch Parliament.

In general, if the carbon price floor is above the level of that in surrounding countries, this can encourage imports of lower priced generation from outside of the Netherlands. This then displaces Dutch generation and moves emissions to a country either without or with a lower carbon price floor. If applied on a regional basis or across the whole EU ETS, the effect is more balanced and more likely to have the desired uplift in baseload prices.

It is unlikely a Netherlands-only measure would have a material impact on offshore wind projects in the Netherlands. Efforts may be better spent pursuing a co-ordinated carbon price floor with a number of neighbouring countries or perhaps more in-keeping with current policies to support measures which could tighten the EU ETS market , for example raising the EU's greenhouse gas targets or enhancing the Market Stability Reserve.

6.2.2 A CO2 based retail price

This would involve a carbon tax being charged on the sale of electricity, from which low carbon electricity would be exempt. The value of this exemption would be the comparable increased cost of purchasing electricity generated from unabated fossil fuels making consumers willing to pay more to low carbon electricity generators to avoid paying the carbon tax. However, under the State Aid Guidelines (Clause 3.7) there may be a requirement for exemptions from any carbon tax to also be applicable to renewable sources from the EU, not just Dutch renewables[32]. This means that, like a national carbon price floor, this measure would be unlikely to have a material impact on offshore wind projects in the Netherlands

[31] E.g. 'Research on the Effects of a Carbon Price Floor', Frontier Economics, 9 July 2018.
[32] A similar mechanism was used in the UK, the Climate Change Levy (CCL) introduced in 2001, which taxed fossil fuel generation but renewable generators could receive an exemption. Under the CCL overseas renewable generators could qualify if they could demonstrate that their electricity was supplied in the UK. The renewable generator exemption was removed in 2015 by the government, in part to prevent UK taxpayers' money benefitting renewable electricity generated overseas.

6.3 Measures incentivising time-shifting flexibility

Most of the measures to incentivise time-shifting flexibility could at least in theory include all types of time-shifting flexibility, with the exception of Measure 3 which promotes flexible behaviour in the switch to electric-heating, industrial processes and transport. The required amount of flexibility could also be determined at a high level through roadmaps supported by market based solutions and revenue incentives in Measures 3 and 4, or via a requirement of the procurement of new offshore wind capacity in Measure 5.

6.3.1 Measure 3 - Provide an additional boost for electrification solutions that include flexibility

Aside from reducing carbon intensity, the switch to electric heat, industrial processes and transport is expected to offer greater flexibility in the use of electricity. To ensure this becomes a reality any support provided for the electrification for these purposes could include an incentive for vehicles or heating to be operated in a flexible manner. This could include incentives emphasising existing price signals to use electricity when prices are low and offer electricity where possible (e.g. electric vehicles with two-way charging) when prices are high.

Ongoing monitoring will be required to:

- understand the extent to which consumer behaviour is responding to market signals to enable better matching of demand with supply; and.
- identify any potential unintended consequences the policy has on the operation of the wholesale electricity market.

Implications for offshore wind tenders and the 2030 offshore target

This measure would give investors in offshore wind projects operational by 2030 confidence that there will be greater ability to time-shift demand and, in the case of electric vehicles, potentially supply in the market. This should help the business case for offshore wind generation and so achievement of the 2030 offshore wind target.

Implications for the wider electricity/energy market (where relevant)

Ensuring flexibility in the electrification of heat, industrial processes and transport from the outset could futureproof the energy market, for example encouraging early uptake of two- way charging for electric cars and the installation of smart heating controls. In particular it would help avoid the scenario where electric heating and transport grows but is used inflexibly exacerbating electricity price volatility.

Use of flexible heat and transport could also have implications for balancing the electricity market; if it works well it could support balancing, but with so many individual actors able to change behaviour quickly, it could make the job more complex, and increase the risk of problems.

If flexible heat, industrial processes and transport are able to offer time-shifting flexibility they could reduce the need for additional system capacity and help move towards a decarbonised electricity system replacing the need for high carbon peaking plants and support decarbonisation objectives.

Interactions with other possible measures

This measure is similar in concept to Measure 7, as both link support for electrification of heat and transport to wider goals; Measure 7 by incentivising use of lower carbon intensity electricity, and this measure by incentivising flexible operation of heat, industrial processes and transport.

Cost and other practical implications

The cost to consumers of supporting electrification of heat and transport could be higher if also requiring them to include flexibility. It could also be complex to link flexibility to support, particularly if the support is paid in advance of operation. Challenges to be resolved include what would qualify, how price signals are defined and how to monitor behaviour. Even with monitoring it could be difficult to ensure behaviour helps better match demand with supply.

6.3.2 Measure 4 - Investigate the potential for products that value time-shifting flexibility

Whilst peaking plant and time-shifting technologies both meet the requirement of providing real time balancing for intermittent generation, time-shifting technologies also offers value to offshore wind. This is because time-shifting technologies allow offshore wind to earn revenue from generation at times it would otherwise not be possible, either by allowing the generation to be used at a later time – as in the case of storage – or by allowing more wind to be utilised at times of higher wind – as in the case of demand side flexibility.

By offering value to offshore wind and other intermittent renewables, time-shifting technologies should also benefit by keeping a proportion of the value themselves. As intermittent capacity increases, the potential to offer the time-shifting services to these technologies will increase, and so the potential value in time-shifting should similarly increase.

Currently the value of time-shifting technologies is monetised in the arbitrage of day ahead and intraday wholesale electricity market prices. In addition time-shifting technologies are able to earn revenue through traditional "flexibility markets" which exist for real time system balancing. However, these markets make no differentiation in the value offered by time-shifting technologies and peaking plant. The incentive is simply to be available at the required time. In addition, most of these markets today provide value only for short duration time-shifting to cover forecasting errors and unexpected generation outages. They do not provide a route to market for longer-duration time-shifting, such as between high and low wind periods that may last hours or days.

The challenge with earning value from arbitrage on the day ahead or the intraday market is that there is no certainty over the long term value of that arbitrage from which to finance a project. For cheaper shorter duration batteries this may be manageable as the upfront cost is lower, but as shown in Section 4.2.3 these are not the most effective for the offshore wind business case.

Longer duration storage generally requires higher capital investment and (with the exception of pumped storage) uses less well tested technologies than lithium-ion batteries that offer most of the storage currently being developed. As with offshore wind projects, more revenue certainty for longer duration storage should help (alongside support where necessary - see Measure 5) these technologies to gain the finance they require.

Demand side flexibility could take many forms, involving both households and commercial end-users changing their consumption patterns in response to electricity market conditions. Greater forward visibility as well as certainty in the value of time-shifting should enable greater investment in demand management technology and/or strengthen the role of aggregators.

To identify how the market could evolve to meet the needs of longer duration storage or demand side flexibility would require the Dutch Government and industry stakeholders to work together. Relevant stakeholders include traders, storage developers, large consumers, and aggregators. Consideration would need to be given to what products could be viable now or into the future as well as the practicalities of operating such a product, including the requirement for facilitation.

The options range from products that extend the availability of time-shifting arbitrage opportunities beyond just day-ahead market to weeks, months or even years to provide greater visibility of the future arbitrage value, and the potential for bilateral agreements (e.g. tolling contracts) that value flexibility over longer timescales to enable financing.

Implications for offshore wind tenders and the 2030 offshore target

Undertaking a study would in itself would have little impact on offshore wind tenders or the 2030 target. If it resulted in products emerging to offer value to time-shifting technologies, it would require that any tender scheme for offshore wind exposes offshore wind to capture price risk to enable the value of mitigating that risk to be traded in the market.

Introducing products to the market will only be effective if the technologies are cost effective. This measure therefore should not be considered alone as a solution to mitigating the cannibalisation effect, in practice it may be that is sits alongside Measure 5 with the intention that it takes over for particular technologies as they become cost effective.

If it is considered as a standalone solution the risk is that it could distract from bringing forward technologies that are desired but at least initially require some form of regulatory support.

Implications for the wider electricity/energy market (where relevant)

If implemented, any encouragement of time-shifting flexibility should help support system balancing as levels of intermittent generation increase. It could also reduce the need for regulatory intervention and so potential distortions to the electricity market.

Interactions with other possible measures

This measure should be considered in parallel with Measure 5, regulatory support for time-shifting technologies. In understanding whether markets could evolve it will be important to understand how close to market particular technologies are and the need for support to bring them to market. At least for some technologies, and hydrogen in particular, this is likely to be a first step to reaching sufficient maturity that they can be deployed without regulatory intervention.

In the meantime if products do evolve this could reduce the level of support required under Measure 5.

Cost and other practical implications

The cost of undertaking a study is relatively low.

A review should improve understanding of this relatively new area but there is the potential for the conclusions of a review to be unclear or even misleading. The challenge is that as it would be considering emerging technologies the knowledge base of stakeholders could be low making a constructive discussion more difficult. In addition it can be difficult to consider products that don’t yet exist.

One area of particular importance is the timing for introducing a product: too early and it fails due a lack of demand, too late and the market could become more dependent on support than necessary.

6.3.3 Measure 5 – Run joint tenders for offshore wind and time-shifting flexibility

This measure would directly link offshore wind capacity tendered to time-shifting flexible capacity, such as DSR, longer duration storage and hydrogen. This would provide a firmer method of ensuring sufficient time-shifting flexibility to pursuing ambitions for both in parallel under a roadmap.

It could be implemented by requiring that for every GW of offshore capacity tendered an appropriate level of time-shifting capacity is secured to at least partially mitigate the cannibalisation effects of the offshore wind capacity being tendered.

The link could be via two separate tenders, one for offshore wind and one for time-shifting flexibility, run in parallel to ensure that the volumes are consistent with one another. Or there could be a requirement on bidders for offshore wind projects to include the development of time-shifting flexibility as part of an integrated tender for both technologies.

If it is introduced as a requirement of bidders it gives offshore wind developers responsibility for identifying solutions to the cannibalisation problem at the same time the new offshore wind farm becomes operational. Combining investments in offshore wind and time-shifting technology may improve the potential for investment in time-shifting technologies and so increase uptake.

Implications for offshore wind tenders and the 2030 offshore target

If the two tenders were held separately, depending on the rules, it is possible offshore wind tenders could be held back if there were issues identifying time-shifting flexibility.

If tenderers for offshore wind projects and time-shifting flexibility were integrated it is likely to reduce the number of organisations able to compete for projects.

Challenges in finding organisations able to offer time shifting flexibility could be particularly heightened in earlier years due to a low capacity of time-shifting capacity in the pipeline.

Less competition for projects, or even the potential for no bidders, could make it more difficult for 2030 targets to be met or mean support would be higher (or simply non-zero) than it would be otherwise.

Furthermore, linking offshore wind to time-shifting flexibility could make the tender scheme for offshore wind more complex to administer.

On the other hand as with Measure 4, this measure would give investors in offshore wind projects operational by 2030 confidence that there will be greater ability to time-shift demand and supply in the market, thereby reducing capture price risk.

Implications for the wider electricity/energy market (where relevant)

If less offshore wind is tendered (including beyond 2030) it would slow the decarbonisation of the Dutch energy sector.

Interactions with other possible measures

This measure goes one step further than Measure 2 and provides a direct link between the increased volumes of offshore wind and the development of the necessary flexibility to accommodate the increased offshore wind volume.

At least in earlier years to gain sufficient interest tenders for time-shifting flexibility it is likely that support for time-shifting flexibility would also need to be offered (Measure 6).

If addition if the co-location of time-shifting flexibility and offshore wind are encouraged this may help optimise use of the onshore grid (Measure 8) reducing system costs.

Cost and other practical implications

It is unlikely to be possible to completely remove the cannibalisation impact of the additional wind with the tendered volume. There will be timing issues with deploying the levels of time-shifting capacity required before 2030, so this measure if pursued may be more appropriate once time-shifting capacity is better established in the Netherlands.

6.3.4 Measure 6 – Revenue support mechanism for time-shifting flexibility

Longer duration storage technologies such as hydrogen, mechanical storage and chemical storage are at the early stages of development[33] and so are not currently viable at commercial scale. This is because current costs may be too high and/or the technology has not been sufficiently demonstrated for the purpose of electricity storage[34] to give investors the comfort that it will perform as expected. Equally the potential for widespread Demand Side Response (DSR) has not yet been demonstrated.

Offering support for Demand Side Response and longer duration storage should enable learning and reduce costs in the same way it has for renewable electricity generation.

The revenue support mechanism would need to be carefully structured to incentivise DSR and longer duration storage that acts to complement the generation patterns from intermittent renewables such as offshore wind (i.e. beyond the 2-4 hours currently offered by lithium-ion batteries).

Implications for offshore wind tenders and the 2030 offshore target

The introduction of a support mechanism for DSR, longer duration storage and hydrogen will increase deployment of these technologies. If investors in offshore wind projects commissioning prior to 2030 have confidence that there will be greater ability to time-shift demand and supply in the market, it will reduce their perception of future capture price risk. This will support the business case for offshore wind generation which would help towards achievement of the 2030 offshore wind target.

Implications for the wider electricity/energy market (where relevant)

If demand and/or supply can time shift, the electricity system will benefit from the reduced need for additional system capacity. It should also help move towards a decarbonised electricity system replacing the need for high carbon peaking generation capacity.

Interactions with other possible measures

Support for time-shifting technologies could also allow for products to emerge to value time-shifting flexibility (Measure 3) if the technologies are exposed to arbitrage revenue risk.

Cost and other practical implications

Providing support to time-shifting technologies could be costly for consumers.

It could be complex to administer to ensure that incentives match the requirements of offshore wind and other intermittent technologies.

[33] With the exception of pumped storage which is very site specific.
[34] Some longer duration storage technologies (e.g. compressed air storage) use demonstrated techniques, but the components together have not been demonstrated for this purpose.

7. Interventions to support other revenue streams

The additional potential revenue streams to offshore wind considered in this chapter are revenues from Guarantees of Origin (GoOs) and ancillary services. Hydrogen provides another alternative revenue stream in the longer term, though as hydrogen could also help reduce the cannibalisation effect, measures to promote hydrogen are discussed in Chapter 6.

7.1 The potential for a bankable value of Guarantees of Origin

It is a requirement of EU law that all Member States have a Guarantees of Origin scheme. This is a mechanism for certifying the source and quantity of renewable energy produced each month. GoO certificates are generally purchased by suppliers from generators to meet the requirement under Full Disclosure that any declaration that consumers are supplied with renewable sources is backed by a GoO certificate. The value in GoOs comes from the willingness of consumers to purchase green electricity. Trades of GoO's have seen prices in the Netherlands in the order of €5-€10/MWh[35], values under long term PPAs are likely to be lower. GoOs offer a potentially valuable additional revenue stream but securing a long term bankable GoO value is challenging. The difficultly is that the number of GoOs in the market is expected to grow rapidly and it is not clear that the number of parties willing to pay a premium for the electricity will rise at the same rate. Greater numbers of GoO's will come from new renewable capacity both in the Netherlands and elsewhere in Europe. Potential ways to promote voluntary demand for GoOs include better availability of information on the source electricity supply, which whilst it is desirable from the perspective of greater consumer choice appears unlikely to would be sufficient to provide a long term bankable value.

The alternative to a voluntary market is to mandate the use of GoO's, with the most obvious mechanism being that they must be used to meet specified proportion of electricity consumption. This would be a form of support which brings its own challenges. Measure 7 offers an alternative form of requiring the use of GoOs specifically linked to uptake of electric heat and electricity and is discussed below, while ways to promote voluntary GoO demand are discussed in Section 7.1.2 and a wider supplier obligation scheme is discussed in Section 7.1.3.

7.1.1 Measure 7 – Require supported electric heat, transport or industrial processes to use low carbon electricity

To stimulate demand for renewable electricity the government could require that any support provided for electric heating or transport is only provided if the electricity used to run it is renewable electricity. This would directly link the electricity demand increases from the electrification of heat, industrial processes and transport to the generation of renewable electricity demonstrating that any transition away from high carbon primary energy source (e.g. natural gas or petrol) is replaced by a low carbon primary energy source.

Proof that the electricity has come from a renewable source will be necessary; one possible method to verify electricity has come from a renewable source is through Guarantees of Origin (GoOs).

Implications for offshore wind tenders and the 2030 offshore target

The requirement for renewable electricity to be used in the electrification of heat, industrial processes and transport would increase demand for renewable electricity and therefore the need for Dutch offshore wind generation. Requiring the renewable electricity to be verified with a GoO would also increase demand and therefore value of GoOs, offering an additional secure revenue stream for offshore wind.

[35] World Information Service on Energy, GvO Prices, https://wisenederland.nl/groene-stroom/prijslijst-garanties-van-oorsprong


WLL 650/1300 kg

Under the European State Aid Guidelines[36] it may not be possible to restrict the verification of renewable electricity to Dutch GoOs only, it may be necessary to open verification up to the wider European GoO market. If GoOs from elsewhere in Europe could be used to verify the renewable electricity there is likely to be sufficient availability to meet electric heat and transport consumption at little additional cost. Alternatively, another form of verification, other than GoOs, could be used to demonstrate electricity supplied to supported electrified heat and transport is from Dutch renewables. However, this could be complicated to administer and could also be subject to State Aid restrictions.

Implications for the wider electricity/energy market (where relevant)

The requirement for supported electric heat, industrial processes and transport to use low carbon electricity offers a co-ordinated approach to decarbonisation ensuring that electrification of heat and transport is truly low carbon.

Interactions with other possible measures

This measure is relatively stand-alone, although support for heat and electricity may indirectly be the result of the roadmap in Measure 1 or actions to keep it on track in Measure 2.

Cost and other practical implications

The requirement for supported electric heat, industrial processes and transport to use low carbon electricity verified with a GoO could increase the cost to consumers of electrifying heat, industrial processes and transport.

It would also add additional complexity in administering support for electric heat and transport technologies.

RED FLAG:
State Aid restrictions may require non-Dutch renewable electricity to also be eligible meaning little benefit to Dutch offshore wind.

7.1.2 Wider linking of GoOs to customers/ increasing visibility of GoO purchases

Full Disclosure requires customers to have access to the technology mix of their electricity. Any declaration of renewable generation has to be backed by GoOs. However, this still leaves much information about the generation unclear to consumers, including the renewable technology, country of origin, installation date, whether it's supported, time of day of generation, etc. In the Netherlands, it is possible for large consumers to access some of this information from CertiQ , a subsidiary of TenneT (the Dutch TSO), but this information is not available to smaller or domestic consumers.

Requiring more of this information to be available to consumers which (with the exception of the time of day of generation) forms part of the GoO certificate should help differentiate the value of different types of renewable generation. Our expectation is that unsupported Dutch offshore wind would be amongst the most desirable.

In addition, greater transparency over organisations renewable consumption could help encourage them to seek greener electricity. This could be achieved via publication of large commercial organisation performance on GoO's, particularly Dutch GoOs, in some form of 'green list' 'This would be centrally available identifying or ranking renewable electricity consumption by large organisations supporting consumers' capability to choose a 'green' company. Although the intention is that such a scheme would increase demand for Dutch GoOs, it is not clear how much value this would add in practice[37].

[36] Guidelines on State Aid for Environmental Protection and Energy 2014-2020, European Commission, (2014/C 200/01) – The current guidelines are due to expire at the end of 2020 but the EC intends to prolong the guidelines for a further 2 years (until end 2022).
[37] A similar scheme in the UK – the Carbon Reduction Commitment Energy Efficiency scheme which ranked organisations according to action on energy efficiency proved ineffective after the few years according to the evaluation of the scheme.

7.1.3 Supplier obligation/renewable e-mixing obligation

A supplier obligation or renewable e-mixing obligation would mean putting an obligation on suppliers or customers to source a proportion of their generation from renewables. Similar schemes have been operated in a variety of countries across Europe and beyond[38]. Typically, some form of proof of origin (i.e. green certificates) is used to demonstrate compliance and a financial penalty for non-compliance is used to encourage progress towards targets. The financial penalty is what provides these green certificates with a value and so an additional form of revenue for renewable generators. The value of certificates tends to fluctuate in response to shortfall between the amount of generation and size of the obligation.

Obligation schemes are an attractive proposition because they provide a direct connection between incentivising renewables and future renewables ambitions. However, as Green Certificate schemes involve payment from consumers to generators they are considered a form of subsidy and would require State Aid approval[39]. In addition, as a form of subsidy it could be less effective at improving the offshore wind business case than alternative forms of support (e.g. a one or two-way Contract for Difference scheme) as it does not offer the price certainty that helps bring down financing costs.

7.2 The potential to uncover value from ancillary services

Additional revenues may be available to offshore wind generators by providing system balancing services, however there are barriers to be overcome.

Most wind turbines, both currently installed and new models, have the technical capability to provide downward frequency reserve services by decreasing their output. Upward response/reserve services are also technically possible, with upwards Frequency Containment Reserve provided by synthetic inertia emulators and upward Frequency Restoration Reserves possible while the turbine is operating at less than maximum output.

Wind turbines can generally also meet frequency reserve product technical characteristics in terms of timings, and other criteria.

Historically, ancillary service provision has not been a commercially viable option for wind. When TSOs have tendered for a reserve or response type of product, applicants have been required to be able to provide symmetric reserve or response. However, wind may not necessarily be able to be responsive in terms of increasing production unless already curtailed at its own cost and generally is also self-curtailing to decrease production, resulting in reduced revenues and loss of subsidy support. Furthermore, TSOs would typically buy reserve relatively far ahead and even with increasing accuracy, wind forecasts are highly uncertain, especially far in advance.

However, under the revisions outlined[40] to be implemented as part of the Electricity Balancing Guideline[41], generators will be able to provide separate products that are either a downward or an upward service. As part of the changes, the requirements are also moving towards procurement far closer to real-time and shorter commitment periods, such as moving towards the day-ahead stage, when wind forecasts are more accurate than (for example) a week or more in advance. If these rules changes are adopted, this may become a more credible source of additional revenues for wind. Nevertheless, we would expect the proportion of revenues earned from ancillary services to remain low in future.

[38] Including the UK, Italy, Poland in Europe and Australia, California and Japan more widely.
[39] Green Certificate schemes are permitted under the State Aid Guidelines, provided it does not result in overcompensation nor dissuade renewable energy producers from becoming more competitive
[40] Over the course of 2019, TSOs and ENTSO-E are drafting proposals regarding the implementation of the various constituent elements of the Electricity Balancing Guideline.
[41] EU Commission Regulation 2017/2195, November 2017.

8. Interventions to keep costs down

The main project costs are capex and opex costs and financing costs. All three are considered in this Chapter. There are also other system costs which cover the costs of installing and transporting generation to the system..

8.1 Options for reducing capex/opex costs

The Netherlands already has several measures in place to aid the pathway to lower development costs ('devex'), capital costs ('capex') and operating costs ('opex') for offshore wind. Possible measures to (further) explore:

- **Technology standardisation:** Through collaboration amongst industry participants, offshore wind could be further standardised, thereby boosting productivity whilst maintaining competitiveness. This could streamline the production, installation and maintenance of wind turbines and sites, facilitating cost reductions in those areas.
- **Pipeline visibility:** Providing forward visibility within the offshore wind sector (from the developers) to the supply chain is important. This way, the supply chain can plan, making provision for new capacity or skills as required; and parts can be ordered in bulk, allowing cost savings via economies of scale.

This can also be further supported through having a high degree of certainty that tender rounds will take place (announced by a clear schedule with demonstrated commitment over time), provided by the RVO (Rijksdienst voor Ondernemend Nederland, Netherlands Enterprise Agency) and Dutch Government.

- **Harmonisation of member state rules around wind connections:** The setting up of wind farm site connections to multiple countries or via hybrid interconnections could be more standardised. In particular this has the potential to benefit the development hybrid interconnections if both parties have the same arrangements. It may also allow a more streamlined approach for developers/projects looking to work across EU member states and may save on devex fees (e.g. seabed and other surveys). In practice, it may be difficult to reach agreement on a consistent approach and it is possible the agreed approach could be considered worse than the existing one by developers and potentially policy makers. The benefits are also unlikely to be material to the business case.

8.1.1 Measure 8 – Optimisation of the onshore grid

The connection of substantial offshore wind capacity and the injection of associated generation output into the system together have the potential to trigger the need for reinforcement of the onshore system and/or congestion management. Investment to reinforce the system creates a cost for consumers. This measure focuses on initiatives to encourage more efficient use of the onshore grid in order to moderate investment requirements where possible in order to limit the cost to consumers. The aim is to encourage siting of demand load and sources of flexibility in areas of the system that complement the connection of the anticipated offshore wind capacity. This could include, for example:

- steps to enhance connections and grid reinforcement policies to appropriately reflect the wider network context to, for example, improve complementarity between offshore wind connections and siting of new large electricity users to avoid the need for system reinforcement;
- ensuring that network charging does not place artificial barriers in the way of coordinating the locations of offshore wind and complementary demand; and
- publication of 'heat maps' to identify and flag the areas of network that are favourable for connection of demand or flexible resource, taking expected offshore connections into account.

Implications for offshore wind tenders and the 2030 offshore target

As part of the Dutch Offshore Wind Roadmap, TenneT has analysed the capacity on the onshore wind grid to ensure there is enough capacity to meet the 2030 target. Initiatives considering higher levels of capacity that help to support efficiency in both the use of the network and further investment in it have the potential to:

- ease possible onshore congestion and reduce the scale of constraint management actions that TenneT needs to undertake to manage the system; and
- allow for faster connection or avoid delays to connection if, absent these initiatives, more substantial network reinforcement would be required to accommodate the offshore wind connections.

Focusing on the implications for offshore wind, these initiatives have the potential, therefore, to reduce possible curtailment of offshore wind resulting from capacity beyond the 2030 target, which can also impact on the Dutch Offshore Wind Roadmap capacity. It should also allow for earlier connection of projects beyond 2030 than may otherwise be the case. Both potential outcomes are beneficial for delivery of offshore wind.

Implications for the wider electricity/energy market (where relevant)

Initiatives to support more efficient use of, and investment in, the network should also deliver benefits to the wider market. Improvements in the efficiency of investment in network reinforcement or extension should help to moderate grid investment costs and so associated costs to consumers. Similarly, this should help to manage onshore grid congestion and constraint management costs which are also borne ultimately by consumers.

Interactions with other possible measures

The types of initiative being considered here are expected to be consistent and compatible with others, such as the development of roadmaps for electric heat, electric transport, hydrogen and flexibility (Measure 1) and also the potential for coordination between tenders for offshore wind and for flexibility (Measure 5).

Cost and other practical implications

Our expectation is that this initiative will require relatively small scale revisions to connections and network charging policies and planning processes to allow for a more cohesive, system wide approach in the round.

While it may be relatively simple and low cost to implement, the expected savings linked to more efficient grid investment and congestion management have the potential to be substantial.

8.2 Options for reducing financing costs

Ensuring risk is allocated appropriately and reduced where possible will be key to encouraging new finance into the sector. Possible measures include:

- ensuring financing structures are as efficient as possible, by matching the financial characteristics of projects as closely as possible to investors requirements;
- putting in place market based hedging mechanisms, including corporate and utility Power Purchase Agreements (PPAs); and
- explicit support through policy measures.

These options are discussed in turn below.

8.2.1 Measure 9 – Coordinated discussion on innovative financing structures

To reach 2030 targets and allow subsequent growth in the offshore wind sector, new sources of capital will need to be tapped. In order that this new capital can be drawn into the sector, the current range of financing structures may need to be broadened to allocate risk appropriately and meet the investment or lending criteria of new participants.

This measure would therefore promote coordinated discussions between current industry participants and potential future providers of equity and debt to consider what sort of financing structures might be required to access new pools of capital.

Without wishing to prejudge the outcome of such discussions, it seems likely they would consider a range of possible measures, which could include options such as:

- alternative models for the allocation of risk between future investors and lenders;
- options for easier entry/exit for financing parties (e.g. tradeable instruments/
- securitisation of debt);
- the potential role of government-backed institutions such as the European Investment Bank ;
- the possible role for a 'green investment bank' to stimulate marginal investment opportunities;
- a potential role for insurance companies to cover 'tail-risks'.

Whilst these discussions may eventually happen naturally without intervention (indeed, they may already be taking place on a limited bilateral basis), they could be accelerated by a more coordinated approach facilitated by government and/or industry so that potential solutions (and barriers to their implementation) can be identified and developed more quickly. Bringing a wide range of parties together at an early stage, a common understanding of available risk allocation models would also help build knowledge and increase comfort levels within possible future providers of capital.

Implications for offshore wind tenders and the 2030 offshore target

In addition to allowing more finance to be brought into the sector, more optimal financing structures could also reduce the overall costs of capital faced by future projects. This in turn could lead to higher levels of offshore wind deployment, increasing the chance of meeting 2030 targets without regulatory intervention, and/or lower cost to consumers.

Implications for the wider electricity/energy market (where relevant)

Multilateral discussions of financing structures could potentially be extended beyond offshore wind, which could benefit other types of renewables and other capital-intensive green technologies (e.g. hydrogen).

Interactions with other possible measures

The discussion on innovative financing structures has interactions with investigating the potential for, and barriers to, long term hedging products (Measure 10) as future financing structures may drive a requirement for new hedging instruments; conversely, development of new hedging instruments may open up new financing options.

It also has interactions with using a regulatory measure to reduce financing risk (Measure 11) as ultimately, the outcome of discussions on financing structures could be a conclusion that some degree of regulatory risk mitigation is a necessary or more cost-effective means of attracting capital into the sector.

Cost and other practical implications

The costs of coordinating and facilitating multilateral discussions between the industry and potential new sources of capital are likely to be low.

The practical challenges will include:

- ensuring sufficient representation from all interested parties, including those not currently involved in the sector; and
- managing productive discussions between parties with potentially conflicting interests,(e.g. those already active in the sector may welcome inflows of capital to their projects, but not the potential for increased competition from new entrant competitors).

Ultimately, however constructive discussions are, it may not be possible to identify viable solutions without also using other mechanisms to reduce risk.

8.2.2 Measure 10 - Investigate the potential for, and barriers to, long term hedging products

The greater the revenue certainty for a project, the lower financing costs should be. This measure considers potential market-based solutions to this, while Measure 11 considers the regulatory solutions.

There are two main revenue uncertainties faced by an offshore wind developer, baseload wholesale prices and capture rates. Under this measure a review would be undertaken to identify the potential for long term hedging of both aspects either together or independently.

Parties that benefit from opposing prices movements and want long term price certainty offer a natural hedge to offshore wind. Natural hedges include consumers that desire low prices where offshore wind desires high prices and time-shifting technologies that desire large differentials between peak and trough prices, where offshore wind desires small differentials.

A review would need to explore with relevant stakeholders what the different parties desire, what options could be used to match their needs and how it could be implemented (e.g. by facilitating a market). Once scoped out it will also be critical to understand whether the options are viable, including what the potential demand might be on both sides, whether that could result in sufficient value for both parties and the timescales for reaching this point.

The options could range from bilateral contracts e.g. corporate PPA's or tolling contracts, or financial products enabling longer term hedging.

Implications for offshore wind tenders and the 2030 offshore target

Undertaking a study would in itself have little impact on offshore wind tenders or the 2030 target.

If it was agreed that the availability of hedging contracts or products could be increased, it would require that any tender scheme for offshore wind exposes offshore wind to capture price risk (as is currently the case) to enable the value of mitigating that risk to be traded in the market.

If it resulted in contracts or products offering greater revenue certainty to offshore wind it would help keep financing costs down and improve the chance of the 2030 target being met.

Implications for the wider electricity/energy market (where relevant)

If a wider hedging market were to emerge, possible counterparties to hedging contracts of products should also benefit from it. This includes the encouragement of long duration storage which is discussed in Measure 3.

Interactions with other possible measures

Measure 3 is an option for the counterparty to capture price risk. Measure 11 provides a regulatory solution to the same problem as this measure.

Cost and other practical implications

The cost of undertaking a study is relatively low.

A review should improve understanding of this relatively new area but as with Measure 3 there is the potential for the conclusions of a review to be unclear or even misleading. It is also not immediately obvious beyond corporate PPAs and some form of contract with longer duration storage what potential hedging opportunities exist. If there is limited demand from these areas then the number of projects able to benefit from this hedging will also be limited.

RED FLAG:
The desire to find a market solution, if ineffective, could mean that in unfavourable market conditions, regulatory price stabilisation is not implemented in time for 2030 targets to be met.

8.2.3 Measure 11 – Use a regulatory measure to reduce financing risk

It is not uncommon for large capital investments to have some kind of government backing to enable the raising of finance. This is because it can sometimes be more cost efficient for the Government or end-users to bear at least some of the price risk and for larger and riskier projects it may not be possible to find finance at all.

In relation to offshore wind, it has been the international norm to date to use regulatory intervention to keep financing costs down for offshore wind. As offshore wind was previously a higher cost option this purpose has tended to be the result of a support scheme which also provides revenue over and above the market price. Now that offshore wind costs are becoming competitive with other technologies the focus is beginning to switch towards regulatory intervention as a means of providing protection from downside risks to revenues.

Regulatory intervention could take many forms, for example:

- capital support – providing a government grant to fund part of the capital cost of the project;
- a regulated asset base model – allows the operator to recover the cost of the investment by charging a regulated price for use of the infrastructure; or
- a revenue stability mechanism – for example, providing a guaranteed level of income per MWh of electricity produced or a floor to revenue from the electricity market.

The relative merits of each option would need to be considered in relation to the main objectives of the intervention. Capital support avoids too much interference with the wholesale electricity market but does not provide much incentive to generate, conversely a price stability mechanism provides a greater incentive to generate but involves greater potential for distortion with the wholesale electricity market. A regulated asset base model can attract a wide range of finance but has a heavy regulatory requirement.

Within each overall model there are also many design options. For example features of a price stability mechanism include whether to offer wholesale price, capture rate certainty or both, the length of the agreement and whether to offer a fixed or floor (and cap) price.

Implications for offshore wind tenders and the 2030 offshore target

Depending on the design it may require change to the design of the current offshore wind tender scheme e.g. capital support or a regulated asset based model could require different timing of the tenders.

Reducing the financing risk will reduce the cost of projects, making projects more likely to come forward in the first place, and so more likely 2030 targets will be met.

Perhaps more importantly though, regulatory intervention provides a clear means of enabling 2030 targets to be met in the instance that progress is falling behind. This is because in this instance it provides a mechanism to intervene to make investments more attractive.

Implications for the wider electricity/energy market (where relevant)

The issue with regulatory solutions is that they can distort the normal operation of the electricity market and consequently the signals to invest in particular technologies or generate from existing plant. In addition, they have the potential to impact on the revenues of existing plant.

In general, the more intervention in the market, the more investors in all technologies become concerned about the impact of regulatory risk making them less reluctant to invest.

The nature of any market distortion would depend on the design of the scheme.

Interactions with other possible measures

If more innovative financing measures (Measure 9) and market based hedging solutions (Measure 10) are identified it could negate the need for regulatory intervention (in the instance the market does not evolve as anticipated in the Reference Scenario).

There is also the potential for this measure to suppress a move to more innovative financing or market based hedging options. So the design of any regulatory intervention would need to take this into consideration.

Cost and other practical implications

Regulatory intervention can provide greater price stability for consumers e.g. with a RAB or price stability mechanism with a cap and floor. Whether actual costs for consumers are higher or lower than without intervention depends on the level of support in comparison to wholesale market prices. So if wholesale electricity prices are high, costs to consumers are likely to be lower as the generator either pays money back to consumers or the regulated returns are lower than the wholesale electricity price. Conversely, if wholesale electricity prices are low, costs to consumers are likely to be higher.

RED FLAG:
The design of any scheme would need careful consideration to minimise distortions to the market, and potential for over payment by consumers

Conclusions

That offshore wind projects have been tendered at zero-subsidy in the Netherlands demonstrates a huge achievement within the industry in bringing costs down over the last decade. The technology itself is continuing to improve with ever larger turbine sizes and adaptations to enable exploitation of a wider range of sites. There is potential for cost reductions to continue. With the increasing push towards decarbonisation around the world, the opportunity for offshore wind is vast. Organisations are understandably keen to establish their position in this market and develop their skills and knowledge to benefit from the opportunity.

It is, however still early days. No country has yet achieved 11GW of operational offshore wind, the 2030 target for the Netherlands. No merchant project has yet been commissioned (although the first is expected in 2022). So there is relatively little experience within the investment community of the risks involved. There is also pressure to take greater risks than may otherwise be the case as securing strategically important offshore wind sites across Europe increasingly requires participation in tenders. These can be highly competitive given the current interest in offshore wind. Tenders have many benefits and have been a considerable driving force behind cost reductions, but it should also be remembered tenders do not always deliver[42].

The Klimaatakkoord Sector Tables raised the question of whether the development of merchant offshore wind projects in the Netherlands was sustainable, leading to the commissioning of this study. Our modelling suggests that they were right to raise this question. Projects currently appear to be going ahead despite relatively low expected returns for merchant investments. If this is for strategic reasons, zero-subsidy offshore may indeed not be sustainable in the longer term, particularly as the pool of capital investors are willing to commit at these return levels is likely to be limited. Over time investors may increasingly be attracted to alternative markets where returns are more secure.

There is some cause for optimism though, if capex and opex costs continue to fall rapidly returns will improve over time attracting a wider range of investors. To increase the chances of these higher returns other interventions can be made to shore up revenue streams. This includes ensuring demand and supply grow in tandem and encouraging deployment of time-shifting technologies such as hydrogen and demand side flexibility to enable offshore wind to capture a greater proportion of the value in the wholesale electricity market. Increases in financing costs may also be at least partly tempered by acceleration of innovative financing arrangements and developing risk management products better suited to intermittent generation.

[42] The offshore wind tenders in the Netherlands are not determined on price, however, there could still be competitive pressure to secure projects if bidding at zero subsidy would mean marginal returns – which is a feasible scenario based on the modelling under this study.

Ultimately, there remains the risk that if returns progress as anticipated under the Reference Scenario outlined in this report and there are high levels of competition for finance, or some of the downside risks emerge, policy intervention will be necessary to offer price stabilisation or an alternative form of regulation to reduce financing risk to ensure 2030 targets are met.

Requiring the Government or end-users to take on risk for large infrastructure investments is not unusual. This is seen in the building of roads, shipping, airports etc. This is because Governments and end-users are generally better able to absorb the risks by socialising them across a large proportion of the population. This has the potential to lead to considerably lower financing costs and so can mean lower costs for consumers overall. The challenge is always avoiding distortion to the market with unintended negative consequences.

The foresight of the Dutch Government in commissioning this study should put the Government and industry in a better position to identify and put in place measures to address risks in a timely and efficient manner. The importance of this is clear from the many examples in the history of renewables policy across various countries where risks have not been identified early, with damaging consequences for the renewables industry[43].

There are many questions still to be answered such as the form of any intervention, and its timing particularly if the Government or end-users are to take on some of the financing risk. Particular consideration should be given to whether a policy 'back stop' should be put in place from the start or only initiated once there is a sign of trouble.

In addition, this study has focussed on the business case for merchant offshore wind. In practice decarbonisation will require the deployment of a wide range of low carbon technologies. Many of these will impact on the offshore wind business case (e.g. electric vehicle and heating technologies, storage and technologies to better enable demand side flexibility), and they are also likely to impact on the business case for other technologies. Any policies designed to support offshore wind will therefore need to be considered in this wider context.

Amongst all these factors, one thing is not in doubt – the energy market will continue to evolve, the immediate outlook and balance of risks will change. Ensuring that the regulatory environment is sufficiently supportive for offshore wind to meet 2030 targets without causing undue costs to consumers or distorting the electricity or wider energy market remain a challenge. A continued dialogue between Ministerie EZK and the offshore wind industry is likely to be required to reach the desired result.

[43] In the case of the Dutch auction schemes, the risk identified is that the business case becomes unviable, which if not caught in time, could mean either targets are not met, or confidence in future investments towards the 2050 decarbonisation target are damaged.

ANNEX A – AFRY'S ELECTRICITY MARKET MODEL, BID3

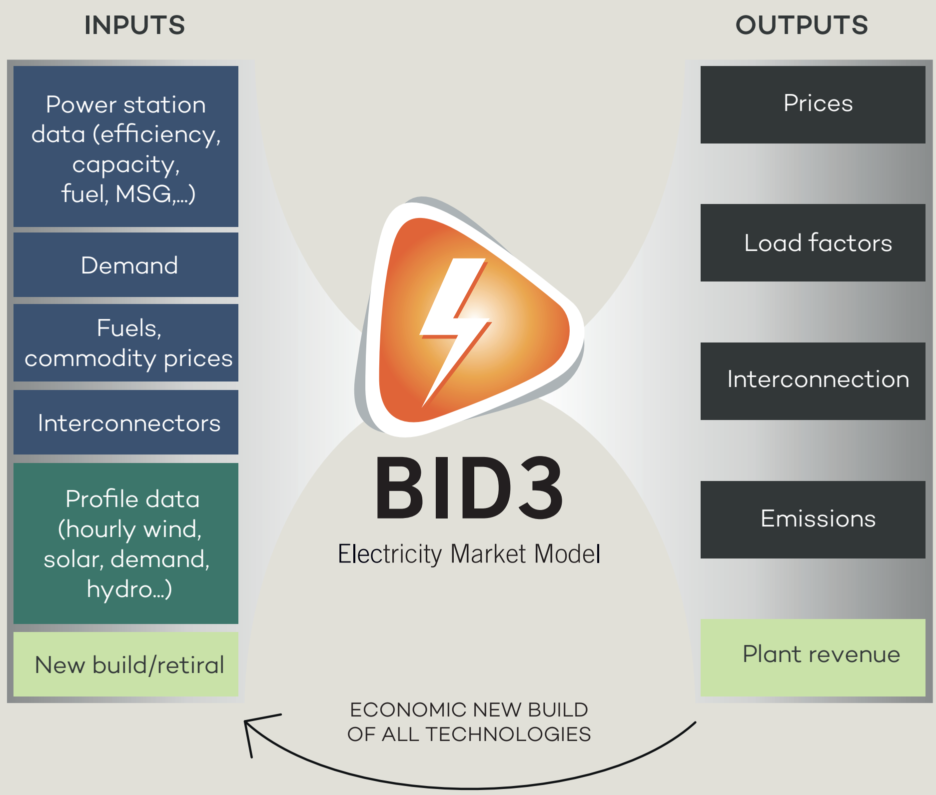
AFRY's electricity market model, BID3, was used to project the baseload wholesale electricity prices and offshore wind capture prices using sets of given inputs that were the foundations of the Reference Scenario and the various sensitivities. The capture prices were then used as one of the inputs for our Investment Appraisal Model as discussed in Chapter 3.

BID3 provides a simulation of all the major power market metrics on an hourly basis – electricity prices, dispatch of power plants and flows across interconnectors. It works in an interactive manner with our commodity market, heat and transport models, receiving the commodity prices, as well as the demand for heat and transport from; and feeding back the power demand for the commodities and the electricity prices to these models.

BID3 is an economic dispatch model based around optimisation. It simulates the hourly generation of all power stations on the system, taking into account fuel prices and operational constraints such as the cost of starting a plant. It accurately models renewable sources of generation such as hydro, reflecting the option value of water, and intermittent sources of generation, such as wind and solar using detailed and consistent historical wind speed and solar radiation.

The result of this optimisation is an hourly dispatch schedule for all power plants and interconnectors on the system. At the high level, this is equivalent to modelling the market by the intersection between a supply curve and a demand curve for each hour.

FIGURE 26 – AFRY'S ELECTRICITY MARKET MODEL, BID3



ANNEX B - MODELLING ASSUMPTIONS

Key input assumptions

FIGURE 27 – KEY INPUT ASSUMPTIONS FOR THE REFERENCE SCENARIO

Input	Unit	Source	2020	2025	2030	2035	2040	2045	2050
Gas	EUR/MWh, real 2018	IEA, World Energy Outlook, 2018	19	21	22	23	24	24	24
Coal	EUR/tonne, real 2018	IEA, World Energy Outlook, 2018	74	71	74	74	75	75	75
Carbon	EUR/tCO2, real 2018	PBL, Effecten Ontwerp Klimaatakkoord, 2019 & NGC, 2018	21	31	46	57	67	79	92
Total demand (minus hydrogen demand)	TWh (converted from PJ)	(Up to 2030) PBL, Effecten Ontwerp Klimaatakkoord, 2019 (Post 2030) PBL, Verkenning van Klimaatdoelen, 2017	115	120	125	170	216	261	306
Offshore wind CAPEX	EUR/kW, 2015 real	Danish Ministry, 2018	1920	1785	1650	1575	1500	1450	1400
Offshore wind OPEX	EUR/kW/yr, 2015 real	Energinet, 2018	60	55	50	49	47	45	43
Offshore wind capacity	GW	AFRY Management Consulting	2.5	6.0	11.5	13.5	17.5	25.5	30.5

Note: Grey indicates interpolated values; installed capacities are shown for the Netherlands only. For offshore wind post 2030, the installed capacities are output values (shown in blue) and it is assumed that the connection costs continue to be covered. Euro values in real 2015 were all converted to real 2018.

Other assumptions on new generation capacity:

- Offshore wind was assumed to meet the 2030 target and then was subject to an economic test and so values beyond 2030 are outputs from the electricity market modelling.
- Onshore wind capacity was capped at 10GW.
- In the Netherlands, to align with the then proposed Bill on the Prohibition of Coal for Electricity Generation (Wet verbod op kolen bij elektriciteitsproductie), of the remaining 4.1GW of coal plant (and coal CHP, combined heat and power) on the system, 1.5GW was assumed to convert to biomass and the rest to close after 2029.
- Other new capacity in the Netherlands was subject to economic tests.

Other assumptions on electricity demand in the Netherlands

- Hydrogen has been separated out from the electricity market modelling and is analysed under the bespoke investment appraisal modelling.
- It was assumed that 6TWh of demand is flexible in 2020 rising to 70TWh by 2050.

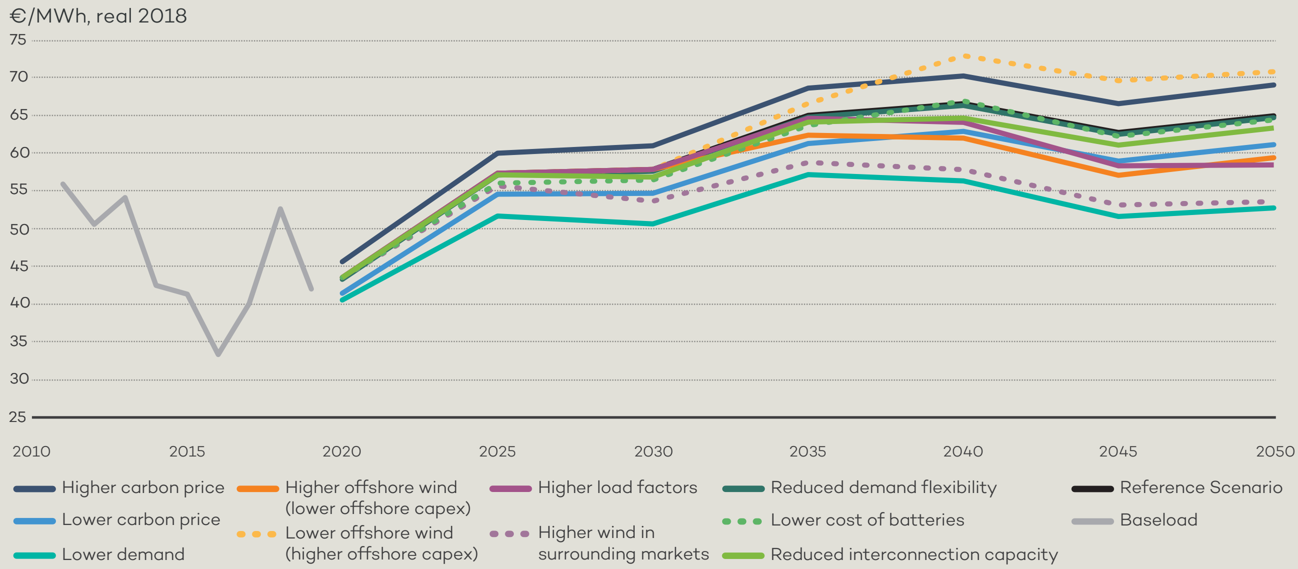
Key policy assumptions in surrounding countries

- Coal phase out in Germany was assumed to result in all coal and lignite plants closing by 2038;
- Nuclear capacity in France was assumed to fall from 63 GW in 2025 to 36 GW in 2050.

ANNEX C - MODEL OUTPUTS

Baseload prices under Reference Scenario and all sensitivities

FIGURE 28 – WHOLESALE ELECTRICITY (DAY-AHEAD) PRICES FOR THE NETHERLANDS, (€/MWH)



Capture prices and rates under Reference Scenario and all sensitivities

FIGURE 29 – CAPTURE PRICES (€/MWH) FOR OFFSHORE WIND IN THE NETHERLANDS AND HISTORICAL BASELOAD PRICES FOR THE NETHERLANDS

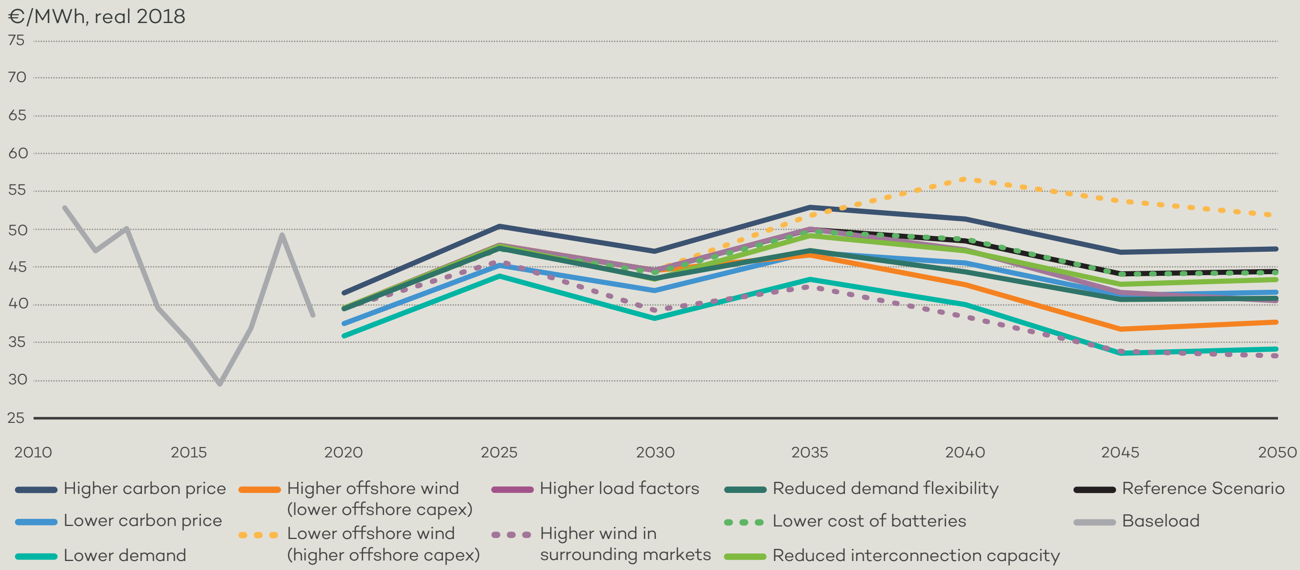
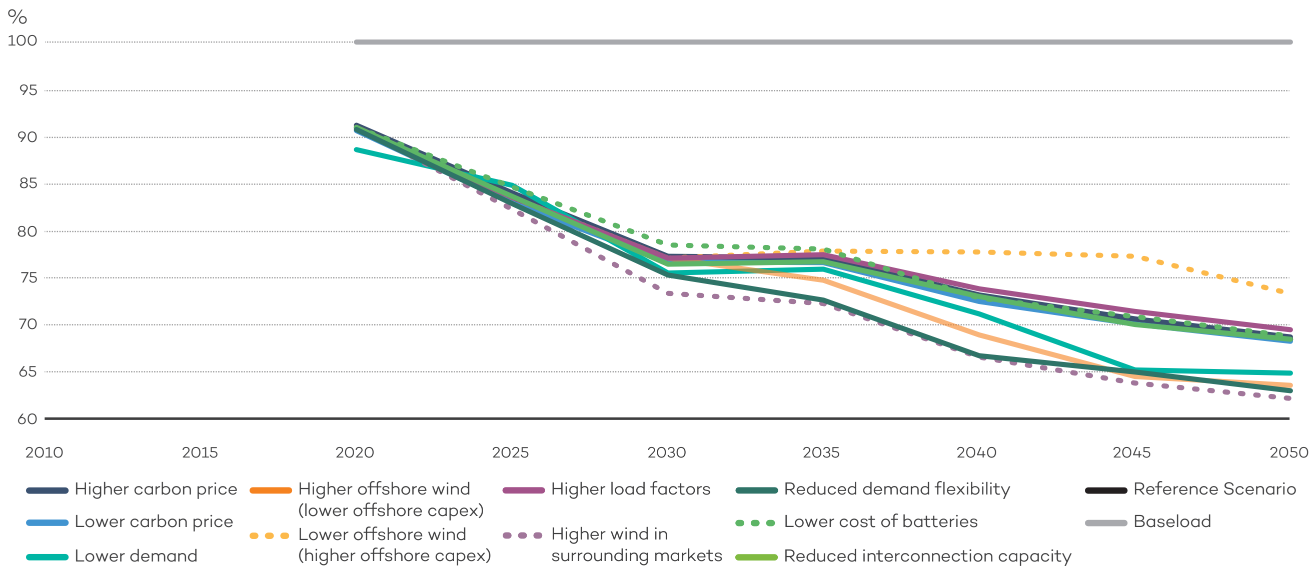


FIGURE 30 – CAPTURE RATES (%) FOR OFFSHORE WIND IN THE NETHERLANDS



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