O&M PORT KONGSGÅRD – MARKET INSIGHT, PORT ASSESSMENT & CONCEPT PLANNING

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EXECUTIVE SUMMARY

The ambitions of the Norwegian government to develop two major offshore windfarms Utsira Nord and Sørlige Nordsjø II towards the end of this decade, requires the establishment of port infrastructure for efficient installation, operation, and maintenance of these assets.

Located 127 nm from the site of SNII and having acquired considerable experiences as a supply base for the offshore and maritime industry, Kongsgård in the Port of Kristiansand has an outstanding position towards competitors to become O&M hub servicing the vessels deployed during the operational life of the SNII windfarm. Further opportunities are likely to arise in the near future, as the SNII phase 1 is likely to be extended and adjacent areas are expected to allow for up to 11.5 GW of installed offshore wind capacity. Furthermore, other windfarms in Denmark and elsewhere are planned to be constructed in distances reachable from the Port of Kristiansand.

However, investments have to be undertaken to become an O&M hub to today's standards meeting the dedicated requirements of OEMs and developers. These investments need to be directed towards onshore warehouses and offices, sustainable solutions such as the provision of green hydrogen, as well as upgrading existing services to accommodate an increased number of port calls in the relevant harbour area.

In case further activities apart from regular O&M campaigns shall be facilitated by the Port of Kristiansand, further investigations and potentially investments e.g., for seabed preparations will be required. These additional activities could include the performance of pre-construction surveys and soil investigations, subsea inspections, unplanned major component exchange campaigns and storage of strategic spare part.

The extensive engagement with key stakeholders is of utmost importance in order to raise awareness for the capabilities and possibilities at Kongsgård, gather input of future users of port areas dedicated to offshore wind, and ensure engagement of the local business community. The stakeholder engagement strategy should emphasize transparency, inclusiveness, and responsiveness to stakeholder needs. This includes engaging with Southwind partners to develop a clear overview of relevant services (UVPs) for the O&M phase, covering both - existing and potential service offerings.

Lastly, communication efforts should be directed towards increasing the positive local acceptance for establishing the O&M port. Engaging in open dialogues with local representatives and communities will help address concerns and highlight the project's positive impacts on the local economy and its sustainable development.

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DEFINITIONS AND ABBREVIATIONS

CTV	Crew transfer vessel
DNP	Defect notification period
EPCI	Engineering, procurement, construction and installation
FTE	Full-time Equivalent
GW	Gigawatt
HVDC	High Voltage Direct Current
ISPS	International Ship and Port Facility Security
LoLo	Lift-on / Lift-off
MBES	Multibeam survey
MEGC	Multiple Element Gas Containers
MP	Monopile
MW	Megawatt
OEM	Original equipment manufacturer
OSS	Offshore substation
O&M	Operations and maintenance
OWF	Offshore windfarm
SNII	Sørlige Nordsjø II
SOV	Service operation vessel
SWL	Safe Working Load
RoRo	Roll-on / Roll-off
ROV	Remote Operated Vehicle
T&I	Transportation and installation
TP	Transition Piece
TSO	Transmission system operator
UN	Utsira Nord
WTG	Wind turbine generator
WTIV	Wind turbine installation vessel

1. INTRODUCTION

This report is directed to Southwind at its partners. Southwind was established with the aim of highlighting the services and qualities, which the Port of Kristiansand, Southwind and its partners plan to offer to play a role in the emerging offshore wind industry in Norway.

This report provides an overview of the market potential for a future O&M hub servicing the offshore windfarm SNII, as well as competitors and operating OWF O&M hubs (chapter 2 to 0) and introduces key stakeholders relevant for Southwind as well as ways to engage with them (chapters 3 to 0).

Chapters 4 to 4.4 describe general particularities of activities performed as part of the O&M phase as well as deployed vessels and logistical approaches to realize these works efficiently.

Furthermore, the present report outlines requirements a future O&M port should comply with and assesses the currently available infrastructure at Kongsgård to showcase potential gaps and need for further investigation/investments (chapter 5 to 5.3).

The report concludes indicating investment costs (chapters 5.4 and 6.1 to 6.2) and presents concrete steps to be undertaken in the upcoming months in order to increase the changes for Kongsgård to become the selected O&M hub for SNII phase 1 (and beyond).

2. MARKET INSIGHT

The offshore wind sector in Norway is forecasted to grow tremendously over the coming decades. The first two Norwegian projects on commercial scale, Sørlige Nordsjø II (SNII) and Utsira Nord, are scheduled to be constructed around 2030. Beyond, the Norwegian government has the ambition for offshore wind to reach an installed capacity of 30 GW by 2040. Investment in ports and local infrastructure will be crucial for realizing these offshore wind projects and enhancing the engagement of Norwegian businesses and communities in the offshore wind industry. Furthermore, the offshore wind industry is set to grow immensely both in Europe and globally. Thus, there is opportunity for Norwegian ports to service further offshore wind farm (OWF) projects in the North Sea. Including, potential collaborations with other ports and service providers in Norway & Europe.

2.1 Market Potential

The global offshore wind market has experienced rapid growth during the last years, with a cumulative installed capacity of approximately 40 GW (2022). The growth of the industry is forecasted to accelerate with the ambitious national and EU offshore wind targets. For example, the EU aims for 60 GW[1] of offshore wind capacity by 2030, almost six times the installed capacity in Europe today. Meanwhile, the UK and Germany alone aim for 50 GW and 30 GW of offshore wind by 2030, respectively.

With all the ambitious offshore wind targets, it's important to focus on the most relevant projects. In this case, confirmed projects that are close to Kongsgård. Proximity to site is a strong driver for selecting an offshore wind harbour for an OWF development, be it as base port for construction or as O&M port during operation. There are several projects close to Kristiansand to be constructed in the coming years. Thus, OWFs within a 300 km radius were selected for consideration, as shown in Figure 1. The sites within this radius are listed in Table 1 sorted by distance from Kristiansand. Further potential lays in the area "Sørvest F" adjacent to the envisaged SNII site with a total expected capacity between 5.7 and 11.5 GW and potential construction start 2027-2031.

[1] Offshore renewable energy (europa.eu), accessed: 05/07/2023.

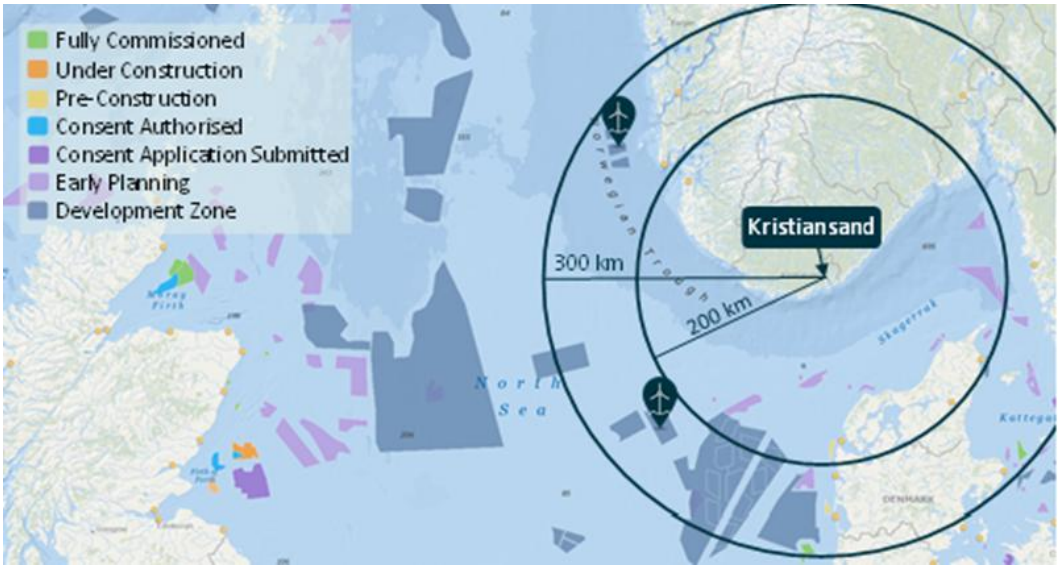


Figure 1: Offshore Windfarms within 200km and 300 km radius from port Kristiansand

Table 1: Planned Offshore Windfarms in proximity to Kristiansand

Name	Developer	Capacity	Distance to Kristiansand	Country	Project Status
Thybo II	TotalEnergies	1320–1760 MW	96 km	DK	Ealy Planning
Freya	Copenhagen Energy A/S	750–1500 MW	102 km	DK	Ealy Planning
Jyske Banke Nord	Copenhagen Infrastructure Partners/ Orsted Wind Power A/S	1040 MW	103 km	DK	Early Planning
Hirtshals Havn	European Energy A/S	2x 160-300- / 500 MW	126 km	DK	Ealy Planning
Odin	Copenhagen Energy A/S	1500–2250 MW	152 km	DK	Early Planning
Mareld	Hexicon AB / Aker Offshore Wind	1000 – 2300 MW	155 km	SE	Early Planning
Vidar	Zephys Vind AB / Vattenfall AB	1400 MW	165 km	SE	Early Planning
Poseidon Nord	Zephys Vind AB / Vattenfall AB	800 MW	175 km	SE	Early Planning
Frederiks Havn Nord	European Energy AS	150–500 MW	176 km	DK	Early Planning
Västvind	Eolus Vind AB	1000 MW	196 km	SE	Early Planning
Sørlige Nordsjø II	TBN	2x 1500 MW	227 km	NO	Develop. Zone
Bøchers Banke	Copenhagen	1100 MW	242 km	DK	Early Planning
Nordsøen	TBN	10x 1000 MW	180 – 300 km	DK	Develop. Zone
Utsira Nord	TBN	3x 500 MW	280 km	NO	Develop. Zone

2.2 Typical procurement strategies in offshore wind projects

A variety of differing procurement strategies exist in offshore wind development projects, depending on capabilities, capacities, risk aversion etc. of the respective developer. A multi-contract strategy allows the developer to award one or more suppliers the completion of each work package with the need for considerable technical resources and interface management, but increased control on the work completion process. An EPCI strategy reduces the number of contracts and consequently the level of involvement required from the developer.

Increasing the number of interfaces to be managed by the developer, naturally effects the needs for staffing and requires considerable experience in handling interface risks. As a result, larger utilities are more likely to award many separate contracts (multi-contracting) than smaller utilities.

Nonetheless, other factors besides company size, its resources and experience play a role when defining contracting-strategies, such as project specific cost/risk analysis, trade-offs between know-how ownership and development, the maturity of the supply chain[2] in the country in which a project is developed and the number of projects the respective developer is handling in parallel. Another important factor is project financing. Lending conditions are amongst others effected by interface risks, how risks are mitigated, and the track record of involved developers and contractors.

Even using a multi-contracting approach, developers tend to allow interested parties to submit bids for several lots, as potential synergy effects can be beneficial and reduce costs. Specifically, there is a trend towards bundling the manufacturing and installation scope for cable-packages. Cable manufacturers move towards building capabilities to install the cables themselves, rather than relying on specialist contractors. Figure 2 exemplarily illustrates typical scope splits of bottom fixed offshore wind projects.

[2] An example is the floating wind industry. At this stage, developers tend to award larger contracts to a smaller amount of contractors to reduce interface risks. That tendency may change once a larger quantity of project have been realized.

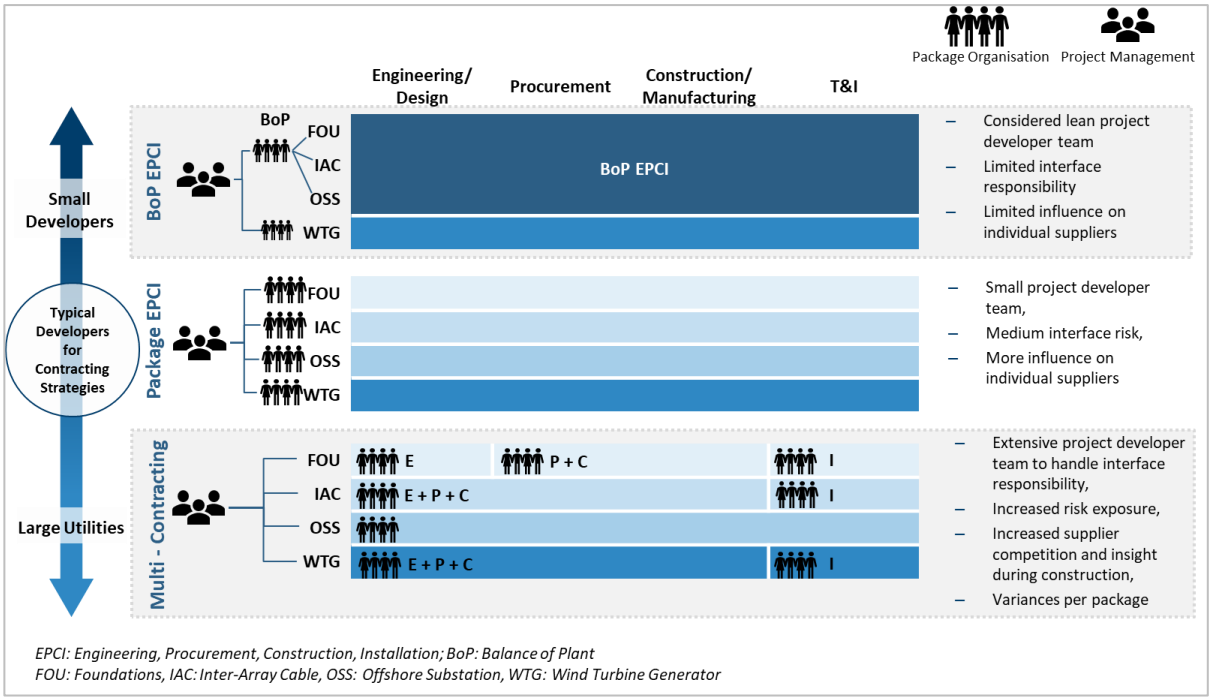


Figure 2: Procurement strategy - exemplary scope split

The developers typically subcontract the turbine supply and commissioning work package to an OEM through a turbine supply agreement. The provision of the turbine installation vessel, however, is not necessarily part of the OEM's scope and may be awarded separately.

Due to vast ambitions to construct offshore windfarms around the globe and the rapidly increasing hub heights, component and especially foundation dimensions and weights, there is a scarcity of installation vessels capable of installing those components. The marine contractors are in a comfortable position and the developers adapt their procurement strategies, to secure installation vessels for their projects. The developers are starting to close reservation agreements with marine contractors well ahead of the installation year, partly even before the vessel in question is constructed and enter into long-term-agreements, securing the vessels for a variety instead of a single project. A similar tendency can be observed looking into manufacturing contracts. Again, a scarcity of capable suppliers of components (e.g., OSS topsides or jackets), leads developers to book production lots for a portfolio of projects.

WTG-suppliers usually provide in-warranty operation and maintenance in the 5 years of operation during the damage notification period. Extended contracts to 15 years are commonly offered optionally. Further subsequent agreements are not out of questions. WTG monitoring and control work is managed by the developers, assuming their role as operators, and sometimes by the turbine OEM as well. In case an SOV is deployed, the

vessel is contracted as a long-term charter by the OEM/developer (depending on who is executing the O&M works).

Subsea O&M activities at inter array cables and foundation structures include regular visual inspections and surveys, commonly performed by a third party; an experienced service provider contracted by the developer. Operations and maintenance at HVDC systems may be performed and in the responsibility of the OSS-EPC contractor of the developer. Alternatively, another contract is closed with a third party being responsible to perform inspections and maintenance works of electrical components as per the manufacturers' specifications. Additional contracts are closed for any subsea services to inspect jacket structure, j-tubes, scour protection at the OSS and export cables.

Decommissioning plans and budgeting estimations are prepared by the developer during the planning phase of the offshore wind construction project and are updated throughout the windfarm's lifetime. The decommissioning work itself is expected to be managed either by the developer or by one or more tier 1 marine contractors.

2.3 Offshore windfarm component dimensions & weights

The wind turbines installed sizes have been increasing to an unmatched rate in the past 15 years. Vestas' V236-15.0 MW is the largest turbines currently operating. The prototype was installed in December 2022 with blade length of 115.5m and a blade tip height of 280m. Commercial installations of turbines with nominal capacities of 14-16 MW are expected in 2024-206. However, OEMs are already offering turbines of the next generation to be installed starting 2030. Turbines of a nominal capacity of 18 MW-21 MW are expected to be readily available for SNII with blade length of up to 135m and hub height of 165m and more. Figure 3 gives an impression of the considerable technological advancement in the (offshore) wind industry.

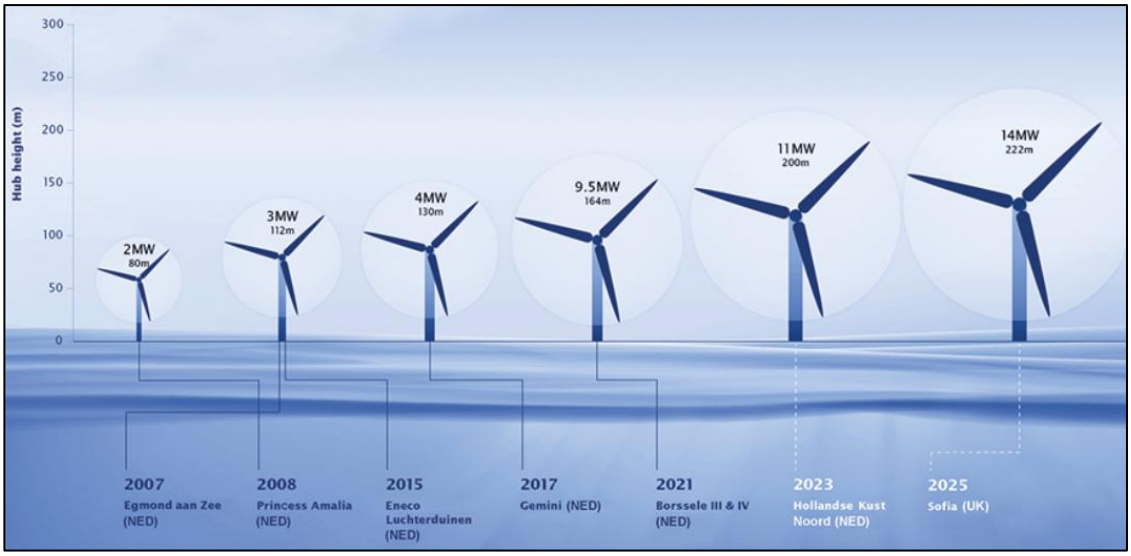


Figure 3: Offshore WTG - size developments

Naturally, sizes and weights of foundation structures to support the wind turbines are increasing as well. However, the specific sizes and weights of foundations depend on various additional factors, including water depth, soil conditions and of course the foundation type. The most commonly used type – the monopile (MP) - is likely to reach its limitations looking at the envisages turbine sizes at SNII, as well as water depths of 53-70m, due to various challenges:

- Design phase: Ensuring maintaining stiffness despite of large diameters
- Manufacturing: Capabilities for producing MPs with diameters of +10m are limited
- Installation: Large MPs are more prone to damage while pile driving due to thickness to diameter ratio
- Installation: The availability of vessels capable of lifting MPs with a weight above 2500t is limited

As a reference, in Q3 2022, the installation of 28 XXL monopiles was completed at Arcadis Ost OWF. The monopiles supporting 9.5 MW WTGs of Vestas, weighting approx. 2,000 t each, with a diameter of 9.5 m and a length of up to 110 m, were installed in water depth between 41 & 46 m. In January 2023, EEW announced to have produced the first monopile of 1,895 t at the Rostock-site in Germany for the 800 MW Vineyard Wind 1 wind farm, which will be the first commercial offshore wind farm in the USA. The monopiles will each have a diameter of 9.6 m and a maximum length of 85 m supporting 13 MW WTGs of GE.

Hence, for SNII, it is likely that alternative foundation designs will be relevant. Table 2 indicates weights and dimensions of WTGs and jacket foundations as they may be installed at SNII.

Table 2: Indicative dimensions & weights of WTG/FOU for SNII Phase 1

WTG		
Turbine type	18 MW	21 MW
Rated power [MW]	17	20
Quantity SNII Phase 1	84	72
Rotor diameter [m]	250	276
RNA		
Blade mass [t]	75	85
Blade length [m]	122	135
Blade root diameter [m]	5.5	6
Nacelle mass (+hub) [t]	950	1400
Nacelle (+hub); LxWxH [m]	22x12x12	30x12x12
Hub height [mMSL]	152 (depending on project)	165 (depending on project)
Tower		
Weight [t]	1300	1500
length [m]	128	140
Diam. top/bottom flange [m]	5.5/8	6.5/9
Foundation		
Foundation Type	Jacket (3-legged)	Jacket (3-legged)
Jacket Height (incl. (TP)) [m]	80 - 110	80 – 110
Jacket + TP + Second. Steel [t]	2000 - 2500	2200 - 2800
Pile Length [m]	40 – 80	40 – 80
Pile Diameter [m]	2.5 - 4.0	3.0 - 4.0
Pile Weight (per pile) [t]	250 - 350	300 - 400

2.4 Competitor/Partner Analysis

The ambitions of the Norwegian government to construct two mayor offshore windfarms towards the end for this decade and the prospects of future further developments in Norway and beyond, is leading to port operators, municipalities and investors investigating possibilities on how to play a role in these projects. Various ports are developing plans on how to service the vessels deployed during the O&M phase of SNII and/or how to become an attractive installation port for the project. Figure 4 shows the locations of relevant ports which will potentially competing against Kongsgård to become the O&M hub for SNII (phase 1).

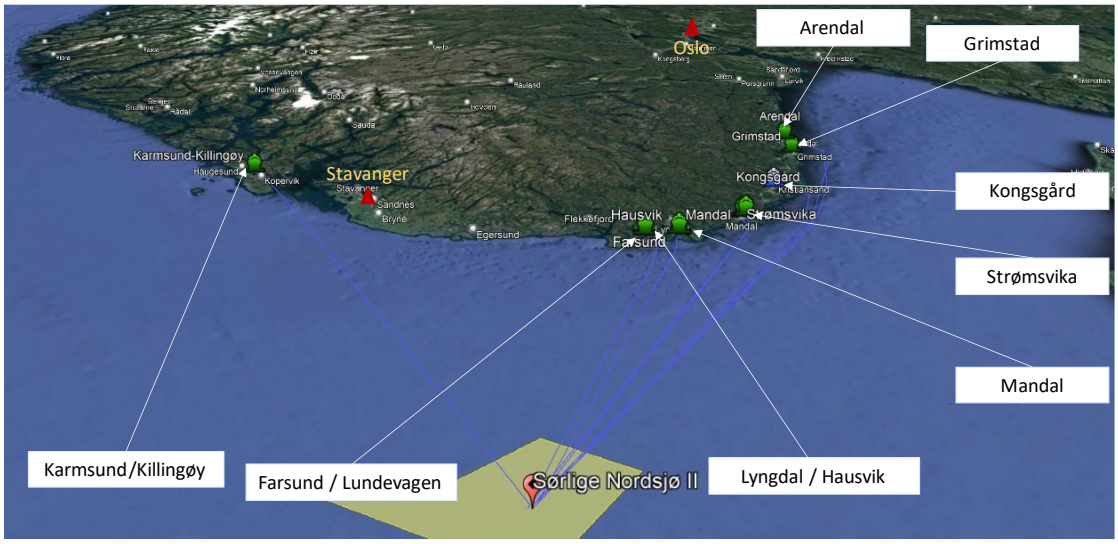
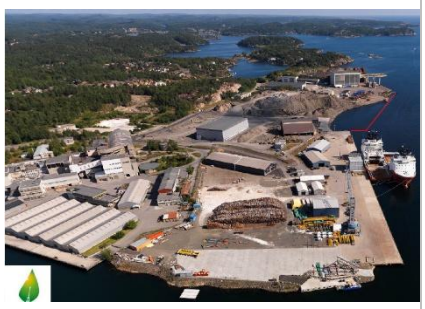
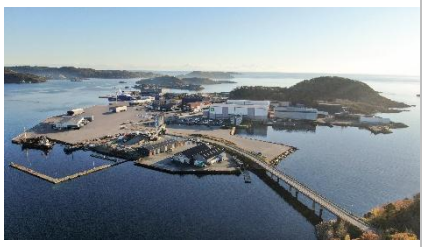


Figure 4: Locations of ports potentially competing with the Port of Kristiansand

The capabilities of the ports, their relevant experience in the offshore industry and required infrastructure upgrades differ greatly amongst the ports in the south of Norway. Details on the ports mentioned can be found in Table 13. It is recommended to follow the developments in these ports and monitor the activities of relevant players aiming to provide O&M services to the offshore wind industry.

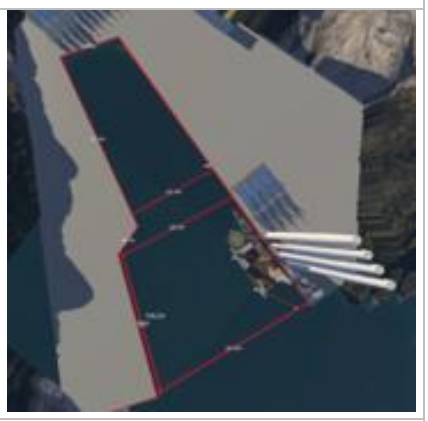
Table 3: Potential competitors to Southwind as O&M port for SNII

Potential O&M Ports near Kristiansand	
Arendal – 170 nm (314 km) to SNII	
The port is located just north of Arendal in the Skagerrak, has several quays and a large area for storage or handling of material just behind the quay. It is suitable for handling logistics and as O&M service for OWFs especially in the North Sea. • Water depth: 5.8 m to 10.6 m • Total Quay length: 700 m • Total land area: 15 ha	
Grimstad / Nymo – 158 nm (293 km) to SNII	
The small port of Nymo is located at the end of the fjord connecting Grimstad to Skagerrak. It has the required facilities to service logistic projects and serve as O&M hub for OWFs. The water depth in the fjord makes the port suitable for vessel related traffic and cargo transport. • Water depth: 7.3 m • Total Quay length: 190 m (130 + 60 m) • Total land area: 25 ha	
Mandal / Gismerøya – 116 nm (215 km) to SNII	
The port of Global Ocean technology is located on the island Gismerøya in front of Mandal and is one of the southernmost ports of Norway. Through its good connection to land via a bridge and the good accessibility by ship it can service logistic project & be used as O&M hub for OWFs. • Water depth: 10.5 m • Total Quay length: 560 m • Total land area: 70 ha • Berth length: 90 m (suitable for one SOV) • Development plans, stakeholder structure, and future use uncertain	

GOT Mandal Strømsvika – 116 nm (215 km) to SNII

This port is located just east of Gismerøya and is currently used as a port for several different tasks. It is planned to develop it into an assembly port for offshore wind but it might also be a valuable option as O&M port.

- Water depth: 11 m to 13 m
- Total quay length: 925 m



Lyngdal / Hausvik – 115 nm (213 km) to SNII

Just at the entrance of the fjord of Lyngdal, the port Hausvik is envisaged as installation port to be built from Q3/2025 onwards. The infrastructure will comprise one long berth and storage area with direct access from the quay, facilitating good manoeuvring and parallel load-out and load-in activities.

- Water depth: 18 m to 19 m
- Total Quay length: 550 m
- Total land area: 200 000 m^2 (option for 300000 m^2)

Farsund / Lundevågen – 102 nm (189 km) to SNII

The existing port in Farsund is due to be expanded and the new area is expected to be available from 2026. It is mainly planned as construction hub but there will be the opportunity to use it as well as O&M base.

- Water depth: 7.5 m to 15 m
- Projected quay length: 280 m
- Total land area: 300 000 m^2
- Uncertainties about financing plan and construction schedule

Karmsund / Killingøy – 138 nm (256 km) from SNII	
This port is located on the west coast of Norway, between Stavanger & Bergen. It is mainly used to serve the offshore oil & gas industry, but several other services are available as well such as a shipyard. It has the capacity to accommodate up to five service vessels at a time and can be developed into a OW O&M port. • Water depth: 8 m • Quay length: 610 m	

Table 4: Operational Offshore Wind Base Ports in North & Baltic Sea

Current O&M Ports in the North Sea & Baltic Sea	
Port of Tyne, UK[3,4]	
Servicing: • Dogger Bank (SSE Renewables/Equinor/Eni) expected to provide service after wind farm commissioning, it is planned to have the capacity of 3.5 GW. • Provide the quay suitable for the state of the art Service Operations Vessels (SOVs) that provide accommodation, and transport for technicians to and from the wind farm.	
Grimsby, UK[5,6]	
Servicing: • Westermost Rough (Ørsted A/S) since 2016. • Race Bank (Ørsted A/S) with SOVs and helicopter since 2019. • Hornsea One (Ørsted A/S) with SOVs and helicopter since 2021. • Lincs (Ørsted A/S), since 2013. • Humber Gateway (E.ON) since 2016.	
Heligoland, Germany[7]	

[3] https://investsouthtyneside.com/port-of-tynes-clean-energy-park-takes-another-step-forward-with-new-major-offshore-wind-base/, accessed: 07/07/2023

[4] https://www.offshorewind.biz/2023/03/15/dogger-bank-om-base-opens/ , accessed: 07/07/2023

[5] https://www.abports.co.uk/locations/grimsby/, accessed: 07/07/2023

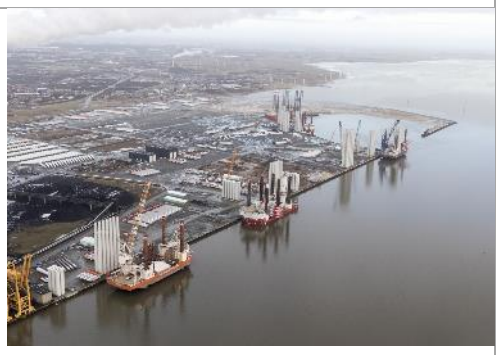
[6] https://lido.hull.ac.uk/Industry/OandM, accessed: 07/07/2023

[7] https://sea-impact.com/offshore-wind-map/, accessed: 07/07/2023

Servicing: • Amrumbank West (E.ON) with CTVs since 2015. • Nordsee Ost (RWE Innogy) since 2016. • Kaskasi II (RWE) expect to provide service from 2023.	
Norddeich, Germany[8]	
Servicing: • Nordsee One (Northland Power) provide include environmental monitoring, inspections, as well as maintenance and repair work since 2017. • Borkum Riffgrund 1 (Ørsted A/S) with CTVs and helicopters since 2016. • Gode Wind 1 and 2 (Ørsted A/S) with CTVs and helicopters since 2018. • Trianel Windpark Borkum I (Trianel GmbH) with CTVs since 2018.	
Klintholm, Denmark	
Servicing: • Danish Kriegers Flak (Vatenfall) with CTVs since 2021 • Baltic 2 (EnBW) with CTVs since 2020	

[8] https://www.offshorewind.biz/2014/07/22/dong-energy-in-norddeich-germany-building-the-om-base-for-the-borkum-riffgrund-and-gode-wind-projects/, 22/07/2014

Table 5: Offshore Wind Installation and O&M Port

Offshore Wind Base Ports	
Buss Terminal Eemshaven B.V.[9], North Sea, Netherlands	
• Terminal Area: 25 ha • Surface load (storage): 35t/m² • Heavy Duty platform: 20t/m² • Water levels > 14 m • Quay lengths 694 m **Reference Projects (except):** 10/2018 – 03/2020: TWB II OWF: Port for inst. of 32 WTG[10] 10/2017 – 09/2018: Merkur OWF: Port for inst. of 66 WTGs 01/2017 – 10/2017: Nordsee one OWF: Base Port for installation of 54 WTGs	 *Figure 5: OW Port Eemshaven*
Mukran Port Sassnitz[11] (Terminal South), Baltic Sea, Germany	
• Water levels ca. 10,5 m • Quay lengths (load-out only): 190 m **Reference Projects (except):** Ca. 01.2018 – 10.2018: Arkona OWF: Base Port for installation of 60 WTGs 2017: OWF Wikinger: Base Port for installation of 70 WTGs 2014: EnBW Baltic 2: Base Port for installation of 80 WTGs	 *Figure 6: Offshore Base Port – Mukran Port*
Port of Esbjerg[12], North Sea, Denmark	
Reference Projects (except): • 4/5 of the offshore wind capacity installed in Europe was shipped out from the Port of Esbjerg. • Horns Rev I and Horns Rev II • Butendiek, Northwind, Sandbank, Dantysk • Humber Gateway, Westermost Rough.	 *Figure 7: Offshore Base Port – Esbjerg*

[9] https://www.buss-terminal-eemshaven.com/en/, 12/07/2021.

[10] Unusual long project duration due to insolvency of OEM during the project execution.

[11] https://www.mukran-port.de/de/offshore.html, 12/07/2021.

[12] https://portesbjerg.dk/en, 16/07/2021.

Offshore Wind Base Ports	
Port of Rønne[13], Baltic Sea, Denmark	
• Newly built port area from October 2019 attracts the offshore wind industry • Construction works included 15 ha port area, designed specifically to handle extreme weights • RoRo-ramp to load-in nacelles/tower sections • Bearing capacity of quay: 50 t/m^2 • Water depth of 11 meters **Projects:** 2022: MHI Vestas selected Port of Roenne as a base port for Arcadis Ost 1 installation in Rugen by 2022 (27 WTGs) 01.2021-06.2021: Kriegers Flak OWF: Base Port for installation of 72 WTGs	 *Figure 8: Offshore Base Port – Rønne*

2.5 Development in Green Solutions

The internationally growing consensus that the usage of green hydrogen enables countries to meet their climate targets, is evidence that green hydrogen will play a key role in the world's future energy production and energy consumption. Hydrogen can be used as a feedstock, a fuel or an energy carrier and has many applications across industry, transport, power, and the building sector. Furthermore, the stable supply of electricity was identified as one of the biggest challenges for the ambitions to rely solely on renewables energy and their fluctuating production. Hydrogen storage and re-electrification could solve this challenge in the future.

Thanks to these characteristics of hydrogen - and most importantly as green hydrogen does not emit CO_2 - the EU identified hydrogen to be a key factor for the goals of the EU's commitment to reach carbon neutrality by 2050. On 8th of July 2020, the European Union announced its European Strategy for Hydrogen, describing the vision of hydrogen use in industries, communication, power engineering, and heating. The plans envisage the installation of electrolysers with a capacity of 6 GW until 2024 and 40 GW[14] until 2030.

The offshore wind industry will play a key role in the production of green hydrogen. First projects have been initiated worldwide[15]. A selection of offshore wind to hydrogen projects can be found in below.

Table 6: Selected Wind-to-Hydrogen projects under development

[13] https://portofroenne.com/business-areas/offshore-wind/, 16/07/2021.

[14] The plan foresees 40 GW in Europe and 40 GW in Europe's neighbourhood with export to the EU by 2030.

[15] https://www.hydrogeninsight.com/policy/offshore-hydrogen-germany-plans-1gw-of-wind-powered-green-h2-production-at-sea-with-pipeline-to-shore/2-1-1392107, 23/01/2023

Project & Electrolyser Capacity	Location	Developers	Commis-sioning	Status (July 2023)
SEN-1 (1GW)	Germany	TBD	TBD	OW development zone, with zone to be exclu-sively used for green H2 production (SEN-1)
NortH2 (10 GW)	Eemshaven, Netherlands	Shell, Equinor, RWE	2027-28	Fully powered by off-shore wind,
AquaVentus (10 GW)	Helgoland, Germany	Consortium of 27 com-panies incl.: RWE, Shell, Siemens Gamesa	30 MW by 2025 5 GW by 2030	Early-stage develop-ment
Deep Purple	Norway	Technip, Vattenfall, ABB, DNV	TBD	Pilot project to create green hydrogen at sea-bed floor

To handle these large amounts of green hydrogen generated in offshore wind farms, major investments are required in ports, to receive, store and distribute it. An example is Brunsbüttel in Germany. The German LNG Terminal GmbH and RWE are investigating the possibilities to use the LNG terminal to import Hydrogen and the port of Rotterdam shows ambitions to become a "hydrogen hub" in Europe. Next to the port of Mukran, Rostock is another port at the Baltic Sea, investing in forming part of the hydrogen-industry. The port has set itself the goal of jointly establishing a 100 MW hydrogen production facility in the seaport as a first step by 2025 with output and capacity to be further increased by 2030.

Apart from that, vessels deployed in offshore wind projects using hydrogen as a fuel, require the development of hydrogen fuelling stations at ports. Windcat Workboats recently unveiled a hydrogen powered crew transfer vessel (CTV) and Edda Wind has delivered hydrogen ready service operation vessels (SOVs).[16][17] In 2022, the first hydrogen bunkering license in the Netherlands has been granted within the port of IJmuiden, allowing Windcat Workboats to bunker the Hydrocat 48 crew transfer vessel with green hydrogen. For SNII, the deployment of hydrogen/ammonia driven vessels is certainly of interest and Southwind should investigate possibilities to develop a suitable infrastructure at Kongsgård.

However, there is a large variety of possibilities to foster sustainability in the Port of Kristiansand. Already mentioned as well as further aspects which should be considered to

[16] https://cmb.tech/news/windcat-workboats-cmb-tech-present-the-first-hydrogen-powered-crew-transfer-vessel-ctv-the-hydrocat-48-ready-for-immediate-operation, 10/05/2022

[17] https://www.offshorewind.biz/2022/10/26/edda-wind-takes-delivery-of-hydrogen-ready-sov-destined-for-seagreen/, 26/10/2022

become competitive related to sustainability are listed below, although parts of these suggestions have already been implemented:

- Invest in infrastructure to be able to receive, handle, store green fuels such as H2 and ammonia as well as bunkering system to supply vessels operating in the SNII OWF with these alternative fuels
- Use of green energy in the port and supply of green energy to equipment/vehicles/vessels operating in the port (vessels as well as cranes, forklifts etc.) and/or vessels/vehicles supplying goods to the port
- Invest in solar cells/photovoltaic and implement solutions to safe energy (smart energy management technologies; energy efficiency improvements in buildings etc.)
- Consider environmental footprint in material selection process for any infrastructure (newly) build in the port and seek for an environmental friendly design of buildings
- Invest in solutions enhancing biodiversity in the port such as fish-hotels/biohuts
- Invest in technology to limit wate and increase rate of re-using materials aiming towards a circular economy
- Investigate in potential carbon capture solutions which can be realized in the port
- Support R&D-efforts of educational institutions and local business linked to sustainable solutions relevant for ports/offshore wind

National & EU funding for investments in OW infrastructure

2.6

Investments in infrastructure to support the offshore wind sector is critical to reach the ambitious offshore wind targets in Norway and Europe. Consequently, Norwegian and European funding schemes are available to encourage port and infrastructure investments. Table 6 below lists funding schemes both in Norway and the EU.

Table 7: List of funding schemes

#	Relevant for	Further Info	Applic. Deadline	Note
	Fund: Nye muligheter			
1.	Harbours	Link	Not known	Export of offshore wind technology and services
	Fund: Eksfin			
2.	Export based projects	Link	None	Financing support, guarantees and loans
	Fund: Horizon Europe			
3.	Projects tackles climate changes	Link	2027	EU research & innovation fund
	Fund: «Tilskudd til forstudie» - Innovasjon Norge			
4.	Established companies with income-generating activiy	Link	None	Grant for feasibility studies
	Fund: Grønn plattform - Forskningsrådet, Siva and Innovasjon Norge			
5.	For enterprises and research institutes engaged in green growth, driven by research and innovation	Link 1 Link 2	March	Minimum support 30.80 MNOK. Application deadline 8 March (for sketch), June deadline for main application.
	Fund: Havvind 2035 - Enova			
6.	Port areas	Link	None	Transport and logistics technology based projects
	Fund: «Demonstrasjonsprosjekt i næringslivet» -Forskningsrådet			
7.	Research and new technologies	Link	June 7	Demonstrate new technology for applications with major socio-economic benefits.
	Fund: Skattefunn			
8.	Tax deduction scheme for companies with projects within R&D	Link	None	Receive support as a tax deduction & get 19% of the costs deducted in the tax settlement
	Fund: Innovasjonsprosjekt i næringslivet			
9.	For companies that implement projects with a high degree of innovation and R&D content.	Link	07.06.2023	Annual application process. The projects must facilitate lasting value creation through the development of new products, processes or services.
	Fund: Miljøteknologiordningen			
10.	Companies that develop environmental technology for sale.	Link	None	Relevant for R&D in coordination with University,

3. KONGSGÅRD BECOMING AN O&M HUB FOR OFFSHORE WIND

The Port of Kristiansand has ambitions to become the preferred O&M base for SNII. In 2014, Port of Kristiansand opened a new quay front in Kongsgård, which since then is servicing the marine and offshore industry. The Port of Kristiansand and the municipality are eager to increase revenues from the offshore industry and attract in particular the offshore wind industry by establishing an O&M hub for the offshore windfarm SNII. The present infrastructure is already capable to function as an O&M port. However, investments will be undertaken in alignment with relevant stakeholders to develop available areas in the optimal manner to accommodate personnel onshore involved in the O&M phase and facilitate the operation of SOVs and other vessels deployed during the windfarm's operational lifetime.

A first stakeholder assessment and concrete measures to engage with them are presented in chapter 3.1 and 0. In the following chapters, a general overview about activities and deployed vessels relevant for operating and maintaining and offshore windfarm are presented and works to be performed in Kongsgård are detailed. The gap assessment compares the requirements to function as an O&M hub and the currently available infrastructure.

Figure 9: Aerial view of Kongsgård in the port of Kristiansand

3.1 Stakeholder Assessment

It is evident, that a large variety of stakeholders will be involved in O&M activities and/or have interest in them or need to provide input to allow Kongsgård to become the O&M hub for SNII. In order to succeed in attracting O&M activities in Kongsgård, it is crucial for Southwind to be aware of the key stakeholders. Key stakeholders are shown in Figure 10. Further development/adaption will be required in the future when going to the commercial phase of being selected as the preferred O&M base in the second half of 2023.

Figure 10: Stakeholders O&M port

Southwind needs to develop an understanding of the interests and potential influences of the various stakeholders and establish a well-defined plan, how to engage with them throughout the development/planning and the operational life of the OWF. Concrete measures to engage with the stakeholders and develop and maintain a professional, practice-orientates and constructive relationship need to be defined. Exemplary aspects which are of relevance for Southwind are listed below in Table 8.

Table 8: Stakeholder - interests/relation with the O&M port

Stakeholder	Involvement (main aspects) and relation to O&M port
OWF key players	
OWF Developer/ Consortium	• Selects OEM and manages the interfaces with the OEM • Closes contracts with EPCI contractor or third party for O&M of HVDC OSS • Closes contracts w. (local) service providers e.g. for subsea inspections • Responsible for overall project management/interface management • Potentially takes over O&M for WTGs after 5 years • Personnel of developer will be based in O&M port control centre
OWF Investors	• Investors will be part of the consortia participating in the bidding round • Interest is generally to mitigate (mayor) risks e.g. risks of delays etc. • Depending on the different roles of the parties of the consortia, the engagement will vary
OWF Owner	• The consortium developing the OWF is assumed to be the owner at least the 5 first years of operation
Suppliers & Service providers	
OEM	• Performs WTG O&M activities during DNP • Provides O&M manuals for WTGs & trains technicians of the developer • Defines certain vessel requirements for the deployed SOV • Defines certain port requirements • Selects and contracts O&M port as part of SSA • Daily joint operations between O&M team of OEM & personnel of O&M port • Personnel of OEM will be based onshore in O&M port
Component suppliers (excl. OEM)	• Provide maintenance plans e.g. for electrical components on OSS • Suppliers' personnel will be involved in O&M activities of OSS & potentially require office space in the O&M port
3rd party service providers	• Performance of inspections & surveys contracted by the developer or its subcontractor (e.g. visual subsea inspection; MBES; TSS) • Survey vessel may operate from the O&M port, however flyby operations are possible and/or operation from "home port" of service provider • Helicopter service provider: Contracted by developer; Helicopter base should be as close as possible to the O&M port
Personnel of subcontractors	• Skilled manpower is needed to maintain OWF e.g. for bolt tightening works, high voltage service, crane inspections, coating repairs • OEM & developers are likely to outsource part of these tasks and contract various subcontractors, which will partly operate in the O&M port • Daily joint operations between technicians of subcontractors and personnel of O&M port
Vessel providers	• Provide SOV for WTGs; ROV support vessels; vessels for main component exchange & O&M of OSS • Subcontracted by developer or service providers of developer (e.g. OEM)
T&I Contractors	• Provide as-built documentation relevant for O&M • May provide useful lessons learned relevant for O&M activities • May get involved in case of a mayor unplanned repair/exchange campaign • Potential interaction with O&M port in case unplanned maintenance campaign to be performed using Kongsgård as a base port
Local authorities & interest groups	
Port authorities /Owner	• Oversees port developments • Manages leasing contracts for different areas of the port

Municipality & Politicians	• Have an interest in fostering the local community
Governmental authorities	• Define regulations linked to e.g. work hours, survey/inspection schedules, safety standards etc. • Key role in OWF permitting processes
Local Community	• Can benefit from an OWF O&M hub in Kristiansand • Can provide required services for establishing & operating the O&M port • Have a right to be properly informed about considerable industrial developments affecting the community
Educational institutions	• Can provide substantial support in foster knowledge exchange & developments, (re-) training of local workforce and providing skilled professional

The engagement in thorough discussions within Southwind and its partners about the key stakeholders, their potential interest and influence is recommended. Based on the initial considerations outlined in Table 8, the stakeholders can be grouped to identify suitable approaches managing them and derive actions to be undertaken. The respective stakeholder map is shown in Figure 11. Concrete measures to be undertaken at the current stage of the SNII project are included in following chapter 0.

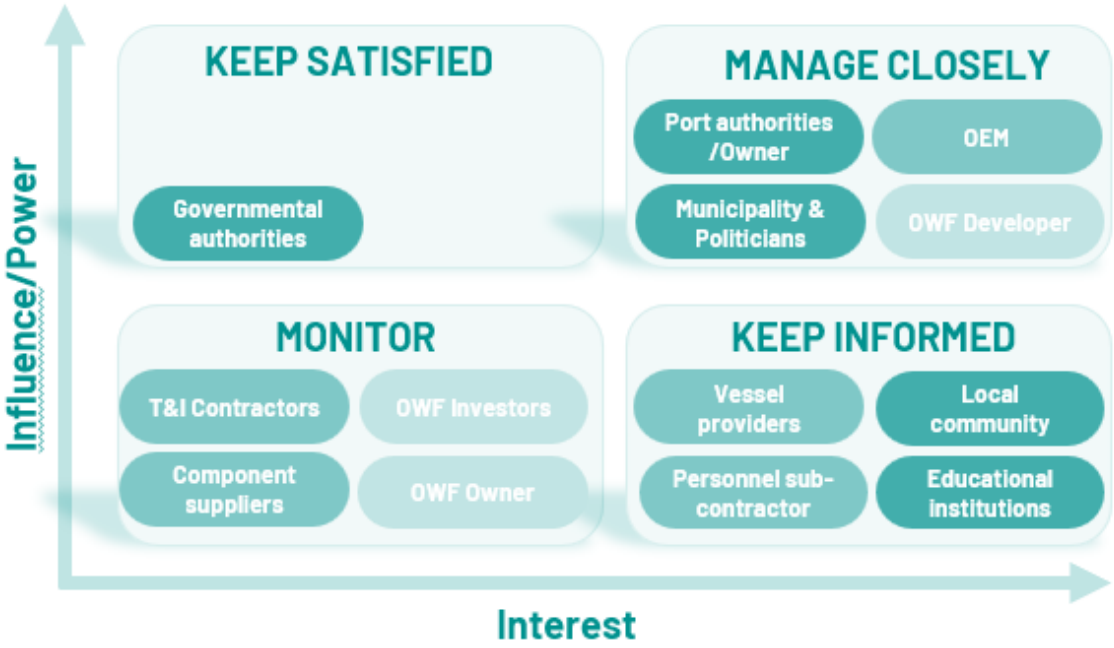


Figure 11: Stakeholder mapping

3.2 Stakeholder engagement

An early and intensive engagement with the key stakeholders should be commenced shortly to:

- Promote Southwind's capabilities, the facilities at Kongsgård and the reduced risks selecting Kongsgård as O&M port compared to other ports in south Norway
- Ensure proper understanding of available facilities which are available as of today
- Gather requirements from the OEM and developer concerning office/warehouses, quayside infrastructure etc. and convey the message the Southwind is willing and capable to consider and implement them, developing the port infrastructure/onshore facilities
- Ensure alignment with and support from authorities/municipality, politics, local community and Port of Kristiansand
- Investigate possibilities to offer Kongsgård-facilities for additional services than regular maintenance – base port during impact assessment, O&M port for unplanned maintenance activities, spare part storage hub e.g. for IAC

Elements of stakeholder engagement are:

- Regular consultation meetings/hearings/round tables/workshops
- Regular project updates and information events
- Website providing project updates and information about activities/plans of Southwind at Kongsgård
- Nomination of dedicated single point of contact at Southwind for stakeholders

Concrete and most pressuring measures to be undertaken by Southwind are detailed in following Table 9.

A particular example of the importance of stakeholder engagement are providing studies performed by the University of Agder. They show that the community engagement in wind projects is often insufficient leading to a lack of support in the community.[18]

[18] University of Agder: "For offshore wind to succeed, new policies must be developed.", https://www.uia.no/en/news/for-offshore-wind-to-succeed-new-policies-must-be-developed, 26/01/2023.

Table 9: Concrete measure for stakeholder engagement

Who	When	How	What to talk about (to be further discussed)
OEM	H2 2023	Invite for workshop with site visit in Kongsgård.	1. Requirements towards O&M port such as: • onshore office facilities • Space for warehouses and workshops • Strategy for main component exchange (WTG) 2. "Advertisement" of available facilities & possibilities to develop them to the stakeholders needs. 3. Discussion of further use of Kongsgård as part of strategic spare part strategy 4. Demonstrate the wide range of services and support from all companies, in and nearby the O&M port enabling to support OEM on all necessary areas
Developers	H2 2023		1. Requirements towards O&M port such as: • onshore office facilities/control centre • envisaged strategy/past approaches &requirements regarding of service providers for BoP inspections • spare part strategy/storage locations 2. "Advertisement" of available facilities & possibilities to develop them to the stakeholders needs. 3. Discussion of further use of Kongsgård, e.g., during EIA-phase, T&I works, main component exchange and/or as part of strategic spare part strategy. 4. Demonstrate the wide range of services and support from all companies, in and nearby the O&M port enabling to support Developer on all necessary areas.
Port of Kristiansand	H2 2023		1. Ambitions of Port of Kristiansand developing the port and especially the area of Kongsgård. 2. Exchange information of already undertaken & planned steps (studies, engagement w. local community etc.). 3. Align on how to market the state-of-the-art services and suppliers in and in close vicinity to the port.
Municipality & politicians	H2 2023		1. Ambitions of Port of Kristiansand and Southwind. 2. Interests of the municipality & potential requirements from their side. 3. Steps towards developing a (more) sustainable port. 4. Steps to engage w. local educational institutions such as UiA & enhance competence develop. in the region. 5. Establish a roadmap demonstrating a clear communication strategy supporting the aim to sign contract for O&M port.

4.O&M STRATEGY

Thoroughly developed Operation and Maintenance (O&M) strategies are essential for ensuring the reliable and efficient operation of offshore wind farms over their lifespan. A selection of factors influencing the O&M requirements and respectively the O&M strategy are listed below. The O&M strategy effects the selection of vessels, maintenance schedule and subsequently the requirements to the O&M port.

1. **Turbine technology:** The design, size, and complexity of offshore wind turbines influence the O&M strategies. The turbines of the newest generation to be deployed at SNII may offer sophisticated built-in monitoring systems and enhanced reliability features potentially reducing the amount of required regular visits compared to WTGs installed today.
2. **Location and site conditions:** Site-specific factors such as wave height, wind speed, water depth, and seabed conditions impact O&M strategies, as they affect accessibility, maintenance logistics, and equipment durability. However, most importantly, the distance from shore to port is to be considered.
3. **Contractual agreements:** O&M strategies are often influenced by contractual agreements between owners, operators, and service providers. These agreements outline performance guarantees, response times, availability requirements, & responsibilities for maintenance activities, which can shape the O&M approach.
4. **Data and digitalization:** The availability of accurate and comprehensive data, along with advancements in digitalization and data analytics, affects the O&M activities and can reduce costs.
5. **Economic considerations**: Naturally, O&M strategies and the vessel selection will be assessed and developed considering total costs along the lifetime of the offshore windfarm.
6. **Sustainability**: Considerations concerning GHG-emissions, life-cycle assessments and similar may influence the O&M strategy or at least certain aspects of it.
7. **Regulatory requirements:** Safety regulations, environmental requirements, & certifications influence the choice of maintenance approaches & the frequency/extent of inspections/surveys.

Details of the O&M strategy and dedicated O&M plans will be developed by the selected OEM and respective service providers/subcontractors in alignment with the developer. However, a general approach suitable for SNII is outlined in chapter 1.

4.1 O&M activities

The chart below summarizes activities which are executed during the O&M-phase in offshore wind. Details on specific inspections and surveys which are commonly performed as part of the planned maintenance activities are included in Table 11.

Table 10: Activities linked to the O&M-phase [19]

OPERATIONS	MAINTENANCE	SUPPORT OF O&M	R&D linked to O&M
• Remote condition monitoring • Forecasting (yield, weather & maintenance) • Yield optimisation/plan predictive maintenance • Data and risk analysis • Planning and scheduling • Marine coordination • Comm. network support • Grid integration • Training • Logistics and parts • Emergency response & coordination • Administration • Market analysis/ prediction	• Inspection – Blades, nacelles, tower, safety & access equipment, OSS, cables, foundations • Maintenance – Planned & unplanned • Repair – Minor to Major • Troubleshooting • Specialist tools • Vessels & transit • On site safety	• End of life planning • Decommissioning • Finance • Insurance • Stakeholder management • Sales and marketing • Regulatory considerations • Critical component storage & availability	• Autonomous Systems • Augmented reality • Aquaculture & multi-use • Decarbonised maritime • Recycling • Circular economy

The WTGs and the balance of plant of the wind farm will have a defined scheduled maintenance regime including periodic inspections. Unplanned maintenance activities will need to be carried out on an ad-hoc, responsive basis.

Typical planned maintenance activities & schedules are shown in Table 11. As outlined before, these depend on a variety of factors & will need to be revised considering specific regulatory requirements, manuals of component suppliers & the developer's strategy.

Table 11: Planned maintenance activities

WTG	
Activities	

[19] Reference is made to: CATAPULT, OFFSHORE WIND OPERATIONS & MAINTENANCEA £9 BILLION PER YEAR OPPORTUNITY BY 2030 FOR THE UK TO SEIZE

- Regular visual inspections are conducted to assess the overall condition of the turbines, including the tower, nacelle, and rotor blade
- Inspections of service lift, ladders, davit crane etc.
- Detailed inspections to evaluate structural integrity and identify any corrosion, cracks, or other defects
- The proper lubrication of e.g., bearings and yaw systems needs to be ensured
- Electrical components and connections within the turbine, including cables, transformers, and switchgear need to be inspected regularly and maintained
- Blade inspections are performed by drones equipped with high-resolution cameras, by rope-access technicians or by high-resolution camera equipment located on the transition piece or vessel
- Minor blade repair works; coating repairs, cleaning etc.

Schedule

- Depending on WTG-supplier's requirements – currently major regular service every 12 months is common, but it is expected that for WTGs of future generations, it will be reduced to two-yearly campaigns
- Further visits will be required throughout the year – in average about 5 visits per year and WTG expected

Contractor

- The wind turbine supplier, during the Defect Notification Period (DNP)(commonly 5 years) and for the duration of any agreed contract beyond the DNP (e.g. 15 years)
- Alternatively, the developer can perform O&M activities in-house or engage an Independent Service Provider (ISP). That typically requires agreement w. the manufacturer for supply of spares, software systems & specialist expertise

Vessels

- SOV/ROV/daughter vessel/helicopter – details see chapter 4.3

FOU/IAC

Activities

- Visual inspections performed by Remote Operated Vehicles (ROVs) to check integrity of scour protection, cable protection system, touchdown point, cable entry point etc.
- Regular inspections of foundation structures, both above & below the waterline, to check for any degradation or damage, measurement of PH value inside of MP (if applicable)
- Inspection of grout and performance of rout works (if applicable/required)
- Implementation & monitoring of cathodic protection systems to prevent corrosion of foundation structures
- ROV multibeam survey to assess scour developments, status of scour protection
- ROV cable tracking survey (e.g. TSS350) to confirm burial of cables

Schedule

- Depending on regulatory framework and developer's strategy; however, limited offshore working time to be expected per year – in average 3 to 6 weeks
- TSS surveys to confirm burial commonly required in first years after installation (e.g. year 1, 3 and 5)
- Other routine surveys are likely to be undertaken in the first two years but thereafter on a less frequent basis across the wind farm, until the rate of defects observed justifies more frequent monitoring and inspection
- Severe storms could justify inspection of scour protection etc.
- Generally, a survey campaign every 2 years to be expected

Contractor

- Local service provider to be contracted by developer

Vessels
• ROV support vessel with DP2 capabilities (in case operations close to the OWF-structures are required)[20,21]

Offshore Substation and export cable
Activities
• Regular inspections & maintenance of electrical components, switchgear, transformers, and control systems are to be inspected and serviced as per manufacturer guidelines • Foundation and topside structural inspection • Visual subsea inspections close to OSS inspecting J-tubes, touchdown points, jacket foundation, scour protection • ROV Multibeam survey to assess scour developments, status of scour protection • ROV Cable tracking survey (e.g. TSS350) to confirm burial of cables
Schedule
• Depending on requirements of manufacturer of electrical systems • Quarterly or bi-yearly campaigns expected for electrical systems on OSS • One yearly regular campaign with outage • Duration of up to two weeks per campaign expected • Subsea and cable inspections expected in the years after installation and afterwards depending on regulatory requirements and developer's strategy every 2 years • Severe storms could justify inspection of scour protection etc.
Contractor
• EPC contractor of OSS or third-party service provider for O&M of electrical components • Local service providers for subsea inspections and surveys
Vessels
• SOV/PSV for activities on OSS • ROV support vessel for subsea inspections

Unplanned maintenance activities range from accessing WTGs due to an alarm which can't be controlled remotely to main component exchanges. The frequency of unplanned campaigns highly depends on the turbine model and supplied components, the quality of performed studies and engineering tasks during the planning phase and site-specific conditions. Table 12 provides a high-level overview of potential unplanned maintenance activities.

Table 12: Unplanned maintenance activities

WTG
Activities
• Access on location to deal with the resetting of alarms • Mechanical/electrical Repairs • Major component Replacements

[20] Unmanned surface vessel (USV), capable of launching and recovering a ROV under development, e.g. Fugro: https://www.fugro.com/news/business-news/2023/fugro-blue-essence-completes-worlds-first-fully-remote-offshore-wind-rov-inspection, 25/04/2023

[21] AUVs without need of support vessel are under development; can be launched from CTV/daughter vessel

Schedule
• Frequency of unplan. O&M activities expected to decrease after first years of operation • About 1-2 unplanned visits per WTG can be expected • Required reaction time depending on failure type
Contractor
• OEM performing the works under the SSA and subsequent service contracts shall foresee provision of jack-up barge for main component exchange
Vessels
• Vessels used for regular maintenance campaigns and/or helicopter • Jack-up vessel in case major components to be replaced
FOU/IAC (subsea)
Activities
• Debris removal/cleaning • Repair of scour protection/cable protection; cable re-burial • Cable repair/replacement
Schedule
• Response time depending on criticality of failure • Major issues with cable protection and IAC in windfarms currently in operation in the North Sea – lessons learned considered by the time SNII is installed, should avoid necessity of major cable repair/replacement campaigns
Contractor
• Framework agreements with potential contractors should be closed by the developer to ensure reduced reaction times in case of cable failure/damage
Vessels
• ROV support vessel and in case of major campaigns CLV, TSV etc.; FPV
Offshore Substation and export cable
Activities
• Major component exchange on OSS • Repair of scour protection/cable protection; cable re-burial • Cable repair/replacement
Schedule
• Response time depending on criticality of failure • Replacement/repair of export cable usually not expected unless anchor damage occurs
Contractor
• EPC contractor of substation or third-party service provider for O&M of electrical components • Framework agreements with potential contractors should be closed by the developer to ensure reduced reaction times in case of cable failure/damage
Vessels
• SOV; ROV support vessel and in case of major campaigns CLV, TSV etc.; jack-up barge

4.2 Relevant vessel types for the O&M phase

As mentioned in the previous chapter, a variety of vessels will be deployed during the operational life of an offshore windfarm to perform inspections, repairs, component replacements. Table 13 provides an overview of commonly deployed vessel.

Table 13: Vessels deployed during O&M phase of OWFs

Planned Maintenance – commonly deployed vessels	
 *Figure 12: CWind Hurricane*	**Crew Transfer Vessel (CTV)** Length: 25m Breadth: 8.2m Draft: 1.45m **Works** Transport of technicians, personnel and small parts to the OWF.
 *Figure 13: Edda Mistral*	**Service Operation Vessel (SOV)** Length: 81m Breadth: 17m Draft: 5.4m **Works** Transport and accommodation of technicians offshore for maintenance, transport and storage of parts offshore.
 *Figure 14: Grace Darling*	**Daughter Vessel** Length: 12m Breadth: 4m Draft: 0.9m **Works** Transfer of personnel and small parts from (C)SOV to WTG.
 Figure 15: N-Sea Focus, N Sea	**Survey vessel/ROV support vessel** Length: 35m Breadth: 8m Draft: 2.2m **Works** Subsea survey operations.

 Figure 16: Fugro Pegasus	**Uncrewed surface vessel (USV)** Length: 12m **Works** Inspecting subsea assets.

Unplanned Maintenance – commonly deployed vessels

Main component exchange WTG / OSS

 Figure 17: Voltaire, Jan de Nul	**Jack-up vessel (JUV)**[22] Length: 169.3m (Incl. helideck 181.78m) Breadth: 60m Draft: 7.5m **Works:** Main component replacement such as blade, main bearing, generator.
 Figure 18: UHL F900, United Heavy Lift	**LoLo Vessel** Length: 150m Breadth: 25.6m Draft: 8.3m **Works:** Large component transport such as blades or tower sections.

[22] Due to the large hub height, only a limited number of vessels is capable of lifting and installing components such as blades of WTGs of the newest generation. Hence, in case major components of the rotor-nacelle-assembly (RNA) needs to be replaced, it may be needed to deploy a jack-up vessel of the newest generation, despite of high day-rates and mob./demob. costs. If limited lifting heights are required e.g. for exchanging a transformer of the OSS, alternative vessels may be deployed or non-self-propelled jack-up barges which are towed to/from the site with a tugboat. Furthermore, several companies are working on developing innovative solutions to reduce the need of jack-up vessels for unplanned maintenance works.

 Figure 19: Rotra Vente, Amasus Shipping	**RoRo Vessel** Length: 141.5m Breadth: 23.6m Draft: 6.9m **Works:** Large component transport, typically nacelles.
IAC repair/replacement	
 *Figure 20: Shackleford, All American Marine*	**Survey vessel** Length: 22.2m Breadth: 8.1m Draft:1.85m **Works:** Pre-cable-lay surveys (Hydrographic and geographical surveys).
 Figure 21: Nicole Foss, Foss Maritime	**Anchor handling tugboat (or similar)** Length: 40m Breadth: 13.5m Draft:5m **Works:** Pre-lay-grapnel-run (PLRG).
 Figure 22: Isaac Newton, Jan De Nul	**Cable-Laying Vessel (CLV)** Length: 138m Breadth: 32m Draft: 7.3m **Works:** Major cable repair/replacement campaign.
 Figure 23: Athena, Asso Group	**Trenching Support Vessel (TSV)** Length: 111m Breadth: 25m Draft: 7.7m **Works:** Subsea operation, ROV inspection, Cable repair and laying.

Figure 24: Rockpiper, Boskalis

SUBSEA ROCK INSTALLATION VESSEL[23]
Length: 158m
Breadth: 36m
Draft: 9.4m

Works:
Installation/Repair of scour protection and cable crossings (depending on its design)

4.3 Logistical approaches in O&M

After providing an introduction into O&M activities to be considered and commonly deployed vessels, this chapter shows an overview of common logistical approaches. Influence factors were discussed in previous chapters.

Table 14: Logistical approaches

CTV
• Daily transfer of 12-24 PAX per CTV • Transit speed: 20 knots; Crew transfer Hs 1,5 • Crew transfer via boatlanding of TP
SOV (+ daughter vessel)
• Accommodation of 40-60PAX per SOV • Transfer of personnel up to 2,5-3 Hs via a motion compensated gangway fitted with the matching TP interface or via boatlanding of TP deploying a CTV/Daughter vessel • Can be combined with one or several CTV staying offshore next to the SOV in case of several teams are working in parallel on different WTGs • Provide storage of spare parts and smaller components • Port call typically every 2 to 4 weeks for major crew change, refuelling and re-supply • Intermediate crew change to the SOV, refuelling and resupply of the SOV could be carried out by CTV
Helicopter
• Transport of personnel – 4-8 PAX • Transport of material in case of urgent need (considering the size and weight restrictions as well as the restrictions for hazardous substances) • Helicopters are normally contracted on a long-term basis, with either exclusive or shared access to the aircraft • O&M strategies don't base crew transfers on helicopters but as a supplement to allow for fast reaction times
(Permanent offshore accommodation)
• Accommodation platform for technicians working offshore • Transfer to from the platform and TPs via CTV • Installed in DanTysk offshore windfarm and Horns Rev 2 OWF
(Floatel)

[23] Does not enter O&M port. Mob./Demob. in home port and then shuttling between quarry and OWF.

- Accommodation of ca. 60 pax
- No direct access to TP -> Transfer to WTG via CTV

Figure 25 shows the tendency to deploy SOVs in windfarms 30km or more from shore and the need of their deployment +70km from shore. Each blue circle represents a windfarm and its size the installed capacity (MW).

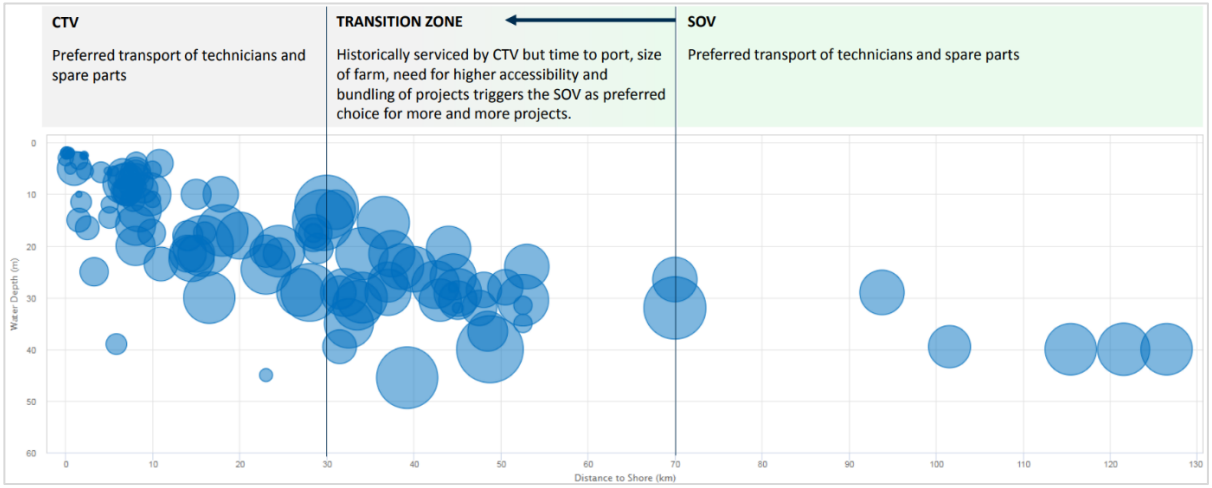


Figure 25: Deployment of CTV/SOV for O&M operations[24]

4.4 Logistics with Kongsgård as O&M hub for SNII

Due to the 120nm distance between Kongsgård and the offshore windfarm, it is necessary to deploy a Service Operation Vessel (SOV) with DP2-capabilities (refer to Figure 25). The SOV serves as accommodation for technicians and provides deck space for spare parts, waste, and tool containers. It will be equipped with a crane for lifting materials to and from the external platform of the foundation and a walk-to-work system to ensure safe access to the wind turbines. Additionally, the SOV may carry a daughter vessel, depending on the detailed planning of O&M activities.

Assuming regular crew changes every 14 days, the technicians will be transferred at the port of Kongsgård. These port calls will also be utilized for restocking the ship with spare parts and essential supplies, refuelling, and disposing of sewage and waste. The scheduling of crew transfers will adhere to the applicable work directives.

If adverse weather conditions prevent timely transit to the port, crew changes will be conducted via helicopter. Helicopters may also be employed when there are critical failures, particularly involving the OSS, and the regular ways of access are not feasible.

An onshore team will be responsible for planning and managing the O&M activities, including back-office engineering capabilities. This team will ensure 24/7 monitoring of

[24] OFFSHORE WIND SERVICE OPERATION VESSEL MARKET PERSPECTIVE, 2020

the wind farm and be capable of performing remote interventions. To optimize the maintenance regime, condition monitoring systems and structural health monitoring systems will be deployed.

For further regular inspection and maintenance tasks such as underwater surveys, structural inspections of foundations and OSS, OSS electrical equipment maintenance, local service providers will be contracted by the developer.

Respective survey vessels may depart from their home ports **(base case)**, but in case Kongsgård port facilities allow for that, the usage of the O&M port for these survey vessels may be beneficial and should be discussed with relevant service providers and the developers.

Planned maintenance campaigns of the OSS are to be performed via another SOV: However, these campaigns are assumed to be performed in a flyby operation without accessing the O&M port **(base case)**.

In case main components need to be repaired and/or replaced, specialised vessels such as cable lay vessels, or jack-up vessels need to be deployed. It is assumed, that such vessels are not operating from Kongsgård and respective spare parts are not stored at its warehouses **(base case)**.

In dialogues with OEMs and developers, Southwind and the Port of Kristiansand should define, what services, apart from facilitating the regular WTG O&M campaign, controlling and monitoring, are of interest and could be offered. Summarizing the above, these considerations shall include:

- Facilitation of surveys performed before start of construction such as:
    - Surveys linked to the Environmental Impact Assessment (EIA)
    - Main Soil Investigation
    - UXO survey
    - Boulder survey
- Facilitation of regular (subsea) surveys of foundations and inter-array-cables
- Facilitation of regular OSS O&M campaigns
- Facilitation of unplanned major component exchange campaigns
    - Provision of storage for strategic/critical spare parts
    - Berthing of jack-up vessel/barges for main component exchange
    - Berthing of TSV/CLV and unloading/transpooling of inter-array-cables

5. SUITABILITY ASSESSMENT

The suitability assessment first summarizes information which was made available to KONGSTEIN about existing infrastructure at Kongsgård. By matching this information with comprehensive requirements which need to be fulfilled in order to operate an efficient O&M port, potential gaps and needs for further investigation and/or investments were identified. Without having performed a site visit and considering the time constraints, conclusions needed to be derived cautiously and a final evaluation of specific criteria was partly not possible. Further discussions among Southwind, the Port of Kristiansand and key stakeholders are recommended as outlined before.

Apart from regular O&M activities, further potential opportunities for the Port of Kristiansand to increase the OW-activities in the port are mentioned.

5.1 Existing infrastructure in Kongsgård

Kongsgård, located in the Port of Kristiansand, offers considerable benefits for servicing the offshore windfarm SNII as its O&M hub:

Table 15: Key benefits of the Port of Kristiansand as O&M hub for SNII

	The currently available infrastructure allows the start offshore wind O&M operations as of today.
	It is one of the closest port to SNII which offers the required infrastructure to start efficient offshore wind O&M operations as of today. Being located 120nm from the site of SNII, makes Kongsgård an ideal location for a SOV-based O&M concept.
	The port infrastructure at Kongsgård has been used by the offshore industry as a supply base since 2014. Relevant actors in the port accumulate vast experience supporting these operations.
	Convenient access with airport and train station in vicinity, ferries operating in the port of Kristiansand and easy road access. Also, hotels, restaurants and supermarkets are available close by.
	The six founding companies of Southwind offer a variety of services and provide a partner network facilitating access to a broad supply chain and job market. The local University of Agder educates skilled professionals & its researchers will engage with the OW-industry.

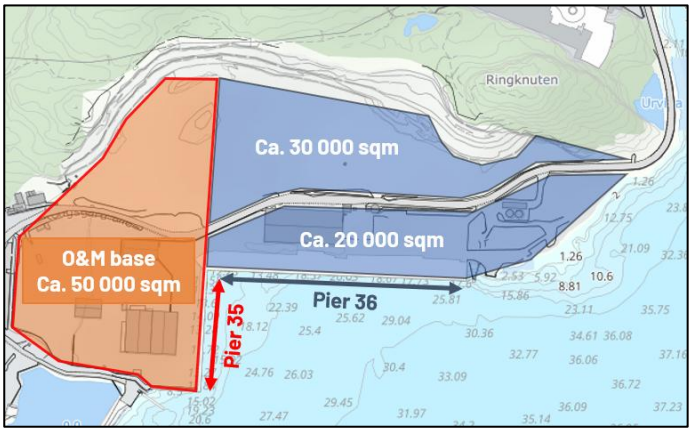


Figure 26: Available areas at Pier 35 and 36 at Kongsgård in Kristiansand

As Kongsgård has operated since 2014 in the offshore and marine industry, the port is duly regulated, adheres to the ISPS code and is ready to service offshore wind O&M activities as of today. Hence, the risk, that suitable O&M port infrastructure is not available in time is omitted choosing Kristiansand as the O&M hub for SNII.

Table 16: Key risks and mitigations

	MAIN RISKS ESTABLISHING AN O&M HARBOUR IN NORWAY	STATUS AT KONGSGÅRD	RISK LEVEL
1.	Existing infrastructure (e.g. berth, quay, warehouses, offices) are not suitable and/or required upgrades are not finalized in time.	Envisaged port areas in Kongsgård are operating since 2014 as offshore supply port and ready to be used for offshore wind activities as of today. Hence, the risk of delays is omitted.	LOW
2.	A change in the O&M concept, adaptions of installation logistics or other aspects require port infrastructure additionally to what was anticipated.	The port of Kristiansand offers flexibility to the OEM, developer and other users of the port involved in O&M activities of SNII, as further areas and quays then the currently proposed (Pier 35 and optionally Pier 36) can be made available.	LOW
3.	Extension of SNII to 7-10GW (Phase 2 and 3) would require contracting another port location.	Infrastructure at Kongsgård (Pier 35/36) are suitable to accommodate O&M activities for SNII phase 2/3. Additional areas can be made available if necessary.	LOW
4.	Misalignments between port operator, municipality, authorities hinder constructive discussions, timely decisions negotiations and closure of binding agreements.	Southwind, the Port of Kristiansand and the municipality are aligned in the ambition to increase the revenues from offshore and marine industry and dedicated to bring the offshore wind industry to Kongsgård.	LOW

Pier 35, in the port area Kongsgårdbukta, and the adjacent areas onshore will exclusively be available for the OEM, developer and their subcontractors to efficiently carry out O&M activities. As per Figure 26, Southwind committed 50,000 m^2 to the OW-O&M activities, and have the opportunity to even further extend.

The distance from the pilot point to Kongsgård is 2.5nm and there are no restrictions on height, depth or width entering the Kristiansand fjord. There are no residential neighbors in port area and a 24h work permit exists for the Port of Kristiansand. The following facilities are available at Pier 35 as of today:

Table 17: Characteristics as Pier 35 available for O&M activities

Pier 35	• Port infrastructure located 120nm from SNII • Quay of 144m w. min. water depth of 13.2m suitable for SOVs & other vessels • 10 mooring points available • 40 m wide Ro-Ro ramp with load capacity 50 kN/m^2 • Onshore facilities of 50,000m^2 including 4500 m^2 indoor located directly next to the berth allow storage of spare parts and equipment & establishment of workshops • Mobile cranes w. SWL of up to 250mt to support load-in/out operations

	• The load capacity at the quays directly at the waterfront is 50 kN/m^2 • Container/material handling equipment can access onshore facilities & quayside • One of the largest shore power facilities in Europe providing green electricity to berthing vessels (outlets along the pier: 2x220-690V, 50-60Hz; total 1,650 kVA) • Office facilities available for onshore personnel & monitoring and control centre • Bunkering, water supply (3 outlets along pier 35) & waste management system • 24/7 shore and sea access

Also, another berth can be made available. Pier 36 offers following infrastructure and opportunities:

Table 18: Characteristics of Pier 36

Pier 36	• Berth length of 307 m and minimum water depth 12.2 m • Ro-Ro ramp with load capacity of 30 kN/m^2 • The quayside can be used to support unplanned maintenance campaigns requiring the deployment of additional vessels such as PSVs and jack-up vessels/barges • Pier 36 can a be used to facilitate WTG commissioning servicing the OEM's CSV • Load-in operations of cables and transpooling to a CLV's carousel have been performed at pier 36 before • Vessels deployed for regular subsea surveys can operate from Pier 36 in parallel to the OEM's/developers SOV servicing the WTGs • Vessels deployed for servicing the OSS can enter the port and (if needed) berth at the same time as the SOV servicing the WTGs berthing at Pier 35

Although already prepared to service as an O&M base, it is necessary to invest in infrastructure and services to become a state-of-the-art O&M hub for SNII and potentially further projects. The following chapter assessing available infrastructure and services and points out needs for detailed investigations as well as investments.

5.2 O&M port requirements and gap analysis

Following Table 19 lists requirements towards the facilities at the O&M port. They are partly of general nature, applicable for all O&M operations. Specific requirements are derived taking the previously described assumptions concerning the services to be offered into consideration.

Following differentiation were made concluding on the current status (as per available information) related to the various requirements:

REQUIREMENT MET: Based on available information, the respective requirement is met, and no additional investments are required.

REQUIREMENT EXPECTED TO BE MET: Lack of information to conclude but due to current activities in the port, it is assumed that respective requirements are met.

TO BE FURTHER INVESTIGATED: Further information to be gathered by engaging with key stakeholders to conclude on required investments or similar.

FURTHER DEVELOPMENTS RECOMMENDED: Not meeting the requirement is no showstopper. However, to be an attractive O&M hub for developers and OEMs, investigation on potential improvements/investments are recommended.

INVESTMENTS REQUIRED: Investments in adaptations/upgrades of infrastructure is required to allow efficient operation of respective activities.

Table 19: Table: O&M port gap assessment (Base Case)

Regular O&M activities (base case)			
1.	Access	• Convenient access for O&M technicians by car, and ideally from nearby airport & train station	
		Status at Kongsgård: Easy access to E18/E39 highway; airport Kjevik and train station close by.	**REQUIREMENT MET**
2.	Hospitality	• Access to hotels, restaurants accessible in <1h by car or public transport.	
		Status at Kongsgård: Various hotels and restaurants located e.g., in Kvadraturen, Kristiansand less than 30min drive from Kongsgård. Additional amenities for personnel working at the port (grocery, canteen etc.) may be discussed if not already existing.	**REQUIREMENT MET**
2.	Parking Area	• An area with parking spots for employees & guests; enough space for a 32-t truck & two 40-foot containers in vicinity to service building and warehouses	
		Status at Kongsgård: No specific information received but expected to be available.	**REQUIREMENT EXPECTED TO BE MET**
3.	Warehouses and external storage areas	• Basic spare parts: Stocked by contractor of employer (at its ownership) • Strategic spare parts: stocked by contractor (at its ownership) at central warehouse location	

		• Available space for oil and grease storage • Required warehouse space depends on OEM's and developers O&M plans and location of storage of strategic spare parts: assumed approx. 2000m^2 • Storage areas and warehouse have access for trucks and lorries	
		Status at Kongsgård: Discussions with OEM/developer to be initiated to detail requirements and envisaged approach e.g. regarding spare part storage locations. However, indoor storage capacities of 4.500m^2 and total storage area of 35,000m^2 available at quays next to pier 35.	**REQUIREMENT MET**
4.	Workshop	• Workshops for work such as sorting equipment brought back from site, kitting of parts and equipment to go to site, and minor refurbishment • Equipped w. power supply for using tools, & complying with local regulation • Area suitable for welding and cutting	
		Status at Kongsgård: No specific information received. Available onshore space should allow for establishing required workshops. Detailed requirements to be assessed in dialogue with OEMs.	**TO BE FURTHER INVESTIGATED**
5.	Office	• Buildings to for operations control centre and offices for other project operations staff of developer with reception area, welfare facilities, lockers, canteen, meeting rooms • Facilities to be sued by OEM's staff and staff of other service providers • Amount of developer's onshore staff at O&M control center, depends on developer's approach, O&M requirem. of WTGs etc.: estimated approx. 20 FTE • Office space: approx. 1000-2000m^2 (depending on layout of building)	
		Status at Kongsgård: As per information made available to KONGSTEIN, currently such dedicated office facilities do not exist. An area available for the construction of required facilities is available behind the quay of pier 36.	**INVESTMENTS REQUIRED**
6.	Communication	• Broadband internet connection 30/30 Mbps (download/upload) • Dedicated phone lines (minimum one per office desk stations) • Communication from base to site (UHF/VHF/Mobile phone network/TETRA)	
		Status at Kongsgård: As comparable requirements need to be met for operating the offshore supply base currently established at Kongsgård, it is expected that no considerable additional investments are required.	**REQUIREMENT EXPECTED TO BE MET**
7.	Weather forecast	• Lidar system to provide wind measurements • Weather forecast to plan load-in/out activities and transit to the site	
		Status at Kongsgård: As comparable requirements need to be met for operating the offshore supply base currently established at Kongsgård, it is expected that no considerable additional investments are required.	**REQUIREMENT EXPECTED TO BE MET**
6.	Waste management	• Waste disposal management services directly at vessel berthing • Disposal of non-hazardous waste, paint, oil, oil filters etc., sewage etc.	

		Status at Kongsgård: As comparable requirements need to be met for operating the offshore supply base currently established at Kongsgård, it is expected that no considerable additional investments are required.	**REQUIREMENT EXPECTED TO BE MET**
7.	Water supply	• Water supply shall be available to vessels at delivery pressure of + 30m^3/h • Shall be available at SOV berth to avoid relocation in port	
		Status at Kongsgård: As comparable requirements need to be met for operating the offshore supply base currently established at Kongsgård, it is expected that no considerable additional investments are required.	**REQUIREMENT EXPECTED TO BE MET**
8.	Bunkering	• Fuel bunkering services at quay • Fuel supply needs to be available 24/7 at SOV berth to avoid relocation in port	
		Status at Kongsgård: As comparable requirements need to be met for operating the offshore supply base currently established at Kongsgård, it is expected that no considerable additional investments are required.	**REQUIREMENT EXPECTED TO BE MET**
9.	Food supply	• During port calls, vessel needs to re-stock food and other goods of daily use -> respective companies close to the port offering these services who can react fairly quickly would be of benefit	
		Status at Kongsgård: Currently operating vessels will certainly be supplied with food, however it is expected that these services need to be "upgraded" to cover the increased and regular activity and demand at Kongsgård.	**TO BE FURTHER INVESTIGATED**
10.	Alternative fuels	• Capability to operate vessels focusing on reducing CO2 emissions e.g., by providing alternative fuels such as green H2/ammonia & bunkering facilities	
		Status at Kongsgård: Thanks to the partnership with Greenstat and North Ammonia, Kongsgård has secured a reliable supply of green hydrogen in near future at a competitive price level. Greenstat is collaborating with Everfuel on the Hydrogenhub Agder project aiming to establish a hydrogen plant at the Fiskaa Industrial Area. Through their joint company, EGP1 AS, they plan to complete the hydrogen plant in Q4 2024, making Kristiansand one of five Hydrogen hubs in Norway. The distribution of hydrogen will encompass several ports, with a strong emphasis on Kongsgård and other areas within Southwind Harbor, providing emission-free fuel for heavy & maritime transport.	**INVESTMENTS REQUIRED**
11.	Material handling equipment	• Reachstacker to transport 20/40-ft containers • Forklifts • Quayside shall be equipped with a crane to load components onto the SOV	
		Status at Kongsgård: Equipment should partly be available at the port or can be purchased/leased as needed. Mobile harbour crane available at pier 35.	**REQUIREMENT EXPECTED TO BE MET**
12.	Port entry	• In case of lock, minimum lock width > 20m to accommodate most recent SOV • Sufficient manoeuvring space and clearance for safe operation of SOV	

		Status at Kongsgård: Currently operating supply vessels exceed dimensions of SOV and are safely manoeuvring in the fjord and port. No restrictions on height, depth or width entering the Kristiansand fjord.	**REQUIREMENT MET**
13.	Piloting	• Piloting services to be provided 24/7 as per applicable regulations	
		Status at Kongsgård: Distance pilot point to Kongsgård is 2.5nm.	**REQUIREMENT MET**
14.	Water depth	• Minimum water depths of 8m in port and fjord for operating SOV/PSV/CTV • If applicable, sands/sediments to be removed in port area regularly in case it would constitute a potential hazard to operating vessels	
		Status at Kongsgård: Min.water depth of 13.2m at pier 35.	**REQUIREMENT MET**
15.	Quay access	• Quayside shall be accessible from warehouse / Contractor's logistic hub for material loading with forklift/trucks • Located within walking distance from offices • Quayside must be accessible and robust enough to accommodate a mobile crane in case containers/equipment need to be lifted exceeding the SOV's crane capacity • 24/7 sea and shore access	
		Status at Kongsgård: The load capacity at the quays directly at the waterfront is 50 kN/m^2. Pier 35 is in direct vicinity of envisaged are for outdoor storage and warehouses and will be in walking distance to the offices once respective buildings behind quay 36 are constructed.	**REQUIREMENT EXPECTED TO BE MET**
16.	Quay berth length and width	• As a minimum SOV of a lengths of up to 95m needs to be able to berth without restrictions at Kongsgård • Beam Overall (BOA) of max. 20m to be expected for SOV	
		Status at Kongsgård: Berth length of 144m at pier 35 suitable for SOV of the newest generation.	**REQUIREMENT MET**
17.	Berth and mooring	• Safe mooring to be provided regardless of sea conditions • Suitable amount of mooring points (approx. every 20m) and bollard strength (approx. 50t)	
		Status at Kongsgård: 10 mooring points at pier 35. No information about bollard strength made available but as supply vessels are currently regularly berthing at the pier, it should suffice for safely mooring a SOV.	**REQUIREMENT EXPECTED TO BE MET**
18.	Tides	• Any expected change of water levels to be monitored and forecasted.	
		Status at Kongsgård: As comparable requirements need to be met for operating the offshore supply base currently established at Kongsgård, it is expected that no considerable additional investments are required.	**REQUIREMENT EXPECTED TO BE MET**
19.	Power supply	• Provision of (green) shore power to berthing vessels to allow shutting down engines in port	
		Status at Kongsgård: One of the largest shore power facilities in Europe providing green electricity to berthing vessels	**REQUIREMENT MET**

		(outlets along the pier: 2x220-690V, 50-60Hz; total 1,650 kVA).	
20.	Security/ HSE	• Establishment of emergency response plans; provisions to secure port areas from trespassing; controlled access of port areas etc. • Restricted access with fences and gates • 24/7 security monitoring	
		Status at Kongsgård: Port adheres to ISPS code. As comparable requirements need to be met for operating the offshore supply base currently established at Kongsgård, it is expected that no considerable additional investments are required. Additional investments however, may be required for newly developed areas and dedicated areas for OW.	**TO BE FURTHER INVESTIGATED**
21.	Heliport	• Heliport to be located close to O&M port to reduce journey time • Arrangements to use local airport needs to be made or a dedicated helicopter base to be developed at the O&M port	
		Status at Kongsgård: Helicopter service provider operating at Kjevik airfield located at a distance of 8km from Kristiansand. Respective heliport operator and service companies to be contacted to clarify suitability for O&M services.	**TO BE FURTHER INVESTIGATED**
22.	Sustaina-bility	• Developers have an increased focus on the environmental impact of their activities linked to all phases of a windfarms lifetime -> port operators shall aim to offer sustainable solutions and innovative approaches to reduce GHG emissions, enhance biodiversity and promote sustainability	
		Status at Kongsgård: Port of Kristiansand has already placed investments to become a green(er) port (e.g. shore power; solar panales etc.). However, further discussions with stakeholders to be undertaken to enhance sustainability and biodiversity in the port.	**FURTHER DEVELOPMENTS RECOMMENDED**
23.	Personnel and qualifications	• Workforce with experience in industry or transferrable skills • Warehouse managers, security personnel, stevedores, forklift/reachstacker/crane operators etc. • For details regarding required workforce and qualifications please see the Ripple effects report. • Training centre in the vicinity for technicians who need to refresh some forgotten training (offshore) certificate	
		Status at Kongsgård: Workforce and skilled professionals available in the Agder county, however competence development to be fostered by the local industry in conjunction with educational institutions. Details are outlined in the ripple effect report provided by KONGSTEIN 07/2023.	**INVESTMENTS REQUIRED**
24.	Expansion potential	• Kongsgård should offer the potential for expansion to service phase 2 and 3 of SNII and allow for flexibility to accommodate further services apart from the regular maintenance activities performed by a SOV.	
		Status at Kongsgård: Pier 36 can be made available for offshore wind activities. To be clarified where the current activities in that area of the port will be "moved to" and whether	**TO BE FURTHER INVESTIGATED**

		further areas could be made available for activities linked to offshore wind.	

5.3 Requirements and suitability assessment for further activities

Further requirements are to be taken into account, in case the O&M port shall facilitate additional activities than described in 4.4. Table 20 lists additional requirements and points out needs for further investigations and investments. General requirements such as water supply, power supply, waste management, equipment (e.g. harbour crane) etc. remain applicable.

Table 20: Requirements to be met for providing additional services

Operational base for third party service providers during environmental impact assessment phase, pre-construction surveys and/or O&M phase			
1.	Quay/berth – survey vessels	• ROV support vessels of 35-45m length securely berthing without obstructing regular O&M activities	
		Status at Kongsgård: Depending on the chosen SOV for regular WTG maintenance and clearance to other vessels berthing at pier 36, the berth at pier 35 may be suitable for a SOV and survey vessel berthing at the same time.	**TO BE FURTHER INVESTIGATED**
2.	Quay/berth – jack-up barges	• For main soil investigation, various jack-up barge/vessels need to be deployed	
		Status at Kongsgård: Experience with jack-up rigs exist at Kongsgård.	**REQUIREMENT EXPECTED TO BE MET**
Operational base for regular maintenance campaigns of OSS			
1.	Quay/berth	• Infrastructure to service additional SOV/PSV deployed for maintenance campaigns at OSS	
		Status at Kongsgård: Pier 36 should be capable of servicing these vessels/barges without obstructing the regular operations at pier 35. Whether pier 35 is sufficient for servicing the WTG SOV and the vessel deployed for OSS O&M needs to be assessed.	**TO BE FURTHER INVESTIGATED**
Base port for main component exchanges (OSS/WTG)			
1.	Seabed in port	• In case jack-up barge/vessel needs to be deployed, jacking in port is likely to be required	
		Status at Kongsgård: Investigations to be performed in case operation of respective vessels in Kongsgård becomes an option.	**INVESTMENTS REQUIRED**
2.	Berth and mooring	• Depending on the component to be exchanged, suitable vessel or barges + towing vessels + mobile crane need to be mobilised	
		Status at Kongsgård: Pier 36 should be capable of servicing these vessels/barges without obstructing the regular operations at pier 35.	**TO BE FURTHER INVESTIGATED**

3.	Water depth	• Depending on the barge/vessel to be mobilised, water depth of min. 10-12m required	
		Status at Kongsgård: With water depth of 12.3m at pier 36, respective vessels can berth at Kongsgård.	**REQUIREMENT MET**
Base port for IAC storage and potential cable repair works			
1.	RoRo ramp	• Load-in of cable basket carousels via SPMTs facilitating IAC storage in the port	
		Status at Kongsgård: 40 m wide Ro-Ro ramp with load capacity 50 kN/m^2 suitable for load-in of cable baskets	**REQUIREMENT EXPECTED TO BE MET**
2.	Equipment and storage space	• SPMT and mobile crane for load-in and transpooling of IAC Storage capacities for IAC	
		Status at Kongsgård: IAC load-in/load-out activities were performed earlier at pier 36. Required equipment should be available for lease. Outdoor storage area should be sufficient, however, to be discussed with developer.	**TO BE FURTHER INVESTIGATED**

5.4 Required adaptations at Kongsgård to become O&M port

To further detail these requirements, early engagement with the main stakeholders (see chapter 3.8) is a necessity. Southwind needs to engage in discussions with the developers and OEMs to understand their envisaged O&M approach and develop a thorough understanding e.g. about:

- envisaged onshore infrastructure for monitoring and control of the OWF and onshore personnel of OEM
- spare part inventory at O&M port and developer/OEM's strategy for storing strategic spare parts such as IAC
- potential need for additional services apart from O&M base for regular maintenance activities

Summarising the assessment of chapter 5.3, following investments in the port infrastructure/services are likely to be required. At this point in time, high-level categories were defined:

Table 21: Indication of investment costs and uncertainties

Investment costs		Uncertainty (related to required investments)	
	**Moderate:** <=2 million **Considerable:** >2 million; <=10 million **High:** >10 million		**Low:** +- 20% **Medium:** +- 20% to +- 40% **High:** +- 40% to +- 70%

Close engagement with Southwind and the Port of Kristiansand is required to establish a detailed CapEx estimation and reduce uncertainties. Ball-park indications of investment costs and attached insecurities are detailed in Table 22 making use of the previously presented categories.

Table 22 :Indicative required investments to establish O&M hub at Kongsgård

Regular O&M activities (base case)			
1.	Workshop		
		• Detailed information about current facilities required • Engagement with future users of facilities required	
2.	Office		
		• Engagement with future users of facilities required • Quotes from architects, construction companies etc. to be gathered	
3.	Food Supply		
		• Services for restocking the berthing vessels with food and other goods of daily used may need to be upgraded and/or developed in the vicinity of the port/in the port area. However, that may not need particular investment from the Port of Kristiansand/Southwind but local businesses aiming to provide these services	
3.	Alternative fuels		
		• Engagement with future users of facilities required • Engagement with potential manufacturers of vessels running on green fuel required • Investigations regarding required storage capacities and infrastructure required for green fuels • Potentially available funds to be identified	
4.	Security/HSE		
		• Information about current set-up required • Cost estimation to be performed once plans for additional onshore facilities are further developed	
5.	Heliport		
		• Engagement with potential service providers and the airport operator to be initiated • Needed investment should be performed by port/service operator	
6.	Sustainability		
		• Costs dependent of ambitions of Southwind/Port of Kristiansand and envisaged investment in infrastructure e.g., for green fuels • Potentially available funds to be identified	

7.	Personnel and qualifications		
		• Engagement with community, municipality, education institutions required • Resources required to steer/develop competence development along the next years	
8.	Expansion potential		
		• Studies to be performed in alignment with Port of Kristiansand to investigate on the expansion potential	

In case previously discussed additional activities shall be realized in Kongsgård, following ranges of investment costs can be expected. As described in Table 23, detailed assessments are pending.

Table 23: Indicative required investments to offer additional services at Kongsgård

Additional services			
Operational base for third party service providers during impact assessment phase or O&M phase			
1.	Quay/berth		
		• Engagement with developer and port of Kristiansand required • Potentially further studies to be performed to identify any occurring costs in case current operations at pier 36 need to be "moved" to other areas in the port	
Operational base for regular maintenance campaigns of OSS			
1.	Quay/berth		
		• Engagement with developer, port of Kristiansand, service providers required • Potentially further studies to be performed to identify any occurring costs in case current operations at pier 36 need to be "moved" to other areas in the port	
Base port for main component exchanges (OSS/WTG)			
1.	Seabed in port		
		• Engagement with developer and OEM required whether port is of interest as base for main component exchanges • Study assessing seabed conditions and applicable loads induced by spud-cans of jack-up barge/vessel Depending whether/to what extent seabed preparations are required (mattresses; rock material etc.) costs increase	
2.	Berth and mooring		
		• Engagement with developer, port of Kristiansand, service providers required • Potentially further studies to be performed to identify any occurring costs in case current operations at pier 36 need to be "moved" to other areas in the port	
Base port for IAC storage and potential cable repair works			
2.	Equipment and storage space		
		• Engagement with developer, port of Kristiansand, IAC manufacturer required to identify storage requirements • Based on these requirements, investment costs can be estimated	

6. COST ASSESSMENT (CAPEX)

Port redevelopments to support OWFs require a variety of port resources. Understanding offshore wind energy industry requirements and what is needed to successfully support the operation and maintenance of offshore wind energy farms is critical for successful port revitalization. As mentioned in section 5.4, the adaption needs to be done for upgrading Kongsgård to become an O&M port.

This section indicates the overall cost calculation for necessary investment needs at Kongsgård to become the preferred O&M base.

6.1 Investment estimates

As Kongsgård is already developed to serve as O&M base minor investments are needed. The main drivers of investment are indicated in the following:

- Alternative fuels for green port services could be provided to increase the interest of OWF stakeholders to choose Kongsgård as O&M base. In case a bunkering arrangement on quayside for compressed gaseous hydrogen is required (either cascade or compression filling) additional investments of approx. NOK 10 - 20 million need to be considered depending on size and bunkering characteristics. Storage arrangements, most likely Multiple Element Gas Containers (MEGCs), are normally provided by the service provider. Nevertheless, they could also be rented/leased or bought. Depending on the vessel requirements and the bunkering facility in terms of pressure level MEGCs at 350/381 bar or 500 bar are used. Depending on the storage size and pressure level investments of up to NOK 12.5 million per tonne of hydrogen are to be considered.
- Soil conditions at Kongsgard will need to be investigated in case jack-up operations would need to be carried out at Kongsgård. Jack-ups have been done before nearby Kongsgård e.g., with the rigs Rigmar and Haven. Hence it is considered that soil data do exist meaning that no soil probes would need to be taken. Nevertheless, a study should be carried out analysing existing data and estimating cost for required seabed preparations (e.g., for rock dumping/installation of mattresses etc.) A study is assumed to come with cost of around NOK 250,000.

6.2 Investments in port developments for OW across Europe & Norway

As the planned capacity and number of projects for offshore wind farms (OWFs) continue to grow, there is a corresponding increase in the demand for O&M support. The investments required for upgrading existing ports to accommodate O&M activities are substantial. Table 24 provides an insight to ongoing projects in Europe that focus on the upgrading of O&M ports. Comparable O&M ports for OWFs typically have investments between NOK 70 – 170 million to upgrade the infrastructure to accommodate the O&M base. As Kongsgård is already further developed the investments are considered to be on the lower side.

Table 24: Benchmarking with relevant ongoing projects

Port	Country	Investment Amount (NOK)	Note
Montrose	UK	~72.04 million	• Upgrade of the infrastructure to accommodate the O&M base.[25]
Esbjerg	Denmark	~2810 million	• From Oil & Gas sector to Wind energy sector.[26]
Grenaa	Denmark	~390.05 million	• 234.03 million for port expansion.[15] • 156.02 million upgrading transportation and onshore facilities.[15]
Hvide Sande	Denmark	~234.03 million	• Upgrade from fishery port to O&M service port.
Killingøy	Norway	> 1 billion	• Upgrade from ISPS-port to O&M service port.[27]
Tyne	UK	~354 million	• £4 +2.1 million by North East Local Enterprise Partnership. • £20 million for upgrading Tyne Clean Energy Park infrastructure.[28]

[25] Inch Cape Picks Montrose Port for O&M Base, https://www.offshorewind.biz/2022/02/07/inch-cape-picks-montrose-port-for-om-base/, access: 03/07/2023.

[26] Socio-economic impact study of offshore wind, 01/07/2020.

[27] LEVERANSEMODELLER FOR HAVVIND, page 59.

[28] https://investsouthtyneside.com/port-of-tynes-clean-energy-park-takes-another-step-forward-with-new-major-offshore-wind-base/, accessed: 04/07/2023.

Grimsby	UK	~203 million	• North East Lincolnshire Council invest £5 million for upgrading Grimsby fishery port to O&M service port.[29] • Orsted invests £10 million for the quayside and the office facilities.[30]
Lowestoft	UK	~339 million	• ABP's invest £25 million development of the Lowestoft Eastern Energy Facility, including expanding quay side space, new offices and facilities. [31]
Arklow	Ireland	~173.74 million	• SSE to invest EUR 15 million for the O&M base for the 520 MW Arklow Bank 2 OWF project in Ireland.[32]

*GBP : NOK = 1 : 13.54 *DKK : NOK = 1 : 1.56 *EUR : NOK = 1 : 11.58

It can be noticed from Table 24 that depending on the goal of the project and adaptation, the scale of investment varies. To be more specific, the original condition of the port, the targeted support for the OWF, and other factors affect the necessary investment. However, the benchmarking results still bring insight into the investment were made to upgrade the port to be sufficient to supporting the O&M tasks for offshore wind farms.

[29] https://www.offshorewind.biz/2013/03/07/uk-grimsby-to-celebrate-another-step-towards-offshore-wind/, accessed: 04/07/2023.

[30]https://orsted.co.uk/media/newsroom/news/2019/09/official-opening-of-the-worlds-largest-offshore-wind-operations-and-maintenance-centre, accessed: 04/07/2023.

[31] https://www.abports.co.uk/news-and-media/latest-news/2021/milestone-reached-for-abp-s-25-million-development-for-the-offshore-wind-industry/, accessed: 04/07/2023.

[32] https://www.offshorewind.biz/2021/06/07/sse-to-invest-eur-15-million-in-arklow-bank-2-om-base/, accessed: 06/07/2023.

7. CONCLUSION AND RECOMMENDATIONS

Table 25: Conclusions and Recommendations

1.	The market outlook shows great opportunities and potential demand for services related to O&M in south Norway, for SNII-phase 1 and especially next phase from 2025 and beyond.
2.	The existing infrastructure and benefits outlined in Ch. 5.1 makes Kongsgård the one of the most attractive ports for SNII at this point in time, but further action are still required.
3.	Actions must be undertaken to promote the existing infrastructure and opportunities at Kongsgård and the Port of Kristiansand. As part of that, a clear strategy and communication is required about to what extent, areas apart from pier 35, the quay behind it and the newly developing areas can be used for offshore wind and to what extent the port offers flexibility to accommodate further increased activities (e.g., phase 2/3 of SNII).
4.	Port of Kristiansand and Southwind with partners need to define key services they can offer to clients in the future relevant for O&M activities – that includes further businesses outside of the Southwind cluster located in southern Norway. In addition, clarity is needed whether further services e.g., during impact assessment, main soil investigation, mayor component exchange can be covered. That is interconnected with the stakeholder engagement as requirements/plans of OEM/developer need to be considered.
5.	Stakeholder assessment and engagement is key to support Southwind's ambitions to establish an offshore wind hub in Kristiansand.
6.	Required investments to allow O&M operations are comparably low as current infrastructure is already capable of servicing offshore supply vessels as of today. However, to establish an outstanding, efficient and modern O&M hub, investments in onshore infrastructure and sustainability are required. Considerable resources to be foreseen for competence development.

8. NEXT STEPS

Table 26: Next steps

1.	Discuss stakeholder assessment and plan for stakeholder engagement in H2/2023, align on concrete action toward potential clients in H2 2023.
2.	Engage with Southwind partners and develop an overview of specific services (UVPs) relevant for the O&M phase (and potentially additional services as outlined before), which can be covered already by Southwind, its partners, their supply chain as well as other businesses located in Agder/southern Norway and also services they are willing to cover in the future.
3.	Develop strategy to foster competence development in the region- and engage with relevant players of the business community to identify further relevant services/competences already existing in the region.
4.	Discuss gap assessment in close cooperation between KONGSTEIN, Southwind and the Port of Kristiansand and detail investment costs estimations.
5.	Discuss and develop marketing strategy to promote Kongsgård at the Port of Kristiansand as O&M hub. As part of that – develop and publish timeline for any (onshore) developments behind the quay of pier 36.
6.	Communicate and increase positive local acceptance for establishing O&M port in Kristiansand, enabling a positive "voice" from with local representatives.