Public information

Grid concepts Sørvest F

An analytical basis for determination of grid concepts for bottom fixed offshore wind in Sørvest F

February 2025

Preface

Electrification and new industrial activities create a need for a significant amount of new and emission-free power production. The Norwegian Government has therefore opened for the development of bottom-fixed offshore wind in the Southern North Sea II area. In 2024, the authorities conducted the first auction for the development of 1.4 GW offshore wind, which was won by Ventyr. The next phase of the development of bottom-fixed offshore wind is planned in the Sørvest F field.

This report responds to an assignment given by the Ministry of Energy in June 2023, where Statnett was requested to investigate possible grid solutions for the next development phase of Sørvest F. In December 2023, the ministry provided additional premises for the investigation and requested that the analysis basis should be sufficient for the ministry to determine the grid concept before an announcement of a new award process.

In the report, we define possible grid concepts for the connection of offshore wind in Sørvest F. The report is also relevant for the other bottom-fixed offshore wind areas in Sørvest A-E. Possible grid concepts include both radial connections to Norway and hybrid connections where the offshore wind is connected to one or more countries in addition to Norway. In the analysis, we calculate and assess price effects, the interaction with the onshore power system, and socio-economic profitability.

We quantify and discuss the overall socio-economic benefits and costs for the entire offshore wind farm and various grid concepts. Similarly, we also assess the business profitability of offshore wind based on electricity sales, support needs, and tariff effects. However, we emphasize that the purpose of this is to highlight the differences between different grid solutions. It would require a larger and more thorough investigation to determine whether it is socio-economically profitable to build offshore wind in Sørvest F.

This document contains an English translation of the executive summary. The complete report is available in Norwegian at Statnett.no.

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Executive summary

The report evaluates five main grid concepts

The Sørvest F offshore area is located 180-240 km from the nearest connection point in the Norwegian grid. The distance requires the connection to land to be built with direct current technology. One of the two main alternatives is to build a radial connection directly from the offshore wind farm to Norway. However, the location, approximately midway between Norway and the countries on the other side of the North Sea, also makes it relevant to connect the offshore wind with connections both to Norway and another country. This is called a hybrid and is the second main alternative.

In this investigation, Statnett has evaluated four hybrid concepts. The three most relevant concepts are called *Trade First (Storhandel), Wind First (Storvind),* and *Wind-Wind (Vind-vind).* Trade First is the concept with the least volume connected offshore wind. It has the ability to send all offshore wind to one country and has the most capacity available for trade. Wind First and Wind-Wind have twice as much connected offshore wind per hybrid, and less available capacity for exchange of power. In Wind-Wind, one of the offshore wind farms is in another country. The fourth main hybrid concept is an asymmetric hybrid to Norway. This is a technically complex concept that may be described as a hybrid and a radial that can be connected. Long lead times mean that hybrid concepts can only be operational from 2035 and onwards.

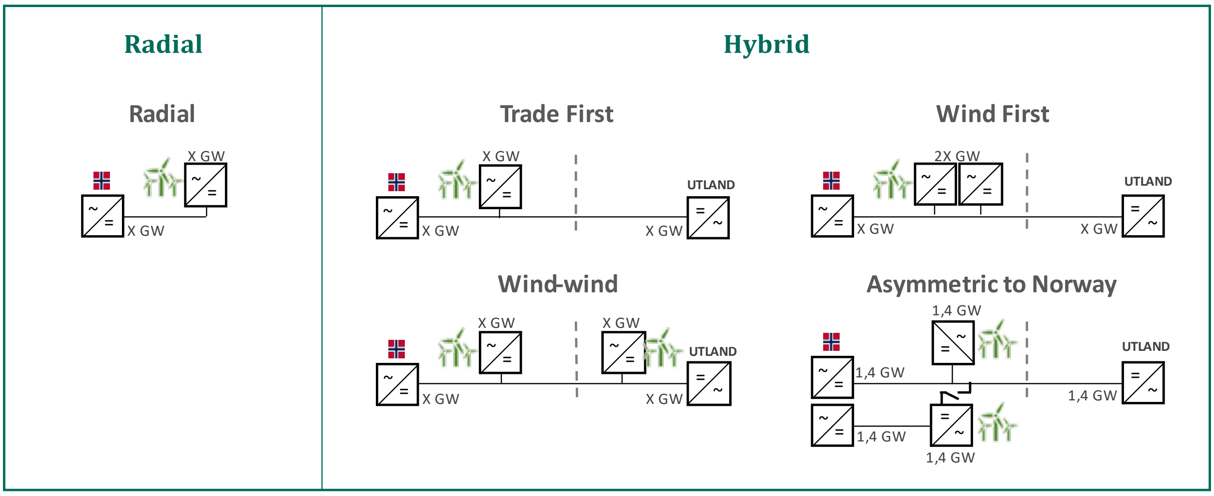

Figure 1: Technical main concepts for bringing offshore wind from Sørvest F ashore.

In the longer term, it may be relevant to develop a more meshed offshore grid in the North Sea where several offshore wind farms and countries are connected. However, high uncertainties means that this is not relevant for the next announcement of Norwegian bottom-fixed offshore wind.

Costs are high, with significant variation in outcomes, for all grid concepts

All grid concepts for Sørvest F have high investment costs. This is due to the long distance to land, increased raw material prices and margins in the supplier market. For a Radial, the grid costs will amount to approximately 40 % of the total cost of developing offshore wind in Sørvest F. This reinforces the need to develop cost-effective grid solutions.

The range of outcomes for costs related to the future preferred solution is significant. The range includes different geographic landing points, and significant uncertainty because of a tight supplier market. How much Norway must pay for a possible development of a hybrid also depends on how the costs are shared with a partner country. For simplicity, we use an assumption of a 50/50 split of the entire grid facility for hybrids – and then discusses sensitivities. For a Radial, Norway's share of the costs is 100 %. For an Asymmetric hybrid to Norway, we use an assumption that Norway's share of the costs is 50% for the hybrid section and 100% for the radial section.

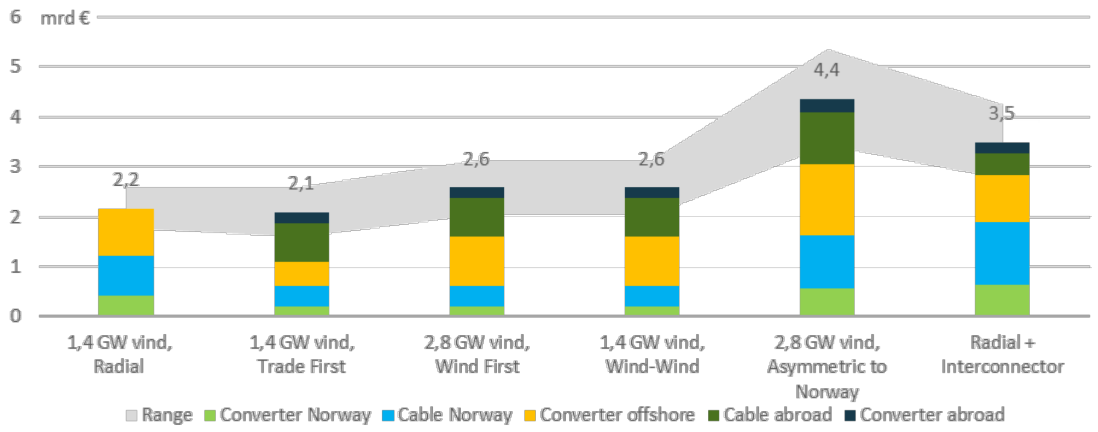

Figure 2: Estimated Norwegian share of investment costs. Shown here for connections to Germany. The alternative with a radial connection of offshore wind plus a separate interconnector is included as a reference.

Between the hybrid concepts, Trade First has the lowest investment costs for Norway in our basis scenario. We use Germany in our basis, as it has a distance close to the average of possible partner countries. With a 50/50 split, this gives Norwegian costs similar to a Radial. Wind First and Wind-Wind connect twice as much offshore wind and thus generates higher costs for the offshore station, but at the same time this concept delivers the lowest grid costs per GW of offshore wind. The costs for an Asymmetric Hybrid are equal to the combined cost of a Radial and a Trade First in addition to some extra costs to be able to connect them.

Future clarification of the final grid solution, agreements with trading partners, and a good procurement process will reduce risk and may reduce Norway's share of the costs for the grid facility towards the investment decision. At the same time, having as much clarified as possible before the auction date will lower the risk and costs for the developer of the offshore wind.

More production and increased exchange capacity provide socio-economic market benefits

Offshore wind has low production costs once it is developed. More offshore wind thus provides a socio-economic market benefit, as it replaces production with higher operating costs in most hours when it is blowing. This benefit is approximately equal to the producer surplus of wind power. This is the difference between the electricity price and the operating cost multiplied by the produced volume hour by hour.

With a hybrid, the total exchange capacity between Norway and our neighbouring countries increases. Thus, the offshore wind can be sent to another country when electricity prices are higher there. In addition, the grid facility can be used for power exchange between Norway and the country we connect to during periods when wind power production is low. This reduces production costs in the overall electricity market and provides an additional market benefit. With a hybrid, however, the producer surplus from the offshore wind constitutes the main part of the total benefit. Our calculations of the market benefit provide the following main points:

- The benefit of offshore wind depends on the electricity price level and therefore has a large range of outcomes.
- Large price differences between Norway and neighbouring countries provide additional benefit from a hybrid.
- The Trade First concept provides the highest benefit.

There is a high uncertainty about market development, and whether the electricity prices will be sufficiently high to cover the costs of developing offshore wind. However, it seems reasonably certain that there will be large price differences hour by hour between Norway and other countries, giving additional Norwegian benefit from a hybrid. Increased exchange capacity provides more economically efficiency in handling variations in inflow and improved utilisation of the hydropower's ability to adjust short-term price variations.

With Trade First, the increase in total Norwegian congestion revenues constitutes around 60 % of the additional Norwegian market benefit that arises through electricity exchange via the hybrid. The remaining benefit is a net increase in producer and consumer surplus in Norway. More offshore wind without other changes results in lower average prices and thus increased consumer surplus for Norwegian consumers both with radial and hybrid concepts.

Offshore wind with a hybrid achieves higher priced socio-economic profitability than a radial

Our calculations show that offshore wind with hybrid achieves higher priced profitability than Radial in most scenarios for benefits and costs. The main reason is that hybrids have higher market benefits, while the costs can be shared with a foreign partner. The Trade First concept, which has the most available transmission capacity, achieves the highest priced profitability. Radial has negative profitability throughout the entire range. We also compare with Radial in combination with a interconnector that does not go via an offshore wind farm. In the same way as hybrid, this concept provides both offshore wind to Norway and a benefit from trade. The concept provides lower profitability than Trade First, as it has significantly higher costs. In sum, both uncertain costs and uncertain benefits provide a significant range in overall profitability for all grid concepts.

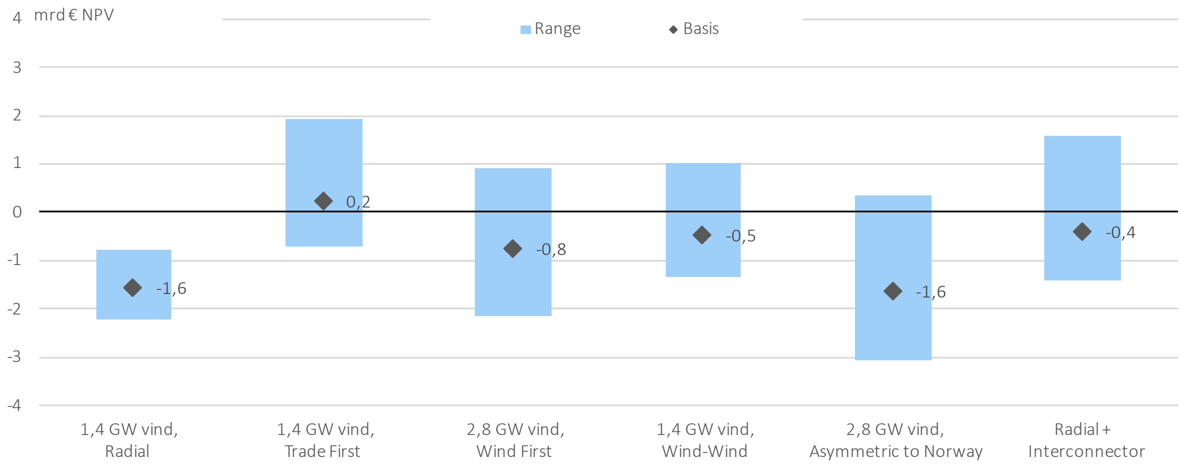

Figure 3: Norwegian socio-economic profitability for offshore wind with various grid concepts. Figures in fixed 2024 billion euros, discounted to 2025. Shown here for connections to Germany.

Our analyses show that the benefit of a hybrid will be approximately at the same level for all the relevant countries around the North Sea. However, the total cost of a hybrid will vary with the distance to the other countries. The sharing of costs with the country we connect to will therefore mean a lot for the choice of partner country, in addition to the possibilities for practical implementation.

More offshore wind on radial and hybrid reduces Norwegian electricity prices

The development of more offshore wind will initially contribute to reducing Norwegian electricity prices. How much prices are reduced depends on how the offshore wind is connected to land, how much offshore wind is developed, the price level in other countries, and how much surplus or deficit there is in the Norwegian and Nordic energy balance.

Our model simulations show that prices decrease the most with Radial to Norway. At the same time, the simulations show that average prices also decrease with hybrid concepts in most scenarios. If there is a deficit in the Norwegian energy balance, the price decrease of a radial and a hybrid will be more similar. In the event of a large Norwegian and Nordic power surplus, the effect will be the opposite. In such a case, prices will initially be lower in Norway than in Europe. While a Radial will lower prices further, the increased exchange capacity with a hybrid will cause prices to increase somewhat in this case.

Since prices decrease the most with Radial, it is likely that we will see greater consumption growth in Norway with such a solution. Increased consumption will consequently contribute to higher prices. This will likely even out the difference in how much prices will decrease in the various grid concepts, compared to no development.

A 2.8 GW increased transmission from Sørvest F to Southern Norway is likely possible given the planned grid development

Planned grid reinforcements will provide greater capacity and fewer bottlenecks internally in Southern Norway over the next decade (ref. Systemutviklingsplanen). At the same time, more offshore wind will provide increased flows in the Norwegian grid, both with radial and hybrid concepts. A connection of 1.4 GW offshore wind to Southern Norway, in addition to the first phase already under development, results in few additional congestions in the planned grid. With a connection of 2.8 GW, our calculations show that there will arise some congestions internally in Southern Norway with the planned grid reinforcement. This is particularly the case before the planned renewal of the 300 kV grid between Rogaland and Telemark is completed. The simulations also show that the congestions are handled efficiently through the market. The consequences will therefore be price differences and reduced socio-economic benefit from the offshore wind development. If the planned grid developments are delayed, the internal congestions and price differences will be greater. More than 2.8 GW in total connected capacity will cause major bottlenecks and may require further network analysis and planning.

In our assessment, there is sufficient transmission capacity in the planned grid to connect up to two 1.4 GW connections with offshore wind to Southern Norway. However, this require that the planned grid reinforcements are completed, and a certain degree of internal congestions is accepted – especially when lines are out for maintenance during the summer. More converter capacity connected to the grid in Southern Norway can also result in stability challenges. The consequences of these challenges must be clarified further before final investment decisions are made.

Hybrid reduces the direct support need compared to Radial

Offshore wind in Sørvest F will most likely not be economically viable without some form of financial support in the form of direct subsidies or exemption from connection charges. The need for support is greatest for a radial where offshore wind developers must absorb the entire grid cost.

With a hybrid, the offshore wind producer will receive somewhat lower revenues from electricity sales. This is because the offshore wind farm will likely constitute its own bidding area to achieve efficient utilization of electricity production. The lower revenues are more than offset by the market benefits from electricity exchange, and parts of this benefit come as congestion revenues to Statnett. This can help finance parts of the infrastructure through the grid tariff and provide lower grid costs for the offshore wind developer. Depending on the regulation, the need for subsidies for a hybrid may therefore be lower than for a radial.

Although a hybrid increases Norwegian total congestion revenues, this will likely only cover parts of the Norwegian grid cost. A hybrid can thus lead to increased tariffs for customers in the onshore transmission grid. The extent to which this happens depends on how much the offshore wind developer will pay in connection charges.

Overall assessment

Overall, it appears most socio-economically rational to build offshore wind with hybrid connections, either as Trade First, Wind First, or Wind-Wind. This provides the greatest profitability because the offshore wind can then be sold in two markets and because the grid infrastructure can be used for profitable exchange when the production from the offshore wind is low. The investigation shows that this conclusion is viable in a wide range of different scenarios for market development and costs. Offshore wind with Radial connection will have a higher need for financial support, but also provides a more significant price reduction in Norway. With a high valuation of increased consumption in Norway, Radial can also be a rational concept.

According to our assessment, the planned grid allows up to two connections with offshore wind to Southern Norway, each at 1.4 GW, given satisfactory clarifications about system stability in the onshore grid. Two hybrids should not be commissioned at the same time to avoid a too large simultaneous change in the power system.

Whether it can be socio-economically profitable to build offshore wind in Sørvest F will largely depend on political choices related to alternatives for new production, climate goals, and overall Norwegian value creation. This is therefore beyond what we address in this report.