Norsk Industri

LEVERANSEMODELLER FOR HAVVIND

DELIVERY METHODS FOR OFFSHORE WIND

Delrapport – Norske havner, verft og byggesteder

Norwegian ports, yards and construction sites for offshore wind

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Content

Cover photo: Aibel

FOREWORD

The role of ports in the blue industry and the offshore wind industry in Norway

Today, the traditional linear concept of ports, whereby goods and passengers are transported from point A to point B overseas, is no longer sufficient as a strategy for port development. Actually, the ports all over Europe take up new roles. Next to logistic operations, the ports and port managers play a critical role in the energy sector, the circular economy and the blue economy, including the offshore wind industry. And their permanent interaction with the local community has become a key management asset. Today, ports have become industrial clusters, whereby their importance is defined by the added value and the employment they create, the marine knowledge they gather, and the sustainable relation they have been built up with the local community. Measuring the importance of a port only by the quantification of the volumes is insufficient. The organisation of an O&M basis in a port to support the operations at an offshore wind park will bring a lot of employment and supply activities, but not so high volumes.

The blue economy and the blue growth strategy offer the ports several opportunities in order to create their particular added value, taking into consideration their geographical, climatological and demographic location. And within the blue economy, the offshore wind energy production and storage takes a key position. The offshore wind industry is characterised by three types of activities: the installation, the operations & maintenance and the decommissioning of wind turbines, each with their own supply and servicing system. This expansion of the operations within the ports entails an evolution of the governance mechanisms of these ports. The port governance moves from landlords for logistical enterprises to community managers and catalyst of the blue industry and the offshore wind energy. The mere management of the port area and the maintenance of the port infrastructure with due diligence, is no longer sufficient these days in order to guarantee sustainable port operations, realising the relevant added value. Within the implementation of the blue growth and offshore wind strategy, the ports can take up different roles. This affects both the port management (software) as the port infrastructure (hardware).

- Ports can act as a **facilitator** within the blue economy. Considering the major awareness of the local community and the importance of clean water and clean air for coastal tourism and fisheries, the ports can invest in the relevant port infrastructure that helps to decline the carbon footprint of the ships that operate at the port. The installation of onshore power supply or the organisation of carbon-low fuels are some examples. Another example is the adaptation of the port infrastructure to the specific needs of the logistic operators for the installation of the offshore wind parks.
- Ports can be an **actor within the blue economy**. Considering the different operations within the port, related to logistics or industrial activities, the port can investigate and analyse its proper operations in order to become more energy efficient and reduce its proper carbon footprint. The installation of smart led lights or the integration of wave energy converters in the breakwaters are just a few of the actions that ports can undertake themselves.
- Ports can be an **investor** in the blue economy. Considering the obligation to reduce the carbon footprint within the port area, the port can play an active role in the production of new fuels. It can become a partner in a centre for the production, storage and distribution of hydrogen on the basis of green renewable energy, which can be used for the ships as well as for the local community.
- Ports can act as the **engine of a cluster** within the blue economy. Considering the opportunity for constructing offshore renewable energy facilities, and considering the multiple competences that are needed to organise the installation and the maintenance of the offshore energy farms, the port can work actively to build a full cluster of marine suppliers, whereby interconnectivity is crucial to make the operations economically efficient.
- Ports can act as a **knowledge basis** within the blue economy. Considering the importance of a good relation with the local community and considering the need to reduce the carbon footprint, the port can install a full set

of sensors in order to monitor the different activities within the port area and in the outer port. In this way, the port can act more effectively in case of emergencies. And moreover, it can build up a full set of data that might be useful for the other industrial applications.

- Ports can act as a **research partner** within the blue economy. Considering the need for permanent innovation in the different fields of the blue economy, the port can operate as a test basis in order to test different prototypes than can be implemented in the field of the offshore industry, aquaculture, desalination and others. Moreover, it can invest in science parks, offshore and research facilities for the industrial innovation. The testing of the different types of coatings for the towers of the wind turbines that will be installed at sea, or the testing of floating solar panels within the offshore wind parks are two examples of research, whereby the port can play an active role.
- Ports can act as a **training partner** within the blue economy. Within the port, there are very diverse marine competences gathered. On the other hand, the developing sectors within the blue economy have high safety and security standards. The port can foresee in the relevant training facilities in order to make sure that the staff, working in the aquaculture, seabed mining or offshore renewable energy, dispose of the necessary certifications.
- Ports can act as a **national or international cooperation partner** within the blue economy. Considering the major challenges in both the traditional and emerging ocean and maritime activities, and the speed of the innovations on the one hand, and considering the limited resources on the other hand, it is of major importance that the commercial position of every port moves from a pure competition model to a model of competitive cooperation, whereby ports and port stakeholders work together to mobilise financing for smart infrastructures that will increase the sea-basin trade and the growth of the blue industry, including the offshore wind industry and related sectors like the production of hydrogen.

Considering these evolutions related to the role of the ports in the overall blue economy and the definition of new roles within port governance, this has direct consequences on the traditional port business model. The ports will need to revise this business model as their revenues are not only linked to the elementary logistic handling of cargo and passengers, but also to the development and the management of an ecosystem for the development of the blue industry, the offshore wind industry, and the sustainable maritime economy. However, this assumes that a stable legal framework has been created by the government in order to implement the construction and maintenance of offshore wind farms, and the ports should have a clear insight in the pipeline of the projects that will be rolled out within the field of blue industry and offshore wind industry.

The Norwegian ports have a long tradition of working offshore and dispose of excellent maritime skills. It is clear they that have many cards to play in order to take up the business opportunity of the offshore wind industry in and out of Norway.

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Sammendrag

Hovedfunnet er at norske havner, verft og byggesteder har potensielt både kaiplass og vanndybder som tilsier at det er fullt mulig i *fremtiden* å bringe frem og sette sammen komponenter til havvind langs hele kysten – fra Kirkenes til Halden. Aktørene er meget interessert i å ta del i en slik utvikling og har en kjernekompetanse på transport av komponenter som kan brukes.

Det er også et viktig funn å konstatere at aktørene i dag i hovedsak *ikke* er rede for utbygging av havvindparker av kommersiell størrelse, hverken organisatorisk eller fysisk. De fleste norske havnene vil ha behov for omfattende investeringer for å kunne legge til rette for industriell produksjon av komplette strukturer for havvind. Det er heller ikke et rammeverk på plass som gjør det attraktivt eller mulig for investorer å gjøre de oppgraderinger som norske havner og byggesteder trenger for å være sikker på en konsistent tilflyt av havvindprosjekter.

Bakgrunn

Havvind krever store områder for fabrikasjon og sammenstilling. Dette gjelder særlig flytende vindturbiner, da bunnfaste vindturbiner blir satt sammen ute på feltet, der de store komponentene kommer direkte fra produsenter i utlandet. Sammenstilling av flytende vindturbiner krever tilgang på dypvannskaier og skjermede lagringsområder. For en flytende vindpark på kommersiell størrelse er det høye krav til områder, kaier og potensiell lagring i sjø. Det finnes noen havner og baser i Nord-Norge, Trøndelag, Møre og Vestlandet som kan håndtere dette. På Sørlandet og langs Oslofjorden er det ikke identifisert tilfredsstillende eksisterende havner som kan håndtere denne type aktivitet.

Norge har hundretalls havner og baser som jobber med olje- og gass-industrien som kan brukes som driftshavner for havvind. De havnene som stikker seg ut med tanke på drift og vedlikehold er de som evner å se et større tjenestespekter i en sammenheng, slik som opplæringssentre og kort vei til gode kommunikasjonsmidler.

Verft og byggesteder brukes til å bygge større komponenter til havvind, slik som transformerstasjoner eller flytende fundament. Verftene anses å være meget gode på å levere komplekse strukturer. Prosjektet har analysert kart over kysten for å finne områder som på lik linje som med "det som ble gjort i olje -og gass-sektoren" kan brukes for å bygge havvindfundament. I første del av rapporten er Rogaland brukt som pilotområde, og når neste del av rapporten er fullført, vil resten av landet være kartlagt. En slik analyse legger til rette for lokal utbygging av havvind i landsdeler som ikke nødvendigvis har tilgang på relevante verft.

En rekke havner oppfatter at de er i en konkurranseposisjon med hverandre, også potensielt i havvind. Selv om det finnes gode eksempler på at formalisert samarbeid mellom havner kan hjelpe til med å øke markedsandeler, åpne nye handelsruter og optimalisere drift, er det fremdeles et stykke for havnene å gå for å komme frem til gode samhandlingsmønstre og felles tilnærming til hvordan man kan drive frem en norsk havvindsatsing.

Havvind er inne i en rivende teknologiutvikling, drevet av større og større vindturbiner, som spiller inn på det meste av infrastrukturen tilknyttet en havvindpark. Innspill fra Wind Europes havnegruppe tilsier derfor at vel så viktig som havnenes fysiske egenskaper er et langsiktig fokus på havvind som sentral virksomhet for havnen, en fleksibel holdning, nærhet til potensielle kunder samt vilje til å investere for å bygge kompetanse for å få innsikt i de utfordringer som havvindindustrien møter. Prosjektet observerer at havnene virker å ha en meget sterk tro på egne ferdigheter og kompetanse overfor havvind, som kanskje er noe høy tatt i betraktning at havvind er en industri som ennå ikke har fått fotfeste i Norge.

Med et ekstremt fokus på marginer og kostnadsreduksjon er havvind en ny industri - ikke en forenklet versjon av olje og gass. Norske havner og selskaper vil stå seg godt på å ha det i mente.

Anbefalinger

Prosjektet anbefaler at havnene oppmuntres til en vesentlig større grad av samarbeid, til å anerkjenne at havvindindustrien har egne drivere som er annerledes enn olje- og gass-sektorens og at hvis man får på plass nye forretningsmodeller så kan norske havner spille en stor rolle i et fremtidig europeisk marked.

Prosjektet ser også behovet for at havnene fordeler oppgaver mellom seg for å unngå unødige investeringer, og at man fortsetter å forsterke det arbeid som f.eks. Kartverket med støtte av Kystverket gjør for å kartlegge dagens status på norske havner. Det er også viktig med en anerkjennelse at selv om vi har mange havner langs kysten vår, er de fleste enten meget tydelig satt opp for tradisjonelle godshåndteringsroller eller for små for de enorme kravene som kommersielle havvindparker stiller.

For å legge til rette for en god havnestruktur for havvind ser prosjektet behov for en tydelig og robust nasjonal ramme for utbygging av havvind, slik at investorer kan være trygge på at investeringene får en avkastning. Det vil også være behov for en gjennomgang av reguleringer på de antatt beste stedene for havvindutvikling samt at norske havner, verft og byggesteder trenger god støtte til å åpne dører til internasjonale forretningsmuligheter

Executive summary

The main finding is that Norwegian ports, shipyards and construction sites have *potentially* both sufficient quay space and water depths, making it entirely possible in the future to construct and assemble components for offshore wind along the entire coast – from Kirkenes to Halden. The key stakeholders are very interested in taking part in such a development and have a core competence in the transport of components that can be used.

It is also an important finding to note that the ports and construction sites are in general currently *not* prepared for the development of offshore wind farms of commercial size, neither organizationally nor physically. Nor is there a framework in place that makes it attractive or possible for investors to facilitate the upgrade that Norwegian ports and construction sites need to ensure a consistent influx of offshore wind projects.

Background

Offshore wind requires large areas for assembly. This applies in particular to floating wind turbines, as bottom-fixed wind turbines are assembled offshore, where the large components come directly from manufacturers abroad. Assembly of floating wind turbines requires access to deep-water quays and sheltered storage areas. For a floating wind farm of commercial size, there are high requirements for areas, quays and potential storage in the sea. There are some ports and bases in northern Norway, Trøndelag, Møre and Western Norway that can be developed further to handle this. In Sørlandet and along the Oslo Fjord, only a few existing ports have been identified that could handle this type of activity.

Norway has hundreds of ports and bases that work with either the fishing industry or the oil and gas industry that can be used as operating ports for offshore wind. The ports that stand out in terms of operation and maintenance are those that are able to see a wider range of services in such a context, such as training centres and a short way to means of communication.

Shipyards and construction sites are used to build larger components for offshore wind, such as transformer stations or floating foundations. The yards are considered to be very good at delivering complex structures and projects. The project has analysed maps of the coast to find areas that, in line with construction for the oil and gas sector, can be used to build offshore wind foundations. In the first part of the report, Rogaland is used as a pilot area, and when the next part of the report is completed, the rest of the country will be mapped. Such an analysis facilitates local development of offshore wind in parts of the country that do not necessarily have access to relevant shipyards.

A number of ports perceive that they are in a competitive position with each other, also potentially in offshore wind. Although there are good examples of formalized cooperation between ports helping to increase market share, open new trade routes and optimize operations, it is still a long way for the ports to go to arrive at good collaboration models and a common approach to how to drive a Norwegian offshore wind initiative.

Offshore wind is undergoing rapid technology development, powered by larger and larger wind turbines, which affect most of the infrastructure connected to an offshore wind farm. Input from Wind Europe's port group therefore indicates that just as important as the ports' physical properties is a long-term focus on offshore wind as a central activity for the port, a flexible attitude, proximity to potential customers and willingness to invest to build expertise to gain insight into the challenges facing the offshore wind industry. The project observes that the ports seem to have a high level of confidence in their own skills and competence in relation to offshore wind, which is perhaps a bit risky considering that offshore wind is an industry that has not yet gained a foothold in Norway.

With an extreme focus on margins and cost reduction, offshore wind is a new industry - not a simplified version of oil and gas. Norwegian ports , yards and possible construction site owners would be well served to acknowledge this.

Recommendations

The project recommends that the ports, yards and construction site owners cooperate at a significantly higher level, recognize that the offshore wind industry has its own drivers that are different from the oil and gas sector and that if new business models are put in place, Norwegian ports can play a major role in a future European offshore wind market.

The project also sees the need for the ports to distribute tasks among themselves to avoid unnecessary investments, and to continue and strengthen the work to map the current status of Norwegian ports, currently conducted by the Norwegian Mapping Authority (Kartverket). It is also important to recognize that although we have many ports along our coast, most are clearly set up for traditional freight handling roles or too small for the enormous demands of commercial offshore wind farms.

To facilitate the overall transition to offshore wind, the project sees a need for a clear and robust national framework for the development of the industry, so that infrastructure investors can be confident that their investments will be recouped. There will also be a need for a review of regulations on the assumed best locations for offshore wind development. Finally, Norwegian ports, shipyards and construction sites need good support in order to be successful with international business opportunities.

1 Introduction

1.1 PURPOSE OF STUDY

Ports, yards and construction sites for offshore wind are key parts of the infrastructure to deliver offshore wind components. Ports enable an effective and efficient flow of products into the offshore wind industry, and the yards and construction sites may be able to leverage their skills to deliver a large number of offshore wind structures to both domestic and international projects. As such, an assessment of the status of the Norwegian ports, yards and construction sites is vital in understanding our total delivery capability.

This reports presents a study aiming to summarise the current status of the ports, yards and constructions sites with a purpose to provide:

- An overview of current capabilities available to support the development of an offshore wind supply chain in Norway
- Reflections on the role of Norwegian ports, yards and construction sites for a role in Norwegian offshore wind, as well as role in a European and global market
- Perspective of possibilities and challenges for the sector supporting Norwegian industry to reach a significant role in offshore wind
- Recommendations on further work

1.2 DISCLAIMER

This study is by no means exhaustive in mapping the relevant ports, but may serve as an indication of the status and possibilities of Norwegian ports, yards and construction sites. The project apologises to any port or yards or potential sites that have not been included. The exclusion of any given port does thus not exclude them from being a strong contender in the offshore wind industry. The conclusions in this report are also based on information gathered in the process, and may be based on incomplete or misunderstood information. A potential supplier or developer would thus be advised to seek further information independently of this report. All maps are taken from norgeskart.no.

Figure 1 - Norwegian ISPS ports (red = public, blue = private) Source: Kystinfo.no

2 The offshore wind market for Norwegian ports, yards and construction sites

Development of offshore wind on the Norwegian Continental Shelf will take time. Norwegian offshore wind parks are not assumed to be operational until the end of the decade.

As shown throughout the project report, there is a need for the Norwegian supply chain and ports to position for European and global market opportunities to seize opportunities prior to Norwegian offshore wind farm developments reaching sufficient maturity. The upside is that the European and global ambitions are significant and that the global market is growing rapidly. The global offshore wind market is currently growing with approximately 19 % per year, with some regions showing a significantly sharper growth.

Large parts of the European market is within easy reach of many Norwegian ports and yards, with only a day of sailing distance or a few days' towing distance. The presence of a strong and experienced Norwegian fleet of vessels adds to the viability of ports and yards promoting their offerings to the European market.

The European and global market for offshore wind
As of January 2021, 33 GW offshore wind has been commissioned globally – and the market forecasts estimates a global market of 228GW by 2030, according to projections from the International Renewable Energy Agency (IRENA). Today, 90 % of the currently installed offshore wind capacity in the world is located in Europe, mostly in the North Sea and the Atlantic Ocean. In the future, about half of the offshore wind development is assumed to be in China and the Far East. However, a significant portion of offshore wind expansion will be in Europe.

The European Commission expects the EU to produce at least 240 gigawatts (GW) of global offshore wind power capacity by 2050. The countries bordering North Sea basin follows this trend with approximately 180 GW offshore wind expected to be deployed in a region close to Norwegian ports, yards and construction sites. Post-Brexit, the UK has a stated ambition of 40GW by 2030, including a range of Scotwind projects that are likely being commissioned towards the turn of the decade. In all, the ambitions represent major market opportunities within reach for Norwegian ports, yards and construction sites.

For Norwegian suppliers, ports and yards will be crucial to develop business, in Europe and globally whilst offshore wind projects matures on the Norwegian Continental Shelf. Norwegian ports have access to sheltered, deep waters and an experienced and capable workforce used to handle highly complex projects in a collaborative fashion. Key European development areas are 3-8 days tow distance from key Norwegian ports and yards, compared between 5-10 weeks days of towing/shipping from Asian yards[1].

1. Distances taken from: https://sea-distances.org/

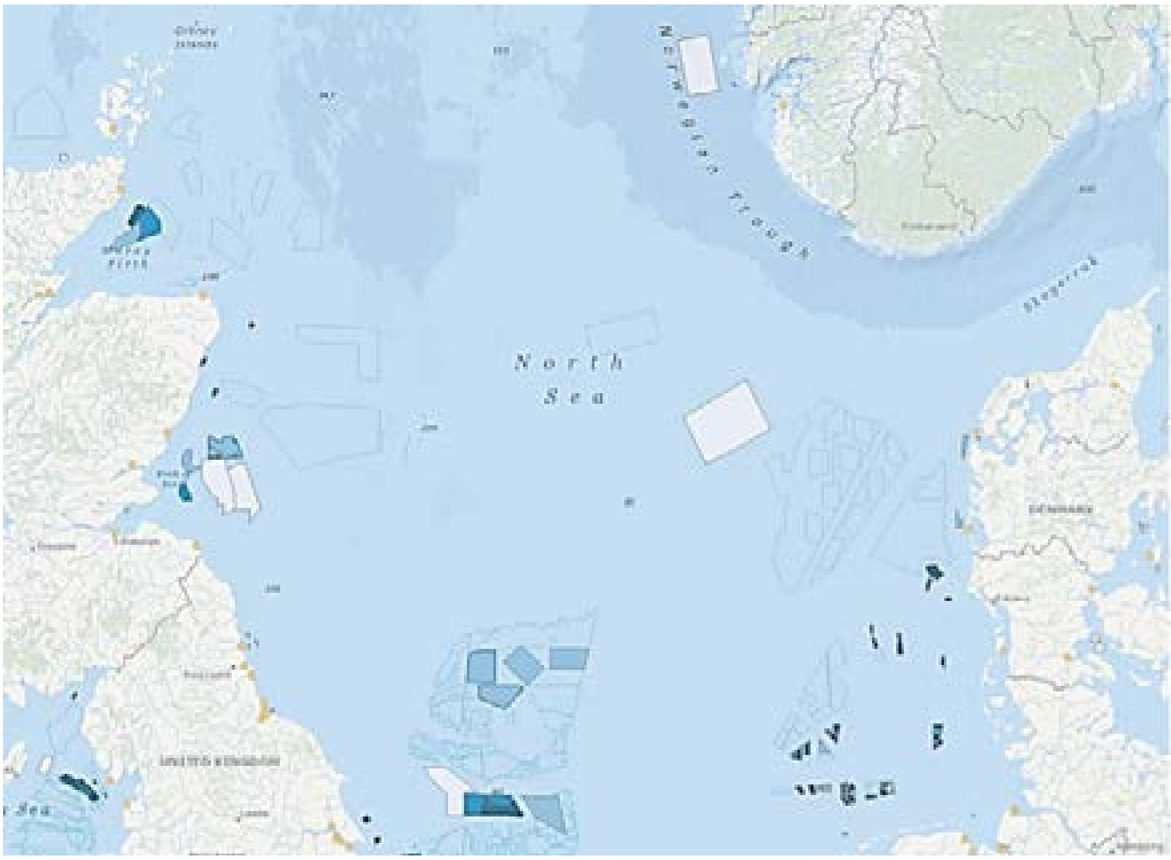


Figure 2 - Possible North Sea basin areas for offshore wind (4COffshore.com) – blue lines indicate future areas for wind farms. (Source: 4C offshore wind map)

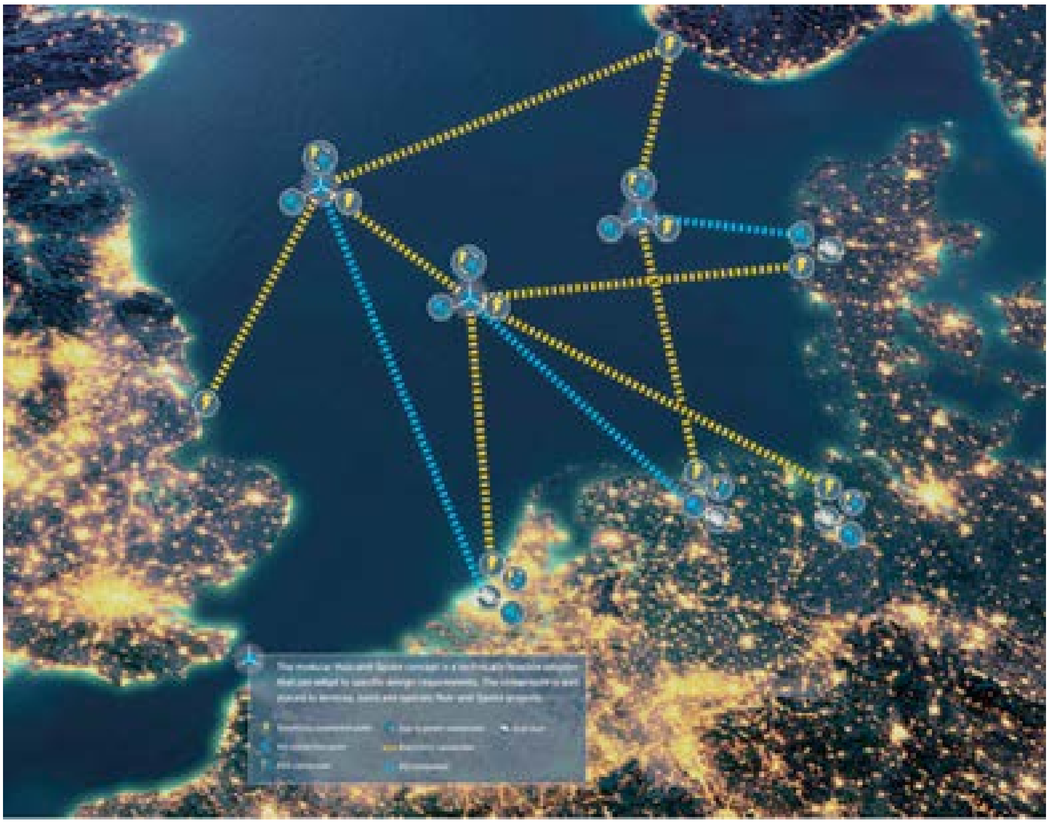


Figure 3 - North Sea Wind Power Hub ambitions for an offshore wind future[2]

2. Close to Norwegian ports and yards, North Sea Wind Power Hub consortium works to facilitate connection and integration of large scale offshore wind into the European energy system, based on the European vision of 230GW of offshore wind, of which 180 GW is estimated to come in the North

3 Business models, ownership, hubs and long-term planning

Traditional port business models may be challenged by the offshore wind industry.

3.1 TRADITIONAL BUSINESS MODELS IN FOCUS

Ports have a traditional focus on their role as landowners and logistics hubs, leasing out land and various equipment and quay fronts, and ensuring the timely transport of components as they have traditionally done

The fairly traditional approach to the core business may need to change to cater to offshore wind. Due to the large number of massive new structures – with blades measuring well above 100 m, heavy nacelles, a large number of semisubmersible structures measuring at least 100 by 100 m, hundreds of kilometers of large mooring chain and cables, offshore wind may represent a new challenge to the ports. Optimising the setup to minimise heavy lifts, reserve suitable areas as well as reducing the number of handling activities will be key factor. New business models to cater for this can well be a game changer.

The municipal ports have a double role which impacts their core business models. They are measured on port income generated from traffic and lease of land and buildings. In addition, they have a stewardship role to drive development of business for the region in which they operate. An example is the port of Bergen, which is expected to grow maritime business for all of the seven municipalities owning the port, including the private ports in the area. This double role can hinder specialisation and a clear drive for offshore wind, but may on the other hand also support regional cooperation.

Business models for ports in Norway, seem at large to be customer driven, with some notable exceptions, and are waiting for large clients to come to them with specific requests prior to changing their approach. Especially in northern Norway, with few large companies available, this can be an issue. Smaller companies lack the necessary execution strength, leaving strategic initiatives up to the ports and the public sector in general.

Some ports are changing their business models through closer cooperation with regional or national partners, opening for a more coordinated approach to goods transport. Offshore wind may, due to large area requirements, further strengthen the need for a business model that intensifies closer collaboration within and between regions.

3.2 PORT OWNERSHIP

Ports in general seem to be capitalized well and there were no indications that access to capital was a hindrance for them to cater for offshore wind. Some ports have been made into stock companies, owned by one or more municipalities. Some of the capitalization comes in the form of property transferred to the ports, which is then let out or developed.

Ports are also content with access to comparatively cheap loans through the Kommunalbank, though perceive implementation of EU regulations as a risk to this access. Ports also see their role as municipal entities as a benefit when it comes to interaction with the public funding apparatus. Offshore wind will require investments, and a deep knowledge of regulations, public entities and the inability to go bankrupt, all provides a safe basis for the municipal ports. This is not the case for all ports.

Some ports as standardized stock companies, and are able – in principle – to go bankrupt, nor do they have access to cheap capital – but are still expected to serve multiple municipalities and act as a public servant. This is deemed challenging. Should the ports be forced into companies, with dividends paid to owners, they see a challenge in keeping prices low. However, customer pressure has also forced private companies to keep 'public' price levels in areas where there are both sets of ports, and large clients seeking to use them, such as in Stavanger.

The downside of being public institutions revolves largely around the increased bureaucratization, adherence to EU procurement regulations and inability to charge extra to build up funds. A situation where ports needs to charge real costs, whilst still adhering to a bureaucratic governance model, is seen as challenging.

3.3 VALUE OF HUBS AND VALUE CHAIN FOCUS

Academic literature on industrial development is very clear on the added value of industrial hubs. In certain sectors, such as ship yards and furniture, Møre is a good example of how industries co-locate and trigger innovation and spin-offs. To have a strong offshore wind sector, supporting a holistic value chain may be necessary. Some offshore wind hubs are developing. The foremost might be centered around the Stord-Haugesund axis a short distance from the coming Utsira Nord field, having multiple yards, strong shipping companies, new offshore development companies, cable manufacturers, industry organisations and the Metcentre for offshore wind, bolstered by the Port of Karmsund's high ambitions. Agder has access to GCE Node which can drive a coordinated approach. Other regions would do well to examine this.

In Europe, similar approaches are taken. Hamburg announced in January 2021 plans to establish a green hub, including a hydrogen plant[3], the UK plan to invest £160m into port infrastructure[4] and perhaps most obvious hub is centred around a port is the world's foremost offshore wind port, Esbjerg, which has supplied 55 offshore wind farms since 2001, or around 4,000 offshore turbines. For floating wind, the French port of Port-la-Nouvelle, has already taken steps to invest and position for a floating wind farm development in the Mediterranean.

The interviewed ports acknowledge that a holistic hub and value chain focus is important to be able to serve clients better and to drive innovation. Although there are examples of close collaboration from other industries, the ports indicate that the value chain line of thinking is not yet a required level. In part, this is a result of strategies and approaches being driven by single, large clients with their own agendas and not by a holistic perspective on an industry. This has also been mentioned in interviews as a heritage from the organic way the oil and gas sector developed – leading to a geographically spread-out sector development – which again impacts how coastal logistics are set up. Establishing firm agreements may also reduce the area needed to be developed, by optimizing use of area and corresponding logistics.

Photo: Aibel

3. https://www.marasinews.com/environment/plans-hydrogen-plant-and-green-hub-port-hamburg
4. https://www.maritime-executive.com/article/uk-government-commits-to-offshore-wind

A study[5] by the Norwegian Institute of Transport Economics (Transportøkonomisk institutt, TØI) highlights the difficulties om gathering services into joint terminals, can also – analogu-osly – highlight why hubs or formal collaboration for offshore wind may be difficult to establish. Mitigating and addressing these factors may support the development of ports as hubs:

- Uncertainty about the revenue potential and demand for aggregate terminal services.
- Lack of buy-in to the business model from relevant logistics players
- Competition in the logistics industry. Established logistics players apparently have little incentive for a collection terminal to be established.
- Uncertainty about the extent to which collection terminals will contribute to reduced emissions and better city life in the city center. Although a number of studies show that there is a great potential for this, the realization of this potential will depend on several local factors.
- Uncertainty related to the municipality's role and use of instruments.
- Lack of common problem understanding and common purpose and goals.
- Access to relevant competence and knowledge.
- Lack of predictable and steady access to resources

3.4 NATIONAL TRANSPORT PLAN

The National Transport Plan (NTP) is a ten-year investment plan for all modes of transport in Norway passed by the Norwegian Parliament every four years. The plan coordinates the investments carried out by the Norwegian National Rail Administration, the Norwegian Public Roads Administration, the Norwegian Coastal Administration and airport and air traffic operator Avinor. Though it gets approved by parliament, it is not binding.

Sea transport is the most environmentally friendly mode of transport[6]. Sea transport is also the dominant mode of transport for goods. Around 75 per cent of total freight transport in Norway and 90 per cent of all exports / imports are done through Norwegian ports[7]. Growth in the maritime industries and maritime transport is expected in the period 2022-2033, at the same time as increased effects of climate change are expected.

Given the above data, the project is surprised that the role of ports in the NTP is perceived by the ports to be marginal and mainly focusing on the interface role between sea transport and land / road transport. The role of ports as hubs for regional business development is not addressed, and transport of sea logistics is hardly mentioned. The ports addressed the revoked funding for port collaboration as a key element that would support the development of ports' role in offshore wind. Ports as centres for ammonia, hydrogen and energy hubs is not addressed in the NTP. The downside, as told by several interviewees, is a higher level of road transport and with increased costs and increased emissions.

The project thinks it might be worthwhile to enter into a conversation on how offshore wind and green energies in general is catered for from a transport and hub perspective.

3.5 INTERNATIONAL ORIENTATION

With location and distance to offshore wind farms being a key driver for O&M, many smaller Norwegian ports have an understandably low level of international orientation when it comes to offshore wind. The larger ports have had intermittent contact with international ports for collaboration. None of the ports mentioned an avid interest in or understanding of a role for Norwegian ports in a European offshore wind expansion. This is probably related to the need for specific customers to drive such an interest, and possibly an area where Norwegian ports can learn from what the Møre and Trøndelag ports have done regionally with regards to a joint approach to fish exports.

5. https://www.toi.no/getfile.php/1354674-1606480327/Publikasjoner/T%C3%98I%20rapporter/2020/1805-2020/1805-2020_Summary.pdf
6. Rødseth et al. "Marginale eksterne kostnader ved havnedrift" - TØI 2017. https://www.samfunnsbedriftene.no/aktuelt/norske-havner/selv-om-havnedrift-kan-forurense-er-sjoetransport-miljoevennlig/
7. Kystverkets forslag til prioritering av ressursbruk i perioden 2022-2033 (Kystverket, March 2020)

4 The role of a port in the offshore wind value chain

With 4,5 GW of planned offshore wind farms in Norway, Norwegian ports need to understand the requirements the developers and supply chain needs for the ports to be an effective piece of the value chain.

The ports do indicate that they have significant experience in related works for the offshore industry in Norway, but given the strong cost focus, rapid technology development and mass production needs there might be specifics for the offshore wind industry that may be worth investigating further for the ports.

Though the sizes of the individual future offshore wind farms are yet to be determined, there is a European trend that projects grow larger, with the norm in Europe now being around 1 GW – with some select projects significantly larger. The result is that the requirements on the supporting ports are increasing. This goes for marshalling/assembly related ports and construction sites, since structures get larger to support the wind farm.

From a project development perspective, ports and yards come into offshore wind projects at many stages as shown by the diagrams below.

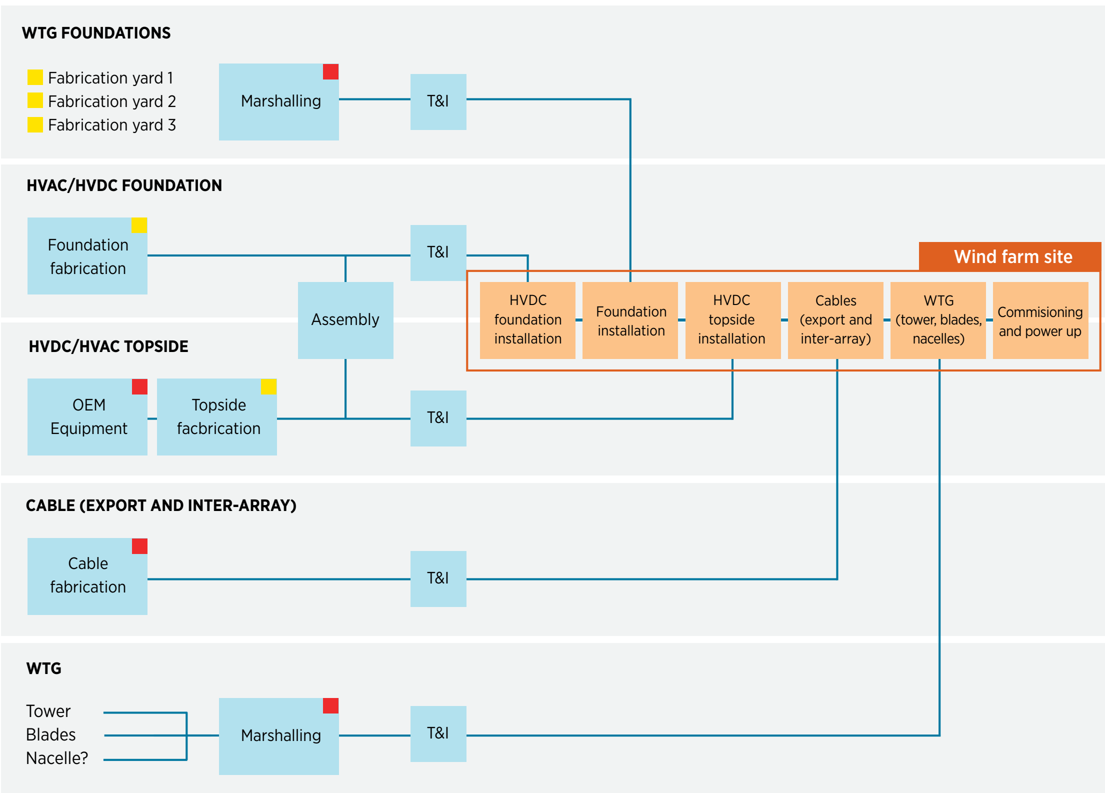


Figure 6 - Bottom-fixed offshoren wind value chain activities that impact ports and yards

4.1 DELIVERY MODEL FOR BOTTOM-FIXED OFFSHORE WIND

Wind turbine generators (WTG):

Wind turbines consist of nacelle – the turbine engine, blades and tower.

The project has assumed in our analysis that the current Norwegian pipeline is not large enough for WTG fabricator sets up local nacelle factories in Norway, but will continue to deliver these directly from European factories. Should the Norwegian pipeline grow significantly, this may change. It is more likely that tower and blade producers see an opportunity to establish a local fabrication site, bringing these products out from Norwegian ports.

It might prove easier for tower production or blade production to establish relevant manufacturing facilities. Studies and international literature indicates a need for about a 200 000m^2 developed area in order to facilitate a blade or tower factory – preferably in close conjunction with a port to avoid overland transport of these massive units. Quay sides should measure above 200m to cater for blades and tower loading, with medium sized cranes – if ship cranes are not used.

In practice – until any suppliers might establish new production facilities in Norway, WTG provision to bottom-fixed wind would most likely follow the standard setup seen in Europe, where large T&I suppliers are awarded installation contracts and transport WTG components straight from European factories directly to the bottom-fixed offshore wind farm. Norwegian ports and yards will thus have a minor role. This might change if wind farms are developed in Northern Norway, where there may develop a need for a marshalling area prior to offshore installation.

Bottom-fixed offshore wind foundations:

The large majority of offshore wind farms use monopiles as the base case foundation. In deeper waters, where there are special soil conditions or significant icing, jackets or gravity based foundations may be used.

There are no current Norwegian suppliers of monopiles, and given the high entry cost and strong competition in the Europe-

Figure 7 - Dolwin Beta at Aibel, Haugesund - Photo: Kjell Strand (Haugesund Avis)

an market, the entry barriers seem high – especially given high Norwegian labour costs and that there are very few sites, if any, monopiles can be used in Norway.

However, Norwegian suppliers are well versed in design, engineering, constructing and installing concrete bottom-fixed foundations as well as steel jackets to the oil and gas industry.

Depending on the foundation type and storage needs, decided by the delivery model chosen, foundation fabrication may require at least 100 000 m^2 – preferably more. Loading of these structures would require barge access or similar, with quay sides of at least 125 m with about 10 m sea depth.

Concrete foundations also known as gravity based foundations can use roughly the same construction and assembly sites that semi-submersible floating construction sites can use.

Historically, the foundation scope for large offshore wind projects have been contractually split between multiple fabricators who have then either shipped them through a transport and installation supplier (often an EPCI supplier with total scope contract with the park developer) directly to a wind farm for installation or to a marshalling port for intermediate storage. Access to storage area at the fabrication yard is deemed important.

HVDC converter stations/HVAC substations:

Wind farms utilize HVDC and/or HVAC stations to convert and transport power to shore. HVAC substations are significantly smaller than HVDC converter station, at about 3000–6000 tons versus 8000–12 000 tons for HVDC. The delivery model depends on the specific company, but the market has seen both contracts with separate substation/converter station foundation contracts or more integrated solutions, such as Aibel's deliveries to Dolwin in Germany. Norwegian yards have shown they can leverage their oil and gas background to deliver both HVDC and HVAC (for oil and gas projects). Ports will only be involved to a minor degree in the delivery of HVDC and HVAC substations.

HVDC and HVAC stations require suitable yards with access to quays able to handle heavy loads where either the HVDC can be floated to sea or to a barge. Area requirements can be significant, where access to cranes and covered halls is vital.

Cable:

Offshore wind cables for bottom-fixed wind are either inter-array cables, connecting a number of wind turbines to an HVDC or an HVAC station. Export cables transport the power from an HVAC or HVDC to a landfall point. In Norway there are a few factories for cable production. From a port perspective, the requirements to cater for transport of cable spoolings is not particularly demanding, requiring a relatively small quay side areas and deep enough waters for cabling vessels to come to shore.

4.2 DELIVERY MODELS FOR FLOATING OFFSHORE WIND IN NORWAY

In floating offshore wind, more work is done by quay or close to shore, for installation of, tower, blades and nacelle, compared to bottom-fixed where tower, blades and nacelle will be installed offshore. This will change the level and nature of involvement from Norwegian ports, yards and construction sites.

Wind turbines:

Floating offshore wind uses the same type of offshore wind turbines that bottom-fixed offshore wind are using. The wind turbines are thus manufactured in the same factories as any offshore wind turbine, and it is assumed highly unlikely that a Norwegian manufacturing site is developed within the intermediate time frame. However, since there are currently no suitable solutions to lift and assemble a wind turbine directly from a floating vessel to a floating turbine in possibly harsh sea conditions, floating wind turbines require either assembly by quayside or in deep, sheltered waters. As an example Hywind Scotland was assembled from using Saipems floating S7000 vessel in sheltered waters at Stord, whilst Hywind Tampen will use a land-mounted crane to assemble tower, turbine and blades at Wergeland Base in Sløvågen.

The main delivery model for floating offshore wind turbines will thus involve shipping the components into Norway for assembly at a suitable location. For spar buoy solutions, this will require sheltered areas with approximately 100 m water depth or more, close to shore within reach of suitable crane including the shipping fairway from assembly site to ultimate wind farm site. For semi-submersible floating wind foundations, a required depth of approximately 15 m to 30 m has been assumed. Access to cranes capable of lifting 600–1200 tons nacelles and blades to a sufficient height – in the range of 100 m up to 150 m in 2021, is key.

Ports, yards and constructions sites may all serve as suitable assembly sites for floating offshore wind, if main requirements are in place, like length of quayside, sufficient water depth along quayside, ground bearing capacity and available crane capacity.

Foundations:

For the purpose of assessing suitable ports, yards and construction sites, floating wind foundations are categorized as either deep floaters (spar buoy) or shallow floaters (semi-sub-

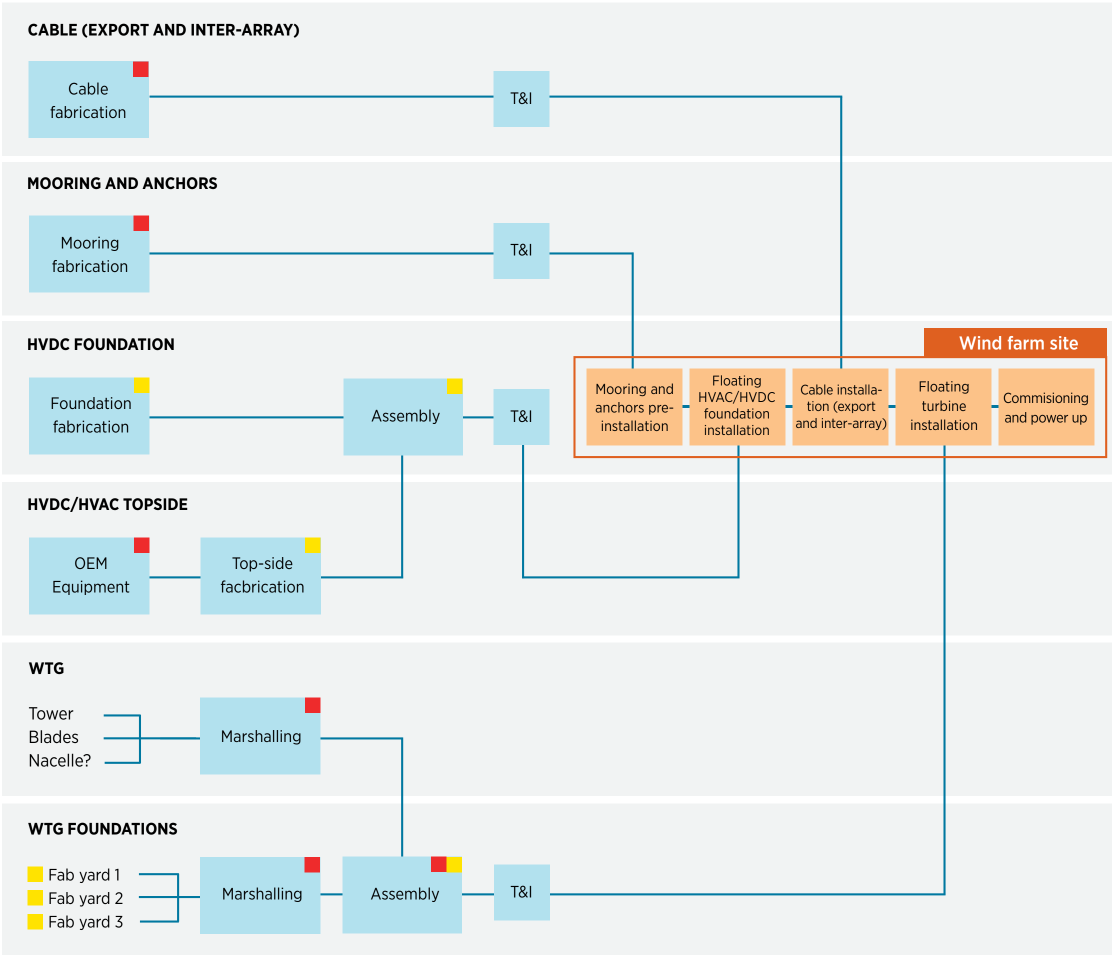


Figure 8 - Floating offshore wind value chain activities that impact ports and yards

mersibles and TLP solutions). Floating foundations may either be manufactured in steel – which requires yards with either trained welders or robotized welding and steel cutting. Some of the components may be shipped in for final assembly from low-cost countries. For semi-submersibles in concrete or steel, each WTG-foundation may require around 10 000 m^2 in fabrication and / or storage area as well. It is thus important for yards and developers to establish a lean fabrication flow to enable a right balance of land-storage and possible offshore storage with temporary mooring. Offshore storage might require anything upwards from 100 000 m^2, possibly with the use of barges for mooring purposes or other cost optimal solutions.

A wind farm of 500 MW, consisting of about 35 floating wind turbine generators – which – if constructed simultaneously might require above 350 000 m^2 area. Assembly can also be done through jack-up vessels operating close to shore for semi-submersible structures.

For deep floaters, the yard or port must have alternative deep water site access to conduct slip-forming, and ballasting/outfitting irrespective of the materials used. Use of barges and barge cranes might be highly useful to enable a rapid construction and to avoid costly vessel usage. Ports, yards and construction sites should have the capability to host these.

When the foundation is finalized, the wind turbine is assembled as described above and the structure is towed to the final wind farm location where pre installed mooring and anchors are in place, normally installed in previous installation season. This typically requires smaller vessels than the vessels used for bottom-fixed offshore wind farms.

HVDC/HVAC:

Similarily with wind turbines, floating HVDC/HVAC needs to be fully assembled at quayside to avoid heavy lifts from floating to floating structures. This will most likely happen at a yard, or through float-over solutions in waters close to a yard or port or at offshore location. Ports and yards should thus have relevant crane capacity or access for suitable vessels to conduct such lifts. After topside assembly onto a floating HVAC/HVDC foundation, the structure is towed to final wind farm location or substructure already installed at offshore location.

Photo: Aibel

Cable:

The port requirements for floating wind cables are not different than for bottom-fixed offshore wind. Cable is normally lain prior to the tow-out of the wind turbines, to enable rapid commissioning and start of production.

Mooring and anchors:

Mooring and anchors may be sourced from countries around the world, however the Hywind Tampen anchors are produced at Aker Verdal. Smaller yards may also fabricate anchors. Mooring is transported to Norway using very large cargo vessels, and ports/yards should estimate that mooring for offshore wind required about 250 m^2 per 1000 meter of mooring. Thus a 33 WTG wind farm would require min 25 000 m^2 for the mooring chain.

Anchors will normally be suction or drag anchors. By themselves they do not require significant storage area or crane capacity. Smaller yards may also look on anchors as an option for fabrication However, there will a large number of these, even when using shared anchors, which will in total require significant storage areas or a lean logistics setup to a storage area. Suction anchors for a 33 WTG wind farm would require approximately 30 000 m^2 for storage.

4.3 EVALUATION OF PHYSICAL CHARACTERISTICS

In our studies of Norwegian ports, yards and construction sites, a number of factors have come up to evaluate whether a given location is suitable for offshore wind. Broadly they can be divided into physical characteristics and strategic / organizational characteristics.

Physical characteristics:

The physical characteristics of a given port indicates what sort of activities may be conducted in that port, or what equipment and components may be transported or stored at that port. A detailed description of relevant physical criteria is given in Appendix 14.

In short, ports have been evaluated by the following physical characteristics:

- Vessel accessibility as indicated by air draft (bridges, power lines hindering WTG-movement), horizontal clearance (narrow fjords, aquaculture) and vessel draft (draft by quay

side and sea depth in access route between quay and open sea).
- Available areas at water front, taking elevation into account. Also evaluated ability to work 24/7 at water front
- Quay lengths and ability to accommodate various types of vessels. Quayside strength – enabling heavy loads and use of cranes.
- Storage areas
- Access from shore, most often by access and distance to national roads 'riksvei' and distance to airports for transfer of specialized personnel
- Core utilities available, such as gas, power and water
- Load-bearing capacity at the port

Yards have been evaluated by the same physical characteristics, though some emphasis and mapping has been done on crane capacity and more specialized yard equipment, such as dry dock size and availability.

Construction sites have also been evaluated using the same physical characteristics as ports. As is described in Appendix 13 – Methodology, the project has, with the support of Norkart, adapted algorithms to perform an automated search along the Norwegian coast to identify suitable and potential building sites. This takes into account available areas on land, at sea, elevation differences, access to roads and distance to larger cities amongst other items and demonstrate water depths of 20 m LAT, 30 m LAT and 100 m LAT.

However, please note that the speed of technology development may invalidate any firm physical requirements specified in this report.

For floating wind farms, the port requirements are somewhat different than for bottom-fixed offshore wind.

4.4 ORGANISATIONAL AND STRATEGIC FACTORS

Given the technological development of the industry, with rapidly increasing wind turbine sizes and corresponding blade sizes, ports and yards also need to ensure that they have the strategic focus and flexibility to adapt to changing conditions. Lessons from Europe shows that a port deemed suitable from a physical perspective at one point, might quickly be far too small given the technology development. It is the recommen-

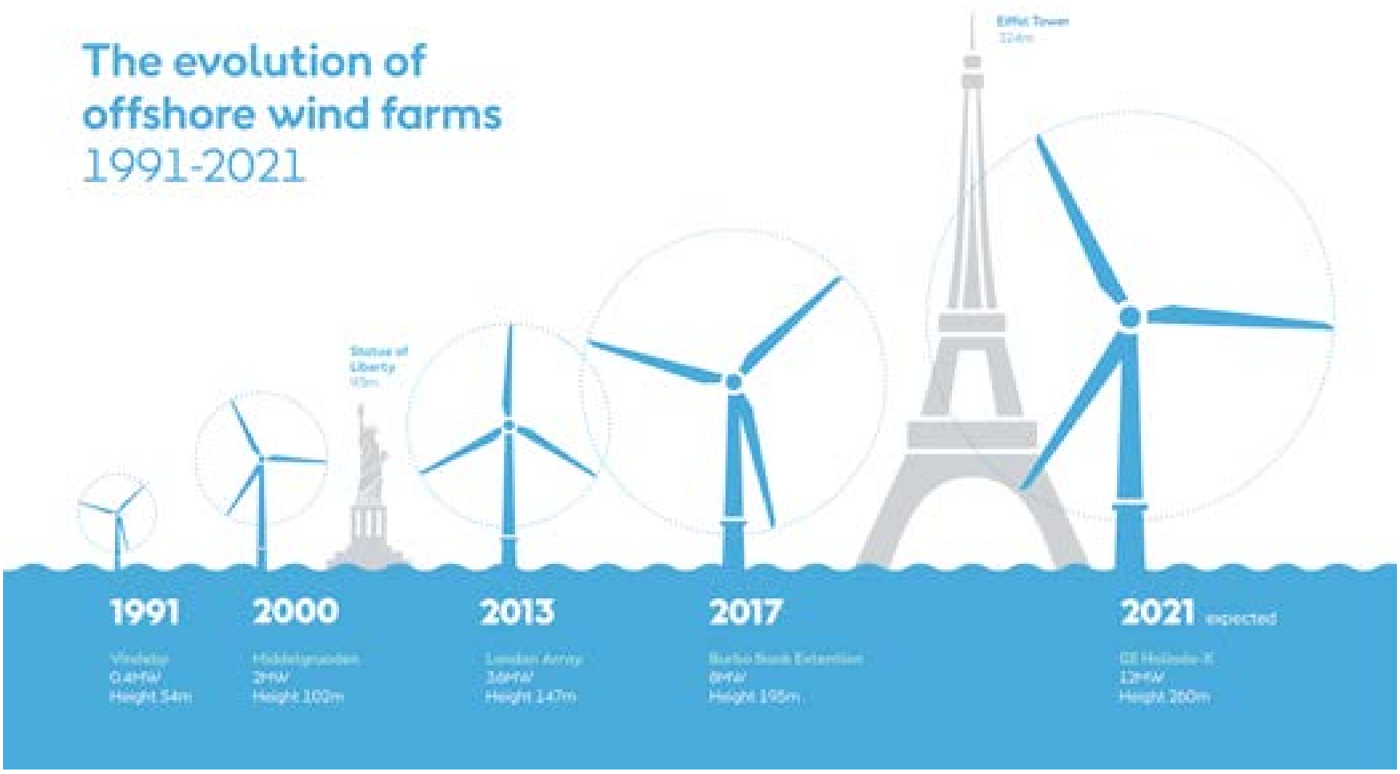


Figure 9 - Evolution of offshore wind turbines Source: Ørsted

Generation	1	2	3	4
Operational	2005	2010	2015	2022
Decription	First heavy lift jack-ups in offshore wind	New designs primarily for offshore wind	Scaled-up design for larger WTG	Next generation for 15MW WTG
Average crane capacity	500	900	1 400	2 500–3 500
Average variable load	2 000	5 000	8 500	10 000–16 000
Typical wind turbine	3 MW	6 MW	9 MW	15 MW

Figure 10 - Development of offshore wind vessels - scale and requirements rapidly increasing (Source: Ulstein Design and Solutions)

dation of Wind Europe's Port Platform group that ports have as strong focus on the organizational aspects of offshore wind as the physical aspects of the ports. This also means that ports should not necessarily invest in cranes and equipment by themselves, but rather cater for flexible areas that enable developers and the supply chain to bring in equipment.

Organisational readiness aligning long-term strategic ambitions, supporting ownership models, flexibility, access to capital, establish close relations to relevant networks of ports that are able to develop joint value propositions, as well as close relations to key developers and the supply chain, suitable work processes, general offshore wind competence and capabilities as well as innovation focus, will be key factors in the drive towards establishing leading offshore wind ports and yards. Overall, the ports respond through surveys and interviews that they are well versed and ready for offshore wind, based on the oil and gas experience acquired since the 1970s, and that most of the organisational factors are in order.

Though there are large similarities between oil and gas and offshore wind, and a definite set of capabilities and competencies that can be transmitted from one industry to the other, the project finds a clear and present danger that the ports under-

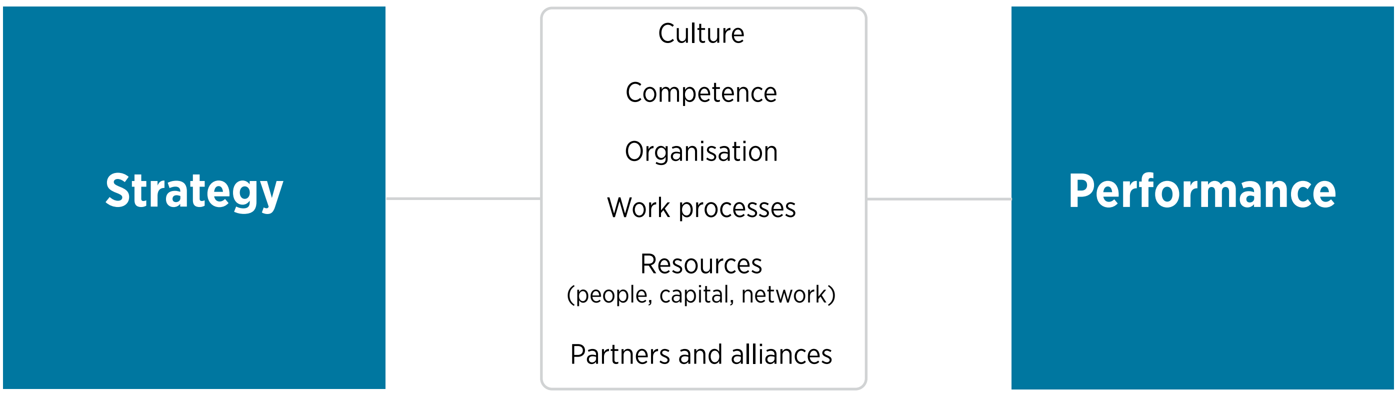


Figure 11 - Organisational factors for offshore wind ports.

estimate the idiosyncracies of the offshore wind industry. The offshore industry is more driven by large-scale factory production and logistics. This is what has been seen in the aircraft and automotive industry with complex logistical chains that needs to deliver on time, all the time, to ensure profitability in an extremely cost-focussed industry. Oil and gas experience is valuable, but not a panacea for offshore wind challenges.

4.5 NORWEGIAN PORT CLASSIFICATION AND GOVERNANCE

Statistics from the Norwegian Coastal Authorities indicate that Norway has 32 major ports (stamnetthavner), over 700 smaller fishery-related ports and more than 3500 registered smaller quays and points of access. Transport by sea is by far the dominating form of transport in Norway and between Norway and other countries. 75 % of all domestic goods transport and 83-90 % of all international goods transport is done by sea. International passenger transport accounts for approximately 5,7 million passengers per year.

The ports that are part of the transport network are mainly owned by the local municipalities. There are no state owned commercially driven ports in Norway. The ports offer services to the shipping industry and other transport and logistics players. In addition, the ports stewards and managers of important infrastructure in the national transport network, fulfilling the municipalities' responsibility for safety and accessibility in each municipality's sea area.

The municipalities have a large degree of freedom to choose the form of organization that is most appropriate for their port activities. Possible forms of organization vary from being an integral part of the municipal administration under the councillor to being limited companies with less opportunity for political influence.

The state plays only a minor role towards port development, and has no direct economic instruments aimed specifically at the ports. Thus, the state does not invest in quay facilities or other infrastructure in the ports[8]. However, the state ensures that the main network ports have adequate connection to the rest of the onshore transport.

For offshore wind marshalling and assembly, the relevant ports for offshore wind should be able to bring in components from non-Norwegian ports. The vessels bringing in such components needs to have an ISSC-certificate and need to dock at ports which are categorized as ISPS ports[9].

In Norway there are 317 different ports with such an ISPS classification[10], with a total of 1253 different registered quays that can receive such materials. Many of these will either be too small or have inadequate physical conditions to be of use for the offshore wind industry. Of the 1253 registered ISPS-ports, 807 are privately owned whilst 440 are publically owned[11.]

REGION	COUNTY	ISPS PORTS
Mid-Norway	Møre og Romsdal	51
	Trøndelag	26
Northern Norway	Nordland	41
	Troms og Finnmark	33
South-Eastern Norway	Oslo	1
	Vestfold og Telemark	25
	Viken	14
Southern Norway	Agder	14
Western Norway	Rogaland	40
	Vestland	69
Mainland Norway	**Total**	**314**
Svalbard	Svalbard	3

8. With the exception of in the fishing ports which is out of scope of this study.
9. Wikipedia: The International Ship and Port Facility Security (ISPS) Code is an amendment to the Safety of Life at Sea (SOLAS) Convention (1974/1988) on Maritime security including minimum security arrangements for ships, ports and government agencies. Having come into force in 2004, it prescribes responsibilities to governments, shipping companies, shipboard personnel, and port/facility personnel to "detect security threats and take preventive measures against security incidents affecting ships or port facilities used in international trade." Source: https://en.wikipedia.org/wiki/International_Ship_and_Port_Facility_Security_Code
10. Compared to about 40 in the US
11. 6 ISPS ports do not have a declared form of ownership in the ISPS database.

The following ports have one or more terminals connected to the main network (main network ports)[12]:

REGION	MUNICIPALITY	PORT	PROJECT INTERACTION
South-East Norway	Fredrikstad	Borg havn	Interviewed
	Moss	Moss havn	Phase 2
	Oslo	Oslo havn	Phase 2
	Drammen	Drammen havn	Phase 2
	Tønsberg	Tønsberg havn	Phase 2
	Larvik	Larvik havn	Phase 2
	Porsgrunn	Grenland havn	Phase 2
South Norway	Kristiansand	Kristiansand havn	Interviewed
Western Norway	Egersund	Egersund havn	Interviewed
	Sola	Stavanger havn	Interviewed
	Karmøy	Karmsund havn	Interviewed
	Tysvær		
	Bergen	Bergen havn	Interviewed
	Øygarden		
	Lindås og Austrheim		
	Flora	Flora havn	
	Vågsøy	Nordfjord havn	Interviewed
Mid-Norway	Ålesund	Ålesund havn	Interviewed
	Aukra		
	Kristiansund	Kristiansund og Nordmøre havn	Interviewed
	Aure		
	Trondheim	Trondheimsfjorden interkom-munale havn	Interviewed
Northern Norway	Mo i Rana	Mo i Rana havn	Interviewed
	Bodø	Bodø havn	Interviewed
	Narvik	Narvik havn	Interviewed
	Harstad	Harstad havn	Interviewed
	Tromsø	Tromsø havn	Interviewed
	Alta	Alta havn	
	Hammerfest	Hammerfest havn	Interviewed
	Hammerfest		
	Nordkapp	Honningsvåg havn	
	Sør-Varanger	Kirkenes havn	Interviewed

12. Kystverket – klassifisering av havner (https://www.kystverket.no/Maritim-infrastruktur/Havner/Klassifisering-av-havner/)

For O&M-related ports, the number is far greater. Subject to categories and requirements given below, existing fishery-registered ports and harbours might serve the purpose. There are today 767 registered fishery ports, distributed as follow:

REGION	# FISHERY PORTS
Mid-Norway	180
Northern Norway	340
South and South – East	52
Western Norway	195
Grand Total	**767**

This shows there are ample opportunities to screen and find suitable locations for O&M ports in Norway. Given the current specific development zones in Norway, Utsira Nord and Sørlige Nordsjø II, ports close to the offshore wind farms, i.e. in Western Norway and Southern Norway, will be the relevant areas in the coming development rounds.

In addition to the ports, Norway also has a number of highly experienced offshore yards that can transition to fabrication for renewable energy production.

Lastly, many of the large oil and gas platforms on the Norwegian Continental Shelf were pioneering feats of concrete engineering, built deep in the fjords without any major infrastructure in the immediate vicinity. Using the fjords in a similar fashion for offshore wind is not only feasible, but may be competitive from a European market perspective. Fjords may also be used for winter storage, enabling all-year foundation fabrication.

Hammerfest
Finnmarksvidda
Saltfjellet
Luleå
Steinkjer
Umeå
Östersund
Vaasa
Härnösand
SVERIGE
Dovrefjell
Rondane
Jotunheimen
Lillehammer
Hamar
Voss
Falun
Gävle
Turku
Mariehamn
Hardangervidda
Oslo
Drammen
Uppsala
Västerås
Stockholm
Karlstad
Örebro
Skien
Mariestad
Nyköping
Vänersborg
Linköping
Göteborg
Jönköping
Visby

5 Northern Norway – Nordland, Troms and Finnmark

5.1 NORTHERN NORWEGIAN PORTS IN NUMBERS:

ISPS-approved ports in Northern Norway

COUNTY	PRIVATELY OWNED ISPS-PORTS	PUBLICALLY OWNED ISPS-PORTS	TOTAL
Nordland	95	42	137
Troms og Finnmark	68	86	154
Total	**163**	**128**	**291**

Possible locations for smaller O&M ports

COUNTY	FISHERY-RELATED PORTS
Nordland	**126**
State owned (wholly or in part)	71
Historically state owned (sold)	52
Not owned	3
Troms og Finnmark	**214**
State owned (wholly or in part)	103
Historically owned (sold)	78
Not owned	33
Grand Total	**340**

5.2 WIND FARMS IN NORTHERN NORWAY

There are no current plans to develop offshore wind in Northern Norway. In the initially proposed areas by the government, there was one wind farm area in northern Norway – Sandskallen – Sørøya Nord, north-west of Hammerfest and the Melkøya terminal. However, this area was not part of the final areas opened for development.

In the 2012 NVE strategic assessment of offshore wind in Northern Norway the following areas were assessed for offshore wind, none of which has been opened:

- Sandskallen – Sørøya Nord
- Vannøya North-East and Auvær – both close to Tromsø (bottom-fixed)
- Nordmela, west of Andøya, close to Harstad (bottom-fixed)
- Gimsøy North, north of Svolvær (bottom-fixed)
- Trænafjorden – Selvær, west of Glomfjord (bottom-fixed)
- Træna vest – west of Mo i Rana and Sandnessjøen (bottom-fixed)

Should any of these, or similar areas, be approved, there will be a need for ports and construction site(s) in the area. Notwithstanding the fact that there are no planned wind farms, the project has assessed ports and construction sites in northern Norway.

5.3 KEY FINDINGS

In Northern Norway Tromsø (Grøtsund) and Hammerfest (Polarbase) seems to be to be the two most developed locations for the offshore wind industry.

It is worth noting that for large scale offshore wind construction projects, the Norwegian Employer Tax[13] is differentiated depending on where the work is performed[14]. This tax is considerably lower in the northernmost counties, and is zero in Finmark, and can impact labour-intensive tasks significantly from a cost perspective.

It is the project's assessment that Tromsø, Narvik (Fornes) and Bodø are the ports best positioned in the region to partake in an upcoming offshore wind market development.

	EMPLOYEE TAX ZONE AND LEVEL						
	14,1 %	14,1 %	10,6 %	6,4 %	5,1 %	7,9 %	0,0 %
COUNTY \ TAX ZONE	**1**	**1a**	**2**	**3**	**4**	**4a**	**5**
Agder	17	6	7				
Innlandet	11	1	14	20			
Møre og Romsdal	14	6	12	3	1		
Nordland					43	1	
Oslo	1						
Rogaland	19	2	6				
Troms og Finnmark					17	1	26
Trøndelag	10	4	6	14	18		
Vestfold og Telemark	16		10				
Vestland	19	7	33				
Viken	55	1	8				
Sum	**162**	**27**	**96**	**37**	**79**	**2**	**26**

Figure 12 - Number of municipalities at different employee tax levels per county

13. Employer's contribution is a contribution that employers must pay for their employees as part of the financing of the National Insurance Scheme. The tax is paid on salaries and other taxable remuneration for work and assignments in and outside employment. The tax rates are set by the parliament every year.
14. https://www.skatteetaten.no/satser/arbeidsgiveravgift/

Figure 13 - Map of Kirkenes

Kirkenes

Kirkenes is the most north-eastern port in Norway and last stop for the logistic route of Hurtigruten and the very last port before the Russian border.

Kirkenes with Tschudi Shipping, Kirkenes and Kimek is l set up as a logistics port[15]. Tschudi Shipping have at present an area of approx. 1 000 000 m^2, zoned and available for development.

The project does not see a massive potential for Kirkenes as a construction port. The port will require upgrades and further development, before it could become a typical port for assembly and marshalling port for shallow floaters (Semi) and deep floaters (Spar). The main element missing is water depths along the existing quay sides, which at present is too shallow for assembly by quayside for either type of structures.

15. The Kirkenes municipality has entered into a friendship agreement with Harbin in China, and local discussions have been held about the possible development of an arctic corridor to China , which may give up to a 40% reduction in shipping time from the Far East. There are also on and off discussions in Finland about developing a possible rail connection between Kirkenes and Helsinki

Figure 15 - Tromsø and Grøtsund port

Tromsø

Tromsø has quays with sufficient depths, almost 100 000m^2 of available storage area – which can be expanded up to 2 000 000 m^2 if necessary. In addition, Tromsø has easy access to housing, airport and trained personnel, experience from onshore wind and is well connected with collaboration agreements with other ports.

For the purpose of offshore wind, Tromsø's main asset is the Grøtsund/Tønsnes industrial logistic port, a former military base that has been taken over by the port of Tromsø. The area has been developed into a port highly rated by the project, and has already been used as a logistics port for onshore wind power. It has 110 m long deep-water quay with 20 m LAT, including a ro-ro ramp are in place and ready to operate.

The area could be suitable for construction site for shallow floater (Semi), assembly of shallow floaters and logistic harbour for components (mast, turbine and blades) for both type of structures. The water depth at the main quay sides are 20 m LAT at the quay sides. Initial start-up of foundations-both shallow and deep floaters (Spar) can be feasible construction start onshore, and towed to a deep water site for deep floater will be required is to complete the construction of the structures.

Hammerfest

Hammerfest seems to be a good option for O&M-related activity.

Polar Base Hammerfest is privately owned port with a focus on serving the oil and gas business. The area has approx. 350 000 m^2 flat outdoor storage area available and approx. 150 000 m^2 in various type of buildings. The area could be suitable for construction site for shallow floater, assembly of shallow floaters and logistic harbour for components (mast, turbine and blades) for both type of structures. The water depth at the various main quay sides are acceptable and reach about 20 m relatively close to the various quay sides, with some minor deepening close to the quayside.

Norsea Polarbase has available area and is suitable for both alternatives for O&M. Initial start-up deep floaters can be feasible construction start onshore, and towed to a deep water site will be required to complete the structures.

The area could be suitable for construction site for shallow floater (Semi), assembly of shallow floaters and logistic harbour for components (mast, turbine and blades) for both type of structures. The water depth at the main quay sides are not far from acceptable 20 m LAT at the quay sides. Initial start-up of foundations-both shallow and deep floaters (Spar) can be feasible construction start onshore, and towed to a deep water site for deep floater will be required is to complete the construction of the structures.

Figure 16 - Hammerfest Polarbase

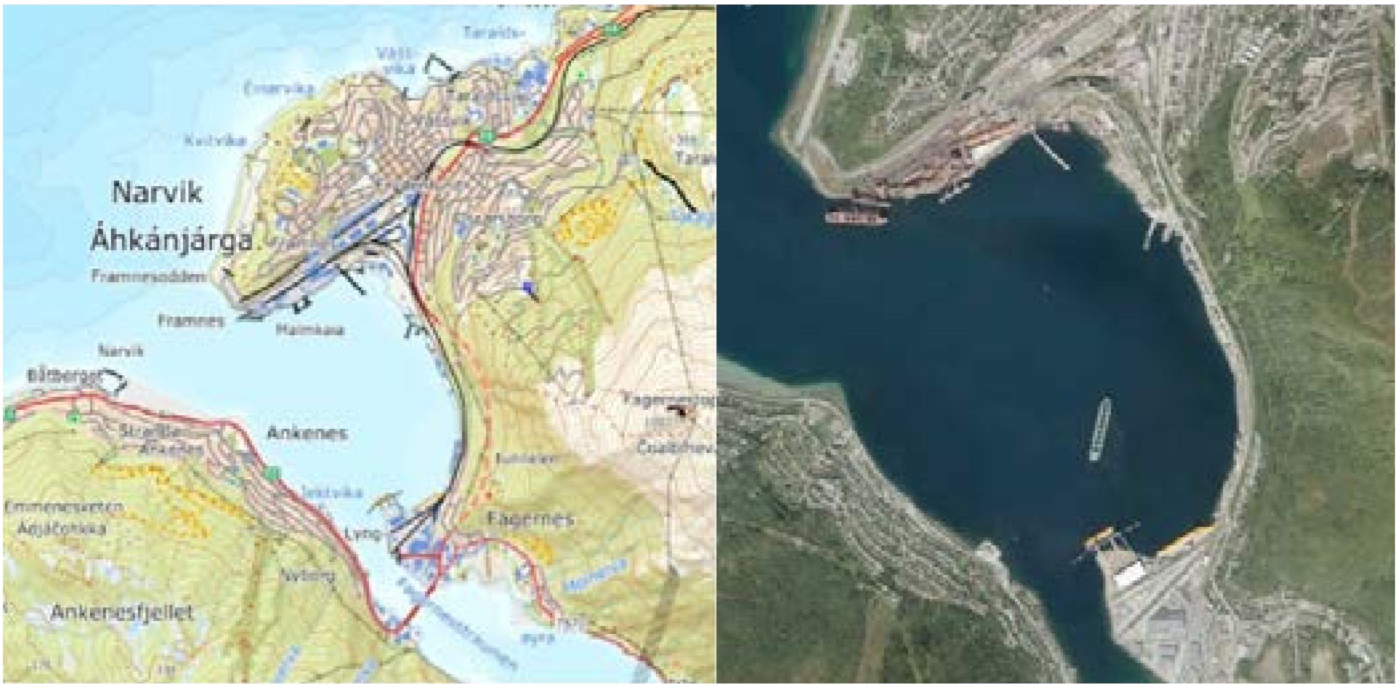


Figure 17 – Maps of Fagerneskaia area and Old Narvik airport - conceptual sketch (NOR24)

Narvik

Narvik (Fornes) is also deemed by the project to be a good option runner in northern Norway. Fornes has access to a 60 m quay with at least 200 000 m^2 for construction purposes requiring a bit of deepening to meet the 20 m LAT. Sea depth in this area will easily handle semi-submersibles construction and assembly. The project also notice the relative closeness of both rail access from Sweden. and the nearby existence of a stone crushing plant which could provide materials for concrete structures. The possible risk to Narvik could be a significant presence of cables crossing the Ofotfjord, which means any floating wind mooring needs to be done with care. The area at Fornes could be explained by land filling and could be a potential onshore construction site of semi-submersible floating wind turbines, launched by submerged barge. The deep floater par bottom section could be constructed onshore and launched by submerged barge and towed to a deep water site for completion and assembly. The deep water site could be somewhat exposed for wind and swell.

Narvik also has a suitable area located where the old airport was located, with significant areas very close to sea, that could be developed into a suitable site after lowering the level of runway to ease the access to sea of heavy structures. It is estimated that a build-out of the airport would require some 1 to 2 million m3 of deployed masses to build the quays.

Bodø

Bodø is an option further south due to its central location. Currently there are no available areas, but there are plans for zoning under development that could offer options due to the relocation of the airport from its current position. One of the areas that could open up is Litle Hjartøya, just outside Bodø port, which is owned by the municipality. This area could offer up to 500 000m^2 readily consented areas, though it should be noted that all infrastructure needs to be developed (roads, quays, water, power etc).

There is also a zoning plan in place to build a mountain hall of about 50,000 m^2 for various building and facilities. The potential area at Litle Hjartøya could be exposed for heavy wind during the winter months.

Figure 18 - Bodø - Litle Hjartøy in the red circle

Figure 19 Bodø - regulatory plan for Litle Hjartøy

Figure 20 - Port of Helgeland

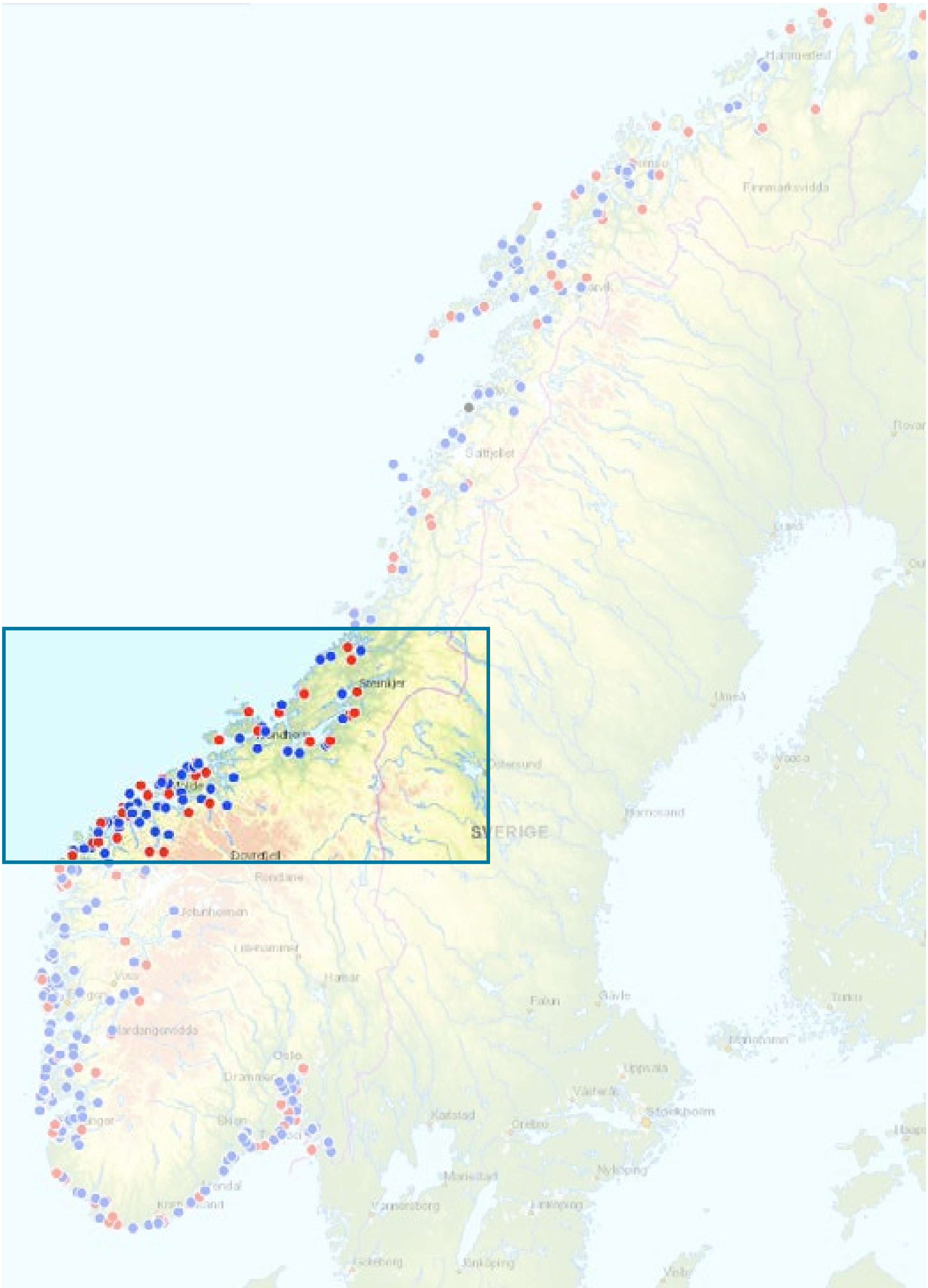
Helgeland

The port of Helgeland is located mid way between Trondheim and Narvik and is also a service port for the traditional oil and gas industry. The main quay area is Horvnes, which has about 100 000 m^2 available area. With 20 m LAT quay depth, Helgeland is seen as suitable for assembly of shallow floaters or and O&M – in addition to marshalling – should the nearby bottom-fixed wind parks be opened by the government.

In addition, the port of Helgeland is not too distant from the Aker Solutions yard at Sandnessjøen which is possible to utilize as potential construction site for shallow floaters, and possible assembly port at Horvnes. The deep floaters are not an option at this potential port due to shallow areas in the likely towing route to open sea. The air gap in towing route from Aker Solutions is 45 meters under the Helgeland bridge. A launching quayside for shallow floaters at a potential Aker Solutions Sandnessjøen construction site will be required.

5.4 SUMMARY

PORT	Logistics	Assembly (shallow)	Assembly (deep)	Construction (shallow)	Construction (deep)	O&M (SOV	O&M CTV
Alta havn	Yes	No	No	No	No	Yes	Yes
Bodø Havn	Yes	No	No	No	No	Yes	Yes
Hammerfest Polarbase	Yes	Yes	No	Yes	No	Yes	Yes
Harstad havn	Yes	No	No	No	No	Yes	Yes
Kirkenes havn	Yes	No	No	No	No	Yes	Yes
Kirkenes Tschudi Shipping	Yes	No	No	No	No	No	No
Narvik Fornes	Yes	No	No	No	No	Yes	Yes
Narvik Havn	Yes	No	No	No	No	Yes	Yes
Sandnessjøen - Helgeland havn	Yes	Yes	No	No	No	Yes	Yes
Tromsø havn	Yes	Yes	No	Yes	No	Yes	Yes


Hammerfest
Tromsø
Finnmarksvidda
Narvik
Saltfjellet
Steinkjer
Trondheim
Dovrefjell
SVERIGE
Östersund
Umeå
Vaasa
Härnösand
Rondane
Jotunheimen
Lillehammer
Hamar
Falun
Gävle
Turku
Bergen
Hardangervidda
Oslo
Drammen
Uppsala
Västerås
Stockholm
Karlstad
Örebro
Stavanger
Skien
Mariestad
Nyköping
Kristiansand
Vänersborg
Linköping
Göteborg
Jönköping
Visby

6 Mid-Norway: Møre and Trøndelag

6.1 MID-NORWEGIAN PORTS IN NUMBERS

ISPS-approved ports in Mid-Norway:

COUNTY	PRIVATELY OWNED ISPS-PORTS	PUBLICALLY OWNED ISPS-PORTS	TOTAL
Møre og Romsdal	133	68	201
Trøndelag	42	46	88
Grand Total	**175**	**114**	**289**

Fishing harbours and ports:

COUNTY	PORTS
Mid-Norway	180
State owned (wholly or in part)	97
Historically owned (sold)	82
Not owned	1
Grand Total	**180**

Figure 21 - Havsul I - first consented, but not yet built, bottom-fixed offshore wind farm in Norway[16]

6.2 WIND FARMS IN MID-NORWAY:

There are no current development ongoing in Mid-Norway. However, Havsul - the only consented offshore wind farm in Norway, a 350 MW wind farm west of Nyhamna terminal and Molde, is located in this region. The wind farm is not yet built. The permit allows for bottom-fixed foundations.

NVA considered the following areas in the 2012 strategic assessment, none of which have been offered up for licensing by the government:

- Nordøyan – Ytra Vikna – Northwest of Namsos (bottom-fixed)
- •Frøyabanken – north of Kristiansund (floating)
- Stadthavet – north of Frøyabanken (floating)
- Olderveggen – west of Måløy (bottom-fixed)
- Frøyagrunnene - south-west of Måløy (bottom-fixed – though at 72 m floating could be an option)

6.3 KEY FINDINGS

Mid-Norway has a huge number of ports. However, given the area needs for both marshalling, assembly and construction of offshore wind farms, the project have found a smaller number of suitable sites than initially expected.

Some of the possible areas are:

16. Source: NVE database: https://www.nve.no/konsesjonssaker/konsesjonssak/?id=27&type=A-1%2cA-6

Figure 22 - Verdal yard (seen from the north)

Verdal

Verdal – a yard north-east of Trondheim, seems to have many of the requirements that is required to build and store structures for offshore wind. The Verdal yard has done work mostly for oil and gas, but has experience in delivering to offshore wind from some time ago. The Verdal yard combined with municipality owned areas north of the yard provides potential access to major areas, though the potential ground bearing capacity of the area under development has not been investigated in the project. The yard measures about 650 000 m^2, with an additional potential areas under development north of the yard. If this is further developed, it is the project's assessment that Verdal will suit the development of both steel and concrete semi-submersible floating wind structures. Verdal could also develop the initial stages of concrete spars, but would require launching with a submerged barge and tow to a deep water site (see below) past a submerged shelf south-west of Leksvik. The potential site at Verdal will require some deepening/dredging of the harbor pool to meet the requirement of approx. 20 m LAT close to shore to be able to launch assemble and store shallow floaters.

Verdal is also set up to build and deliver smaller topsides, such as HVAC stations and is currently constructing the suction anchors for Hywind Tampen.

Orkanger
Orkanger, south-west of Trondheim, offers access to a potential deep water site and a Technip FMC-owned spoolbase. With 100 m sea-depth fairly close to shore, the Orkdal fjord could provide a setup for a spar-buoy completion concrete slip-forming production – possibly with initial concrete production performed at Verdal and then towed down to the Orkdal fjord. Orkanger does have the space to also develop a large dock, should the market conditions warrant this. Final assembly of the wind turbines could be an option.

Figure 24 - Orkdal fjord offers spar bouys slip-forning opportunities

Figure 25 - Kristiansund and Averøy

Kristiansund, including Averøy
Close to Kristiansund, Norsea Vestbase Averøy has an available developed area of about 220 000 m^2 with options to expand the area and with relevant depths for semi-submersible offshore wind turbine foundations. Vestbase Averøy could also be an option for shallow/deep floater production with access to 18-20 m quay depth..

The Kristiansund municipality has zoning plans in place for a further 600 000 m^2 area close to the existing site. Kristiansund base Averøy seems a good fit for O&M services.

The area could be suitable for construction site for shallow floater (Semi), assembly of shallow floaters and logistic harbour for components (tower, turbine and blades) for both type of structures. The water depth at the main quay sides are not far from acceptable, however needs a minor deepening would be required to meet 20 m LAT at the quay sides. Construction of foundation for shallow waters and initial start-up deep floaters (Spar) can be feasible with construction start onshore, where deep floaters would be towed to a nearby deep water site to complete the construction of the structures.

Ålesund

The port in central Ålesund is not deemed suitable for offshore wind by the project, except for minor component transportation. Flatholmen, east of Ålesund, is however deemed suitable. With a quay of 500 m with 20 m water depth only 10m from the quay side, Flatholmen with an expanded area of up to 270 000m^2 could be a suitable location for marshalling, assembly and even construction of semi-submersible concrete foundations.

Figure 26 - Ålesund

One potential outsider here is Gjøsund by Vigra airport, just outside Ålesund, which the project deems to have a massive potential land area available, and also sports suitable areas for storage and assembly. The potential downside is the closeness to Vigra airport as well as possible wind issues in the assembly phase. However, subject to regulatory conditions, the area provides 40 m sea depth access through barge usage. Should the area be repurposed, the area could host well above 2 000 000 m^2 construction, assembly and marshalling area.

Figure 27 - Conceptual area for a large-scale construction and assembly area at Gjøsund

Nordfjord (Måløy)

A highly suitable O&M base in sheltered waters with access to 70 000 m^2 quay area with 345 m quay sides at 9,5 m depth, across the fjord from Måløy. The bridge to the south has 125 m sailing width with a 42 m air gap, which can provide a hindrance to very large vessels. A potential area north of Måløy could also be developed into an O&M base.

Figure 28 - O&M opportunities close to Måløy

There some further points of interest in the Mid-Norway area:

Regional cooperation is perhaps best shown in this area. The **Coastal Port Alliance** where Kristiansund, Nordmøre Rørvik and lately Trondheim port work closely together to promote the region rather than the individual ports. This has resulted in weekly routes to the continent with fresh fish at a level which could not have been achieved individually. A total of 34 central Norwegian coastal municipalities from Nordmøre to Helgeland are behind the alliance.

In addition, **Trondheim port** also works closely with SINTEF[17] and Norwegian University of Science and Technology (NTNU) on innovation and improvement projects, sometimes funded by the EU. As such collaboration with other ports and academic institutions showcase a route ahead for ports to drive a green transition.

Rørvik could also be an interesting point in case. Though it has no major quays, the project sees that Rørvik has an interesting potential for collaboration between public and private sector where each of the parties might by themselves not achieve the best score – but combination could provide an option. Rørvik has a dry dock of about 100 m by 25 m by 7 m where construction is could be feasible, there is a stone quarry close by that could provide relevant materials and an adequate quay setup just across the fjord for assembly and storage for a medium sized offshore wind farm. By themselves the areas would not necessarily support an effort in the offshore wind industry but, through collaboration, this could change. This requires the involved companies and municipality to define a collaborative model, allocate tasks and ensure relevant regulatory changes to enable such industrial growth. The project has seen multiple opportunities for this along the coast.

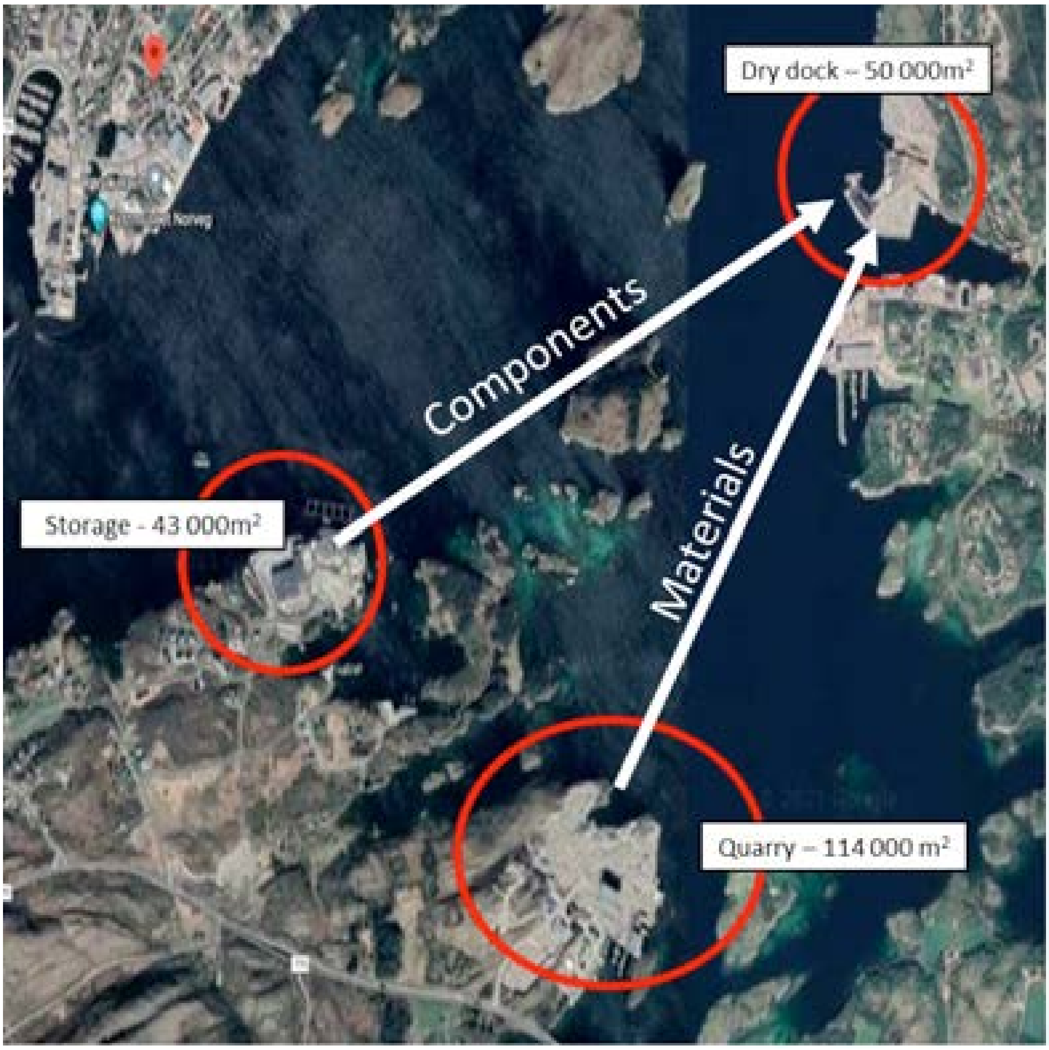


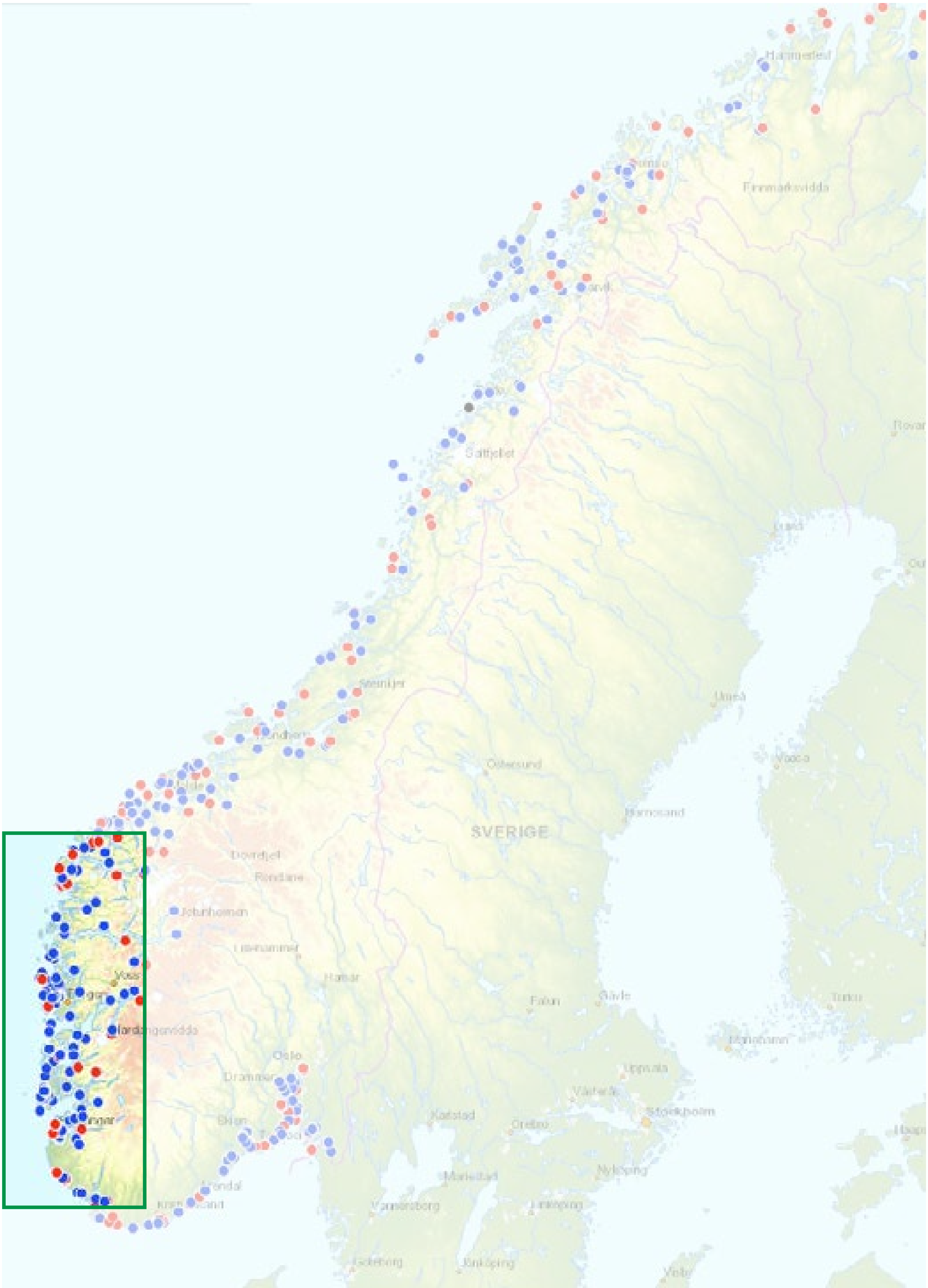
Figure 29 - Opportunities for offshore wind collaboration in the Rørvik area

17. SINTEF is one of Europe's largest independent research organisations. https://www.sintef.no/en/

5.4 SUMMARY

PORT	Logistics	Assembly (shallow)	Assembly (deep)	Construction (shallow)	Construction (deep)	O&M SOV	O&M CTV
Kristiansund Base - Averøy	Yes	No	No	No	No	Yes	Yes
Kristiandsund and Nordmøre	No	No	No	No	No	No	No
Nordfjord havn	Yes	No	No	No	No	Yes	Yes
Norsea Vestbase - Averøy	Yes	Yes	No	Yes	No	Yes	Yes
Trondheim, Orkanger og Namsos	No input	No input	No input	No input	No input	Yes	Yes
Ålesund - Flatholmen	Yes	No	No	No	No	Yes	Yes

Photo: Aibel


Hammerfest
Tromsø
Finnmarksvidda
Narvik
Saltfjellet
Steinkjer
Trondheim
Ålesund
Dovrefjell
Rondane
Jotunheimen
Lillehammer
Hamar
Voss
Bergen
Hardangervidda
Oslo
Drammen
Skien
Stavanger
Arendal
Kristiansand
SVERIGE
Östersund
Umeå
Vaasa
Härnösand
Falun
Gävle
Uppsala
Västerås
Stockholm
Karlstad
Örebro
Mariestad
Norrköping
Linköping
Vänersborg
Göteborg
Jönköping
Turku
Mariehamn

7 Western Norway: Vestlandet

7.1 WESTERN NORWEGIAN PORTS IN NUMBERS

ISPS ports:

COUNTY	PRIVATELY OWNED ISPS-PORTS	PUBLICALLY OWNED ISPS-PORTS	TOTAL
Rogaland	138	38	176
Vestland	170	42	212
Grand Total	**308**	**80**	**388**

Fishery ports:

CATEGORY	PORTS
State owned (wholly or in part)	129
Historically owned (sold)	60
Not owned	6
Grand Total	**195**

7.2 OFFSHORE WIND FARMS IN WESTERN NORWAY

Western Norway will host the first large scale floating wind farm in Hywind Tampen, to be commissioned during 2022 close to the Snorre and Gullfaks oil fields. In addition, Utsira Nord, one of two newly opened areas (1,5 GW floating wind), is in this region. The region has a long history of floating offshore wind, hosting Zephyros (Hywind Demo) at the Metcentre at Karmøy, where both the Tetraspar (Stiesdahl et al) and the OO-Star-based Flagship concept will be deployed within the next few years,. This region is also the closest to the Sørlige Nordsjø I area (not opened).

7.3 KEY FINDINGS

This region has a huge number of ports, some large cities, strong offshore capabilities and competency as well as a number of deep fjords suitable for winter storage of floating wind. The closeness, on par with southern Norway, to the European and UK projects, enables these ports, yards and construction sites to position themselves for a burgeoning European offshore wind industry. Sailing times from the southern parts of Norway to the larger coming wind farms towards the mid North-Sea is negligible for SOV-based O&M.

As a region with a long industrial history of offshore oil and gas work, there is a huge level of activity towards a coming Norwegian offshore wind effort. The Norwegian Offshore Wind Cluster, operating out of the Haugesund area, is a hub for this activity.

Photo: Aibel

Figure 30 - Map of Florø

Florø

Florø is located close to open seas, but is sheltered. The area has an ample quay area with 850 m long quay side, between 7 and 17 m depth. Florø has a about 700 000 m^2 area available, with an option to expand a further 300 000 m^2. Florø could thus serve as a large marshalling and assembly hub,including concrete semi-submersible and deep floater fabrication. Florø also has access to about 500 000 m^2 of sea storage space and operational area.

The area could be suitable for construction and assembly of shallow floaters and logistic harbour for components (tower, turbine and blades) for both type of structures. The water depth at the main quay sides could be acceptable after a bit of deepening/dredging to 20 m LAT close to the quay sides, however the quay sides needs further investigation when it comes to length and availability. Construction of foundations for shallow floaters and initial start-up of deep floaters (spar) can be feasible with construction start onshore, and the foundations towed to a deep water site for deep floater completion.

The potential towing route of 90 m LAT to open sea has been checked, and is feasible.

Lutelandet

Lutelandet – is the westernmost area the project has assessed. Lutelandet has experience with land based wind, and have 350 000 m^2 of developed areas, with potential access of up to 1,4 million m^2. In addition the site offers up to 500 000 m^2 offshore storage and operational areas. The company owning the site, Lutelandet Offshore, is actively pursuing the offshore wind market.

The area could be suitable for assembly of shallow floaters and as a logistics port for components (tower, turbine and blades) for both type of structures. The water depth at the main quayside are 20 m LAT at the quayside in the length of 60 m. Construction of foundations for shallow and initial start of deep floaters (Spar) can be feasible. Deep floaters construction start onshore, and being towed to a deep water site for completion of the the structures.

The project views Lutelandet as a potentially high value marshalling site. However, the site's western location that makes it a good and close site for offshore wind marshalling also makes it fairly open to swells and strong winds – which may reduce the uptime of assembly cranes should the site be selected for assembly and construction purposes.

Figure 31 - map of Lutelandet

Overview of Lutelandet

Figure 32 - Wergeland base, Gulen

Gulen (Wergeland base at Sløvåg)
Gulen is located across the fjord from the Mongstad refinery, and in the offshore wind, the location is probably best known as the coming assembly site for Hywind Tampen. Wergeland base has a number of quays amounting to about 1800 m in 2021, plans to develop a 20 000 m^2 and 20 m deep dry dock and 500 000 m^2 in operational area onshore. Given the experience that will be gathered from Hywind Tampen, Wergeland have announced a Letter of Intent for the purchase of a 2600 t Huismann Skyhook crane[18] and announced an ambition to be the primary assembly site for offshore wind in Norway.

Wergeland base could be used for marshalling, storage, concrete construction of semi-submersibles, spar and assembly of wind turbines. Given the experience at the site, there is ample mooring experience, which is good given the presence of Mongstad just across the fjord. Mongstad is Europe's second largest oil terminal – just after Rotterdam and the level of traffic to the terminal indicates that some considerations should be taken for offshore mooring of a large number of floating wind turbines. The upside it the potential of a green hub, especially given the recently announced plans for the development of a hydrogen factory by BKK, Equinor and Air Liquide

The possible downside of Wergeland base, is the lack of shelter – which may lead to swells and wind issues.

Figure 33 - Hywind Tampen assembly concept sketch (Source: Sweco / FM-Strand)

18. https://www.huismanequipment.com/en/media_centre/press_releases/163-150_Wergeland-and-PSW-to-extend-port-capacity-with-Huisman-Quayside-Crane

Figure 34 - The current port of Ågotnes.

Bergen/Hanøytangen/CCB/Ågotnes
The port of Bergen is second largest port in Norway, and one of the largest container ports in Northern Europe.

Bergen og Omland Havn AS (the Port of Bergen) is a company owned by the following municipalities: Bergen, Øygarden, Alver, Bjørnafjorden, Askøy, Austrheim and Fedje. The port of Bergen has a entered into a formal collaboration with the port of Stavanger and the port of Trondheim to ensure direct shipping of goods to the participating cities rather than through Oslo and eastern parts of Norway.

There is a political drive in Bergen for urban development of central port areas, and as a result, the Port of Bergen is working actively on the establishment of a new cargo port at Ågotnes, Øygarden municipality.

Given the lack of adequate facilities in central Bergen, the project has evaluated the port in the context of the expected move to Ågotnes. Ågotnes has available areas of 160 000 m^2 for transport handling, with a hinterland – albeit a bit elevated above the main quay areas – of another 200 000 m^2. In conjunction with the CCB base, that has ample quay space with about 20 m LAT depth – in some places up to 50 m LAT depth with a robust O&M organisational setup for oil and gas rigs, the Ågotnes port offer significant opportunities. There are sea depth of about 200 m in a clear fairway from Ågotnes and into open sea, going north. Ågotnes is a 30 min drive from Bergen airport Flesland, which makes bringing specialists to the site an easy proposition.

The key issue with Ågotnes could be access from the mainland over the Sotra bridge, which is an older bridge from 1972 with a traffic level of about 27 000 vehicles daily, equivalent to the main entry road into Norway, Svinesund. A new bridge is under development to be finished in 2026, which should fit in well with the development of offshore wind in Norway. Should the Port of Bergen for some reason not move, the central port does not offer much for offshore wind.

Ågotnes could be seen in conjunction with the Semco Maritime owned Hanøytangen yard and dock, across the fjord from Ågotnes. Hanøytangen has about 220.000 m^2 and is able to expand somewhat. There is a significant dock capability[19] and pier in close reach of 100 m sea depth (60 m form shore). The project view a potential collaboration between the port at Ågotnes and Hanøytangen as a potentially valuable offering in offshore wind.

19. w=125m and l=125 m and 17 m LAT

Figure 35 - Plans to move Port of Bergen goods transport to Ågotnes in 2025-26.

Figure 36 - Ågotnes - Hanøytangen basin outside Bergen

Figure 38 - Eldøyane and Aker Solutions Stord yard

Stord
Stord Leirvik contains both the Aker Stord Yard (formely Kværner Stord) and an available assembly area at Eldøyane-Norsea Stordbase. Stord played a part both in the assembly of Hywind Scotland – where the steel spar buoy foundations were brought in from Spain, upended, ballasted and wind turbines assembled using the Saipem 7000 heavy lift vessel. It is also the location of the initial stages of the Hywind Tampen project, to be slip formed in the yard's dry dock prior to towing to Dommersnes, south of Stord.

The Eldøyane area just by the Stord yard provides at least 55 000m^2 of assembly area close to 30 m sea-depth quays. The area is thus suitable for assembly of especially semi-submersibles from shore.

Tømmervika in Digernessundet, south-west of the yard, can be considered as a potential assembly quay side and deep water construction site. This quayside is situated approx. 1,7 nautical mile from Eldøyane/Aker Stord.

Figure 37 - Hywind Scotland turbines ready for assembly at Eldøyane

Karmsund

Karmsund, Haugesund, have announced significant plans to become the leading offshore wind port in Norway. The port has gone public with an ambition to establish an assembly site at Gismarvik with an O&M base at Killingøy[20]. More than 1 billion NOK is to be spent for upgrades to cater for, amongst others, the offshore wind industry.

Karmsund has gained experience from onshore wind, and with the Aibel yard and Østensjø shipping company in the middle of the port, Karmsund have plans to cover the whole value chain in offshore wind, and to become a major cargo hub for transport to Stavanger and Bergen.

Karmsund port has available quay areas amounting to 500 000 m^2 at Husøy, with approximately 18m water depth. As such, it provides ample opportunity for cargo handling and storage. The Killingøy part of Karmsund harbour seems to be a very good set up for O&M for the coming Utsira Nord project(s), obviating the need to establish a base at Utsira island. The port has Karmøy airport close by with some international routes.

Gismarvik has approximately 100 000 m^2 of quay space at 16,5m depth. In the project's perception this indicates a good opportunity for storage of components such as mooring and anchors. Should the nearby Haugaland Næringspark area be levelled down to a suitable height and overhead cables rerout-ed, there is ample opportunity for more activities. The area is looking into hydrogen and other green activities which may lend further strengths to the area.

Both Karmsund could be suitable for construction site for shal-low floater (Semi), of initial start of deep floaters and logistic harbour for components (mast, turbine and blades) for both type of structures. The water depth at the main quay sides are acceptable 20 m LAT at the quayside. Towing to a deep water site will be required is to complete the construction of for deep floater structures.

Figure 39 - Haugesund area / Port of Karmsund

20. https://finansavisen.no/lordag/reportasje/2020/12/19/7598923/ostensjo-og-aibel-har-allerede-etablert-seg-i-havvindmarkedet-et-enormt-potensial

Figure 40 - Stavanger ports

Stavanger

Stavanger is a major transport hub, where especially the Mekjarvik area is seen as a possible offshore wind site. Stavanger's 5500 m of quay side is divided in to three main areas outside the city centre. Stavanger also has access to an international airport within easy reach and has possibly the strongest offshore oil and gas competency level in Norway. There are also a number of bases in the area that can be used for O&M. Just by Stavanger city centre, Rosenberg Worley yard with an approx. 40m x 280 m dock, EPCI capabilities and 1000 employees have developed their own floating wind concept, Flexifloat, and as such shows an active interest in positioning for offshore wind.

Mekjarvik is deemed suitable for both marshalling and assembly, should the current expansion plans be realized, also for shallow-floater assembly. Mekjarvik has about 500 m quay front in total with between 15 and 20 m LAT, with ro-ro capabilities – which can ease assembly.

Risavika and Dusavika as well as Norseabase Tananger are seen as possible places for O&M – but not for any major construction activities. Hanasand, just outside will over time have access to 400 000 m^2, though the shallow fairway to open sea makes this an option only for shallow floaters.

The port of Stavanger has access to 700 000 m^2 with an option for another 255 000 m^2 . East of Stavanger, Forsand – managed by the port of Stavanger, has access to another 200 000 marshalling area. The 7 m LAT depth might be an obstacle to very large vessels and structures.

Jelsa

Jelsa, north-east of Stavanger is northern Europe's largest stone quarry, fairly close to where some of the largest concrete oil and gas platforms were constructed. The project deems this to be an area of high potential offshore wind foundation construction, especially given easy access to deep waters. Jelsa can thus be suitable to both gravity based structures, deep-water and shallow floater construction. The area is in its development infancy and as such a lot of work remains to be done prior to this becoming a real option. If this is realized, Jelsa could have more than 1 million m^2 of which 400 000 m^2 could be dock facility suitable for offshore wind production.

Figure 41 - Norsk Stein at Jelsa

Eigersund

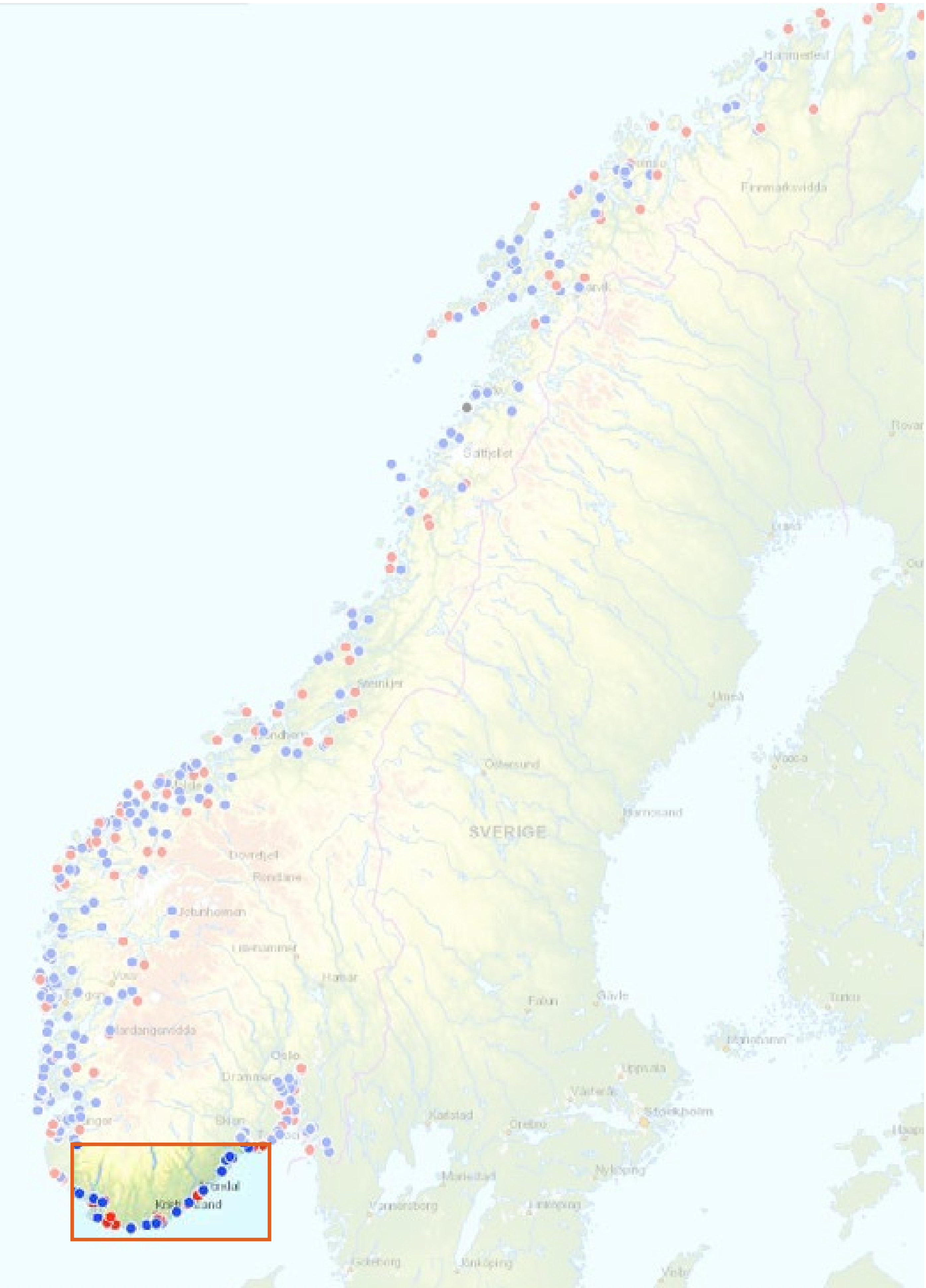
Eigersund is perhaps the foremost example of a location that is working integrated to establish a large-scale O&M-site. Through the Energy Innovation hub, Eigersund has access to training locations onsite, and several companies and institutions have co-located there with O&M in mind.

The port is sheltered, but fairly small. With a narrow fjord with only a 76 m minimum span, and 12 – 17 meters draft, it is not seen as a construction or assembly port. There is a yard at the fjord outlet – which mainly focuses on oil and gas activities with easier access. Eigersund is together with GoT Mandal, the closest ports for O&M on Sørlige Nordsjø II.

Figure 41 - Norsk Stein at Jelsa

7.4 SUMMARY

PORT	Logistics	Assembly (shallow)	Assembly (deep)	Construction (shallow)	Construction (deep)	O&M SOV	O&M CTV
Bergen - Ågotnes & Hanøytangen	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Eigersund	Yes	No	No	No	No	Yes	Yes
Florø Fjordbase	Yes	Yes	No	Yes	No	Yes	Yes
Haugaland Næringspark	Yes	Yes	No	Yes	No	Yes	Yes
Jelsa	Yes	Yes	Yes	Yes	Yes	No	No
Karmsund havn	Yes	No	No	Yes	No	Yes	Yes
Lutelandet Offshore	Yes	Yes	No	Yes	No	Yes	Yes
Sandnes	Yes	No	No	No	No	Yes	Yes
Stavanger - Dusavika	No	No	No	No	No	Yes	Yes
Stavanger - Forsand	Yes	No	No	Yes	No	Yes	Yes
Stavanger - Mekjarvik	Yes	Yes	No	No	No	Yes	Yes
Stavanger - Risavika	Yes	No	No	No	No	Yes	Yes
Stord Base	Yes	Yes	No	Yes	No	Yes	Yes


Hammerfest
Finnmarksvidda
Saltfjellet
Steinkjer
Östersund
SVERIGE
Härnösand
Umeå
Vaasa
Dovrefjell
Rondane
Jotunheimen
Lillehammer
Hamar
Voss
Hardangervidda
Falun
Gävle
Turku
Mariehamn
Oslo
Drammen
Uppsala
Västerås
Stockholm
Karlstad
Örebro
Arendal
Mariestad
Nyköping
Vänersborg
Linköping
Göteborg
Jönköping

8 Southern Norway: Agder

8.1 SOUTHERN NORWEGIAN PORTS IN NUMBERS

ISPS ports:

COUNTY	PRIVATELY OWNED ISPS-PORTS	PUBLICALLY OWNED ISPS-PORTS	TOTAL
Agder	40	44	84
Grand Total	**40**	**44**	**84**

Fishery ports:

CATEGORY	PORTS
Sørøst (South and South East Norway combined)	52
Eier (helt eller delvis)	32
Historisk (avhendet)	19
Ikke eier	1
Grand Total	**52**

8.2 OFFSHORE WIND FARMS IN SOUTHERN NORWAY

Apart from Sørlige Nordsjø II, there are no planned offshore wind farms outside southern Norway. However, southern Norway is the closest location to Sørlige Nordjø II – which may have implications on both the suitability for ports for operations and maintenance, and – outside the scope of ports – likelihood of Norwegian cable landfall from Sørlige Nordsjø II- Sørlandet is also geographically closest to the European developments under way.

8.3 KEY FINDINGS

Farsund

Farsund has the abandoned Lista airport close to sea which can in theory be used for blade and tower fabrication, or storage area, with access ways to the port. There are multiple quays useful for O&M in the main port, and there are initial plans to develop the area just south of Farsund into commercial/industrial areas which could be of use.

Figure 42 - Farsund

Figure 43 – Mandal, Strømsvika and Gismerøy

Mandal

Mandal port has two areas, both which could be of interest to a developing Norwegian offshore wind sector. Gismerøya (GOT), to the south of Mandal has 250 000 m^2 available area with 20m deep quay sides. This area could be expanded further. The the area might discourage large scale fabrication, but the area is very well suited for marshalling and assembly of semisubmersible floaters as well as O&M. Should GOT be used as a assembly location, the project recommends an evaluation of quay modifications.

East of Mandal, there are early plans to develop further quays at Strømsviga, which – if realized – could add additional storage and marshalling area to the region.

Figure 44 - GOT Rig harbour at Gismerøya

1. GOT Office and workshops
2. Surface treatment workshop
3. Welding workshop
4. Mandal deepwater harbour
5. Umoe Mandal

Kristiansand

Kristiansand is the largest city in Agder counties, with access to a well-connected airport. With multiple quay sides of medium size, the port of Kristiansand has the faciliies to serve as a storage area of medium sized components of offshore wind projects and O&M of wind parks. The port of Kristiansand has as an ambition to become the leading offshore operations port in the region.

In Kristiansand, the OneCO yard southwest of central Kristiansand also provides yard services, most likely suitable for smaller vessels and constructions.

Figure 45 - Kristiansand

Grimstad

Grimstad has a potential O&M- and storage area at Nymo in the bay north east of Grimstad city center, with some storage capacity. The fairway out to open sea is less than 20 m, thus the 55 000 m^2 and 125 m long quay area will best suit storage of smaller components requiring lighter vessels to approach. Quay depth is between 7,5 and 9 m.

Figure 46 - Grimstad and Nymo

Arendal

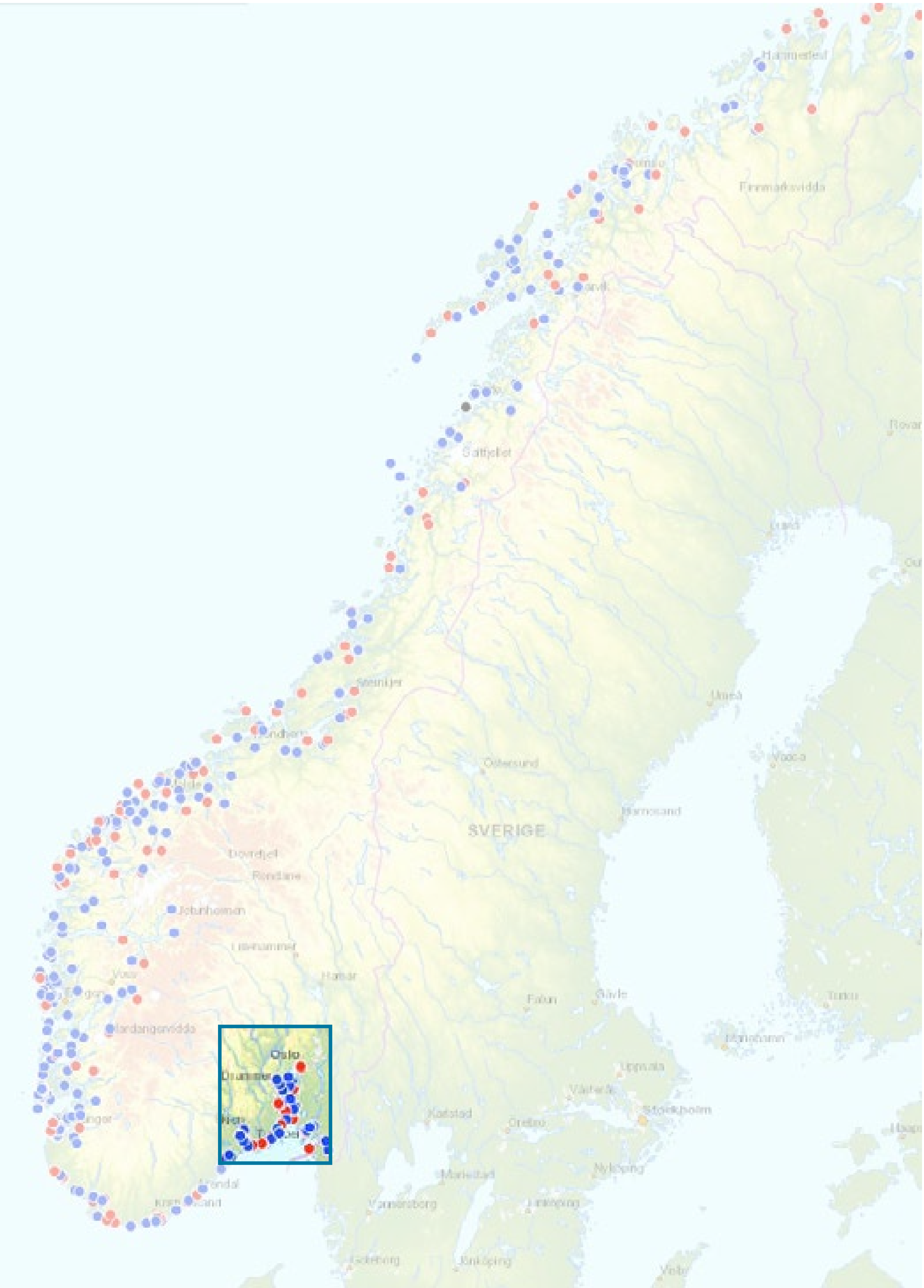
Arendal has access to two quay ports, Arendal main port with 326 m quays measuring between 12,5 to 20 m depth. The port has access to 150 000 m^2, with an additional 75 000m^2 ready in 2021, and another 100 000 m^2 ready for 2024. Arendal port could thus be a possible construction and assembly port, and an obvious marshalling and O&M port. Next to the port of Arendal is Eydehavn. Eydehavn is owned by Nymo, as in Grimstad – above and is under development. With a quay length of 150 m and approx. 10 m quay depth, Eydehavn is most likely a storage and marshalling option.

Figure 47 - Port of Arendal and Eydehavn

8.4 SUMMARY

In addition to a range of suitable ports for O&M, close to Sørlige Nordsjø II, the project observes that the region has a strong collaborative approach through GCE Node – which could well be a model for regional collaboration to other regions in Norway. The ability shown by GCE Node to bring in public, private and organisations in a joint approach to offshore wind should definitely be studied closely by other regions.

PORT	Logistics	Assembly (shallow)	Assembly (deep)	Construction (shallow)	Construction (deep)	O&M SOV	O&M CTV
Arendal Havn	Yes	No	No	No	No	Yes	Yes
Farsund	Yes	No	No	No	No	Yes	Yes
Global Ocean Technology (GOT) - Mandal	Yes	Yes	No	Yes	No	Yes	Yes
Kristiansand Havn	Yes	No	No	No	No	Yes	Yes
Mandal Havn	Yes	No	No	No	No	Yes	Yes
Nymo - Eydehavn	Yes	No	No	No	No	Yes	Yes
Nymo - Grimstad	Yes	No	No	No	No	Yes	Yes
OneCo - Kristiansand	Yes	No	No	No	No	Yes	Yes



Hammerfest
Finnmarksvidda
Saltfjellet
Steinkjer
Trondheim
Dovrefjell
Rondane
Jotunheimen
Lillehammer
Hamar
Voss
Hardangervidda
Oslo
Drammen
Kristiansand
SVERIGE
Östersund
Umeå
Härnösand
Gävle
Falun
Uppsala
Västerås
Stockholm
Karlstad
Örebro
Nyköping
Mariestad
Linköping
Jönköping
Göteborg
Turku

9 South-Eastern Norway: Oslofjorden

9.1 KEY FINDINGS

The ports in south-eastern Norway are in populated areas and quite a distance from potential offshore wind areas. Given the comparatively high population centres, several ports and yards comment that they are converting areas into residential areas or moving industry out of the more central areas. There is no major drive from the interviewed ports to be a front runner in the offshore wind industry, mainly due to lack of relevant areas and distance from the coming offshore wind farms. Since the larger ports control exports and logistics from the hinterland, they might play a role in the larger logistic scheme for offshore wind for smaller component transportation. These functions do not require significant changes to the current infrastructure.

Halden and Borg port – Fredrikstad are both located at the far outer edge of the Oslofjord. These ports do not have major land areas available, and as such as not suitable for construction activities. However, Halden does host a cable factory which can be used for offshore wind activities, and Borg at times does ship cable.

The only other port of note which also works with cable, usable for offshore wind, is Drammen port. Drammen port is the main hub for Norwegian car imports, which takes a lot of the available area. There is a Prysmian cable spooling facility in the port which can be used for offshore wind purposes, and the port is well connected with rail lines running through the facilities.

There might be an option to develop parts of Langøya outside Tønsberg into an assembly site or possibly storage, but with the current level of regulations, it is not likely to be cost efficient in the immediate future.

9.2 SUMMARY

The project assesses that the ports in south-eastern Norway are not positioned for a major role in offshore wind. There is a low level of offshore wind activity in the south-eastern ports, and low potential for large scale offshore wind developments.

10 Norwegian yards

Norway has a thousand-year-old ship-building history, from the viking age through to today. The yards have been core in Norwegian industrial development and a precondition for the fishing and trade industry.

Norway was one of the world's leading shipbuilding nations in the 1970s, but the combination of the oil crisis in the 1970s combined with the emergence of the Norwegian oil and gas sector, lead to a transition in the Norwegian yard industry. The largest yards transitioned to offshore oil and gas, whilst many of the yards in the town centres closed down.

The Aker yard in the middle of Oslo at the end of the 1960s. The area is now a bustling financial, shopping and residential area

The Norwegian yard sector is characterized by many smaller and medium-sized yards along the coast – acting as cluster hubs for the maritime sector with a historically strong focus on the oil and gas sector. The transition from shipyards located in cities to oil and gas yards with focus on one-off oil and gas projects. This has enabled yards to gain deep skills in executing complex projects and deep understanding off requirements for offshore structures. However, the nature of the one-off large projects may also have led to developing physical yard structures that are not optimized for serial production. This impacts the level of investment necessary to transition into a new industry.

Yards are well equipped for some key components in offshore wind. The familiarity with large-scale one-off projects enables Norwegian yards to be well positioned for the coming HVDC and HVAC market. HVDC, with the recent awards to both Aibel and Aker Solutions for HVDC stations on respectively Dogger Bank and as preferred supplier for Vattenfall's Norfolk projects, seem to be very well suited to the current capabilities. HVAC substations are less complex structures, and thus opens for more competition from low-cost markets. The role of Norwegian yards for bottom-fixed HVAC substations is thus less certain. For floating HVAC substations, Norwegian experience in floating structures should provide a firm basis for yard work.

The Aker yard in the middle of Oslo at the end of the 1960s. The area is now a bustling financial, shopping and residential area

Serial production of foundations and for assembly requires significant land areas. The project does notice that the yards studies are, in general, not optimized for serial production. With a large number of small and medium sized buildings, smallish quay fronts, gantry cranes optimal for large one-off projects, the sites themselves are not yet optimal. To make them optimal, significant investments would be needed. A handful of yards do have access to such areas. There are some sites, as shown in the appendix, such SWECO Hanøytangen, Vestland Base (Wergeland), Aker Verdal and the potential Jelsa-site all have significant areas that could be used for serial production at scale. The other yards can do batches to complement a larger effort, but might struggle with the requirements for a large-scale offshore wind farm.

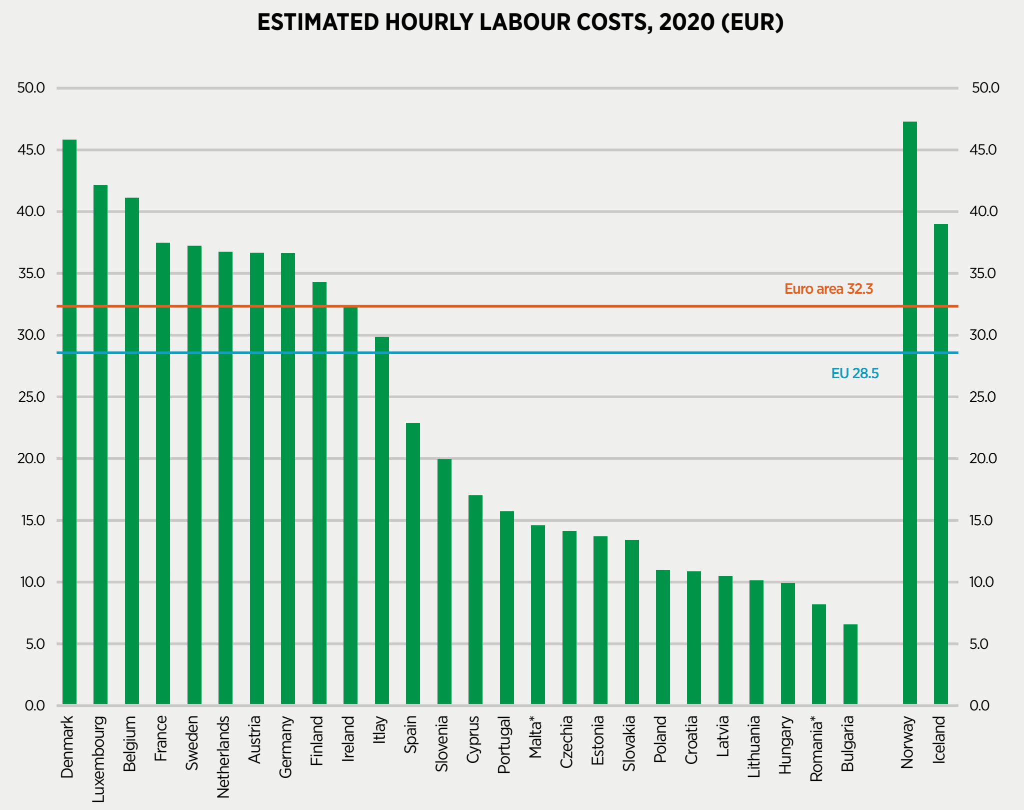


Figure 10.1: Notes: whole economy (exluding agriculture and public administration): in enterprises with 10 or more employees. Provisional data. Greece: data not available. Malta: a negative value was recorded for the non-wage costs in the total economy as labour subsidies received by enterprises exceeded the taxes paid, due to the impact of COVID-19 support measures. As it amounted -0.05€ it is not visible on the chart.
Source: Eurostat (online data code: lc_lci_lev)

It should be noted that a lot of the smaller yards along the coast may play a significant role in fabricating components for offshore wind. Equipment such as foundation outfitting, pin piles, suction anchors and mooring will all require significant fabrication capacity in the coming market development.

Norwegian yards have some issues such as comparatively high labour costs. Norwegian labour costs are at the very high end of the European scale.

Costs levels are significantly higher than can be found in other parts of Europe, not to mention Middle and Far East. There is thus a strong driver for the yards to automate and roboticise a lot of the work performed. Analogies may be drawn to the ship-building industry, where robotization has taken a large role. As an example, Kleven shipyard uses robots for 90% of the topside welding[1]. Such levels may require significant innovation and investment to achieve for the offshore industry.

Another issue is the increasing difficulty in getting access to trained personnel. Trained welders are becoming a scarce resource in the industry, and with the expected growth of offshore wind, will only become more scarce. A lot of the yards use Polish welders, who travel to Norway due to the higher wage level. The Polish government launched a 5,9 GW offshore wind round with a massive emphasis on local content – which means that the developers will be actively seeking Polish welders for fabrication projects in Poland. This will most likely increase the local wage level on these professions, which again will reduce the number of trained people that will come to Norwegian yards. Manning might thus be an issue in the years to come.

The following yards have been assessed and responded to the project queries. Details can be found in the yard appendix on Norsk Industri's project web pages:

- Tønsberg – Agility (closing in 2025)
- Trosvik – Brevik
- Arendal and Grimstad – NYMO
- Egersund - Aker Solutions
- Stavanger - Worley Parsons Rosenberg
- Ryfylke - WindWorks Jelsa (under early development)
- Haugesund - Aibel
- Stord - Aker Solutions
- Bergen - SEMCO
- Gulen - Vestland Base Wergeland
- Verdal - Aker Solutions
- Sandnessjøen - Aker Solutions
- Sandnessjøen - Westcon

1. https://www.tu.no/artikler/hos-kleven-sveiser-roboter-90-prosent-av-skipets-overbygg/225630

11 Reflections and recommendations

The project has found that though the ports and yards are very ambitious to win a role in offshore wind, significant work and improvements must be done for the current port, yard and construction sites to be a real driver for a growing offshore wind industry in Norway.

AREA	OBSERVATION	RECOMMENDATION
Organisational readiness	POSITIVE AREAS • High level of interest • High ambitions IMPROVEMENT AREAS • Clear lack of understanding of offshore wind industry size and implications • Low level of regional collaboration • Strong focus on cargo handling • Low value-chain focus • Customer-driven approach may lead to lack of proactiveness in offshore wind	• Establish firm strategic focus on offshore wind • Incentivise local collaboration • Recognise the need to cover offshore wind competency gaps • Drive a culture and mindset change through incentivising new business models • Drive development of value-chain-covering hubs
Infrastructure	POSITIVE AREAS • Many areas with considerable potential • Huge number of small and medium sized quays IMPROVEMENT AREAS • Old equipment • Low quay side tolerance level • Large investments needed • Few areas primed for industrial and serial production	• Split tasks between ports to enable focused investments • Establish a systematic approach to port and construction site infrastructure development • Leverage ongoing efforts by Kartverket and Kystverket to detail infrastructure gaps
Frame conditions	POSITIVE AREAS • Robust ownership model IMPROVEMENT AREAS • 'Project-by-project approach rather than firm national offshore wind vision stops necessary investments • Ownership model seen as positive, but may not incentivize regional innovation • Capital is available, but no clear view on how to best invest	• Establish a firm national offshore wind road map giving confidence to supply chain and infrastructure investors • Assess whether local regulatory conditions support development of offshore wind industrial activities • Support ports and the supply chain in finding relevant funding nationally and internationally

Appendix 1: Methodology

ASSUMPTIONS

The study was split into several work streams to focus on:

- Ports for assembly and logistics – using criteria from international studies aiming to assess suitable locations for offshore wind manufacturing, marshalling, logistics and assembly of offshore wind farms.
- Ports for operations and maintenance – identifying high level criteria to assess suitability of ports for either SOV og CTV-based operations and maintenance.
- Offshore yards – identifying criteria to assess the suitability of Norwegian offshore yards to provide services and products to the offshore wind industry. Ship yards are treated in a separate report elsewhere.
- Construction sites – identifying criteria and applying these to find suitable locations to set up as construction sites for offshore wind based on mostly concrete structures – leveraring the experience gained from the concrete structures developed for the oil and gas sector in Norway.

The study was mainly a desktop exercise. Discussions with select ports and key players in the coming offshore wind industry, either one-on-one or in workshops, were held. The discussions focused both on bottom-fixed and floating offshore wind. Floating wind has largely been the focus of the public debate related to Norwegian offshore wind, but the largest announced area, Sørlige Nordsjø II, will largely be bottom-fixed. As is shown in the market section below, the EU and the UK plans for up to 220 GW of offshore wind by 2050 in areas not far from Norway – which is equal to about 14 700 15MW-turbines. About 70% of the components are identical between floating and bottom-fixed. This means the study has also had both bottom-fixed requirements as well as floating wind requirements in mind when appraising the status. We have assumed some standard criteria for evaluation purposes. These can be seen in chapter XXX.

As is shown on the map above, Norway has a huge range of ISPS-related ports, and hundreds of fishery-related harbours which could serve as operations and maintenance harbours. A non-exhaustive selection of large ports was thus made. For O&M-ports, there are too many for any meaningful listing and assessment. Work has thus focused on identifying recommended criteria through discussions with key companies and selected parties. Some O&M-ports suitable for larger vessels, or where multiple activites – such as wind turbine training, academia and other activities have been combined to kick-start an O&M hub, have been mapped.

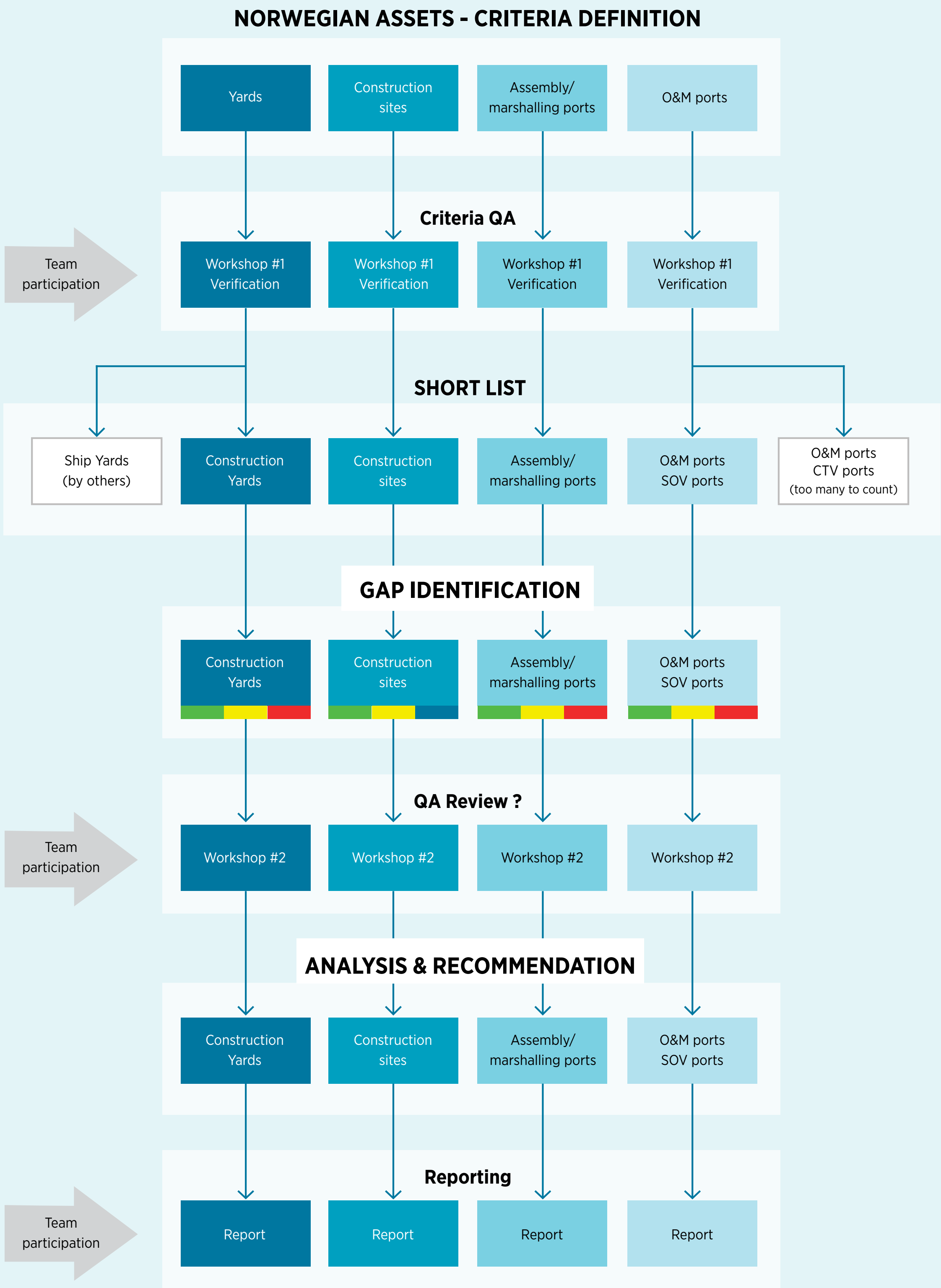
Based on a long-list of ports and harbours, a defined set of criteria, based on know-how and experience from team members as well as international literature and studies, were applied. The results are high-level and shown as traffic lights. The team is very well aware of the immature stage of the assessment, and do not claim to represent any form of finality. Many of the ports have ambitious plans combined with a high level of confidence in understanding the industry, which should enable options and opportunities not seen yet by the team.

Workshops were held with ports in the Northern Norway, Møre and Trøndelag, Vestlandet and Agder regions. Individual discussions with ports around the Oslo fjord and key ports and industrial areas around the country has also been held. We experienced a massive interest in the topic, and a huge willingness to move into this new industrial venture.

Based on advice from Wind Europe's Port Platform, the group also focused on strategic focus and flexibility in the ports and yards that have been interviewed. The main reason for this is that the rapid technology development in the industry may in a few years' time invalidate sites and ports which may seem perfectly adequate today. A long-term strategic approach to offshore wind – possibly in combination with other green economy initiatives – such as hydrogen and carbon capture, ability to adapt to new business models, bolstered by deep client relations and industry understanding is even more vital in Wind Europe's experience than just access to quay fronts.

Dialogues were held with industry representatives, academia and relevant organisations on the value of a structured approach to developing offshore wind hubs in order to enable large scale clusters to settle and thus to drive innovation, establish networks and to optimize logistics – thus driving down Levelised Cost of Energy (LCoE) to more quickly enable Norwegian offshore wind industry development. The study barely scratches the surface here and it is recommended that if there is a next phase, this should be a focus.

A number of European ports are repositioning themselves as green hubs for offshore wind, hydrogen and other green energy activities going beyond the classical transportation hubs and into construction, assembly, siting for manufacturing and so forth. The scope of the study did not allow for an in depth assessment of such activities. However, as is shown in the recommendations, further work is recommended to be done in this area to understand the repositioning of ports into such green hubs.



Study approach for Ports, Yards and Construction sites

Appendix 2: Norwegian ports

LIST OF Norwegian PORTS, CONSTRUCTION SITES AND YARDS

See attached Excel-file

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