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Norwegian Offshore Wind Auctions

Strategic Recommendations for Phase 1 of Sørlige Nordsjø II

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Preface

This report marks the initial deliverable from the advisory project on designing the auction for wind power capacity at Sørlige Nordsjø II. Sørlige Nordsjø II is the first auction for wind power capacity in Norway, and Vista Analyse carries out the advisory in a collaboration with Guidehouse and Procurex.

The report is a high level study on strategic choices to be made in the design of the auction. Authors are with Vista Analyse and Guidehouse. Marty Barclay from Procurex has provided peer review on chapter 3. Cassandra Velten has been the main contact point at the Ministry. We thank her and the Ministry team for a good cooperation with constructive discussions.

November 18th, 2022.

Haakon Vennemo
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Executive Summary

We provide advice on the design of the auction for phase 1 at Sørlige Nordsjø II. A two-sided CfD and upfront investment support are feasible schemes with pros and cons, but upfront investment support has not been much used in past auctions. If a CfD is chosen we recommend a long reference period. We recommend that the auction should be 'Anglo-Dutch', that is, a period of open bidding followed by a final sealed bid from the top two bidders.

Auctions of offshore wind energy are coming to Norway

Auctions to allocate acreage for renewable energy production are fairly common across Europe and North America. In some auctions bidders indicate the highest price they are willing to pay. In others they indicate the lowest support they are willing to receive, and in some it is not determined beforehand.

Norway has decided that auction is the main model for allocating acreage for offshore renewable energy production. The initial auction will comprise Sørlige Nordsjø II. Sørlige Nordsjø II is developed in two phases, each with a capacity of 1500 MW, and there will be one auction for each phase.

Presently the Ministry is preparing for the auction of 1500 MW at Sørlige Nordsjø II phase 1. The Ministry has set "an efficient allocation of the licenses to be auctioned, with the purpose of realizing the highest sum/lowest support" as the objective for the auction. Vista Analyse, Guidehouse and Procurex have been engaged to help set up the auction. This report is the first deliverable of our engagement.

In the report we primarily discuss which support scheme to use, and which auction format to use. By support scheme we mean whether the object of the auction should be investment support, the electricity price or something else. By auction format we mean whether the auction should be of the sealed-bid type, or ascending type, or some other type.

The auction at Sørlige Nordsjø II is to be preceded by a pre-qualification stage. In the final chapter of the report we provide comments on pre-qualification and other regulatory elements (grid connection, penalty framework, timing) from the perspective of the auction.

Both upfront investment support and a two-sided Contract for Difference are viable support schemes

While there are several possible support schemes, we find the two-sided Contract for Difference (CfD) and upfront investment support to be the two most promising candidates for Sørlige Nordsjø II phase 1. An auction for upfront investment support simply asks bidders to state the lowest level of support they are willing to receive for the acreage, or, if the auction crosses zero, the highest amount they are willing to pay for the acreage. Support or payment is carried out prior to operation and possibly prior to investment.

An auction for a two-sided CfD asks participants to state the lowest price they accept for their production. The state will guarantee that price and takes on most of the market price risk. The winning bid may imply a CfD price that is higher, or lower, than the expected market price. A high CfD indicates support.

Upfront investment support has the advantage of not distorting the design and operation of the wind energy plant. The CfD, by contrast, partially or wholly (depending on various adaptations) shelters the operator from information about market conditions inherent in the price signal. A CfD with a short reference period means that the operator effectively faces a fixed price. A CfD with a long reference period ensures that the operator faces short term price signals, whilst removing risk from long term fluctuations in the electricity price.

The most important advantage of the CfD contract is that it reduces uncertainty about future income. This reduces the risk that the winning bidder finds that it has overestimated the future income from the project, and defaults, abandons or delays the project.

If the developers have a higher cost of risk than the Norwegian government, a CfD scheme has the further advantage that it transfers market price risk from the developer to the government. We note on this point that a CfD probably will reduce the cost of financing for the winning bidder, but this is by itself not a sure sign that the bidder faces a higher cost of risk. A change from an uncertain to a certain income stream should always reduce the cost of financing, no matter who experiences it.

The upfront investment subsidy is rarely used in renewable energy auctions, while the two-sided CfD is common. The reasons for the relative popularity of CfD seem to be that the financing cost of the bidder goes down, and the risk of defaulting on the project is lower. There also seems to be a liquidity concern, especially whenever the auction turns into a payment mode. If the winning bid is a payment, the investor of the upfront scheme will have to fund both the physical installation and provide payment to the state at the same time.

If a CfD is chosen, we recommend an annual reference price. An annual reference price insulates the operator from deviations to the annual price trend, which arguably matters the most for long-term profitability. But it exposes the operator to seasonal price volatility, which is important for operational choices. In effect an annual reference price significantly reduces the distortionary impact of a CfD and removes most the objection to the scheme from the objective of market integration.

We also provide advice on the maximum support implicit in the CfD-contract, the length of the contract, and price indexing. We advise against a maximum payment from the winning bidder, and we recommend that the cap on payments from the state to the developer is set sufficiently high as to not be binding for the winning bids.

We recommend an Anglo-Dutch auction

In ideal circumstances all auction formats give the same outcome. In practice, however, which format to use is important for the success of the auction.

Open bidding for the CfD price is considered to yield a lower price (or lower investment support) than other auction formats, and are called efficient. In an open-bid system the auctioneer declares a (high) reservation or ceiling price and participants bid lower prices in succession until one bidder obtains the winning bid. (Confusingly this format is called the ascending type). Another advantage of the format is that participants may learn from bids of others what the true value of the object might be. Learning from others will reduce the risk that the winner defaults on his obligations and the project is not carried out. This is particularly valuable when the object is unfamiliar and there is significant market uncertainty, which is likely the case in the auction for Phase 1 of Sørlige Nordsjø II.

An alternative to the open bids of the ascending type auction is the first-price sealed bid auction whereby bidders put in one bid for support, the lowest bid wins, and the winner receives the support level that she asked for. This format is the most common renewable energy auction format, to the extent that it is not always considered an auction, but a tender (perhaps particularly so when combined with other criteria).

The sealed bid auction has some advantages over the open bid ascending type. In particular, it makes sure that the winner receives the minimum support he himself is willing to receive (as opposed to that of the second highest bidder in an open format (ascending type)). This is particularly important since Sørlige Nordsjø II is a "flagship type" auction. In an ordinary first-price sealed bid auction bidders are expected to "shade" their bids, i.e. bid lower than their true valuation in order to gain some profit for themselves. In a flagship type auction bidders are expected to be risk-averse and will not risk shading their bids. In other words we expect the winner in such an auction to bid his true valuation.

The auction format we recommend combines attractive features of both the open- and final bid formats. We recommend open bidding that is stopped when two bidders remain. These two bidders are then allowed a final sealed bid, which determines the outcome. The efficiency of this format (i.e. support level) is theoretically almost as good as fully open bidding (ascending type). In fact, efficiency can be better if the final bidders are risk averse and determined to win the auction. Further, the risk of collusion is lower when final bids are sealed, and it has been shown that the format attracts more participants than other formats.

Open bidding followed by a sealed bid is a fairly common format in commercial auctions around the world. In the economics literature is known as an 'Anglo-Dutch' format. Practitioners sometimes call it a 'final blind' auction.

The reservation or ceiling price is an important feature of the auction format. We recommend basing the reservation price on the current LCOE (levelized cost of electricity) estimate for offshore wind at Sørlige Nordsjø from NVE, with a reasonable margin.

The ultimate sign of success is that the wind-farm produces electricity

A successful outcome of the auction is not guaranteed until the wind-farm begins operation. To put it differently the auction would ultimately be a failure if the wind-farm is not built. With a slight misrepresentation of theory we denote the risk of non-operation as the winner's curse. Minimizing the risk of the winner's curse should be emphasised both when choosing the support scheme and the auction format, and we have phrased our recommendations accordingly.

In a strategy to reduce the risk of winner's curse the Ministry can also help by removing uncertainty about common costs and regulatory elements. The Ministry can reduce the risk of winner's curse in the following ways:

- *Remove regulatory uncertainty*: The Ministry should aim to clarify all profitability-relevant regulations before the auction begins. Important examples are the possibility for future taxation, or the outcome of the application for concession.
- *Reduce uncertainty about grid costs*: The Ministry should reduce uncertainty about the radial connection point and grid connection costs.

In addition, it is helpful that the Ministry funds and shares information about geotechnical assessments. Well-designed pre-qualification criteria, and penalties for defaults are other tools.

1 Introduction

The report covers three main themes:

- Pros and cons of different support schemes, that is, what should be the good to be auctioned and the object of bids. We recommend that the Ministry either chooses upfront investment support or a two-sided CfD. If a CfD is chosen the reference period should be one year.
- Pros and cons of different auction formats. We recommend that the Ministry chooses open bidding followed by a final sealed bid among the two top bidders, the so-called Anglo-Dutch format. The reference price should equal the most recent NVE estimate of the levelized cost of electricity at Sørlige Nordsjø II, plus a reasonable margin.
- Additional regulatory questions of relevance for the auction, including some implications of pre-selection for the auction and a discussion of penalties and timelines. We recommend that uncertainty about future regulatory processes and costs be removed as much as possible, and that the number of pre-qualified bidders should be at least eight if possible.

This is a high-level strategic document. When the support scheme and auction format is chosen by the Ministry we intend to provide advice on the details of the chosen scheme and format.

2 Choice of support scheme

An important issue in auction design, and indeed in the regulatory embedding of the auction, is the type and form of support payment (support scheme), and in an auction the auctioned good. Should it be a support payment per unit of energy produced (operating support), or per capacity installed (investment support) or something else? We call this the choice of support scheme. In this chapter we discuss pros and cons of different schemes. We draw on theory and on practical experiences from previous auctions in the renewable energy field.

Although we mainly frame the discussion in terms of the structure of the support from the state to the operator, the discussion is just as relevant for an outcome with payments from the operator to the state, and it is an important consideration that both outcomes should be possible and yield good results.

There are many types of support schemes, and many possible design variations for each broad type of scheme. Our first conclusion is that two schemes are most promising: upfront investment subsidies and two-sided CfDs.

Our second conclusion is that upfront investment subsidies per capacity installed and CfDs have different advantages and disadvantages, and which support scheme is preferable depends on what criteria is given most weight as well as specific beliefs regarding how relevant the problems with each support scheme are. If a CfD is chosen, we recommend the use of a long (annual) reference period to ensure that the operator faces short term market signals.

2.1 Which schemes are relevant?

We briefly present a range of possible support schemes in Table 2.1, before narrowing it down to the most relevant schemes for the more detailed discussion in Section 2.2.

Table 2.1 Some possible support schemes[1]

Scheme	Description
Upfront investment subsidy *NOK per MW installed* The object of bids is the investment subsidy and the winning bid is the lowest subsidy.	The developer receives an upfront subsidy per capacity installed in NOK, an investment subsidy.
Fixed premium *NOK per MWh produced* The object of bids is the subsidy per unit produced and the winning bid is the lowest subsidy in NOK per unit produced.	The developer receives a subsidy in NOK per unit produced on top of market revenues. Revenue per unit time is given by: $$(p+s)x$$ Here, p is the market price, s is the subsidy and x is production, all per unit of time.
One-sided CfD *Payment from state to bidder when market price is below CfD- strike price; no payback from bidder to government in case market price is above strike price* *NOK per MWh produced* The object of bids is the strike price and the winning bid is the lowest strike price.	The developer is guaranteed a minimum price, as the state pays the difference between a pre-defined strike price and the market price. With strike price $q_{\min}$ per unit of time the state pays the difference $p - q_{\min}$ if $p < q_{\min}$.
Two-sided CfD *Payment from state to bidder when market price is below CfD- strike price, and from bidder to state when it is above* *NOK per MWh produced* The object of bids is the strike price and the winning bid is the lowest strike price.	The state pays/receives the difference between strike price and reference market price whenever the market price is below/above the strike price. With strike price q per unit of time the state (1) pays the difference $p - q$ if $p < q$ and (2) receives the difference $p - q$ if $p > q$. A two-sided CfD is a subsidy if the strike price is higher than the expected market price. *Strike price:* If the reference market price is determined *hourly*, the CfD is essentially a fixed price contract since prices in NO2 are set on an hourly basis. If the reference market price is the *yearly or monthly* market price, or some other longer period, the developer receives/pays the difference between the strike price and a reference price which is not necessarily equal to the actual hourly market price (i.e., the CfD premium is adjusted annually / monthly in that case). Hence, longer reference periods provide short-term market integration incentives, as short-term market price signals remain in place.

[1] Payment schemes are symmetric to the listed support schemes.

Experiences from other countries

Contracts for difference (CfD), either one-sided or two-sided (also known as double-sided) are a common format of remuneration in Europe, and for offshore wind support schemes in particular. For example, the UK has been using hourly two-sided sliding premiums in its offshore auctions since 2015. France has been allocating monthly two-sided CfDs in its offshore wind auctions since 2017 (e.g., for Dunkirk and Normandy sites and floating offshore OWPs in Mediterranean Sea & Brittany).

Denmark and the United Kingdom have used two-sided CfDs in multiple successful auctions. The third round of auctions in the UK in 2019 saw bid prices of around £ 40 per MWh. In Denmark successive rounds of auctions have generally seen lower prices, with prices of € 49.9 per MWh for Kriegers Flak in 2015 (Jansen, et al., 2022). In the latest Danish auction of this type, the Thor tender, two-sided CfDs based on an annual reference market price have been implemented. Moreover, payment streams that can be made from the winning bidder to the state were capped at 2.8 billion DKK. Thor OWP was awarded in November 2021 to RWE at a strike price of 0.01 ore/kWh. Since five bidders bid the same price, the winner of the tender was decided by lot. A CfD with a strike price of (almost) zero implies that a developer must pass on all revenues generated from energy production to the Danish state for the duration of the support scheme. The reason why this was a rational decision by bidders is because of the cap on the payment streams. Hence, once the first 2.8 billion DKK are paid to the Danish state, the CfD is fulfilled, and RWE can keep all revenues from any further production at the market price. The cap is thus similar to a negative bid to pay 2.8 billion DKK to the Danish state to build the OWP. Generally, Denmark has seen a high rate of realization of winning bids for offshore wind, whilst low penalties for non-completion in the UK has given rise to some option bidding (Welisch & Poudineh, 2019).

The Netherlands and Germany have been using one-sided CfDs in the past. In Germany three one-sided CfD auctions in 2021 had winning bids of € 0 per MWh. Reasons for these low bids could be that the owner have a long time span to make a final investment decision and can therefore wait for lower costs and higher prices, that grid costs are socialized and that winning bids were required to retain the option of delivering planned projects in the future (Jansen, et al., 2022). The specific design of these auctions can therefore be said to encourage a certain level of option bidding.

The Netherlands has recently switched to qualitative criteria (also sometimes referred to as a beauty contest) selection of projects without allocating any form of subsidy. Moreover, Germany will switch to a new offshore wind support scheme that differentiates between centrally and not centrally predeveloped sites as of January 2023. For not centrally pre-developed sites, an auction for the allocation of one-sided CfDs continues to be foreseen. In case of multiple zero bids, an additional dynamic bidding procedure on a concession payment from the developer to the state that will be split over 20 years is organized. This means that the auctions contains to possible bidding components, with the second being introduced if the CfD price is zero. This is therefore not a pure CfD-auction. For centrally pre-developed sites, selection of a bidder is based on a negative bid on the amount of a payment to the state plus additional qualitative criteria (but no support payment is allocated).

Fixed premiums have been used in the Danish open-door procedure, under which developers can submit unsolicited applications for a license for preliminary investigations (i.e., no auctions). Upfront investment support, to our knowledge, has not been allocated in European offshore wind auctions.

2.1.1 Removing the least promising support schemes from consideration

The first step in our analysis is to narrow the options by removing the least promising support schemes from further consideration. This allows us to go into more detail in analysing the more promising options. Our method for narrowing down is a pair-wise comparison of two similar support schemes. When one has clear drawbacks according to important criteria for this auction compared to a broadly similar support scheme, it will be dropped for further analysis.

One-sided vs two-sided CfD

The first pair-wise comparison is between one-sided and two-sided CfDs. They are similar in that they change the price faced by the project owner from a variable market price to the CfD-price, and shift risk from the bidders/project owners to the state. The primary difference is that a two-sided CfD allows for payments from the project owner to the state as well as from the state to the project owner if the project is expected to be profitable without support or if the market price becomes higher than expected. In a two-sided CfD, the expected bid is close to the developers total LCOE.[2] With a one-sided CfD payments can only go one way, and with a profitable project the expected bid is zero. An overarching goal of the auction is to achieve the "lowest support/highest payment".

If there is a need for support to realise the project, there will be no difference in the *expected* net level of support given with the two schemes. The bidding price with one-sided CfDs would be somewhat lower to account for the upside the project owner can be expected to receive in periods of high prices, but the expected net level of support would be the same.[3] The *realised* level of support/payment can however differ between the schemes. If market prices end up higher than expected at the time of bidding, a two-sided CfD ensures that the state captures this upside, giving a lower realised support. If the market prices end up lower than expected, the somewhat higher CfD-price in a two-sided CfD-auction means that the realised level of support might be higher than for one-sided CfD.

If there is no need for support from the state to realise the project, then the auction result in *a one-sided* CfD will be the minimum possible bid, generally a CfD-price of zero, whilst with a two-sided CfD one can expected bids at or close to the bidders estimated LCOE. Zero bids for one-sided CfD are sometimes presented as a success, but this situation has two undesirable effects. First, the state forfeits possible payments from the project owner, undermining the goal of "highest payment". Secondly, there can be several zero bids, making it difficult to allocate the project to the most efficient potential operator. This can be dealt with by specifying some alternative bidding rule once a CfD-price of zero is met, as is being planned for some future auctions in Germany, but this needs to be planned in advanced and complicates the auction. We do not recommend an auction with two possible bidding components for the first auction carried out in Norway. For SNII it is not certain whether there is need for support to realise the project, even if cost estimates by NVE indicate that some support is necessary. Based on these considerations we conclude that one-sided CfD are inferior to two-sided CfD given the goals of this auction and can be dropped as an option in this preliminary stage.

Experiences from other countries: An important trend in offshore wind auctions in Europe has been lower required levels of support over time, as the technology has matured. There has in the last few years been carried out several auctions with bids at, or close to zero. In 2017 and 2018 auctions in

[2] More complex designs, such as a cap on paymnents and longer reference periods will change the expected bid.

[3] This conclusion rests on some assumptions regarding risk and bidding behaviour, that we will not go into detail here.

Germany gave bids of € 0 for more than half the awarded capacity in one-sided CfD auctions. In 2021 three German auctions all gave winning bids of zero in one-sided CfD auctions. This means that no direct price support was necessary and market participants signalled that they would be able to construct and operate the offshore wind parks in questions with market revenues alone. In several auctions there were multiple bids at the minimum price of zero, and the winner had to be awarded by lot. A similar situation occurred in the recent Danish Thor tender. Here, five of the six bidders bid the minimum price of 0.01 øre/kWh, and the winner was chosen by lot. The Thor tender was a two-sided CfD auction with a maximum payback from the concession owner to the state set at 2.8 billion DKK (see above). The multiple zero bids show that several companies were willing to pay the state this maximum payment in order to receive the right to develop the project.

However, it should be noted that zero bids are not tantamount to the development of offshore wind being free of public support. In the German auctions, the cost of grid connection is socialised. Grid connection can account for as much as 30 percent of total investment cost and is especially significant where the distance to the shore is high. In Sørlige Nordsjø II grid connection is bound to be a significant issue. The distribution of grid costs is therefore another important policy choice for the auction. Furthermore, CfDs imply that risk is transferred from the producers to the government. In addition, caps on paybacks in two-sided CfDs allow bidders to recuperate investment costs with the additional expected market revenues beyond the payback amount.

Fixed premium vs ad valorem fixed premium

A second pair-wise comparison is between a fixed premium and a premium that is a percentage of market price (ad valorem premium). The ad valorem premium implies higher transfers from the state when prices are high, which is unattractive from a political point of view. From a market disturbance point of view an ad valorem scheme may have less negative effects on operation as it does not alter relative prices, but we do not consider this a major advantage and focus on the fixed premium.

Three schemes for further consideration

We assess these three schemes as the most relevant:

- Upfront investment subsidy
- Two-sided CfD with a short (hourly) reference period
- Two-sided CfD with a long (monthly or yearly)

In addition we also discuss a fixed premium scheme. This can in some respects be seen as an intermediate option between upfront investment subsidy and two-sided CfD, with many similarities with the latter when it has a long reference period.

A fundamental difference between the upfront scheme and the two others is that the upfront scheme incentivizes investment through a subsidy at the investment stage, while the others incentivize investment through a subsidy during the operations phase. As will be clear from the subsequent discussion, an advantage of the upfront scheme is that it does not affect the design or operation of the wind farm. A disadvantage is that it may increase the risk of project default.

Being the least complex scheme, the upfront scheme will be part of the more detailed discussion in section 2.2. As two-sided CfDs are widely used and have some interesting properties, these will also be discussed more in detail. For two-sided CfDs the properties change in important ways with some design variation, particularly the choice of a long or short reference period (discussed in more detail in section 2.3.1). A short reference period means that CfD-payments to or from the developer are calculated based on the difference between the CfD price and the market price at any given time (typically hourly). This means that the project owner is completely shielded from price fluctuations. A longer reference period of a month or even a year, means that the payments are based on the difference between average market price over the reference period and the CfD-price. This exposes the project owner to more short-term variation in market prices. Hence, less market risk being shifted from the project owner to the state, but improved incentives to adapt to market prices. This is an important trade-off.

Finally, we have included the fixed premium scheme. This scheme retains some properties of the up-front subsidy, in particular the exposure, at the margin, to volatile prices; while also retaining some properties of the CfD, in particular being a subsidy during the operation phase. By extension, a two-sided CfD with an annual reference period is equal in its economic properties to a fixed premium that is revised annually.

2.1.2 The scheme should allow for outcomes with payment

We recommend that the auction allows for outcomes where the winner *pays* the government for the right to apply for a license. Allowing for payment ensures that the government receives a compensation for letting a developer utilize valuable natural resources, should offshore wind be profitable at the auction stage without support.

This recommendation is in accordance with one of the primary objectives of the auction, which is to achieve low support or *high income*. Furthermore, based on cost and price estimates from the Norwegian Water Resources and Energy Directorate ("NVE"), we find that there is a possibility that offshore wind at SNII is profitable without government support. The NVE estimates are presented in more detail below.

All of the examined schemes can allow for payments to the state from the developer with the proper design. For a two-sided CfD, any bid price below the expected market price entails an expected payment to the state. For an upfront subsidy, negative bids must be allowed in order for this possibility. One can envisage mechanisms where a modified one-sided CfD also allows for payments to the state if the type of bidding changes if a price of zero is reached. Such a hybrid-scheme would be complex and is not examined further here.

Profitability of offshore wind at SNII

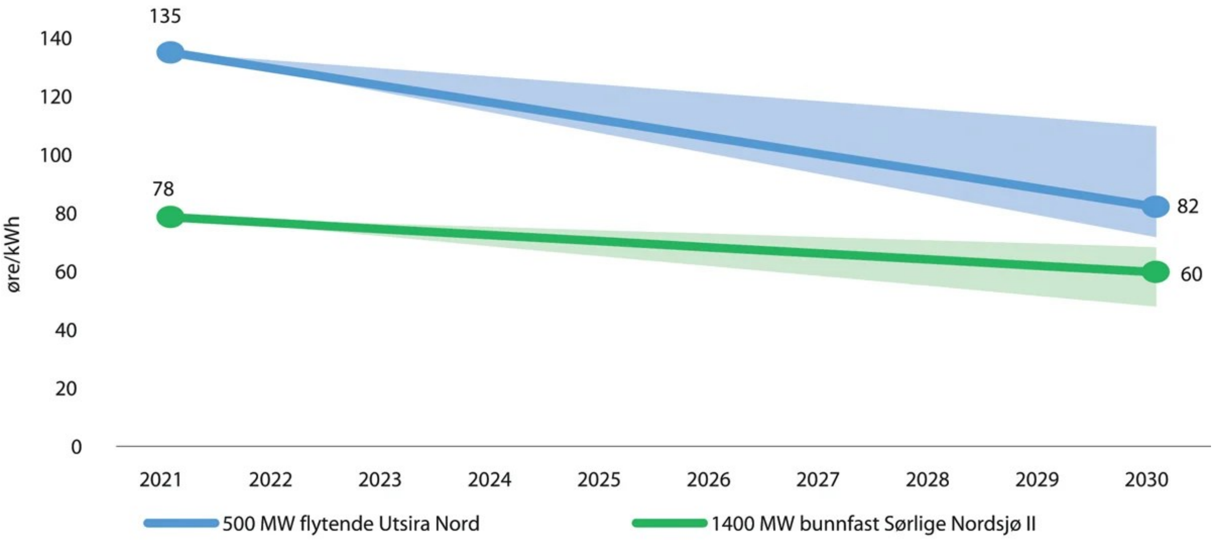
In 2021 NVE estimated the profitability of fixed offshore wind at SNII, in relation to a government white paper on energy policy.[4] NVE estimated that the levelized cost of energy (LCOE) would be 78 øre/kWh[5] if such a plant was to be built *today*, including offshore grid costs and using a 6 % real discount rate. Taking into account expected cost reductions, NVE estimates an LCOE between 48 and 68 øre/kWh *in 2030*. The LCOE essentially is the average (real) electricity price a project must have throughout its lifetime in order to break-even.

[4] Meld. St. 36 (2020–2021) Energi til arbeid

[5] 10 NOK = €1. Equals €78/MWh.

The NVE estimates can be seen from Figure 2.1, which also includes the estimates for floating offshore wind at Utsira Nord.

Figure 2.1 NVE estimates of LCOE for Utsira Nord and Sørlige Nordsjø II, including offshore grid



Source: White paper on energy policy (Meld. St. 36 (2020–2021) Energi til arbeid)

In NVE's most recent long-term power market analysis, from 2021, the electricity price in Norway's southernmost bidding zone NO2 was estimated to be in the range of 51-54 øre/kWh in the analysed period from 2025 to 2040.

Whether the LCOE and the expected market prices are close or far apart is a matter of judgment. On the one hand the estimated cost exceeds the price by around 50 percent. On the other hand, the price and costs are not an order of magnitude apart. It cannot be ruled out that fixed offshore wind at SNII will be profitable without support. Although the current sky-high electricity prices throughout Europe and southern Norway are expected to fall, we believe an updated long-term price estimate could potentially be above the estimate from 2021. For instance, NVE assumed an EU ETS price of 44 EUR/ton CO2 in 2025, increasing to 55 EUR/ton in 2040, while the price has fluctuated between 60 and 90 EUR/ton throughout most of 2022 indicating that the long-term estimates of ETS prices in the forecast might be too low. Higher emission prices lead to higher electricity prices so long as fossil fuel-based production is the marginal producer. Statnett's most recent Short-term market analysis for 2022 to 2027 revise price expectations upwards and indicates a price in Southern Norway of 50-70 € per MWh in 2027 (Statnett, 2022). Whilst 2027 might be before SNII can be expected to come online, this nonetheless indicates that the expected market prices in the medium term are close to the LCOE estimated by NVE.

Moreover, costs estimated without carrying out detailed planning of the project are uncertain and NVEs estimates of costs may therefore be overstated. There have been several auctions for offshore wind in Europe where the result has been no support required to realise the projects. These have typically been in shallower water and closer to shore than SNII, and in some cases the grid connection costs have been borne by the state. These auction results nonetheless show that offshore wind is approaching profitability in Europe. In Denmark the Danish Energy Agency (DEA) has instituted an «open door scheme" for new offshore wind, and has received interest for subsidy-free construction of several projects at similar or greater distance from the shore to that of SNII (Energistyrelsen, 2022). An argument going in the opposite direction is that the current high prices of raw materials and inflation could lead to a lasting increase in the cost of new projects, whilst financing cost may increase due to higher interest rates.

Furthermore, there could be learning effects which further increase the value of this project to developers. Developing the project could also have a symbolic value to some potential bidders, as it is the first large-scale offshore wind project in Norway. For these reasons as well, it is conceivable that the winning bid will take the form of a payment.

2.2 Assessment of relevant schemes

In this section we assess the properties of the relevant schemes with regards to the following issues:

- Market integration and possible distortions
- Market price risk
- Risk of winning bidder abandoning the project
- Liquidity
- Fiscal policy framework
- Uncertainty about future taxation
- Administrative costs
- Possibility of overcompensation (ex-post)

We will argue in section 2.3 that market integration/avoiding distortions incentives, and price risk, are the most relevant and pressing concerns, whilst the other issues listed are of secondary importance.

2.2.1 Market integration and possible distortions - Effects on design and operation

In this section we look at several different ways in which the support scheme can give distorted incentives to the producer. Overall, the conclusion is that an upfront subsidy has the best characteristics on this issue, and that a CfD with a short reference period has the worst characteristics. Longer reference periods, as well as other adaptions of a CfD, reduce and in some cases remove the distorting effects on producer incentives.

The CfD and the fixed premium have the property that the price received by the developer/operator of the plant generally differs from the market price. The market price is known to send a signal of willingness to pay for electricity. Hence, in a CfD and the fixed premium the price signal is distorted. The distortion might affect how the wind farm is designed and operated.

Even though the scope for distortions is limited in intermittent power generation where production is largely given by the wind resources, we have identified potential challenges related to the following situations/issues:

- Low/negative value of production
- Decisions affecting the timing of production
- Grid integration and supply of reserves (ancillary services)

Note that the list is of *potential* distortions of developer behaviour. We discuss in each section whether the distortions are likely to be an issue and the severity of their consequences. We consider issues relating to low/negative value of production to be likely to arise in practice, but the consequences can be largely mitigated through design choices. Issues relating to timing of production are moderately likely to arise. Problems of grid integration becoming a significant issue is something we consider to be more hypothetical in the Norwegian context with ample flexible production in NO2.

The upfront subsidy does not distort the price signal. A subsidy on capacity may induce the operator to emphasise capacity/effect over operation/energy but in the case of SNII capacity of the grid connection is capped at 1,4 GW and the maximum allowed production capacity for the project is 1,5 GW (taking into account loss in the grid connection and production not being at capacity at all times).

Low/negative value of production

During certain times, the gross value of electricity production (MWh) from the wind farm can be low, zero or negative. This could be the case with high intermittent electricity production, demand saturation and/or limited grid capacity. In such situations it could be efficient for the wind farm to limit or stop production. The CfD and fixed premium will completely (CfD with short reference period) or partially (premium or CfD with a long reference period) insulate the wind farm from the market price and stimulate the farm to continue operation in these cases.

Requirements in the revised EU Climate, Energy and Environmental State Aid Guidelines (CCEAG) that the CfD payment must be discontinued if the market price is negative, effectively removes this issue.[6]

With CfDs with long reference periods, problems can still arise when the short-term market price is low, if the average market price for the reference period is above the CfD-price. When the average market price for the reference period is above the CfD-price, the operator must pay per kWh the state the difference between these two prices. If the short term (hourly) market price goes below the sum the operator must pay per kWh, then the operator has an incentive to shut off production. This is not desirable as production with a low but positive market price still has value. This issue can be dealt with by suspending CfD-payments to the state for all production at times when the market price is below the level where this issue arises.

Properties of the various schemes are discussed in Table 2.2, with c as marginal cost, p as the market price, s as the fixed premium subsidy, q as the CfD strike price and p_{ref} as the CfD reference price in the case where it differs from the market price.

[6] Point 123, CCEAG: «beneficiaries should not be incentivised [...] must not receive aid for production in any periods in which the market value of that production is negative». https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022XC0218(03)&from=EN

Table 2.2 Distortions in cases with low/negative value of production

Scheme	Distortion
Upfront subsidy/payment	*None*
Fixed premium	*Wind farm stops production too late:* The producer price is $p + s$. The market price p must then be below $c - s$, possibly below zero, for the wind farm to stop. The scheme causes the wind farm to continue production in cases where production has negative value.
Two-sided CfD (Hourly)	*Wind farm does not stop production:* The producer price is q, i.e. fixed. The wind farm thus is unresponsive to the market price. The scheme causes the wind farm to continue production in cases where $p < c$, price is lower than cost, where production has negative value.
Two-sided CfD (Yearly or another period longer than hourly)	*Wind farm stops production too late:* The producer price is $p + (q - p_{ref}) > p$, where $(q - p_{ref})$ is the annually based CfD subsidy. The CfD essentially works in the same way as the fixed premium subsidy, with $q - p_{ref} = s$. The scheme causes the wind farm to continue production in cases where production has negative value.

Timing of production

Although the time of production is largely given by the wind resources, there are some degrees of freedom both in the design and operations phase, which means that the price faced by the operator is relevant for:

- *Maintenance:* It is likely that there is some flexibility in when planned maintenance is carried out.[7] It would then be beneficial to perform maintenance at times where the *value* of production is lowest, not when the *volume* of production is lowest.
- *Batteries and other storage solutions:* Storage solutions might make it possible to shift the time at which power is delivered to the grid, from low to high price hours. We have not investigated whether this is a current possibility for SNII. It may become more likely as the 30 years concession time progresses.
- *Choice of configuration in design phase:* there might be trade-offs in the design phase.[8] Maximising production volume could lead to different choices than maximising production value if choosing a design that allows for more production when prices are expected to be high entails lower production at other times.

These issues are relevant only for support schemes where the operator faces a different price at the margin than the market price. With a CfD with a hourly reference period, the operator faces only a constant CfD-price and will therefore seek to maximise produced volume and minimise costs, with no regard to the market price. By contrast, an operator that receives an upfront subsidy or an annual

[7] The ease and cost of doing maintenance is also highly seasonally dependent, with maintenance in harsh winter months more complicated and expensive. This is in all likelihood a more important consideration than adaptation to short term price fluctuations

[8] The trade-off could be between different turbine designs with different power curve (e.g. a different cut-off or cut-in wind speed), or in the lay-out of the wind farm to prioritise output for different wind directions and wind strengths.

average CfD-price will be exposed to hourly market prices at the margin and there will be no distortion to the timing of production.

Table 2.3 Distortions in the timing of production

Scheme	Distortion
Upfront subsidy/payment	*None.* When costs are constant the unit gain from switching production between periods is $(p_h - p_l)$, i.e. the difference between the high price (p_h) and the low price (p_l).
Fixed premium	*None.* The loss from low production when the price is low: $-((p_l + s)x - c)$ The gain from high production when the price is high: $((p_h + s)x - c)$ Here, c is cost, x is production and s is the subsidy. p_h and p_l as above. The unit gain from switching production between periods $(p_h + s) - c - (p_l + s) + c = (p_h - p_l)$ $(p_h - p_l)$ is the same expression as in the case of upfront subsidy, in other words, no distortions.
Two-sided CfD (Hourly)	*Wrong incentive to change production from low-price to high-price hours.* The loss from low production when the price is low: $-((q_1 + s)x - c)$ The gain from high production when the price is high: $((q_2 + s)x - c)$ Here, q1 and q2 are two hourly CfD-prices and the other symbols as above. The unit gain from switching between periods $(q_1 - c) - (q_1 - c) = (q_1 - q_2)$ $(q_1 - q_2)$ is in general different from $(p_h - p_l)$, although it is possible that it will have the same tendency (the bidding will take costs during periods of high market prices into account).
Two-sided CfD (Yearly or another period longer than hourly)	*None.* The CfD essentially works in the same way as the fixed premium subsidy, with $q - p_{ref} = s$. I.e., the *absolute price difference* is unaffected.

Incentives to integrate efficiently to the grid and provide ancillary services

The increase of intermittent renewable power sources makes managing electricity grids more challenging and can give rise to a need for expensive system investments. The low market prices in periods with high production of intermittent renewable energy and higher prices when intermittent production is low, gives an incentive for energy producers to invest in production or storage capacity that reduces these problems. CfDs with short reference periods shield producers from this market price. This has been raised as an issue in the UK and has been put forward as an argument for discontinuing the use of CfDs (Catapult Energy Systems, 2021). Norway has large amounts of flexible renewable energy in the form of hydropower and has an electricity market where most consumers and producers face short-term price signals, giving ample incentives for adaptations. We therefore consider this to be a less important issue, than in other countries that have nonetheless opted to use CfDs.

Ancillary services (frequency stabilization reserves) are services which producers of electricity provide beyond simple generation in order to balance the grid in the short term. Ancillary services from offshore wind power could become a viable alternative in the future, in some circumstances. We have not assessed the potential value of such reserves. However, we note that the TSO Statnett in recent years have been investigating other sources than hydropower with reservoir for contributing reserves, with the development of fast frequency responses (FFR) to help stabilize the grid in situations with little inertia in the power system, for instance due to high intermittent power production.

It is thus relevant to assess whether the support/payment scheme affects the incentives of offshore wind farms to offer ancillary services.

Without energy storage, provision of ancillary services (frequency stabilization reserves) implies reduced “standard” production:

- Downwards adjustment is by itself a reduction
- Upwards adjustment requires available capacity, i.e. that ordinary, baseline production is reduced beforehand

Distortions with different schemes, without energy storage, are discussed in Table 2.4.

Table 2.4 Distortions in supply of ancillary services, without storage

Scheme	Distortion
Upfront subsidy/payment	*None*
Fixed premium	To provide ancillary services the operator gives up unit production at cost $(p + s)$. This cost is higher than the market price (p) $$p + s > p$$ Will supply *too little* ancillary services.
Two-sided CfD (Hourly)	Cost of lower production is higher, and *too little* ancillary services supplied, if the strike price is above the market price: $$q > p$$ Cost of producing less will be lower, and *too much* ancillary services supplied, if the strike price is below the market price: $$q < p$$ If reserves from offshore wind power primarily are interesting in the case of much wind, little hydropower production and low prices, the former case (*too little*) is the most likely.
Two-sided CfD (Yearly or another period longer than hourly)	The CfD essentially works in the same way as the fixed premium subsidy, with $q - p_{ref} = s$. Thus, offshore wind will supply *too little* ancillary services.

With storage, such as batteries, the discussion of distortions is much the same as in the discussion of timing of production. However, whether the supply of ancillary services is too low or too high depends on whether the actual case necessitates shifting from low to high price hours, or the other way around.

We consider the issue of disincentives for the provision of ancillary services to be of less importance in Norway compared to other countries, as hydropower production largely fulfils this role in the Norwegian grid today, but the importance of this issue is increasing (Statnett, 2016).

Offshore buyers of electricity

There is a possibility that the wind park could in the future have the option of selling the electricity that is produced to other destinations than the Norwegian grid. This could for example be to offshore uses, such as oil platforms or perhaps offshore production of green hydrogen or synthetic fuels. With upfront subsidies, the operator of the wind park will be willing to enter into such contracts as long as the price offered is higher than the expected price in the grid onshore, taking into account the possible transmission loss when transferring power via the DC-cable to the grid. Offshore uses of power, if they materialise, would be expected to have a high willingness to pay, as it is costly to supply energy to such uses. With a CfD, normally only sales to the grid give rise to CfD payments. Therefore the operator would only be willing to enter into contract if the price paid by the offshore user of power exceeds the CfD-price. With a CfD-price that is above the expected market price, this produces a distortion as the most efficient outcome is if the operator is willing to sell power offshore as long as the price offered is higher than the market price. This inefficiency only arises if offshore users' willingness to pay is between the market price and the CfD-price.

With a CfD-price *below* the market price, the operator would have an incentive to sell the power at a price that is above the CfD-price. If they sell the production at a price that is below the market price, this reduces the total value of produced power and depriving the state of income from the CfD. Prohibiting sale of electricity to offshore uses if the CfD-price is below the market price, would solve this problem, but at the same time stop economically beneficial sale of the power to offshore uses at prices above the market price. To solve this issue there would need to be an arrangement whereby the state is paid the difference between the market price and the CfD-price, whilst allowing the operator to divert the power to the offshore use.

A better option to deal with all issues regarding offshore uses would however be to *include* power sold to offshore uses in the calculation of CfD payments. In this case the payment to or from the operator should be the difference between the onshore market price and the CfD price for all production, giving the operator an incentive to sell to offshore uses only when the offshore price is higher than the onshore market price.

2.2.2 Market price risk and financing cost

In this section we look at how the different support schemes shift risk, and whether this is a relevant consideration. The conclusion is that a CfD shifts market risk from the developer to the state. This will in turn reduce the developers' financing costs. If the state has a lower cost of carrying (systematic) risk, this is desirable, but if the cost is the same, this issue is not relevant for the choice of support scheme.

There is risk to the future income from offshore wind power production. The relevant risk to an owner and the state alike is the risk that cannot be dealt with through diversification, called systematic risk.

One major source of risk is the future power price. A feature of the two-sided CfD is that it transfers market price risk from the developer to the state. With the hourly market price as the reference price, a two-sided CfD is essentially an hourly based fixed price contract. The entire market price risk (up to an eventual cap on payments) is transferred to the state, which covers (receives) the difference with low (high) market prices. With a longer reference period, some market price risk is transferred from the developer to the state, whilst some market risk remains with the developer. If there is positive systematic risk associated with the income from offshore wind production, a risk reduction is valuable to the developer. To put it simply, there is positive systematic risk if income is higher than expected in good times and lower than expected in bad times. A high discount rate is then warranted, since the value of higher income in good times does not outweigh the cost of lower income in bad times.

There is still a possibility that the grid connection to SNII will be required to be ready to become part of a future meshed offshore grid, or to supply offshore users. A meshed offshore grid would most likely have its own set of prices in an offshore bidding zone. It is very difficult for bidders to predict what the market prices will be in a hypothetical future offshore bidding zone, or when a meshed grid might be ready. This is an additional source of price uncertainty.

In principle the CfD and fixed premium may also amplify volume uncertainty and risk as the expected support is a function of the volume produced, but we consider this a lesser problem in practice.

A third source of risk is uncertainty regarding building cost. This uncertainty is not affected by the types of support scheme discussed here and is therefore not relevant for our discussion.

The question then becomes whether risk is less, equally or more costly to the state, than to the developers. The cost of risk has implications for the appropriate discount rate. If the developer has a higher cost of risk, the value of the project for the developer has to be computed at a higher discount rate. And vice versa.

Table 2.5 lays out the consequences of price risk for the three schemes under discussion. If risk is less costly for the state, the risk alleviation of CfD pulls in the direction of that scheme. If risk is equally costly for the state, the allocation of risk does not affect the choice of scheme. We find it unlikely that risk is more costly for the state than for the developer, but if so, risk pulls in the direction of the upfront scheme.

Table 2.5 The consequences of price risk for the three support schemes

Cost of risk	Consequence for choice of scheme
Less costly for the state	Pulls toward CfD
Equally costly for the state	Allocation of risk does not affect choice of scheme
More costly for the state (unlikely)	Pulls towards upfront scheme

We stated above that the developers should only care about systematic risk. We believe this is a reasonable assumption, given that the potential bidders as (consortia of) large corporations. They or their owners have access to capital markets and can diversify away unsystematic risk. The state, as well, cares only for systematic risk.

There is no doubt that transferring risk from the developer to the state will reduce the formers financing costs and therefore the cost of realising the project. Stable income from CfDs will contribute to making the project more "bankable". This however does not in itself mean that it is desirable to transfer this risk. Carrying the risk has a hidden cost for the state, and the question is whether this cost is lower than the reduction in the developers' financing costs.

There is however a question of whether systematic risk as seen from a company perspective is equal to systematic risk as seen from a state perspective. Some arguments in this regard are:

- Owners of the winning operator may own stakes in many firms, but even as a group they are generally less diversified than the state
- Managers of the winning operator care about risks that from an owner perspective are unsystematic since owners have difficulty separating risk events from bad management
- The level of uncertainty regarding future grid connections is lower for the state, as it has a central regulatory role that can influence the outcomes. Benefits or disadvantages for SNII can be internalised in the decisions of the state.
- Owners of the winning operator are free to diversify as broadly as the state
- The Norwegian state holds 30 per cent of the considerable petroleum fund in bonds with low risk, suggesting that the state is averse to the average market risk of physical investments (as represented by the stock market). A higher expected return could be achieved by increasing the stock share and assuming risk, but it has been chosen not to do so.

If the cost of systematic risk is lower from a state perspective in this sector the same would be the case in many more sectors. We don't see the state providing loans and guarantees on a grand scale. The financial sector is mostly commercial. On the other hand, the state in Norway arguably operates as a guarantee fund in times of crisis (e.g. bank crisis of 1990 and financial crisis of 2008-9).

2.2.3 Risk of winning bidder abandoning or delaying the project

In this section we analyze whether the support scheme affects the possibility of the operator abandoning the project after the auction due to over-optimistic bidding. We find that CfDs lessen this risk.

There is a further consideration that merits attention regarding risk: Might the operator pull out of its obligation to build the plant if expected operating and market conditions become less favourable than expected? Reneging on the obligation is a breach of contract and can be met with penalties. Nevertheless, there might be situations where it is less costly for the winning bidder to pay those penalties than to complete the project or even continue operations. From the perspective of the operator, the option of reneging on the contract is a way of reducing downside risk. From the perspective of the state, it is a factor that increases risk. The probability of the developer reneging on the contract increases if there is a "winner's curse", where the winning bidder is the company that has most overestimated the value of the project. This phenomenon is discussed in more detail in section 3.2.1.

If the winner's curse arises from overly optimistic assessment of future market prices, then a CfD-contract will remove this risk, while an upfront subsidy at the investment stage does not. Other possible sources of wrong expectations, such as overly optimistic assumptions on costs, are not affected by the choice of support scheme. From a practical point of view the risk of discontinuing the project might be more important to account for when choosing support scheme than systematic risk (the preceding section).

A related issue to the risk of the winning bidder abandoning the project, is that the winning bidder submits a bid with the intention of only realising it when market prices eventually make the project profitable. Even if there are penalties associated with delaying the project, these penalties can be factored in as the cost of holding the real option. Bidders applying real option theory will value the project higher (Martinez-Cesena & Mutale, 2012), and therefore have more competitive bids. This is undesirable for the state if the goal is a timely realisation of the project. Bidding under one's true cost to get a real option often takes place in the expectation of higher carbon prices leading to higher electricity prices, and this problem is removed by the use of a CfD as support system (Welisch & Poudineh, 2019).

2.2.4 Liquidity

In this section we look at the effect of support scheme on liquidity for the developer. We conclude that this is an issue of little importance, as the bidders are expected to be companies and consortia with significant financial resources and broad access to capital markets.

The choice of support scheme affects the liquidity of the project developer. The developer is likely to face some financing cost associated with increased liquidity needs.

With an upfront subsidy, the developer receives payment from the state prior to or close in time to incurring the major investment costs of building the wind park. Support given in the form of a CfD means that the payments from the state occur in the operational phase, when the developer has lower costs as well as access to income from the sale of the electricity produced. If the project requires net support from the state to the developer, upfront support is therefore more advantageous from a liquidity perspective for the bidders.

If however the wind park is profitable without state support, and the result of the auction is that the winning bidder will pay the state, the situation is reversed. An upfront payment will coincide with the investment costs, whilst payments in the form of CfD will coincide with income generated from the production of electricity.

In any event, we consider the effect of the choice of support scheme on the liquidity position of developers to be of little importance. All bidders are expected to be companies and consortia with significant financial resources and broad access to capital markets. Indeed, the pre-qualification requirements are supposed to ensure that bidders have sufficient financial capacity to carry out the project. Therefore, the bidders are unlikely to face any major liquidity constraints, and the effect of the choice of support scheme on their liquidity is not a material concern.

2.2.5 Fiscal policy framework

The Norwegian state might prefer payments that are predictable, transparent and which fit within the ordinary budget process. An upfront subsidy is the support scheme that is most consistent with those goals. Using CfDs as the support scheme however means that the annual payments are less predictable, that the total cost at the time of the auction is unknown[9], and that the state takes on a hidden cost through the assumption of risk. The budget process in the Norwegian central government has methods of dealing with these issues, but they are not perfect. It is likely that budget rules in any event will require setting a maximum sum that can be paid in support. Whether this is a relevant concern or not should be determined by the relevant ministries and the government. It is likely that it is desirable for the state to cap the total payments that can go to the operator.

2.2.6 Uncertainty about future fees and taxation of offshore wind

In this section we analyze whether the support scheme can mitigate uncertainty for the bidders regarding future fees and taxation. We conclude that a CfD might lessen this uncertainty somewhat.

Norway has resource rent taxation on hydropower and oil, and there have been discussions on the possibility of introducing similar taxation on wind power, including potentially on offshore wind at some time in the future. The Ministry of Finance has stated that it will look into how a future resource rent tax on offshore wind can be designed.[10] Furthermore, the current government has recently proposed a temporary tax on profits form hydropower and land-based wind power on revenue when the power price exceeds 0,7 NOK/kWh. The unexpected introduction of this tax illustrates for bidders the uncertainty of the tax environment in Norway for the electricity sector. It is therefore likely that bidders will take into account the possibility of extra taxation being introduced for offshore wind in the future. Both a resource rent-based tax and other taxes would affect the profitability of SNII. It is rather difficult for bidders to estimate the probability of such taxes being introduced and what form they could take in the future.

[9] While the precise final level will be unknown, introducing a cap on total support can give certainty that the payments will not exceed the level of this cap. We discuss this design option below in 2.3.1.

[10] https://www.regjeringen.no/no/aktuelt/kraftfull-satsing-pa-havvind/id2912297/

Uncertainty about taxation should be reduced to the greatest possible extent before the auction. At the very least, it should be established whether the support resulting from the auction will be taxed or not.

Operator profitability will also be affected by fees, in case of a concession fee. Uncertainty about fees is similar to uncertainty about tax.

This type of regulatory uncertainty negatively affects the auction result and may cause the bidders to submit less favourable bids. Furthermore, there is a risk that the highest bids are placed not by the best producer, but by an inferior producer with a more optimistic estimate of the likelihood of future tax changes.

Whilst future taxes can in theory be applied regardless of the support scheme that is chosen, there are support schemes that make future adverse tax changes more or less likely. Adverse tax changes are most likely in situations where the profits from the offshore wind become unexpectedly high. If the chosen support scheme is an upfront subsidy, it is possible that the winning bidder ex ante requires a subsidy to be willing to carry out the project, but that the power prices end up higher than expected, giving profits. In this scenario it can be tempting for the state to claw back the value of the subsidy and those profits. Bidders may take the probability of this happening into account in the bids submitted, i.e. increase the required subsidy. This increases the expected costs for the state.

With a two-sided CfD as the support scheme, the state already captures all (hourly CfD), or most (annually) of the upside from periods of high prices. This removes much of the potential justification for introducing new taxes on offshore wind in the future, giving the bidders less uncertainty in the auction.

On the other hand, a tax would not have negative effects on auctions happening after the introduction of the tax. There are several arguments for introducing a resource rent tax on offshore wind power, which it is outside of our scope to investigate. A tax may be introduced even if it is not really necessary with respect to profits from SNII. One option is then to keep the SNII investments outside of the tax. However, this could be administratively demanding. Thus, it is a possible outcome that a tax which covers SNII is introduced even if a two-sided CfD is chosen for SNII, especially in light of SNII being small relative to the Norwegian offshore wind ambitions.

2.2.7 Administrative costs and familiarity for market participants

An up-front subsidy is easier to administer for the state than a fixed premium, which is easier again than CfDs. Simpler and less costly administration is a relevant consideration, but in our view not very important given that even the CfDs are not unreasonably costly to administer.

That the support scheme is one that is used in other countries makes it more likely that market participants are familiar with it and can properly analyse the consequences. CfDs are widely used as a support scheme. Short reference periods are somewhat simpler for the market participants to analyse, but long reference periods have also been used in several previous auctions. Upfront investment support is more rarely used but is on the other hand a very simple concept to analyse. In any event the potential bidders are sophisticated actors that have the capacity to analyse and understand the different support schemes. We therefore do not consider this to be an important consideration.

2.2.8 Possibility of ex post overcompensation

Ex ante the risk-adjusted expected level of support for the different support schemes can be assumed to be the same.[11]

However, the situation ex post will differ depending on whether the actual market prices end up higher or lower than expected at the time of bidding. Specifically, if the market prices end up being higher than expected, an upfront investment support will lead to higher net payments than expected, whereas a CfD will lead to the same level of payment as expected. Conversely, with lower market prices than expected after the project has been built, upfront investment support will lead to the project owner having received less revenue from the project than desired at the time of bidding.

If the state has a strong preference for avoiding the possibility that the conclusion ex post is that the project has been overcompensated, then a CfD ensures this, whilst upfront support does not. However, a more rational approach would be to make decisions based on the present expected value in which case scenarios with ex post overcompensation should not carry higher weight than other scenarios. With such an approach this ceases to be a relevant issue.

2.3 Summary and recommendations

Table 2.6 summarises the considerations described in the previous sections.

[11] This simplifying assumption is based on inter alia, no option bidding or difference in the cost of holding risk, issues which are discussed elsewhere in this report.

Table 2.6 Pros and cons of different support schemes

Issue	Importance and relevance of issue	Upfront investment subsidy/ payment	CfD short reference period	CfD with long reference periods and other possible adaptations
Risk of winning bidder abandoning or delaying project (a variant of Winner's curse/option bidding)	High to medium, can also be reduced through choice of auction format and requirements for bidder	-	++	+
Market integration/avoiding distortions in incentives	High, but can be mitigated effectively	++	--	-
Efficient distribution of market price risk	High if state has a lower cost of risk, irrelevant if not	(-)	(+++)	(++)
Liquidity effect for operator	Not important	+/-	-/+	-/+
Alignment with fiscal policy framework	Medium	++	--	--
Taxation uncertainty for bidders	Medium	-	+	+
Administrative costs	Low	+	--	-
Avoiding ex-post overcompensation	Low	--	+++	++
Familiarity for market participants (use in other countries and ease of understanding)	Low	+	++	+

Source: *Vista Analyse. Note: The ideal outcome would be given +++. A strongly negative outcome would be given ---. Signs in parenthesis means that the relevance of the issue is conditional on a priori assumptions that are outside the scope of this report.*

Three issues stand out as being potentially of high importance. These are (1) reducing the risk of overly ambitious bidding leading to the project being abandoned or delayed, (2) ensuring good market integration by avoiding distorted incentives, and (3) allocating risk in an efficient manner.

The first of these favours the use of CfD as the support mechanism, although this issue can also be addressed by the choice of auction format (se chapter 3). The importance of market integration and avoiding distortions depends on what adaptations developers can make to respond to variable prices to maximise value of production. Some possible adaptations, such as the possibility of offshore wind providing ancillary services or implementing energy storage, are mostly hypothetical. Other possible adaptations could be more important, but their magnitude is unknown. This issue favours the use of an upfront subsidy over a CfD. However, the issues of market integration with a CfD can be mitigated effectively through several measures. The most important is choosing a CfD with a long reference period. This ensures that the operator faces short-term market prices, thus removing most distortions. A remaining distortion with a CfD with a long reference period is the situation when temporary low market prices in a situation of payment from the operator to the state make production unprofitable. This can be dealt with by suspending payments from the operator to the state when these conditions arise.

Because a long reference period greatly reduces the problem of distorted incentives, we recommend a CfD with long reference period over a CfD with short reference period.

Efficient allocation of market price risk is a consideration that is only relevant if the state has a lower cost of carrying market price risk. This is a controversial question, with no universally agreed answer. It is outside of the scope of this report to settle this debate. Our recommendation is that the Ministry decide what they think is the correct answer regarding this question and weigh the considerations of market price risk accordingly.

All in all we conclude that both a CfD with a long reference period and upfront subsidies are support schemes with many positive attributes, that are well suited to achieving the goals of the Sørlige Norsjø II auction. The advantages and disadvantages of each differ, and choice between the two therefore depend on the state's precise weighing of the different issues.

If a CfD is chosen, there are several design components that must be addressed. These are discussed in the next section.

2.3.1 Design recommendations for CfD support schemes

Length of the reference period

The most significant issue with the use of a CfD is the distortion of market prices and incentives for the producer. It is however possible to design a support scheme with a CfD that allows for short-term market integration by keeping short-term (sub-annual) market price signals in place. The precise length of the reference period is a trade-off between incentives and what market fluctuations it is desirable to shield the bidders from.

There is a considerable seasonal variation in electricity prices in Norway, with higher prices on average during the winter and early spring, when heating needs are higher and hydroelectric production is lower. An annual reference period gives the developer incentives to take these variations into account in the design and operation of the wind park, which is desirable. A long reference period means that the operator takes some market risk and bidders must make independent assessments of the intra-year variability of power prices. However, the intra-year variability of prices is a lot smaller and more predictable than the overall uncertainty of the future level of market prices. Exposing the project operator to this variability therefore does not obliviate the advantages of a CfD over upfront subsidies. It is for example unlikely that different and overly optimistic assumptions of the intra-year variability of prices amongst bidders alone is enough to give rise to a winner's curse. We therefore consider this to be a good trade-off.

We recommend a reference period of one year if CfD is chosen as the support scheme. With such a long reference period, the developer is paid the difference between the average market price for the year, and the CfD-price. With a long reference period the operator might choose to enter into a PPA. This should not be seen as a problem or something that needs regulation. It can be economically efficient for the parties of the PPA to shift market price risk.

There are several additional questions to resolve, such as whether the reference price is determined in the previous period or in the given period (with payments ex post), whether the price is a simple average or a mean weighted by volume, and whether the periods of zero prices with no CfD-payment should be excluded from the calculation of the average price. These are issues that we propose be raised in the public consultation.

Periods of low market prices

To deal with the problem of the incentives for the producer when the market power price is near zero, we recommend that the volume produced when the market price is below a given threshold close to zero is excluded from the calculation of a CfD-payment.[12] For example, in the Danish Thor tender, in years where the offshore wind park operator has to pay a CfD premium to the government, the premium payment is stopped in hours where the market price is smaller than the premium to be paid, so that incentives to generate are maintained. Moreover, no support should be paid in any negative price period. This should be done on an hourly basis.

In years when the average market price for the annual reference period is above the CfD price, the project owner has to pay the difference between these two prices to the state for each unit of energy produced. If the market price net of production costs in a given hour is at or below the difference between the CfD price and the annual reference price, the producer has an incentive to shut off production. This is not desirable because even if the market prices are low, any positive price net of production costs means that the production has value. We therefore recommend that the CfD payment be reduced or suspended for the hours when the market price is at or below the difference between the CfD price and the reference price.

Incentives to provide ancillary services or power to offshore uses

The issue of incentives to provide ancillary services or power to offshore uses can be partially dealt with through only offering CfDs for part of the production. Already, the maximum capacity of the wind park is set at 1500 MW, while the Norwegian grid can only accommodate connections of up to 1400 MW. The maximum production capacity is set higher because wind parks do not produce at full capacity most of the time. This difference incentivises the project operator to find uses for the excess power produced when the park is producing at full capacity, such as delivering power to offshore uses. A possibility could be to apply the CfD to only a part of the total production. This would give the operator incentives to find uses for the remainder of the production. We do not at this time recommend this solution but propose that this possibility is raised in the public consultation.

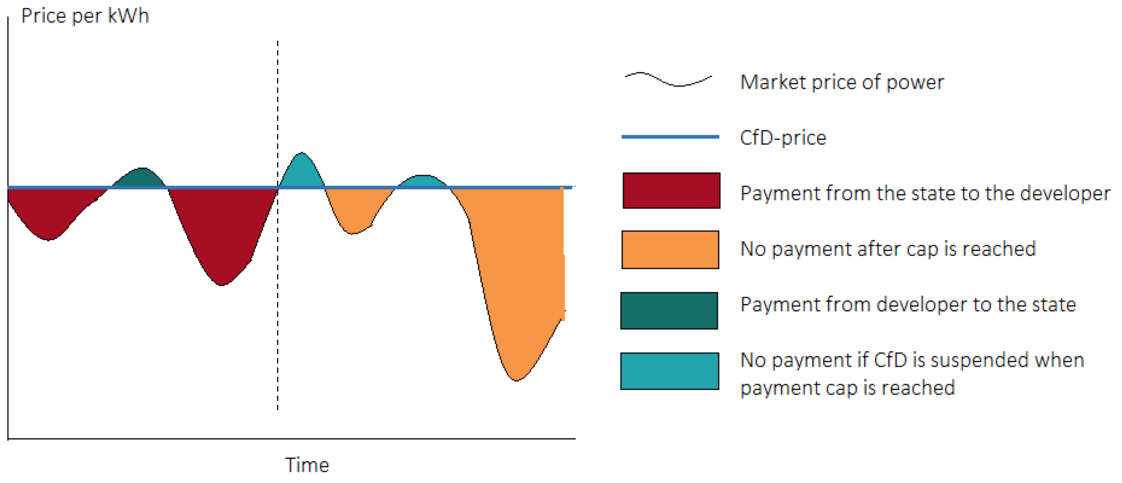
Caps on total payment and duration of the support period

CfDs introduce uncertainty for the state regarding the exact volume of required support payments to the bidder. This is typically dealt with by setting a cap on the total payment. In the Thor wind auction in Denmark, the state set such a cap at 6.5 billion DKK. Figure 2.2 illustrates how a cap operates. After the payments to the developer has reached the level of the cap (marked by the dotted vertical line), no more payments are made. Such a cap raises several practical issues and can have a significant impact on the auction result. The best way of controlling the total level of payment from the state is by setting a reservation price in the auction. We recognise that a cap may nonetheless be necessary within the Norwegian fiscal framework. The level of and design of such a cap must be chosen with great care. A first consideration is that the cap needs to be set high enough for the project to be expected to be

[12] As noted above this is becoming a requirement in EU state aid regulations

profitable by at least one, but preferably multiple bidders. If the cap is set lower than this, the auction could fail. Since the state does not know in advance the assumptions of the potential bidders, the cap should be set so that the project is profitable even with quite pessimistic assumptions on costs and market prices.

Figure 2.2 Illustration of the effect of different caps on payment



Source: Vista Analyse

A cap should ideally also not be set any lower than the difference between the reservation price and the expected market price with reasonably pessimistic assumptions, multiplied by the duration of the support scheme.

If the cap is set at such a relatively high level, it is unlikely that it will be reached for any bids for CfD-prices below the reservation price and will therefore have a limited effect on bidding behaviour. If the cap is set so low that it is likely to be binding for the leading bidders, this makes it difficult to compare bids. A bid with a lower CfD-price then simply means that the cap is reached somewhat later, whilst the total level of support is the same. While the present value of the total sum being paid generally is lower if the cap is reached later, one can imagine situations where this is not the case. For example if one bidder expects a period of low prices early in the support period, followed by a long period of higher prices with the cap being reached only after this period, the expected present value of these payments can be higher than the expected present value for a bidder that expects a less variable market price. In such a scenario it is the different bidders expected timing of a fixed sum of payments that determines the auction result, rather than who has the best project. This is a highly undesirable result.

In some auctions countries have also set a cap on the level of payment from the operator to the state. In the Thor wind auction in Denmark, the state set this cap at 2.8 billion DKK. We advise against setting such a cap. Such a cap can give problems in resolving the auction if there are several companies that place a higher value on the project than the cap. As noted in previous chapters, this was the case for the Thor auction in Denmark, where there were five bidders offering the minimum price of 0.01 øre per KWh (which is equivalent to paying the cap over the first 2-3 years), and the auction had to be resolved by the drawing of lots. This means that it is up to chance whether the bidder with the highest valuation wins, and the state “leaves money on the table".

If there is a cap on the payment from the state, but no pre-set cap from payments in the other direction, a question arises relating to whether the cap should apply to net or gross payments. We recommend that any cap is defined in terms of gross yearly payments, not net payment. This means that if the state over a number of years with prices below the CfD-price pays the operator a sum equal to the cap, and this period is followed by a period with high electricity prices where the operator pays the state, this does not mean that the state again becomes obliged to pay the operator when prices are below the CfD-price. If not the state could end up paying the sum of the cap multiple times, after the operator has received the CfD-price for a long period. This can then be considered to be an unnecessary overcompensation ex post. The disadvantage with this is that even with the same average price, the cap is reached more rapidly if there is more volatility in the average annual prices.

Another design element for CfDs is the duration of the support period. A common length for the support period is between 15 (UK)and 20 years (Denmark, Germany and the Netherlands). The shorter the support period, the more weight the bidders must place on the market prices after the expiry of the period (Welisch & Poudineh, 2019). This somewhat reduces the advantages of a CfD in terms of not risking option bidding and winner's curse, without any commensurate benefits. All else equal a longer support period should not affect the present value of net expected support. A longer period typically entails lower bids. The support period should not be longer than the depreciation period of the investment according to EU state aid guidelines, but this should not hinder a 20-year period as used in Denmark.

When the support period should start is also an issue that requires consideration. Should it start when production starts, or when the last turbine is ready to deliver power to the grid? The latter approach is the one chosen in Denmark. If the support period starts from the very first production, this means that the project owner might be weary of connecting part of the planned capacity to the grid as soon as is ready, as this will "waste" part of the support period on a period with only partial production. Turbines that are ready to produce, but are not connected, is a loss to society. On the other hand, the Danish approach can lead to a significant period without CfD at the beginning of the life of the wind park. The ideal solution is that the support period starts for the capacity that is connected to the grid, and capacity that is connected later has a support period that starts and ends later. It needs to be checked that this is not unduly complicated to administer.

If the Ministry considers there to be a need to limit the size of total possible payment and therefore set a low cap, it is better if the support period is also shortened so that the lower cap is unlikely to be reached. However, there is in any event a limit to how low the cap can be set without risking a failed auction.

A final issue is whether to index the prices in the CfD, and if so, according to what index. The practice in Denmark is not to index. This would reduce the real value of the CfD over time, which is particularly problematic if inflation is high. In the UK the CfD price is adjusted annually according to an inflation factor based on the Consumer Price Index (Low Carbon Contracts Company, 2017). We propose that the CfD be indexed to inflation, and that the choice of index be a question in the public consultation.

Penalties in the case of the project being cancelled or delayed by the winning bidder is discussed in section 4.4.

3 Auction formats

In this chapter we discuss which format should be chosen for the auction, in order achieve the overall objectives of the government. The objectives are (1) to efficiently allocate the licenses and (2) to achieve the highest sum/lowest support. As the two parts of this objective are not in all cases fully compatible, we have chosen to treat them as two separate entities here.

The objectives correspond with established properties in auction theory: *Efficiency* in an auction context means that the license is won by the bidder with the highest valuation. Auctions that realize the *highest possible sum/lowest support* for the seller are known as *revenue-maximizing* or *optimal auctions*.

The outcome of this auction can be either a subsidy from the government to a developer, or a payment from the developer to the government. Furthermore, what the bids look like will differ depending on whether an upfront or a CfD scheme is chosen. To avoid confusion about the terms used, we will briefly explain the three most relevant auction types here in the introduction:

- *First-price sealed-bid auction:* Each bidder submits a "best and final" bid. In the case of an *upfront* scheme, the bid will be the size of the subsidy (or payment). With a *CfD* the bid will be for the strike price. The highest bidder (lowest subsidy or lowest strike price) wins and pays its own bid. A first-price sealed-bid auction is sometimes referred to as "Dutch" auction.
- *Ascending auction*: The term "ascending" refers to how bids in a standard auction would start low and increase until only one bidder remains. However, in this case it gets a little more complicated. With an *upfront scheme,* bids start at a high subsidy and decrease, possibly turning into payments and then increasing as in a standard auction. With a *CfD scheme*, bids start at a high strike price and decrease all the way, until only one bidder remains. An ascending auction is sometimes referred to as an "English" or open-bid auction.
- *Anglo-Dutch auction:* This is a hybrid auction. There is first an ascending stage. The upfront subsidy or CfD strike price starts high and gradually decreases until only *two* bidders remain. Then these two bidders submit sealed final bids as in a first-price sealed-bid auction, and the winner pays its own bid.

We first give an overview of standard auction formats and explain why we consider the formats mentioned above to be the most relevant. Then we discuss how these formats address important concerns in auction design. Experiences from other countries are presented throughout the subchapters. We also discuss the topic of a reservation price (section 3.3). Finally, we recommend an auction type to use for phase 1 of Sørlige Nordsjø II ("SNII").

3.1 Which auction formats are relevant?

In this section we present standard auction formats and discuss which formats are most relevant to investigate more in detail for SNII.

As the governments auction a single license for SNII phase 1, we focus on single-object auctions and largely ignore the literature on multi-object auctions. Note, however, that the bidders still may think strategically and consider future license allocations which may affect bids in the current auction. We discuss such issues below (3.2.5).

In this section we will to a large degree use standard terms from auction theory. As explained in the introduction these terms can sometimes be confusing in our context, because the auction outcome can be either a subsidy or a payment, and because of the different support schemes. In Table 3.1 we explain what is meant by standard auction theory terms in the context of this auction.

Table 3.1 An explanation of auction theory terms in the context of Sørlige Nordsjø II

	Upfront investment subsidy/payment	**Two-sided CfD**
Concepts		
What is a bid, and who wins?	A bid is for the total amount of upfront subsidy (or payment).	A bid is for the price at which electricity is sold (the "strike price").
Low bid	High subsidy	High strike price
High bid	Low subsidy or high payment	Low strike price
Winning bid	Winning bid has lowest required subsidy or the highest payment.	Winning bid sells electricity at the lowest price.
Auction formats		
First-price sealed-bid	Bidder submits "best and final" bid, which will be a subsidy or a payment.	Bidder submits "best and final" bid, which will be a strike price.
Ascending type (English)	Initial bid is a very high subsidy. Subsequent bids decrease the subsidy. Eventually bids may turn into payments, and increase.	Initial bid is a at a high strike price. Bids reduce the strike price.
Anglo-Dutch	In the ascending stage, the upfront subsidy starts high and gradually decreases until two bidders remain. Then these two bidders submit sealed final bids as in a first-price sealed-bid auction.	In the ascending stage, the strike price starts high and gradually decreases until two bidders remain. Then these two bidders submit sealed final bids for the strike price as in a first-price sealed-bid auction.

Source: Vista Analyse

3.1.1 Overview of auction formats

The two main auction formats are open-bid and sealed-bid auctions. In open-bid auctions, each bid is announced to all participants to the auction. In sealed-bid auctions, by contrast, each bid is known only to the seller. Open-bid auctions (especially the ascending auction type) are game-theoretically often classified as dynamic games in which the participants make sequential moves. Sealed-bid auctions are considered static games, in which the participants only move once.

Both auction formats can be divided into two classes depending on how the final price is set: first price and second price. In first-price auctions, the winner pays the winning bid. In second-price auctions, the winner pays the second-highest bid. In Table 3.2 below, we present the resulting four types of auctions and their rules.

Table 3.2 Common auction formats and their general rules

	First price	Second price
Sealed bid	**First price, sealed bid** The seller gets sealed 'best and final' bids from each bidder. The highest bidder wins the auction and pays the winning bid.	**Second price, sealed bid** The seller gets sealed 'best and final' bids from each bidder. The highest bidder wins the auction and pays the second-highest bid.
Open bid	**Descending** The seller sets a very high initial price. Then the seller lowers the price until a bidder publicly accepts the price. The bidder wins the object and pays the bid. Descending auctions are sometimes called "Dutch" auctions.	**Ascending** The seller sets some initial price. The bids can be open-outcry (often called "English" auctions), continuously increasing with time ("Japanese") or some other technique in which the bids are ascending and common information to all bidders. The bidder with the ultimate highest bid wins the object and pays the bid.

Source: Vista Analyse

It is possible to combine these four "pure" auction types into hybrid auctions, meant to capture "the best of both worlds". One highly relevant format is the Anglo-Dutch[13] auction (Klemperer, 1998). The Anglo-Dutch auction has two rounds. The first round is ascending until only two bidders remain. Then these two participate in a first-price sealed-bid auction, with a reservation price equal to the bid that initiated round two.

When bids are subsidies (negative payments) an ascending auction involves a decrease from a high subsidy level or high electricity price to a lower level.

First-price and second price-auctions differ fundamentally in what the optimal bidding behaviour is. This will be explained next.

The optimal bidding behavior in first-price auctions is to bid somewhat below one's own valuation. This behavior is often referred to as "bid-shading". The reason for bid shading is that in a first-price auction, bidders get zero profits if they bid their exact valuation, because they pay their own bid. Therefore, they look to gain profits by reducing their bids somewhat compared to their valuation. This implies that a bidder could lose the auction even if it has the highest valuation. First-price sealed bid auctions are strategically equivalent to descending auctions. There is no fundamental difference between choosing the price you would like to bid in a first-price sealed-bid auction, and deciding at which price you will "cry out" in a descending auction (Dutch auction). The optimal bid strategies are the same in these two auctions. Because of this, we often refer to both jointly as first-price auctions.

The optimal bidding behavior in second-price auctions is to bid one's own valuation. Bidders gain nothing from bidding higher or lower. Bidding their own valuation is a *dominant strategy*[14]. This is straightforward in second-price sealed-bid auctions, bud also applies to ascending auctions: Bidders should drop out when the standing bid reaches their valuation. If they drop out sooner, they risk losing the auction when they could have won. The price at which the second-last bidder drops out of an ascending auction is the ultimate standing bid. Thus, the winner in practice pays a price equal to or marginally above the valuation of the second-highest bidder.

Table 3.3 gives an overview of the relations between the different auction types.

[13] "Anglo" refers to the English-type first round. "Dutch" refers to the first-price-type second round.

[14] A dominant strategy means that the strategy is optimal regardless of what others do.

Table 3.3 Overview of relations between auction types

Auction	Alternative name	Optimal bidding behavior	Outcome similar to	Common uses
Ascending	English, Japanese	Exit when standing bid reaches your valuation	Second-price sealed-bid	Norwegian real estate market, art, collectibles
Descending	Dutch	Bid-shading	First-price sealed-bid	Dutch flower market, tobacco
First-price sealed-bid	Blind	Bid-shading	Descending auctions	Private and public procurement
Second-price sealed-bid	Vickrey	Bid your valuation exactly	Ascending auctions	Not much used
Anglo-Dutch		Bid-shading, but less severe	Begins as ascending, ends as first-price	E.g, demand response (flexibility) New York City region.

Source: Vista Analyse

Under certain conditions the four standard auction types are revenue equivalent, i.e., the seller's revenue is independent of auction type.[15] That means that, if the assumptions of the theorem hold, it does not matter which auction type the seller uses because the revenue will be the same for all standard auction types. This result is called the "revenue equivalence theorem" and is important in auction theory.

However, there will often be deviations from the necessary assumptions, which allow for a ranking of auction types with respect to expected revenue.

3.1.2 Common formats in renewable energy auctions

The most common auction type used in RE auctions is the sealed-bid auction, whereby the bidder received the priced offered ("first price"). According to the AURES auction database[16], out of 820 auction rounds captured for 20 EU countries for various RE technologies, including offshore wind, between 2011 and 2021, only 28 auction rounds were implemented as open-bid auctions (ascending or descending auction). The seven countries that had implemented offshore wind auctions until 2021 have implemented them as first-price, sealed bid auctions.

While the RE industry is more familiar with sealed-bid auctions than with open-bid auctions, open-bid auctions can also work well. Countries like Portugal, Greece, and Brazil have implemented open-bid auctions. In Brazil, multi-object RE auctions have been hybrid. The first stage operates as an ascending price auction. The auction is initiated with a high price (high subsidy) that is expected to create excess supply and bidders state the quantity (MWh) they would supply at this price. While there is still excess supply, the auctioneer decreases the price (subsidy) until demand is met, in addition to a certain margin. This margin would be used in the next stage to keep competition among the bidders who pass the first stage. The second stage is a first-price, sealed-bid auction, where bidders cannot bid higher than the

[15] See, e.g., Klemperer (1999) for an overview of the literature and the necessary assumptions for the revenue equivalence theorem to hold.

[16] http://aures2project.eu/auction-database/

price (subsidy) disclosed in the first stage. The second stage is held to meet the actual demand and assure that there is no collusion between a small numbers of bidders[17].

The Netherlands RE multi-object auctions, known as the SDE+, defined an annual subsidy budget and operated as a sealed-bid auction with ascending ceiling prices. The auction consisted of two rounds each year, each round consisting of three phases with ascending ceiling prices. Each phase is open for one week and the budget is auctioned on a first-come, first-served basis. On the day the budget is exhausted, all applicants from that day are ranked based on their bids and the lowest are accepted first. If there are multiple bids at the same price, a lottery will take place to decide which projects are awarded[18].

An example of Anglo-Dutch is the "Demand Response" auction for Consolidated Edison, which is the electric utility serving the New York City region. This auction was done as a part of a "Demand Response" project. Demand Response is needed by electric utilities to reduce the load on the electric grid duration peak demand periods, such as very hot summer days. The goal in Demand Response is to pay large electricity users to reduce their electric usage "on-demand", i.e., within hours of the request by Con Ed. in exchange for their agreement to reduce their electric demand, Con Ed pays them. The auction was conducted among pre-qualified bidders who demonstrated HOW they would reduce their usage when called on. The auction was done on a price-per-kWh basis, with the maximum load reduction procured for the lowest cost per kWh. Many awardees were given Demand Response contracts as a result, far exceeding the expectations of Con Ed.

3.1.3 The most relevant auction formats

We consider these auction formats to be most relevant for SNII:

- Ascending
- First-price sealed-bid
- Anglo-Dutch

The reason we do not further investigate the *descending* auction format, is that it is similar to a first-price sealed-bid auction in all relevant aspects. Thus, the subsequent discussion of the latter also applies to descending auctions.

We also do not further investigate the second-price sealed-bid auction. This format is equal to an ascending auction in one important aspect, they are both second-price. However, they also differ in some aspects. An ascending auction has better properties with respect to winner's curse, although a second-price sealed-bid is still better than a first-price sealed-bid. On the other hand, a second-price sealed-bid auction has better properties than an ascending auction with respect to collusion. However, as we will discuss more in detail below, we do not believe collusion to be a major concern for SNII phase II – at least not in a way that can be easily remedied by the auction format. In summary we find the ascending auction to be the most promising of the second-price auctions.

3.2 Assessment of the most relevant auction formats

In this chapter, we assess the most relevant auction formats with respects to the following concerns:

[17] http://aures2project.eu/wp-content/uploads/2021/07/design_elements_october2015.pdf

[18] http://aures2project.eu/wp-content/uploads/2019/12/AURES_II_case_study_Netherlands.pdf

- Winner's curse
- Efficiency
- Risk-averse bidders
- Familiarity
- Collusion
- Entry

3.2.1 Winner's curse

The winner's curse is a phenomenon where the bidder with the most optimistic expected valuation of the project wins the auction. Winning the auction provides new information that was not known before winning, namely that all the other bidders have lower expected valuations than you. As the optimistic winner you may be at risk of building and/or operating at a loss.

With regards to this auction, there are two different ways in which winner's curse could be a challenge:

- The classic winner's curse problem from auction theory, in which the possibility of winner's curse leads all bidders to bid lower, resulting in lower auction revenue.
- The problem of the winner not carrying through the project if the actual value is lower than expected.

The classic winner's curse from auction theory could really be described as a "seller's curse". If all bidders correctly anticipate that they may be too optimistic, they will shade (lower) their bids to avoid this risk. This leads to lower expected auction revenue. However, in situations where all bidders *don't* behave optimally and fail to consider this effect or fail to correctly calculate how much to shade their bids, the outcome may be an actual winner's curse. This outcome is also bad for the government, which is at risk that the winners leave their obligation to build and operate the project because of lower-than-anticipated project profits.

In the remainder of this section, we describe in some more detail what the winner's curse is and whether there is reason to expect winner's curse challenges in Sørlige Nordsjø II. Then we describe measures to reduce the challenges including the use of an ascending auction type.

Information structure

Whether or not the winner's curse is an issue depends on the information structure. There is a higher risk of winner's curse in auctions with higher degrees of *common value*. Common value means that the true value of the acreage (*ex-post*) is the same for every bidder, for instance because their costs are approximately the same. Before the auction (*ex-ante)*, bidders form beliefs about the true value, and update their beliefs after learning new information. Learning that another bidder has a high expected valuation makes it more likely that the true value indeed is high.[19] Thus, learning that all other bidders have lower expected valuations than you, upon winning the auction, will inform you that the true value likely is lower that you expected.

In (independent) *private value* auctions, however, there is no such problem. In such auctions, the value of the object solely depends on bidder's own private valuations irrespective of what others think. For

[19] This means that the values are "affiliated", which breaks the revenue equivalence theorem (Milgrom & Weber, 1982).

instance, your costs of building and operating the plant may be lower than that of others, and your winning bid signals your low cost. Learning other's expected valuations will in this case not affect your own expected valuation.

There are both common and private factors in Sørlige Nordsjø II. Such factors are relevant on both the cost-side and the income-side for firms because the bids will depend on the *profit* bidders expect to accrue from the project. We present an overview over potential common and private factors in Table 3.4, where some factors have both common and private elements.

Table 3.4 Common and private factors

Factor type	Income side	Cost side
Common	• The price of electricity. • The sales volume (e.g., electricity market conditions and wind conditions) • Correlation between price and volume • Common learning effects	• Grid connections costs • Seabed conditions • Other regulatory uncertainty • Factor costs
Private	• Portfolio diversification • Corporate social responsibility • Private learning effects	• Firm-specific technology and cost-structure • Bargaining power in factor market

Source: Vista Analyse

Other measures to mitigate winner's curse

Before we turn to the properties of different auction formats with respect to winner's curse, we will briefly discuss other measures to mitigate the risk of winner's curse.

The Ministry can reduce the risk of winner's curse by reducing or removing uncertainty about common factors. It should reveal all relevant information that may reduce common value uncertainty (Milgrom & Weber, 1982).

On the cost side, the Ministry can reduce the risk of winner's curse in the following ways (to be further discussed in chapter 4 below:

- *Remove regulatory uncertainty*: The Ministry should aim to clarify all profitability-relevant regulations before the auction begins. Important examples are the possibility for future taxation, or the outcome of the application for concession.
- *Reduce uncertainty about grid costs*: The Ministry should reduce uncertainty about the radial connection point and grid connection costs.

In addition, it is helpful that the Ministry funds and shares information about geotechnical assessments.

As commented in chapter 2 the chosen type of support scheme will directly affect uncertainty on the income side. The important difference is between a CfD on the one side, and fixed premium and upfront subsidy on the other. Using an hourly based CfD will remove price uncertainty for bidders because they will always sell at a fixed price, no matter the actual price. An upfront subsidy or a fixed premium scheme will by contrast not reduce uncertainty about price and these schemes will therefore be more exposed to the winner's curse.

However, with regards to volume uncertainty it is the other way around. If wind resources are worse than expected, the support from operations phase schemes such as a CfD will be lower. If wind resources are better, the support from these schemes will be higher. Thus, these schemes amplify volume uncertainty. With regards to volume uncertainty, an upfront subsidy has better properties.

Properties of different auction formats with respect to winner's curse

Ascending auction types have good properties when there is a risk of winner's curse (Milgrom & Weber, 1982). The sequential bidding structure of such auctions help bidders learn about other bidders' valuation by observing at which price others drop out of the auction. Learning that many bidders drop out early will make remaining bidders vary of being aggressive and cause them to (correctly) lower their valuation. Or, if many bidders remain when the standing bid gets closer to their own expected valuation, they will (also correctly) increase their expected valuation and thus make improved bids resulting in higher expected auction revenue.

This mechanism may be familiar to many from real estate auctions. One might be unsure about the actual value of a house. Seeing that there are many other bidders might lead one to bid higher than one would if it was not an ascending auction.

We expect common value factors to be more important than private value factors for Sørlige Nordsjø II. This pulls towards an ascending auction.

Text frame 3.1 Summary of winner's curse

- Winner's curse is an important concern and may lead to lower auction revenue or in the worst case non-completion of the project.
- The Ministry should aim to reduce regulatory and cost uncertainty as much as possible to reduce risk of winner's curse.
- A CfD scheme will remove price uncertainty and thus reduce risk of winner's curse compared to the other to support schemes.
- A CfD scheme will amplify volume uncertainty, but we consider that volume uncertainty less important than price uncertainty.
- Ascending auction types help bidders gain information during the auction and will reduce risk of winner's curse.

3.2.2 Efficiency

Efficiency means that the bidder with the highest valuation wins the auction. Efficiency and revenue are positively correlated, because a higher general willingness to pay for the object leads to higher auction revenue. Sometimes, however, optimality comes at the cost of efficiency.

Ascending auctions, which are (similar to) second-price auctions are robust to inefficiency because a stronger bidder can always outbid weaker competitors. First-price auctions, however, have some risk of inefficiency. The reason is the strategic uncertainty in first-price auctions, where bidders must shade (lower) their bids to gain profit. Miscalculation in this process may lead to a situation where a strong bidder shades their bid too much, resulting in a weaker bidder winning the auction.

Text frame 3.2 Summary of efficiency

- Ascending auctions ensure an efficient allocation.
- First-price auctions may cause inefficient outcomes, because of strategic uncertainty.

3.2.3 Risk-averse bidders

The bidder's attitudes to risk can affect the auction outcome. Bidders can either be risk averse, risk neutral or risk seeking. Risk-neutral bidders are indifferent between an uncertain but expected profit of x and getting x for certain. Risk-averse bidders will prefer to get x for certain over getting x in expectation. They need a risk premium a to be indifferent between having an expected profit $x + a$ and getting x with no uncertainty. Risk seekers, in contrast, prefer the possibility of obtaining a higher-than-expected profit over getting something for certain; they have negative risk premia. We do not consider risk-seeking attitudes further.

First-price auctions will provide higher expected revenue for the seller than second-price auctions, if bidders are risk-averse (Klemperer, 1999; Vasserman & Watt, 2021). Only first-price auctions (descending or sealed-bid) are affected by the risk attitudes of bidders. In these auctions, the optimal strategy for bidders is to bid below their own valuation, but above the expected valuation of the second-highest bidder. A risk-averse bidder is averse to losing the auction unnecessarily and would prefer to bid a little higher to increase the probability of winning at a cost to the value of winning. This is not the case in second-price auctions, where risk attitudes do not matter for optimal bidding strategy. In such auctions, the dominant strategy is to bid your valuation and you risk nothing in doing so.

We put some weight on this issue, given that this is the first offshore wind auction in Norway and that we expect several of the bidders to not want to lose this auction.

Text frame 3.3 Summary of attitudes to risk

- First-price auctions will provide higher expected auction revenue if buyers are risk averse.

3.2.4 Familiarity

As discussed in chapter 3.1.3 first-price sealed-bid auctions have been common for renewable energy. Furthermore, such auctions are common in public procurement more generally, but then often as a part of multi-criteria auctions. Its simplicity and widespread use is an argument in favor of the first-price sealed-bid auction.

However, although less used for renewable energy, we do not believe that an ascending auction would be particularly unfamiliar. It is a well-known format in auction theory and is also in widespread use, e.g., in housing markets.

The Anglo-Dutch auction is likely to be less familiar. However, it has been used for renewable energy purposes before in Brazil and the state of New York, and is well described in articles by recognized auction expert Paul Klemperer. Furthermore, our software partner Procurex has extensive experience with conducting Anglo-Dutch auctions, in their experience often referred to as "Final Blind" auctions. Finally, it is really just a hybrid of two well-known auction formats.

Text frame 3.4 Summary of familiarity

- Although a first-price sealed-bid auction is the most familiar format in the renewable energy context, the other auction types should be relatively well-known, are well-defined in auction theory and also see widespread use.

3.2.5 Collusion

We have assessed whether collusion is an issue which should affect the choice of auction type for SNII phase 1. Collusion in an auction context means that bidders coordinate to obtain an auction outcome more favourable to them. Collusion can either happen *explicitly*, by the forming of cartel agreements and commonly prohibited by law, *tacitly*, by signalling intentions only through behavior, or a combination of the two. Explicit communication is helpful for coordination, but not necessary for collusion to happen (Fonesca & Normann, 2012). There have been several examples of government auctions with lower-than-expected revenues, likely because of tacit collusion (Klemperer, 2002a; Klemperer, 2002b).

We do not view collusion as a major issue for SNII phase 1, mainly because it is a single-unit auction. For firms to collude, there must be some way of sharing the gains from collusion. This is much harder in single-unit auctions than in multi-unit auctions. Bidders cannot easily "divide the pie" between them, because there is only a single lot to be allocated. We consider the possibility of side-payments between the winner and other colluders as very small.

The upcoming SNII phase 2 auction could make the two auctions combined resemble a multi-unit auction, but we are still not particularly worried about collusion. Due to the sequentiality, it would be more difficult to sustain collusion. The winner of the first phase would have little incentive to honour an agreement and bid low in phase 2, unless there is a credible threat in terms of future auctions in wind energy.

Implications for auction design if within-auction collusion was a concern

Ascending auctions are vulnerable to collusion. Because the auction format is open, deviations can be discovered and retaliated against during the auction and not only afterwards. Furthermore, bids can be used for signalling.

Collusion is more difficult to sustain in a first-price auction. In an ascending or other second-price auction there is no incentive among the colluders to deviate from the agreement since the bidder with the highest valuation would win anyway. In first-price auctions, however, collusion relies on everyone bidding very low while the designated winner bids marginally more. But then everyone would have an incentive to deviate by bidding marginally more than the agreed sum, winning the auction themselves. Knowing this, everyone increases their bids even further, and so on. This mechanism in first-price auctions makes collusion agreements unstable and non-credible.

The possibility for collusion across auctions

As we have touched upon above with regards to phase 2, firms can collude *across* auctions. Across-auction collusion can either *over time* or *across region*s at any given time, or a combination of the two. Collusion across regions essentially turns individual single-object auctions into a larger multi-object auction. Collusion over time is possible in repeated, dynamic interactions where competitors realize that a self-enforcing agreement can be sustainable since (i) retaliation is more costly than the short-term gain of deviation and (ii) retaliation is credible (Ivaldi, Jullien, Rey, Seabright, & Tirole, 2003). As offshore-wind auctions happen more frequently, bidders may develop bid-signalling strategies, effective punishments, and entry-deterrence strategies that may make future auction rounds more vulnerable to collusion (Klemperer, 2002b).

It is difficult to design auctions that protect against across-auction collusion. In general, though, using first-price auctions will make collusion more difficult, as explained in the previous paragraph. If an ascending auction is used, however, it should be designed to make signalling through bids more difficult, by for example only allowing fixed-increment bids or using an open-exit design[20]. This would prevent so-called jump bidding, where a bidder bids higher than the minimal increment. Such bids are irrational, because it in essence means bidding against yourself at the risk of paying a higher than necessary price. It can be used, however, to signal aggressive intentions which make tacit collusion possible (Avery, 1998).

We do not put weight on the possibility for across-auction collusion. Not because it is not a potential issue, but because it is difficult to see how auction design could significantly reduce the risk of such collusion.

Text frame 3.5 Summary of collusion

- Collusion is not a major issue for SNII phase 1
- First-price auctions are preferred if collusion is a concern
- Ascending auctions should be open-exit or fixed-increment to make collusion more difficult
- Across-auction collusion is more difficult to prevent than within-auction collusion

3.2.6 Entry

Having many bidders enter the auction reduces the risk of low revenues, inefficiency, and collusion (Klemperer, 2002b). Entry is costly to all bidders, because the time and resources spent preparing to participate in the auction have alternative uses and thus opportunity costs. Weaker bidders may choose to opt-out of the auction altogether, expecting to lose against a perceived stronger competitor. In the worst-case scenario, all weak bidders stay out, leaving only the strongest bidder to participate. This bidder would then pay a very low price for the object. Knowing this, stronger bidders may try to deter entry.

Firms have incentives to establish a reputation for being aggressive in auctions, causing others to stay out of later auctions if they know that the perceived aggressive competitor will participate (Klemperer, 2002b). This mechanism may affect bids positively in Phase 1, because firms can try to establish a reputation or get a toehold in the Norwegian offshore wind market. However, it may negatively affect Phase 2 revenue if the winner of Phase 1 successfully deters Phase 2 entry. The net effect on auction outcome is ambiguous.

The choice of auction type can affect entry decisions (Klemperer, 2002b). In *ascending* auctions, bidders can always outbid each other in the end even if they were outbid early. Therefore, bidders expect that the strongest or most aggressive bidder always wins and may stay out because the low perceived chance of winning. The auction outcome is not as clear in *first-price auctions*, because of strategic uncertainty

[20] Open exit means that the standing bid automatically increases, and bidders announce their irrevocable exit from the auction.

about how much to optimally shade bids. This uncertainty gives weaker bidders a chance of winning against stronger competitors, which all else equal increases entry relative to ascending auctions.

We do not consider low entry an important issue in SNII phase 1, as our impression is that there is great interest for participating in this auction. However, we believe entry could be an issue in phase 2.

Text frame 3.6 Summary of entry

- First-price sealed-bid auctions have better properties with respect to entry, as it yields weaker bidders a chance of winning.
- We do not consider low entry an important issue in SNII phase 1.

3.3 Reservation price

Reservation prices, also known as ceiling prices, define the maximum subsidy level and limit the risk of high support costs for governments/consumers in case of uncertain or limited competition in the auction or collusive behaviour between bidders. As a general point, maximum premiums should be seen as a safeguard against the risk of inadvertently awarding projects to very high-priced bidders, not as the mechanism by which RE prices are driven downwards – that should be achieved through competition.

The reservation price could be defined using an LCOE calculation or based on a previous feed-in tariff (FIT). Since there are no FITs in Norway and NVE has estimated the LCOE for Sørlige Nordsjø II, the reservation price could be set based on an LCOE calculation. The reservation price should be set at a level that allows sufficient room for competitive price discovery and should thus not be set too low, implying a very low subsidy which could deter auction participation.

Disclosing the reservation price to bidders in advance has the advantage that it prevents otherwise qualifying bids from being rejected simply because bidders did not know the reservation price. The disclosure of the reservation price also gives bidders more planning security, increasing the acceptance of the auction. A disadvantage of disclosing ceiling prices in sealed-bid auctions where competition is low is that it can weaken the competitive price discovery of the auction if bidders orient their bids toward the ceiling price.

According to the AURES auction database, all EU countries that implemented RE auctions between 2011 and 2021, including for offshore wind, defined a reservation price. The reservation price was disclosed ahead of the auction in all countries. Only Spain in 2021 for multi-object solar PV and onshore wind, and Denmark for a multi-object solar PV auction in 2018, have not disclosed the reservation price before the auction. Considering the advantages and disadvantages of and country experience with reservation prices, the reservation price should be disclosed to bidders ahead of the auction.

3.4 Recommendation

Table 3.5 summarizes our assessment of the different auction types. The ascending and Anglo-Dutch types are compared to the first-price sealed bid auction, which is set as the reference. The pluses and minuses thus indicate strengths and weaknesses relative to first-price sealed bid. Pluses and minuses cannot be counted across rows.

Table 3.5 Pros and cons of different auction types, relative to first-price sealed-bid

Issue	Importance	**First-price sealed-bid** Sealed final bids for subsidy/payment (up-front) or strike price (CfD).	**Ascending** *Upfront:* High to low subsidy, eventually low to high payment. *CfD:* High to low strike price.	**Anglo-Dutch** As ascending until two bidders remain, then sealed final bids.
Winner's curse	High	*Reference*	+++	++
Efficiency	High	...	+++	++
Risk-averse bidders	Medium	...	---	-
Familiarity	Medium	...	-	--
Collusion	Low	...	--	-
Entry	Low	...	--	-

Source: Vista Analyse

We assess winner's curse as the most important concern with regards to the choice of auction type for SNII. This is partly due to the classic winner's curse problem in auction theory, but mainly due to the risk of the project not being carried out. This pulls towards an ascending auction, secondarily towards an Anglo-Dutch auction. Although there is a risk of winner's curse in the second stage of an Anglo-Dutch auction, we believe this risk to be much smaller than in a first-price auction.

We consider efficiency, that the lot is allocated to the bidder with the highest valuation, as the second most import concern. This also pulls towards an ascending auction, secondarily towards an Anglo-Dutch auction. Again, we believe the difference between these two types to be small. While an ascending auction ensures that the bidder with highest valuation wins the auction, an Anglo-Dutch auction ensures that the winner is one of the two bidders with highest valuation.

We also put some weight on risk-aversion, due to the flagship nature of this first Norwegian offshore wind auction. In a first-price sealed-bid auction, bidders will weigh the possible profit from a low bid (high subsidy) against the probability of not winning. A risk-averse bidder will want to bid higher (lower subsidy) to increase the probability of winning. The bidder does not want to risk losing. This can lead to a high winning bid (low subsidy), which increases government revenue (reduces government expenses). This is beneficial. The ascending auction does not allow for this, as the winning bid is likely to be just above the second highest bid. However, the Anglo-Dutch allows for this to some degree, because there is a strategic consideration in the final first-price sealed-bid round.[21]

Finally, familiarity is also a concern we put some weight on. Most offshore wind power auction have been sealed-bid first-price auctions. However, ascending auctions are used in many different contexts and are relatively well known. The greatest challenge with ascending auction might be which terms to use, as the *ascending bids* are really *decreasing subsidies* in this context, as long as the standing bid still implies a subsidy. In the case of a CfD, the *ascending bids* are *decreasing strike prices*. We believe this is a challenge that can be overcome. A solution could be to use the term *open-bid* auction, which is less precise but also less confusing.

[21] Note that with respect to this concern, the term risk is used in another way than in the discussion of risk allocation in chapter 2.2.2 on support schemes. This is about the strategic considerations of bidders. Uncertainty about profitability is dealt with in the discussion of the winner's curse.

Although Anglo-Dutch auctions are much less used, we do not discard them due to lack of familiarity. As mentioned in the section on experiences from other countries, such auctions are used for renewable energy in Brazil and for demand flexibility in the state of New York. Furthermore, our partner Procurex has extensive experience with such auctions, which in their experience are often referred to as “final blind” auctions.

Collusion and entry are generally important concerns in auction design, but we do not believe them to be crucial in the auction for SNII phase 1. As there is only one lot, it is difficult for collusion to be a major issue. Cross-auction collusion, across phases or regions, could be a concern, but it is hard to see how it can be mitigated through the choice of auction type. Due to the considerable interest in participating in the auction, we do not regard entry as a challenge. However, note that with respect to both these considerations, an Anglo-Dutch auction has better properties than a pure ascending auction.

Based on our assessment, this is our ranking of the auction types:

1. Anglo-Dutch
2. Ascending
3. First-price sealed-bid

We recommend the Anglo-Dutch auction because it retains most of the good properties of the ascending auction with respect to the concerns we find the most important, while also having some of the good properties of the first-price sealed-bid auction with respect to the less important concerns. The main argument against is that it is a relatively novel auction type in this context. However, as it is not overly complex and Procurex has extensive experience with this type of auction, we consider this a manageable challenge.

This is our recommendation regardless of which support scheme is chosen. However, if an upfront scheme is chosen, the case for an Anglo-Dutch or ascending auction is even stronger. This is due to the good properties of these auctions with respect to the winner’s curse.

Furthermore, we recommend that a reservation price is set as a safeguard. In the case of an upfront scheme, the reservation price will be the highest possible subsidy. In the case of a CfD scheme, the reservation price will be the highest possible strike price. While the reservation should be set taking into consideration LCOE estimates for SNII, it should not be set so low that it causes potential bidders to not enter the auction.

4 Further considerations of relevance for the auction

This chapter collects regulatory issues and problems that have implications for auction design and/or the success of the auction in terms of achieving its objective: "An efficient allocation of the licenses to be auctioned, with the purpose of realizing the highest sum/lowest support". The chapter has the following subsections:

- Requirements to pre-qualification criteria from the perspective of the auction
- Pre-development responsibilities between state and bidders
- Grid connection and payment
- Realization deadlines and penalties

4.1 Requirements to pre-qualification criteria from the perspective of the auction

Pre-qualification requirements are used to increase the probability of timely project realization and to prevent bidders from participating in the auction with no robust probability of realizing the project. Pre-qualification criteria can be financial or technical/environmental in design, and they can relate to the bidder in general or to the Sørlige Nordsjø II project specifically. Pre-qualification requirements for the auction of Sørlige Nordsjø II will be developed by the Ministry and are not part of our assignment. However, the design and implementation of pre-qualification criteria may have a bearing on the success of the auction. This section deals with the interaction of pre-qualification criteria and auction success.

A viable auction requires a number of qualified bidders. It is difficult to think of a reason why a limited number of bidders is optimal in the sense that an additional qualified bidder will reduce the expected success of the auction. The reason is of course that the additional bidder may be the one that goes on to win the auction.

If the number of qualified bidders for some reason should be restricted it is important that the number is sufficiently large. From the perspective of the auction we recommend that the number of bidders should be at least eight if there is a sufficient number of qualified candidates.

From the perspective of the auction a fixed number of participants determined by the Ministry will probably create an "arms race" between contestants who seek to be included as bidders. This will induce them to invest heavily in producing the required documentation at the societal cost of providing a number of duplicates. More importantly, perhaps: it will induce them to make promises for their project design in environmental, technical and other dimensions which will add costs to the project should it be implemented. This arms race may lead to over-fulfilment of qualification criteria at the cost of higher support to the winning bidder.

Another possibility is that too few contestants will bother to participate in pre-qualification given the up-front costs. This may lead to fewer than eight bidders in the auction, and – depending on who drops out – perhaps not the ideal composition of bidders.

The alternative to a competition for a fixed number of slots in the auction is to set fixed hurdles that contestants should pass, and give a slot to everybody that passes. A compromise would be to set fixed hurdles in some dimensions (financial strength?) and allow a competition in other dimension (environmental safeguards?).

Many NSEC countries have in pre-qualification opted for the sole use of financial pre-qualification criteria (e.g., Denmark, Germany, and the Netherlands) and/or bidder qualification requirements (e.g., France, Denmark), given that sites are pre-developed to a large degree by authorities. The UK makes use of various technical pre-qualification requirements (e.g., planning authorizations and lease agreements for the site), given its decentralized system of site selection.

4.2 Pre-development responsibilities between state and bidders

Site selection and the cost of geotechnical studies are issues that generally are of concern in wind energy auctions. In this case the site is selected and seabed mapping at the site will be carried out prior to the auction on behalf of the Ministry, and later paid for by the auction winner.

Norwegian practice on this point corresponds to European best practice as it is being practiced in Belgium, Denmark (except nearshore & open-door procedure), German and the Netherlands.

The Offshore wind energy act and associated regulation put forward requirements for pre-development applications and permits that the winner of the SNII auction needs to undertake within predefined time limits. From the point of view of the auction the uncertain approval of applications are uncertainties that it would be advantageous to reduce as much as possible.

The uncertainties are somewhat reduced if the pre-qualification criteria are aligned with the legal requirements. For instance, a bidder may commit in the pre-qualification stage to pursue a program for the study of bird migration and adapt the location of his turbines to what the program reveals. If the evaluation is aligned with the legal process and in effect is a pre-approval of (this part of) an EIA some regulatory uncertainty is removed at the bidding stage. The main uncertainty in this case, however, is what the program reveals and how the location is affected.

In Europe some variation exists regarding the responsibilities attributed to the state body or the developer. In general, a minimum level of preliminary and basic site investigation performed by a public authority seems advantageous as it contributes to de-risking developers, and it allows for a more controlled rollout of offshore wind capacity to meet deployment targets. It is possible to go further, and let a state body provide a one-stop-shop where the successful developer receives all the required permits and licences to start developments, as is the case in the Netherlands. In other NSEC countries developers are still required to fill in pre-development applications, as is the case in Norway.

4.3 Grid connection and payment

The selected grid connection regime or grid delivery model for offshore wind farms defines stakeholder roles and responsibilities during the different project phases. The grid delivery model determines who finances the grid connection and where the interface lies between a developer and the governing TSO, transmission asset owner (TAO), or offshore transmission owner (OFTO). The adopted regime balances cost to consumers and government control over planning and realization timelines with de-risking of developers in the various stages of the project.

There are two main grid delivery models for offshore wind farms, developer-built/decentralised and TSO-built/centralised. Under the developer-built or decentralized grid delivery model (also applicable in Norway), the offshore wind farm and offshore wind transmission assets fall under the responsibility of the developer; this represents a deep grid connection regime.

In NSEC countries and the UK, various models are adopted that combine responsibilities of the two main models. The UK is currently the only market with a full developer-built offshore grid delivery approach. In Denmark, the developer of the Thor offshore wind farm is responsible for the offshore substation and export cable. The grid delivery models in other NSEC countries with an offshore market have generally evolved from direct connections established and operated by commercial parties towards a TSO-built model where the TSO or TAO has a legal obligation or a government mandate to design, build, and operate the offshore grid. Other NSEC countries have no significant amount of offshore wind farm capacity in place yet and have a more decentralised model (increased grid delivery responsibilities for the wind farm developer), for example, Ireland’s current system.

For the upcoming auction for Sørlige Nordsjø II, it has not been decided whether the project developer or Statnett will develop the radial connection to shore. In any case, it is likely that the radial will be classified as customer specific, which implies that the developer pays the full cost. However, this is yet to be concluded.

Statnett would be responsible for potential onshore grid reinforcements. Statnett is currently in the process of identifying connection points in the onshore grid that have sufficient capacity. While nowadays many countries have moved to a TSO-led development (due to higher efficiency/better grip on offshore wind developments), many NSEC countries had developer-led developments in the early stages. Overall, Norway would not be contradicting the general trend with the choice to go first developer-led (with the option to later switch to TSO-led).

According to Norwegian law, the developer should pay 100% of the costs of onshore grid infrastructure built specifically to serve the offshore wind farm. These costs should be determined and announced before the auction. At the very least bidders should know in advance of the auction the exact location of the substation, the voltage level, and the capacity. This information will be crucial for their bid.

However, even if the location is made known to the bidder, there are still risks for the project developer related to the landfall (delayed permits, uncooperative local authorities). To reduce these uncertainties, the government could start preparing the permitting process for the radial connection cable as soon as the onshore substation has been identified by Statnett, so that such issues to some degree can be resolved before the auction. This could shorten the realization time needed by the project developer.

If investments in the meshed grid are necessary, the developer will have to pay 50% of its proportional share of these costs. The proportional share depends on the number and size of others benefitting from the investment. Our impression is that the need for such investment is small for SNII phase 1, but may be larger for phase II. We recommend (1) that need for and cost of such investments is determined before the auction and (2) that the Ministry considers letting the government pay these costs. If the government pays these costs, they will likely be more than recuperated in the auction. This will reduce uncertainty for the bidders and reduce the probability of non-completion. Alternatively, the government could set a cost cap above which it covers the costs. If the cap is not set too high, this will reduce much of the uncertainty.

4.4 Realization deadlines and penalties

The realization period specifies the time during which the auction winner needs to apply for a concession, i.e., the exclusive right to build the offshore wind farm within a specific area in Sørlige Nordsjø II, and the time until which the project needs to be commissioned, i.e. be in operation. If the realization periods is exceeded, i.e., a project fails to be completed in time or the auction winner exceeds the time to conduct the necessary project specific assessments in an area and apply for a concession to develop and produce renewable energy in that area, the right to the acreage will be withdrawn and additional penalties may be imposed. Realization periods need to reflect realistic project delivery periods while avoiding lengthy delays that would encourage speculative behaviour and thus increase the risks that projects are not realized.

The Regulation to the Offshore wind energy law ("havenergilovforskrifta") states that the winner of the auction (in this case) "initially" shall submit a proposal for a project specific research program.[22] The program will include an environmental impact assessment. The Ministry approves the program.

Within two years from that point the winner must submit his application for concession, appending the EIA and other documentation. According to present rules, the concession owner should submit his "detailed plan" two years after approval of concession. However, the government is assessing whether the concession application and the detailed plan can be processed simultaneously to shorten the process. Finally, the plant should start operation within three years following approval of the detailed plan. All in all we are looking at a period of about eight years depending on approval processes from a winner is selected to production should start (i.e. the realization period is about eight years). However, the period might be shorter if the concession application and the detailed plan can be processed simultaneously. The Ministry may grant multiple two-year extensions to the deadlines, but this is at their discretion. Otherwise, oversitting a deadline may lead to withdrawal of the right to get to the stage of operation. Of course, these are maximum time limits.

These regulatory deadlines compare to the ideal duration of the realization period, which depends on several elements, including

- **Realistic timeframe to conduct necessary assessments and commission the project**: The penalty-free period to conduct site-specific assessments and commission the project should be informed by international best practice. Otherwise, adverse implications for risk levels incurred by bidders and as a result potentially higher bid price in the auction may be the result, while at same time increasing chances of project non-realization.
- **Infrastructure development and permitting:** Realization periods should be aligned and coordinated with the required infrastructure development lead timelines. The realization period should consider both the lead times for the offshore infrastructure as well as the lead times for the required onshore infrastructure. See our discussion in 4.3.
- **Supply chain:** Supply chains are currently under great pressure as internationally the offshore wind roll-out increases in pace. This could result in production slots being fully booked to the point that a short realization period may not be achievable by the developers.
- **First of a kind:** Since this will be the first offshore wind tender in Norway, some discretionary time may be considered in case of unforeseen lags in permitting or slow coordination of the different actors.

[22] §3: «Dersom eit føretak som oppfyller krava i havenergilova § 3-5 ønsker å søke om konsesjon til eit energianlegg, skal det fyrst sendast inn ei melding til departementet, med framlegg til eit prosjektspesifikt utgreiingsprogram.»

For the realization period, different systems are in use across NSEC countries. In the UK, contracts are awarded for delivery in a particular year. In the Netherlands, for the most recent tenders the realisation period was 4 years. However, in the Netherlands, the government has performed the environmental impact assessment prior to the award. In Germany, the realisation period starts from grid completion onwards – projects then have 18 months to realize. It seems that the current Norwegian regulation gives considerably more leeway than this.

Bid bonds may be asked from bidders before participating in the auction to ensure the successful bidder's commitment to enter a contract after being awarded. If a successful bidder does not sign the support contract, the support counterparty/auctioneer will retain the bid bond, otherwise, the bidder receives the bond back.

Furthermore, financial guarantees can be demanded, which together with penalties in the case of non-delivery or delay beyond the contractually agreed realization period, can contribute to timely delivery of projects. Beyond the already foreseen withdrawal of the right to build the park in case the offshore wind park is not commissioned within the set realization period, submitted financial guarantees at the time of entering the auction may be confiscated partly or in full, depending on the extent of the delay or non-commissioning (so-called completion bond). In line with international best practice, imposing financial guarantees in the range of up to 10% of estimated project costs may be suitable to ensure project delivery. However, this only serves as a rough indication and should be revisited as the auction design is defined in more detail.

When determining the extent of penalties, a right balance needs to be struck between maximizing realization rates and avoiding excessive risks for project developers. If penalties are set too strict and financial guarantees are too difficult to obtain, it may lead to low participation, and bid prices might increase. If penalties are too low, it might lead to a longer realization period or even non-realization. There is a risk of the bidders treating the auction as only the first stage of a two-stage investment decision, where winning the auction secures a real option that can be exercises if the conditions prove favourable (Welisch & Poudineh, 2019). The limited cost of entering the auction and low penalties, can be seen by the bidders as the price of acquiring the real option. Besides the full or partial confiscation of the financial guarantee, penalties can take several forms, such as lowering of support level or the shortening of contract validity period by the time of the delay. Penalties may also be escalated over time to account for the extent of delays or deviation from contractual obligations. Termination of the contract would be a penalty by itself if there is profit in the contract.

As noted in the final bullet point above, since this is the first offshore wind auction in Norway, the risk of delay may be high compared to other markets in NSEC. Comparatively high penalties may add to this risk from a developer point of view. At the same time, ensuring timely realization by ensuring only serious bids are considered is key for creating confidence in the Norwegian market. Implementing sufficiently high penalties also decreases the winner's curse risk and ensure that bidders submit adequate bids that are likely to allow for successful project completion. In this sense well-designed penalties may reduce the need for strict pre-qualification criteria.

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