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1. Introduction

Climate change and transition away from fossil fuels is one of the major challenges of our generation. There is even more demand for wind energy in the context of green hydrogen and the "Fit for 55" targets and the EU Green Deal (European Commission, 2021a). Accordingly, there will be an expansion of offshore wind energy in Europe, particularly in the North Sea due to its favourable conditions. The number of turbines installed yearly needs to double by 2025 and with increasing size of turbines, also the complexity of projects is rising (Wind Europe, 2021a; 2021b). But not only the commissioning of new turbines needs to be looked at but also the question of decommissioning old offshore wind farms. As the average running time of an offshore wind turbine amount to 20-25 years, pioneer plants in the North Sea are increasingly reaching the critical stage and first decommissioning projects have already been conducted. A market analysis shows that two cycles of decommissioning can be expected in the North Sea Region. The first cycle is already ongoing for the next years and is related to relatively low numbers of turbines to be decommissioned. The second cycle, however, which is expected to begin at the end of this decade, means large volumes in almost all regions of the North Sea (see Figure 1). While the first cycle functions as a kind of test case for decommissioning strategies and methods, the high volumes in the second cycle require developed solutions. Accordingly, questions of infrastructure or qualification, which have a long lead time, need to be addressed now to have sufficient preparation time (Kruse, 2019; Smartport, 2020; CRF Consultants, 2016).

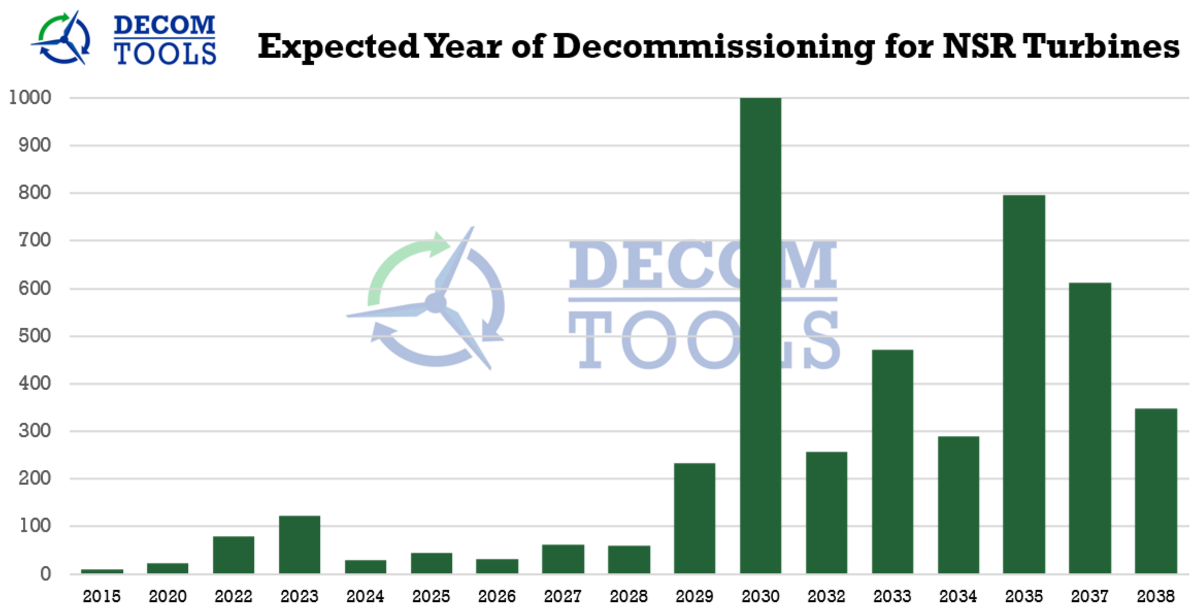

Figure 1: Expected Year of Decommissioning for Offshore Wind Turbines in the NSR

Source: Kruse (2019).

The predictability of offshore wind turbine decommissioning is comfortable in certain aspects as the number, age, and technical details of already working turbines are known while commissioning new turbines is subject to various uncertainties such as political frameworks. On the other hand, decommissioning and recycling of offshore structures such as oil and gas platforms or onshore wind turbines are well established but decommissioning offshore wind turbines is still a case (Ramsay, 2021; ARUP, 2014). The uncertainty thereby not only involves questions of adequate decommissioning vessels, capacity, and availability of employees, but also recycling of materials such as steel, concrete, or composite materials (Ramsay, 2021).

Against this background, the report at hand is prepared as part of the project "Eco-innovative concepts for the end of offshore wind energy farms lifecycle (DecomTools)" which funded by the European Regional Development Fund (ERDF) Interreg North Sea Region (NSR) programme 2014-2020. The project recognises that an overall sustainable approach to the offshore wind farms' end of lifecycle is still missing, and the project shall assist in closing this gap. This is achieved by devising and developing eco-innovative concepts that:

- Reduce decommissioning costs by 20 per cent and environmental footprint by 25 per cent (measured in CO2 equivalents),
- Increase the know-how and expertise of North Sea Region (NSR) involved stakeholders.

The project consortium consists of thirteen partners from six NSR countries, namely Belgium, Denmark, Germany, the Netherlands, Norway, and the United Kingdom. The four-year project will carry out research, demonstrate pilots, and develop working tools in different areas such as logistics, infrastructure, ship design, safety, or up-/re-cycling. Already available technologies will be combined to tackle some of the major aspects of the decommissioning challenges, including optimisation of existing (port) infrastructure. Transnational cooperation and multidisciplinary cross-sector competences will improve framework conditions for innovation and technology transfer in this specific niche area and help the sector to become more sustainable.1

The report at hand will deal with the topic of infrastructure. A complementing report on qualification is published in parallel. The underlying research consists of published evidence, a local quantitative assessment in the partner regions of DecomTools in Belgium, Denmark, Germany, Netherlands, Norway, and the United Kingdom, as well as several in-depth interviews with stakeholders around the North Sea Region. The interviews were carried out between 2019 and 2021 and amount to a total of 13 interviews with infrastructure providers, knowledge institutions, service providers, training facilities and other experts. The findings are complemented with findings from a previous interview round conducted for a stakeholder report, also in the scope of the DecomTools project (Kruse, 2020).

[1] For more information about the project, see https://northsearegion.eu/decomtools/about/

2. Infrastructural Requirements – General

Until now, infrastructural questions of decommissioning in the North Sea have primarily been addressed in terms of oil and gas decommissioning (see e.g. Nexstep, 2021). Thereby, the infrastructural requirements have to be adapted to cope with the increasing deployment of new offshore wind farms which now support about 3GW of new wind farms every year and need to deliver about 11GW in 2030. Moreover, the challenge of decommissioning old offshore wind farms at the same time with about 300 installed turbines of 700MW being older than 15 years and having to be repowered or decommissioning in the near future increases the call for action in terms of infrastructure (Wind Europe, 2021b). The geographical focus of decommissioning and related tasks such as recycling will be located in Germany, the Netherlands and Denmark which now have the oldest offshore wind farms as early pioneers in this market (Ramsay, 2021). It is still subject to discussion whether decommissioning will be conducted in the same ports that were used for the construction of offshore wind farms or whether also new ports have the chance to enter this new business (Ramsay, 2021). However, distances and transportation costs will play an important role as the experience from oil and gas decommissioning has shown which makes it inefficient to transport decommissioned infrastructures to facilities e.g. outside of Europe. Therefore, the North Sea Region will most likely benefit from the regional socio-economic effects arising from decommissioning installations in the North Sea (ARUP, 2014). Quantifications of decommissioning offshore wind parks are thereby also subject of the COASTAL project, which is also funded by the European Union (European Commission, 2021b; CORDIS, 2021)

Although the type of infrastructure, equipment, vessels, and technologies differs depending on the type of the wind turbine, its size, its foundation and other factors, some general requirements can be identified. These will subsequently be divided into port infrastructure and storage, operation and maintenance, and recycling in order to paint a differentiated picture of decommissioning infrastructure.

2.1 Port Infrastructure

Ports are undoubtedly an essential part not only for the commissioning of offshore wind turbines but also for their decommissioning (Frangoul, 2021; Brown, 2014). The experience from oil and gas decommissioning shows that upgrading major infrastructure can take up to a decade and involve significant investment, even more if the new infrastructure has to be newly designed and developed (ARUP, 2014). Therefore, it is highly relevant for ports in the North Sea Region to plan on time and reach a certain level of coordination among each other so that a sufficient supply of infrastructure is ensured without building over-capacities. Regarding actual decommissioning operations in ports, the requirements range from hosting decommissioning and transport vessels and their crews, storage for decommissioned components, as well as further processing (Wind Europe, 2021b).

In this regard, however, it is not yet clear whether the subsequent steps of decommissioning, for instance cutting, recycling, or further processing of components, will be conducted in the ports themselves or in specific facilities elsewhere (Ramsay, 2021). While the transport cost minimising option would be in-port processing by specialised companies, this would require sufficient space and capacity to accommodate the decommissioned turbines (Elkinton et al., 2014; Wind Europe, 2021b). Since ports already face pressure due to limited storage space, this might give rise to the establishment of decommissioning hubs in the North Sea Region. On the other hand, smaller ports might come into play as decommissioned blades are considerably smaller than those of newly constructed wind farms and do not need that large port areas. Still, it is expected that demand for breakbulk shipping is likely to increase as a consequence of decommissioning, particularly considering a potential re-use of certain components. This calls for a critical survey of transport connections such as railway, water, or motorway connections and possibly their diversification (Ramsay, 2021). A further demand for space in ports arises from installation of an increasing number of new turbines of increasing size. This trend will, even if decommissioning was not considered, lead to ports having to expand their land, reinforce quays and enhance their deep-sea berths. It can be expected that an increasing number of vessels will be deployed in ports for decommissioning, thereunder potentially new vessel types particularly for this task. Ports will therefore have to provide the infrastructure to host a larger fleet (Wind Europe, 2021b).

These expansions in terms of berths, reinforced quays, storage space, capacity, and transportation networks will require significant investment. It is estimated that European ports will have to invest about €6.5 billion until 2030 alone to support the expansion of offshore wind installations. Costs of constructing a decommissioning facility within a port or refurbishing an existing facility are estimated in a range between €5 million to €10 million per investment. However, it is doubtful that the estimated number of five investment projects of decommissioning facilities is sufficient and also the financial calculation is more of a rough approach. Accordingly, the European Commission is requested to formulate a strategy for port development in the context of a new boost for offshore wind and the upcoming challenge of decommissioning. Considering the high societal value of such investment an alignment with the EU Recovery and Resilience Plan or the Green Deal appears to be consistent (Wind Europe, 2021b).

Several ports are already investing in new infrastructure for decommissioning. Moreover, those ports that are already actively involved in the decommissioning of offshore structures in the North Sea such as oil and gas installations, can be taken as an example to get an idea of the kind of required adaptations. For instance, in the UK, the Forth Ports (Dundee, Rosyth, Leith) already provide decommissioning solutions including disposal and recycling solutions, access to on-site craneage, office and staff facilities, several specialists, or logistic support. Moreover, a new quayside of 200m length delivers a heavy-lift capacity (Forth Ports, 2021). A new decommissioning facility is also planned to be established in Montrose in the UK. Here, a metals processing company announced plans to construct a new decommissioning facility focusing on offshore oil and gas infrastructure. Aside from direct quayside access, and shipping opportunities, on-site downsizing and processing of decommissioned components are among the features. Decommissioning capabilities are also expanded at the port of Aberdeen (Montrose Port Authority, 2021). The same holds for the port of Cromarty Firth, also in the UK, offers several sheltered, deep-water berths, an experienced on-site supply chain, heavy lift infrastructure as well as reinforces quays and accompanying laydown area (Port of Cromarty Firth, 2021). Also, other UK ports such as Lerwick have been involved in decommissioning of offshore oil and gas projects and therefore can provide the necessary infrastructure of quays, laydown areas, lifting infrastructure and experienced personnel (Lerwick Port Authority, 2021).

UK ports already benefit from their experience in decommissioning oil and gas infrastructures and could therefore have an advantage over other ports. The same applies to Norwegian ports which have benefits from decommissioning experience from oil and gas projects which also includes particular infrastructure such as decommissioning facilities. But also Danish ports such as the port of Thyboron are equipped with heavy-lift quays for decommissioning of offshore oil and gas facilities (Thyboron Port, 2021). Moreover, the port of Rotterdam in the Netherlands, which was primarily used for the construction of new offshore wind farms, is investing to exploit the opportunities of offshore decommissioning. Building a new offshore wind centre to decommission both oil and gas platforms and, perspectively, offshore wind farms while also allowing for the construction of new wind farms, can be regarded as an approach to diversify port operations beyond freight and cargo. The significance and business rationale are underlined by the investment sum of €70 million in the first step and about €150 million for the total undertaking. The money is thereby, among others, invested in the construction of a heavy-load deep-sea quay (Offshore Technology, 2017).

Further requirements to cope with the upcoming offshore wind farm decommissioning challenges are found in the tasks of operation and maintenance. To reduce transportation time, service technicians and service vessels should be based close to the project sites. As distinguished from the actual decommissioning and transport of components, the infrastructural requirements are less strict. For instance, specific quayside equipment is not required but sufficient space accommodating additional vessels and crew needs to be provided. On the other hand, tidal constraints or lockgate limitations need to be considered which makes some ports less attractive in terms of decommissioning (Wind Europe, 2021b).

2.2 Recycling Infrastructure

When it comes to recycling of components of offshore wind turbines, several different materials are to be distinguished. Particularly steel makes up a large part of a turbine being used in the foundation, the tower, the gears, and the generator. Some early near-shore foundations are constructed using concrete, but this is expected to be a temporary phenomenon in decommissioning as newer turbines refrain from the use of concrete. However, different metals are used for early as well as modern wind turbines in the generators, or electric components so that their recycling will play an ongoing role. Finally, composite materials are the third large group of materials that recycling facilities need to adapt to. While metal and steel are relatively easy to recycle, composite materials pose a significant challenge. Glass reinforced plastic (GRP) is currently downcycled as fibre material or fuel for cement production while carbon fibre reinforced plastic (CFRP) can only be disposed. Developing new recycling techniques is therefore a challenge to be addressed. These requirements also impose a challenge when it comes to infrastructural considerations.

Until now, the supply chain for recycling and disposal of wind farm components remains nascent. In many places, the required infrastructure is not yet established so that breakbulk shipping demand can be expected to increase in order to transport decommissioned components to specialised recycling facilities (Ramsay, 2021).

However, locations have an advantage, that have already been involved in related recycling activities. Apart from oil and gas component recycling, particularly decommissioning of onshore wind components provides valuable experience to be put into play. In the case of Germany, there appears to be a concentration of recycling infrastructure in Northern Germany (particularly Hamburg, Bremen and parts of Lower Saxony. However, also regions in Western Germany (North Rhine Westphalia), Southern Germany (Bavaria), or Eastern Germany (Saxony) play a role when it comes to recycling of metal, concrete, or composite material. A focus on offshore components is particularly taken in recycling facilities in Northern Germany due to its geographical proximity to the North Sea and the Baltic Sea. Nevertheless, certain parts of offshore components might also be transported to facilities in other parts of the country when capacities in the North run full or when lower prices are expected to compensate for the higher transport cost.

3. Infrastructural Requirements – Expert Interviews

The more theoretical analysis based on literature research above has been complemented by an own qualitative study. Here, several interviews with regional experts were conducted between 2019 and 2021. In general, 4 interviews in Norway (with a recycling company, maintenance and service companies, and a decommissioning company), 2 interviews in the Netherlands (with a port, and a transport and service provider), 3 interviews in Denmark (with a port, and two training providers), 4 in Germany (with a port, and three service providers), were analysed for this report and will be summarised below. Also, previous interviews from an earlier report on stakeholder demands were considered for the identification of infrastructure recommendations (Kruse, 2020).

3.1 Ports

The interviewees have repeatedly underlined the central role of ports when it comes to decommissioning of offshore wind infrastructures – as an operation hub, storage space, potential further transport of components, and in terms of potential further processing and recycling on-site. Interviewed ports recognise the opportunities arising from decommissioning and repowering over the next years. Particularly the chance to acquire additional value on-site on ports and diversify the own service portfolio is widely acknowledged by several interviewees. Figure 2 presents an exemplary overview of ports in the North Sea Region which have been involved in decommissioning (either of oil and gas or offshore wind infrastructures) before and gives an idea of the geographical spread.

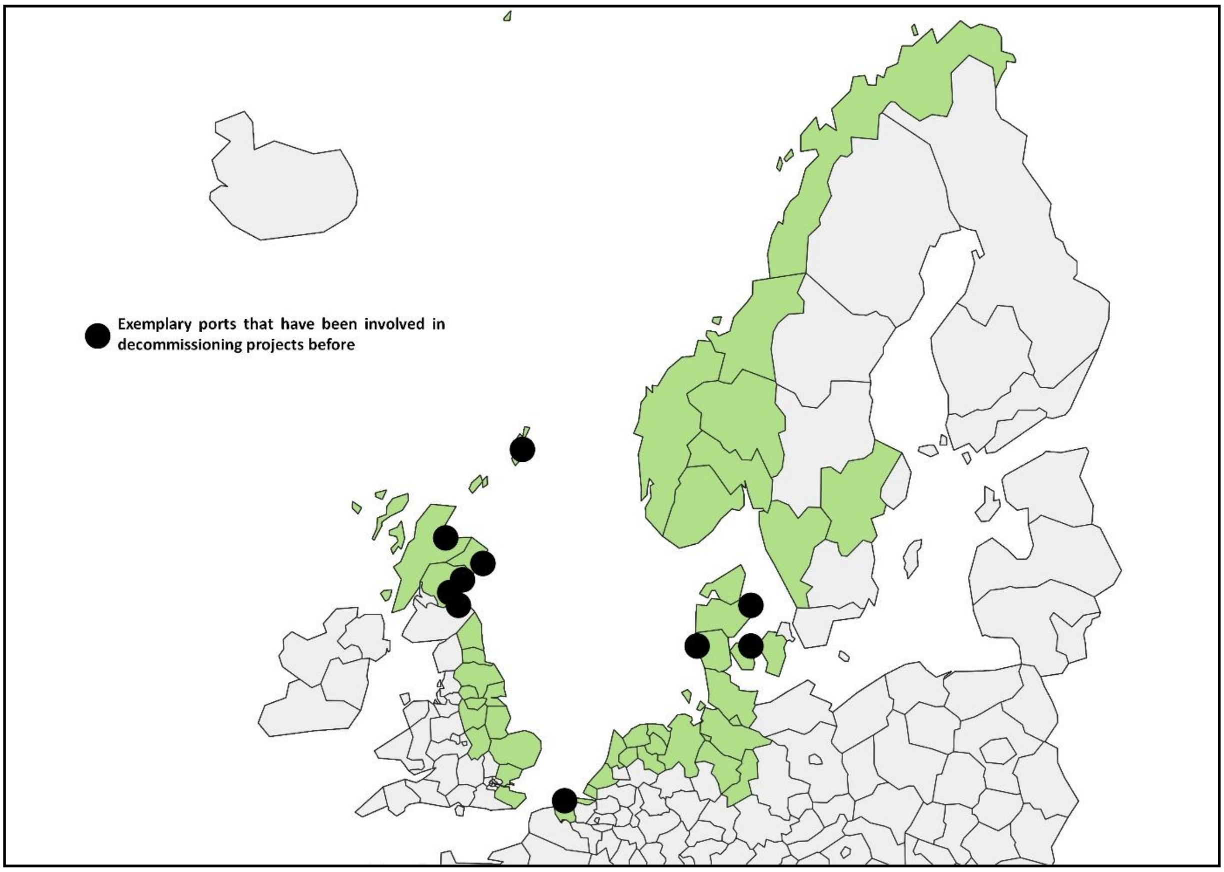

Figure 2: Exemplary ports in the North Sea Region which have been involved in decommissioning

But, in order to exploit these opportunities, an experienced supply chain is required. Not every port is sufficiently equipped with decommissioning facilities and those ports which already established decommissioning facilities are in advantage. Decommissioning ports are thereby not only found in the UK with a focus on oil and gas but also in countries such as Denmark and Norway and also with a focus on the decommissioning of ships or other offshore infrastructure. In this context, some interviewees claimed their scepticism whether large adaptations would be required for ports as decommissioning will primarily involve transportation. Adaptations in ports will, from this perspective, primarily involve increasing volumes, for instance in terms of accommodation, or storage capacity.

However, it is remarked that cutting, separation and further processing of decommissioned components requires infrastructural adaptations, also in ports. It has been mentioned as a possibility to settle companies working with decommissioning in the port directly in order to reduce transportation cost and time which, again, can require infrastructural adaptations and implies spare space. If instead recycling and further processing are conducted in facilities outside the ports in the hinterland, the corresponding transport infrastructure need to be critically examined and possibly adapted before the large volumes of decommissioning come into play. Particularly railways have been discussed here as a chance to make land transport smoother and greener. Another opportunity of recycling on-site of ports is the potential leveraging of synergies with related sectors that rely on resources that are extracted in the decommissioning process. An example could be the use of fibres from wind blades which might be interesting for the automotive sector. However, new recycling techniques are required at this stage.

A stakeholder from Denmark explained its perspective that decommissioning of offshore wind farms will not be large enough of a market for the next decade so that particularly ports who are already involved in decommissioning and recycling will get involved as an add on. Moreover, ports who have been used for the construction of offshore wind farms appear to be at an advantage when it comes to later decommissioning. Together with the notion that ports need a certain quantity of spare space to get involved in decommissioning in general and decommissioning of offshore wind infrastructures in particular limits the number of suitable ports.

3.2 Vessels

Different stakeholders have expressed different views on the question whether new vessel models will be required to conduct the decommissioning of offshore wind farms. On the one hand, stakeholders recognise the decommissioning challenges but see much larger projects realised in countries such as China so that a development of new vessels appears to be unnecessary, and the existing capacities of available vessels are considered to be sufficient. On the other hand, large vessels for decommissioning are considered an integral part of infrastructure and a potential shortage in capacities, at least temporary, should be expected. In this context, also the development of new vessel types specifically for decommissioning activities in the offshore wind sector is discussed since the requirements differ from the offshore construction procedure. The DecomTools project has put a lot of thought into the development of a sustainable ship type that is design to decommission wind turbines in more efficient way. The vessel is equipped with the latest available technologies and many innovative tools such as a flattner rotor, solar panels, and LNG engine (Askari & Halimah, 2021).

3.3 Recycling

When it comes to recycling of decommissioning offshore infrastructures, particularly Norwegian interviewees have reported previous and decades-long experience and particular interest looking at offshore wind decommissioning projects. Apart from discussed solutions of on-site recycling in ports or transport to hinterland facilities, Norwegian companies possess their own port infrastructures for decommissioning oil and gas platforms. These ports are specifically designed for the requirements of decommissioning, provide large quay areas, heavy lifts, and deep-water quays, and adapt to the characteristics of oil and gas, e.g. with cleaning and filtering systems to handle water spills and chemicals. These infrastructures underline that cutting, sorting, and recycling is already usual business in Norway and accordingly the infrastructure is sufficient. However, as decommissioning is a new challenge for the majority of North Sea countries, comparable recycling infrastructures have not been constructed regionwide. To reduce transportation costs and ensure an equal distribution of capacity, infrastructural adaptations in the rest of the North Sea Region appear to be a future task.

4. Infrastructure Requirements - Summary

Ports

- Ports play a central role for offshore wind decommissioning as operation hubs, storage spaces, for potential further transport of components, and in terms of potential further processing and potential recycling on-site.
- Decommissioning as a chance to acquire additional on-site value for ports and diversify the portfolio.
- Infrastructural adjustments have a long investment horizon and need to be taken now.
- Adaptations in ports will at least involve improving transport connections, increasing volumes, for instance in terms of accommodation, and increasing storage capacity.
- Smaller ports too can play a role for decommissioning but those are in advantage that have already dealt with decommissioning of oil and gas infrastructures.

Vessels

- Availability of suitable vessels for decommissioning needs to be ensured. Maybe new vessel types need to be developed.

Recycling

- Different materials are involved in decommissioning offshore wind farms for which either existing recycling facilities are sufficient (e.g. steel) or new facilities and procedures are needed (e.g. composite materials).
- Locations which have been involved in recycling before have an advantage.
- On-site recycling in ports or transport to hinterland facilities?

5. Sources

ARUP (2014): Decommissioning in the North Sea – Review of Decommissioning Capacity, Edinburgh.

Askari, H.; Halimah, A. (2021): Presenting an Ecco-Sustainable Approach to Decommission Offshore Wind Parks by Designing a New Ship, New Tools and Efficient and Reliable Procedure, [online], available at: https://northsearegion.eu/media/18659/decomtools-vessel-design-an-eco-sustainable-approach-to-decommission-offshore-wind-parks-by-designing-a-new-ship-new-tools-and-efficient-and-reliable-procedures-compressed-2.pdf [accessed February 25th, 2022].

Brown, M. (2014): High Level Review of Decommissioning Yards for ex-North Sea Facilities, Presentation of Offshore Decommissioning Conference.

CORDIS (2021): Collaborative lAnd Sea integration pLatform, [online], available at: https://cordis.europa.eu/project/id/773782 [accessed November 29th, 2021].

CRF Consultants (2016): Status Capacity and Capability of North Sea Decommissioning Facilities.

Elkinton, C.; Blatiak, A.; Ameen, H. (2014): Assessment of Ports for Offshore Wind Development in the United States, Garrad Hassan America Inc.

European Commission (2021a): A European Green Deal – Striving to be the first climate-neutral continent, [online], available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en [accessed November 9th, 2021].

European Commission (2021b): Projecting the infrastructure impacts of decommissioning offshore wind parks in the Belgian North Sea, [online], available at: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform/30189;keyword=Projecting%20the%20infrastructure%20impacts%20of%20decommissioning%20offshore%20wind%20parks%20in%20the%20Belgian%20North%20Sea;isExa= [accessed November 29th, 2021].

Forth Ports (2021): Decommissioning, [online], available at: https://www.forthports.co.uk/decommissioning [accessed November 29th, 2021].

Frangoul, A. (2021): Europe's ports will need $7.9 billion of investment to support offshore wind expansion, report says, [online], available at: https://www.cnbc.com/2021/05/28/europes-ports-will-need-7point9-billion-to-support-offshore-wind-report.html [accessed May 31st, 2021].

Kruse, M. (2019): Market Analysis Decom Tools 2019, [online], available at: https://northsearegion.eu/media/11753/market-analysis_decomtools.pdf [accessed December 10th, 2021].

Kruse, M. (2020): Stakeholder Analysis Decom Tools 2020 [online], available at: https://northsearegion.eu/media/13115/stakeholder-report_decomtools_final.pdf [accessed December 10th, 2021].

Lerwick Port Authority (2021): Decommissioning, [online], available at: https://www.lerwick-harbour.co.uk/sectors/decommissioning [accessed November 30th, 2021].

Montrose Port Authority (2021): New decommissioning facility to be established in Montrose, [online], available at: https://montroseport.co.uk/2021/09/01/new-decommissioning-facility-to-be-established-in-montrose/ [accessed November 29th, 2021].

Nexstep (2021): Re-use & Decommissioning report – On the Road, [online], available at: https://www.nexstep.nl/wp-content/uploads/2021/07/Nexstep-Re-use-and-Decommissioning-Report-2021.pdf [accessed November 29th, 2021].

Offshore Technology (2017): Wind-powered offshore decommissioning in Rotterdam, [online], available at: https://www.offshore-technology.com/features/featurewind-powered-offshore-decommissioning-in-rotterdam-5889885/ [accessed November 29th, 2021].

Port of Cromarty Firth (2021): Decommissioning, [online], available at: https://www.pocf.co.uk/decommissioning/ [accessed November 29th, 2021].

Ramsay, M. (2021): Breakbulk Movers to Define Circular Wind Role, [online], available at: https://www.breakbulk.com/Articles/positioning-for-decommissioning-work [accessed November 29th, 2021].

Smartport (2020): Offshore wind farm decommissioning – An orientation of possible economic activity in the South Holland region and the Rotterdam port area, Rotterdam.

Thyboron Port (2021): Offshore decommissioning [online], available at: https://www.thyboronport.com/offshore/decommissioning [accessed November 30th, 2021].

Wind Europe (2021a): Offshore Wind in Europe – Key trends and statistics 2020.

Wind Europe (2021b): A 2030 Vision for European Offshore Wind Ports – Trends and opportunities.