# HOW OFFSHORE WIND DEVELOPMENT CAN SUPPORT COASTAL REGENERATION

## GLOBAL OVERVIEW AND BEST PRACTICES FOR SOUTH KOREA

GLOBAL WIND ENERGY COUNCIL

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## Attribution

How Offshore Wind Development Can Support Coastal Regeneration: Global Overview and Best Practices for South Korea. Global Wind Energy Council. 2024.

## Acknowledgement

This report was commissioned by the Global Wind Energy Council (GWEC). The Carbon Trust set out the core economic benefits and wider social and environmental effects of offshore wind development, researched global best practices, approaches and mechanisms for ensuring that offshore wind development supports local, coastal regeneration, and set out recommendations for the South Korean context. Energy and Space conducted a comprehensive analysis of the potential economic impacts stemming from offshore wind development in South Korea. Their contributions further include providing key information and insights on global best practices, methodologies, and mechanisms, as well as offering a nuanced overview of South Korean case studies that facilitated invaluable policy recommendations.

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# Foreword

As the demand for reliable, scalable and sustainable energy continues to accelerate in South Korea, the pursuit of renewable sources have become imperative. The country currently stands at the pivotal moment of its energy transition - beyond its net zero emission ambitions by 2050 and growing energy demands. With a staggering 624GW of technical potential for offshore wind, encompassing both fixed bottom and floating types, South Korea stands as a beacon of abundant renewable energy opportunities. At COP28, together with aother 118 countries, South Korea furthered its climate ambitions by joining the pledge to collectively triple the world's renewable energy capacity by 2030.

Offshore wind has not only emerged as a resilient renewable energy solution for South Korea, but it has also become recognised as an important industrial opportunity, which can aid in the economic revitalisation of key coastal regions. Recognising the need to quantify this opportunity and provide practical suggestions on how to maximise this opportunity, the Global Wind Energy Council commissioned this report: ''How Offshore Wind Development Can Support Coastal Regeneration: Global Overview and Best Practices for South Korea''.
The report examines the immense potential that offshore wind presents for South Korea's coastal areas, with a specific focus on its role in fostering economic benefits and attracting investment.

Although South Korea has announced a 14.3 GW installation target for offshore wind by 2030, there is less than 150 MW of current installed capacity. The market at present lacks a streamlined permitting process that provides clear guidance, specifically on timing and to engage with local communities. At the same time, understanding of the core benefits and opportunities of offshore wind neds to be strengthened among local stakeholders. Without greater understanding, local stakeholders may not support offshore wind development, and coastal communities may not be able to access the economic benefits offshore wind can create.

This report not only underscores the importance of offshore wind development for South Korea but also serves as a call to action to the policymakers. It is an invitation to embrace a comprehensive and holistic strategy that goes beyond energy production and facilitates sustainable economic and industrial development. Global insights, in the form of international best practices, have been drawn from successful initiatives worldwide. This report aims to provide guidance on how the country can harness the full spectrum of benefits offered by the offshore wind industry, including unlocking job opportunities, creating investment into ports, re-invigorating coastal communities and stimulating the entire supply chain. Concurrently, we hope to provide local stakeholders with quantitative evidence that measures the true potential of offshore wind in South Korea's coastal communities.

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# Exhibits

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# Acronyms

| | |
|---|---|
| DK | Denmark |
| IO | Input-Output |
| IRA | Inflation Reduction Act |
| MW | Megawatts |
| GW | Gigawatts |
| GVA | Gross Value Add |
| O&M | Operation & Maintenance |
| CapEx | Capital Expenditure |
| OpEx | Operating Expense |
| EBL | Electricity Business Licence |
| ESG | Environmental and Social Governance |
| EIA | Environmental Impact Assessment |
| EU | European Union |
| RPS | Renewable Portfolio Standards |
| RECs | Renewable Energy Certificates |
| FTE | Full-Time Equivalent |
| OFW | Offshore wind |
| OWF | Offshore wind farms |
| MOTIE | The Ministry of Trade, Industry and Energy |
| MOF | The Ministry of Oceans and Fisheries |
| UK | United Kingdom |

# EXECUTIVE SUMMARY

# Executive Summary

Offshore wind (OFW) is a reliable, scalable sustainable source of electricity, and many countries around the world are pursuing commercial deployment to support the transition towards a carbon-neutral society. The South Korean government has set a target of reaching 14.3 GW of OFW before 2030, and as of 2023, the country has 140 MW of installed capacity across six windfarms.

Despite this ambitious target, commercial OFW development is experiencing delays, due in part to a lack of local acceptance, coordination among multiple stakeholders within the development process and wider policy outlining economic benefits.

Beyond decarbonisation, offshore wind can offer South Korea other economic, social and environmental benefits. Commercial-scale offshore wind deployment will require a significant mobilisation of the workforce as well as development of major infrastructure, creating employment opportunities not only offshore, but in ports, the surrounding coastal communities and across the wider supply chain. These benefits are particularly important for South Korea, whose coastal cities and towns have seen declining populations, low birth rates and internal migration to cities by the younger populations over the past several years.

The anticipated scale-up of offshore wind development serves as a window of opportunity for the country to pursue economic and social regeneration along its coasts. But seizing this opportunity will require a well-established policy framework and support from regional and national institutions. Offshore wind development can support coastal regeneration, but this will require planning, stakeholder engagement, and collaboration between government and industry.

This report sets out the core economic and wider social and environmental benefits of offshore wind development and discusses how these benefits could be leveraged in order to achieve coastal regeneration. The report also highlights the potential economic impacts of offshore wind development in South Korea, using an input-output (IO) analysis to estimate the expected value-added and employment for the construction of 14.3 GW of OFW planned for 2030.

Assuming that by 2030, a total of 14.3 GW of OFW farms will be constructed, the report finds that the gross value added for a fixed OFW project is approximately **45.3 trillion won for 7 years, and for floating OFW project, around 41.7 trillion won** to the Korean economy.

Each year during the Operations & Maintenance (O&M) phase, the report finds that **87.26 billion won** for a fixed bottom and **57.82 billion won** worth of gross value added can be estimated (Exhibit 11).

Offshore wind is expected to create in total 770,200 jobs, including 376,200 jobs in fixed OFW and 394,000 jobs in floating OFW as a result of CapEx (Capital Expenditure) over the project lifecycle of the 14.3GW of OFW farms. For the O&M phase, for the year of 2030 alone, it is estimated that 11,689 FTEs can be created annually in bottom-fixed OFW, while there would be 5,917 FTEs created in floating. Many of these jobs, especially in the construction, installation and then O&M phase lasting the project lifetime, would be locally deployed.

Finally, this report highlights best practices, approaches and mechanisms for ensuring offshore wind development supports coastal regeneration, based on case studies from more mature offshore wind markets. These best practices include:

### Revitalisation of existing assets

Brownfield sites, ports and existing industrial sites in coastal communities can be redeveloped to support offshore wind. The redevelopment of these assets requires local jobs – from project planning, construction, to manufacturing of components.

### Innovation and efficiency through industrial clusters

Ports are utilised throughout the lifespan of the offshore wind farm and create economic benefits due to the cluster of industry and developers. This streamlined supply chain and cluster can create jobs and stimulate local economic growth; however, it is key for decision makers to consider a long-term approach to development.

### Technical upskilling through education, training

To meet OFW targets, investment is required in local training centres, partnerships with further education institutes and training programmes with industry stakeholders to increase and specialise the workforce in coastal communities.

### Recommendations for the regeneration of coastal communities

Based on these best practices and lessons learnt, we outline main recommendations for the South Korean government, across different ministries, to ensure that offshore wind development helps to support the regeneration of coastal communities. The recommendations are categorised according to government stakeholder (i.e national, local, both governments).

#### Local governments

1. Build a local regeneration vision with citizens early on to build social acceptance and lasting political support for OFW developments.

2. Build the workforce capacity with local research institutions and other knowledge partners, noting that local municipalities can act as a bridge between the industry sector and provide necessary public financing and support.

3. Establish inclusive governance of the cluster with stakeholders to bridge the gap to engage with public councils in determining the future of industrial clusters.

4. Strengthen international networks between local governments that can be utilised to enhance the capacity to plan and implement effective climate action at the local level.

#### National government

1. Expand the number of Free Economic Zones to enhance an Offshore Wind Industry Cluster and to provide a competitive playing field for FDI, which could translate into job creation and regional economic growth.

2. Working with local government, industry and local stakeholder communities to develop standardised guidelines for engagement, considering existing practices in community engagement and codifying them into regulation.

3. Consider the introduction of a tax credit system, or a similar incentive, for the wind power supply chain.

4. Prepare long-term plans on port and grid infrastructure for offshore wind to help developers make informed investment decisions.

#### Both local and national governments

1. Carry out an assessment of coastal communities at a local and national level, including an understanding of the baseline status of economic, social, environmental factors, including cost-benefit analysis to determine the areas which would benefit most from strategic investment.

2. Develop a national plan for coastal community regeneration, coordinating with local authorities, communities, and industry for shared understanding of impacts of different stages of offshore wind projects to local communities.

# BACKGROUND AND AIMS

# Background and aims

## Aim and scope of this study

As of 2023, South Korea has 125 MW[1] of installed fixed-bottom OFW, however, the government has established an ambitious goal of 14.3 GW of OFW by 2030, which means there is a considerable effort required to meet expectations.

The challenges associated with the current projects can be attributed to several factors.

Firstly, the process for establishing a new offshore wind farm is developer-led, also known as an ‘open-door procedure’. Unlike in a government-led development scheme, a private developer selects potential project sites and applies for an Electric Business Licence (EBL) and other required permits to relevant government agencies. However, there is insufficient standardisation and guidance[2] as to best practice for local community engagement, compensation, who are the key stakeholders to engage, what levels of governments need to be engaged and other issues of concern, including difficulties in coordinating with governmental bodies.

At present, local acceptance for OFW could be improved. Guidelines for engagement strategies where residents can become involved in the process of developing projects are not sufficient.[3][4][5][6][7][8] The potential benefits of offshore wind are not well-known enough among the public, and when benefits are communicated, they can be met with distrust.

Finally, OFW development is largely only considered in energy policy; the government has yet to establish a comprehensive and visionary industry policy to support the sector. This has resulted in insufficient support for offshore wind development from the industrial sector more broadly.

This report aims to:

- Set out the core economic benefits and wider social and environmental benefits of offshore wind development and discuss how these benefits could be leveraged in order to achieve coastal regeneration (Sections 1-3).

- Showcase the potential economic multiplier effect of OFW as an industry by using an input-output (IO) analysis to estimate the expected value-added and employment for the construction of 14.3 GW of OFW planned for 2030 (Section 4).

- Highlight best practices, approaches and mechanisms for ensuring offshore wind development supports local, coastal regeneration, based on case studies of similar efforts around the world (Sections 5-6).

1 Electric Power Journal, 27/12/2023 (Accessed 2024, February 2). Source: Link.
2 MOTIE & KMI. A guide to offshore wind power generation with resident fishermen (Guideline). 2023. Source: Link.
3 The National Assembly Research Service (NARS). Current status of offshore wind power and future tasks focusing on improving permitting delays and securing resident acceptance. 2022.
4 Park, J. M., Lim, H. S., Park, S. A., & Cho, G. J. A Study on the Fishermen’ Acceptability of Offshore Wind Farms. 2021. Source: Link.
5 Relevant Ministries. Offshore wind power development plan that cooperates with residents and coexists with the fishing industry. 2020. Source: Link.
6 Choi, G. R., Lee, S. G., Leem, K. H., Joung, M. S., & Kim, T. Y. Searching for Ways to Manage Public Conflicts for Sustainable Offshore Wind Power Development. 2023. Source: Link.
7 Lee, S. H. & Park, J. P., (2020). A Study on Local Acceptance of Offshore Wind Farm: Focus on Maldo. 2020. Source: Link.
8 Monthly Electrical Journal. (2023.4.6). Offshore wind power, an emerging energy source, how to solve the problem of resident acceptance? (Accessed 2024.02.01). Source: Link.

# Global status of offshore wind energy

Offshore wind plays a crucial role in the energy transition by providing a reliable, scalable, and sustainable source of electricity, contributing to the reduction of greenhouse gas emissions, and fostering economic development and innovation in the renewable energy sector. There has been significant scale-up of offshore wind globally over the past two decades; there is now over 64 GW installed.[9] Countries with notable case studies are Denmark and the United Kingdom. Denmark today has over 2 GW of offshore wind installed and was the location of the first offshore wind farm Vindeby in 1991 which is formed of 11 turbines and generating 5 MW.[10] The United Kingdom commissioned its first offshore wind farm in 2000 and is the second largest offshore wind market with capacity of over 14 GW.[11][12] Due to this commercial scale-up, offshore wind has not only become a significant economic driver for countries at a national level but has also helped reshape their coastal communities through the introduction of a new industry and accompanying initiatives.

Commercial-scale offshore wind development can support:

- Job creation in order to support the development, construction and operations of wind farms
- Infrastructure development for ports and other access infrastructure
- Increased opportunities for the local supply chain
- Diversification and transition of the local economy
- Development of education and research opportunities
- Indirect benefits to local economies such as boosts in associated travel and accommodation sectors

Offshore wind development can act as a job catalyst, providing access to renewable energy as well as enabling other socio-economic benefits in the region.[13] However, collaboratively, governments and the OFW industry need to consider planning, stakeholder engagement, infrastructure development including construction and refurbishment, and training and education of the local workforce. The past two decades of industry operation in Europe provide several 'lessons learnt' regarding offshore wind development and coastal regeneration. These lessons and best practices can and should be considered in emerging offshore wind markets like South Korea.

# Overview of the South Korean offshore wind energy market

## Renewable energy policy and targets

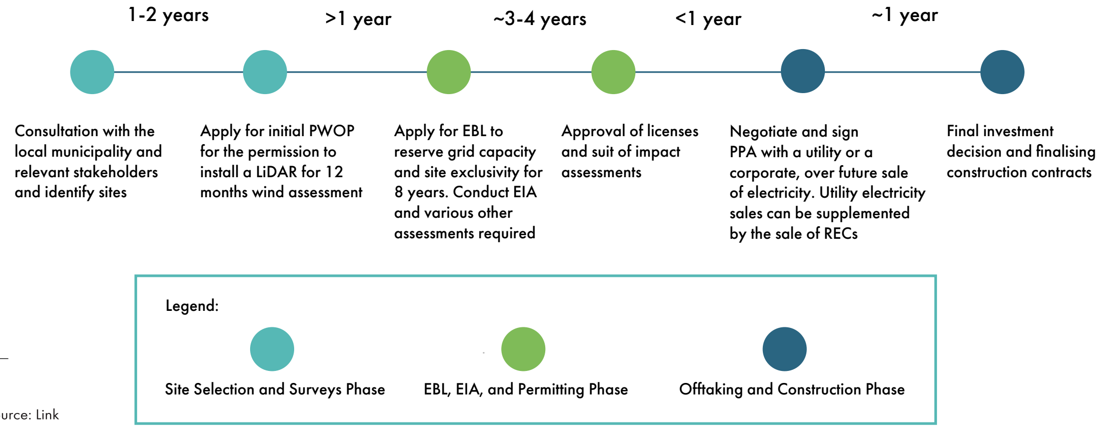
In 2017, the South Korean government announced the Renewable Energy 3020 Implementation Plan[14] which articulated specific deployment targets for the first time (20% of electricity produced by renewables by 2030). In 2023, this goal was confirmed by the 10th Basic Plan for Electricity Supply and Demand Plan[15] , which states that 30.6% of the electricity production should come from renewables by the end of 2036. The country's OFW target was also updated to 14.3 GW by 2030.

## Planned and operational offshore wind

As of 2023, there are six fully operational wind farms with a combined capacity of 158 MW. The country has an estimated project pipeline of more than 14 GW for the period between 2022 to 2035, and the South Korean OFW market represents a sizable portion of OFW activity in the Asia-Pacific region outside of China.

The current permitting process can take between seven to ten years and operators must obtain various licences, such as the EBL, through 29 law and more than ten government organisations. A total of 84 projects representing 27.8 GW have acquired EBLs up to the end of 2023, with the majority of the planned projects located in the areas of South Jeolla province, followed by Busan and Ulsan.[16]

**Exhibit 1: Typical OFW project development process in South Korea**[17]




[9] GWEC , Offshore Wind report 2023. Source: Link
[10] Ørsted, Making Green energy affordable; Source: Link
[11] Higgins, P. and Foley, A., The evolution of offshore wind power in the United Kingdom. Renewable and sustainable energy reviews, 37, pp.599-612. 2014. Source: Link
[12] 4C-Offshore. Accessed: 24 January 2024.
[13] United Nations, Percentage of Total Population Living in Coastal Areas, 2007; Source: Link
[14] MOTIE. Renewable Energy 3020 Implementation Plan. 2017. Source: Link.
[15] MOTIE. 10th Basic Plan for Electricity Supply and Demand Plan. 2023. Source: Link.
[16] The Carbon Trust. Challenges and opportunities for South South Korean offshore wind supply chain. 2023. Source: Link
[17] 4C-Offshore. Accessed: 24 January 2024, Carbon Trust internal research.

To speed up permitting, "The Special Act for Promotion of Offshore Wind Power Development[18]" has been proposed, but a two-year delay in passing this bill to support a move to a government-led development scheme has meant there is still uncertainty about future permitting for projects. The change is expected to simplify the complex permitting process, provide transparency, lower investment risks, and improve government visibility. However, a number of issues around the implementation of the bill still need to be resolved, including further discussion and dialogue with stakeholders from the fishing industries, civil society and government ministries.

As a coastal nation, South Korea has congested waters and must integrate OFW development alongside existing marine activities such as shipping, recreation and a sizable area reserved for national defence purposes. The latest version of South Korea's Maritime Spatial Plan has been in force since 2020. The plan contributes to clarifying the division of marine space into different uses. However, the proportion of energy development zones is low, and adjustments need to be made if South Korea is to meet its OFW target. It is recognised that more dialogue is needed with local communities and fishermen should be involved as early as possible in the planning process to limit future delays.

Offshore wind development support is provided through an RPS (Renewable Portfolio Standards). Large conventional power producers have renewables targets as part of their total power generation and this can be met by purchasing Renewable Energy Certificates (RECs) per MW/h. Different technologies as well as varying locations receive varying levels of REC multipliers and the surcharge is transferred to the consumer market through their electricity bills. Offshore wind has a REC weighting of at least 2.0 and further additions can be given through factors such as if more than 1% of the project is owned by local communities. Previously, a Local Content Requirement rule gave an additional weighting to the REC, but this was removed in 2023 by the Ministry of Trade, Industry and Energy (MOTIE).

[18] South Korea Ministry of Government Legislation. (Accessed 2024, Feb 1) Source: Link.

# OFFSHORE WIND ENERGY BENEFITS TO COASTAL COMMUNITIES

# Offshore wind energy benefits to coastal communities

Offshore wind development can lead to economic, social and environmental benefits at all stages of development – from planning, construction to (O&M) and decommissioning.

We define 'core economic benefits' as the direct, indirect and induced impacts of offshore wind development:

- **Direct impacts:** Employment directly linked to the offshore wind project.
- **Indirect impacts:** Wider supply chain employment and demand for sub-contractor goods and services.
- **Induced impacts:** Economic expenditure relation to retail, hospitality and wider goods and services linked to employment opportunities under direct and indirect impacts.

At a project level and industry level, these core economic benefits are often estimated and reported in terms of gross value add (GVA) or number of full-time equivalent jobs.

With adequate public and private sector support, offshore wind development may also result in certain environmental and social benefits. From an environmental point of view, governments are not only requiring offshore wind developers to monitor and mitigate against negative environmental impacts, but also are incentivising them to contribute to nature recovery efforts. Similarly, both government and industry can develop programmes to ensure new jobs are accessible to a wide population and provide opportunities to those who could transition into the workforce from other industries.

The following sections set out the core economic, environmental and social benefits of offshore wind development in more detail.

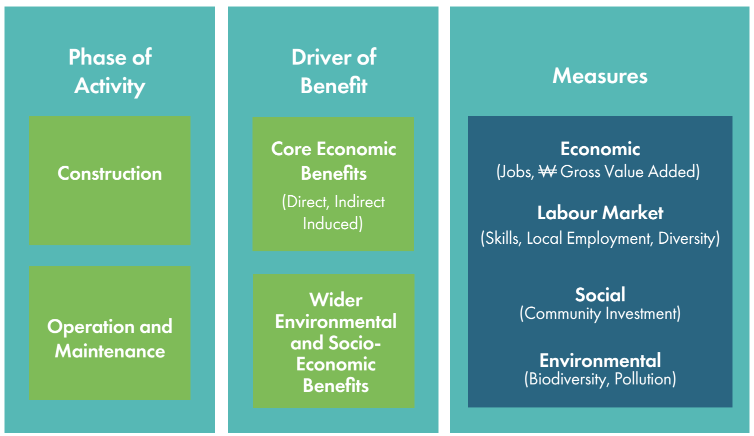
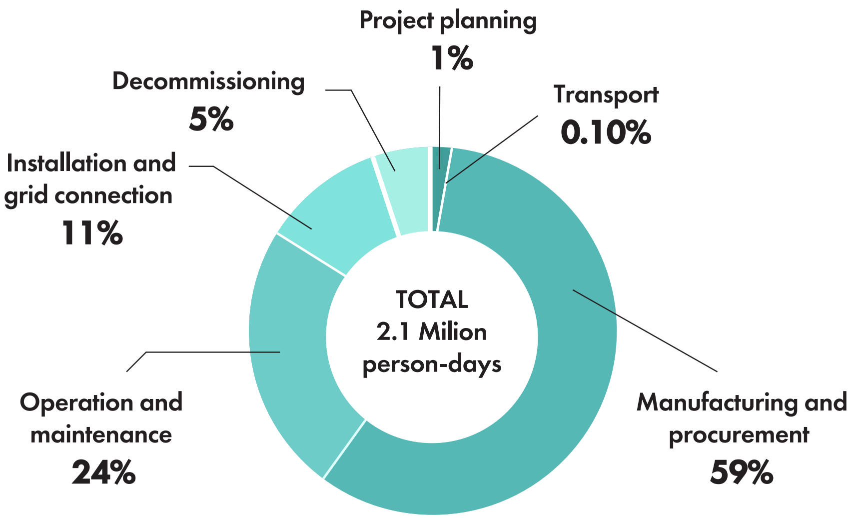



**Exhibit 2: Generalised Social and Economic Benefits of Offshore Wind Development**

# Core economic benefits in each stage of offshore wind development

Offshore wind development requires significant resources, and each new deployment will create new jobs at each stage of the project development process. Exhibit 3 illustrates typical distribution of jobs across the development of an offshore wind farm. The following section will provide an overview of the potential benefits that offshore wind can bring at each stage of development, as well as highlighting the wider economic benefits associated with offshore wind development.

**Distribution of human resources required along the value chain for the development of a 500 MW offshore wind farm**




Source: IRENA

**Exhibit 3: The distribution of human resources required along the value chain to develop a 500 MW offshore wind farm (Rearranged from IRENA)** [19]

[19] IRENA, Renewable Energy Benefits: Leveraging local capacity for Offshore Wind. 2018. Source: Link

## Planning, manufacturing and construction and installation

**Project planning** refers to the early work on site assessment, technical and financial feasibility studies, environmental impact assessments and permit acquisition. Many of the jobs related to the planning stage are temporary and require specific knowledge. As such, large companies often utilise their international workforce to bring experience from completed projects. However, there are opportunities for local employment, particularly as crew for survey work if local mariners are supported to acquire relevant additional permits and qualifications. Additional manual labourer support may be required for any necessary civil engineering work or infrastructure upgrades.

**Manufacturing and construction** of components locally can depend significantly on local content requirements, existing domestic industries and raw materials, the expected pipeline of projects the site can manufacture for, and the ability to address the logistical and costly impact of storing and transporting large components. Most jobs are created at this stage with major components required (e.g. blades, substructures, substations). Employment in manufacturing and construction includes a range of skills from low to highly skilled e.g., for electrical subcomponents. While some of the skills will be difficult to acquire locally, factory jobs can provide significant employment opportunities, and if there is a pipeline of projects it can be cost effective for companies to help support training initiatives including apprenticeships to address the skills shortage. South Korea could utilise existing ports and manufacturing and construction expertise, especially from shipbuilding industries.

**Installation** requires specialised vessels and qualifications. The installation of OFW foundations is a labour-intensive process, requiring trained ship crew and crane operators. Turbines are moved to their designated location by a specialised vessel, set on the foundation, and connected to the grid.

**Offshore cable infrastructure** plays a critical role in offshore wind development and its effective planning is crucial to deliver electricity efficiently and reliably from offshore wind farms to consumers. It is also of relevance to local communities as the development, construction, and maintenance of offshore wind transmission infrastructure create job opportunities for residents. This includes positions in engineering, construction, operations, and maintenance, stimulating economic growth and providing skilled employment opportunities. A good example is the recent £65m investment by JDR Cable Systems in a high voltage subsea cable manufacturing facility in Northumberland which will create 170 jobs in the region and likely serve sites across Europe.[20]

International firms are increasingly investing in training through centres and apprenticeships to train local people.

### Operations and maintenance

The O&M stage has the longest impact on communities, as the average lifespan of an individual OFW farm is 25 years. Local industries can be developed or supported through skilled workers for the wind farms. There are also many low- and medium-skilled jobs (e.g. catering, cleaners, security personnel etc.) created. The creation of O&M training and education centres can support more skilled jobs (see Sections 6.2 and 6.3).

**Table 1: Types of jobs in OFW Development. Source: IRENA (2018); GESI (2022)[21]**

| Value chain | Activity | Jobs |
|---|---|---|
| **Project planning** | Site screening, feasibility study, environmental impact assessment, local community participation, engineering design, and project development | Legal, real estate, and regulatory specialists, financial analysts, marine engineers, environmental and geologists, as well as seafarers |
| **Procurement** | Design specifications, procurement | Procurement specialists, engineers |
| **Manufacturing** | Manufacturing and assembling nacelles, blades, towers, as well as monitoring and control systems | Factory workers, quality control specialists, marketing and sales personnel, engineers, business managers and management executives |
| **Transport** | Parts transport and shipment | Driver, seafarers, and technical staff |
| **Installation** | Preparation of project farms, civil engineering, on-site assembly of parts | Construction workers, technical staff, marine engineers, seafarers, health and safety specialists, logistics and quality specialists |
| **Grid connection and commissioning** | Cable and grid connection, project commissioning | Construction workers, technical staff, engineers, health and safety specialists |
| **Operation and maintenance** | O&M for the project cycle (25 years in general) | Operators, electrical and marine engineers, construction workers, crane operators, seafarers, helicopter pilots, technical staff, lawyers, business managers and management executives |
| **Decommissioning** | Dismantling the project, recycling, disposing of the equipment, and clearing the site | Construction workers, technical staff, drivers, engineers, seafarers, environmental scientists, health and safety specialists |

[20] Business Live, "Contract to build £65m Northumberland factory for JDR Cable Systems agreed," 2018; Source: Link
[21] Green Energy Strategy Institute (2022), Regional Economic Impacts of Offshore Wind Development in South Korea.

To develop a 500 MW offshore wind farm, an estimated 2.1 million direct person-days is required, in addition to indirect or induced jobs related to the economic activity of the wind farm such as hospitality.[22]

# Wider environmental and socio-economic benefits

Over the last several years, there has also been significant effort to address the impacts of offshore wind development on nature and wildlife, as well as ensure that development contributes positively to people and places.

**Environmental benefits**

While any major development will have an impact on natural habitats, governments and industry are increasingly looking at ways to both mitigate impacts and restore habitats. For example, the Netherlands' 2022 auction for the Hollandse Kust West Site VI was based partly on ecological innovation; projects that contributed to innovative nature recovery efforts with widespread applicability across the industry were awarded more points.[23] The selected project, Ecowende, aims to create a new ecological benchmark for offshore wind development, so that projects can have a 'net positive' impact. Ecowende is also testing innovative technologies and approaches, such as special UV paint on turbine blades to make them more visible to birds and a corridor within the wind farm to preserve birds' freedom of movement.[24]

In other cases, project developers can support local environmental efforts to align with their own environmental and social governance (ESG) ambitions. For example, 50% of sea marsh habitats in the UK's Humber Estuary have been lost since the 1900s in part due to local commercial developments and reduction of sand dunes. Ørsted, in line with their goals for net-positive biodiversity impact across new projects before 2030, is working with Yorkshire and Lincolnshire Wildlife Trusts to help with the restoration of the habitat and rewilding for the lost oyster population.[25] Blauwwind is a consortium that developed Borssele III and IV in the Netherlands. The consortium is pursuing specific nature enhancement projects, including an eight-year initiative designed to support the long-term monitoring of oyster field development and survival and growth rate.[26] While these initiatives are important, integrating environmental initiatives into actual offshore wind developments, like Ecowende, are more likely to lead to industry-wide progress.

**Social benefits**

Through specific policies and programmes, government and industry can also ensure that offshore wind development contributes to wider social aims, like the just transition.

The wider offshore wind industry requires specialist skills and knowledge, and collaborations and partnerships have been essential to ensure that the local workforce is able to build this expertise. UK Research and Innovation has funded the partnership between three universities in the Northeast UK – Hull, Durham and Sheffield – and Orsted and Siemens Gamesa Renewable energy to provide students and researchers the opportunity to learn about and support OFW innovation.[27] Some industry leaders have launched their own apprenticeship programs to encourage people without formal qualification or from adjacent industries to develop relevant expertise.[28] Specific mechanisms to support upskilling through education and training are discussed in more detail in Section 5.

Another method of increasing local opportunities is through community benefit funds, which have been set up by developers to support projects and initiatives for communities living closest to wind farms. For example, RWE invested £4.5million in 2022 from their wind energy community funds through 488 separate grants with the priorities chosen by local communities and the funds directly managed by local independent organisations.[29] Similarly, Ørsted have three offshore wind community benefit funds in the UK which are administered by an independent charity, collectively awarding £9.5m to 680 projects improving community and local environments.[30]

**Infrastructure: the role of ports**

Finally, there can be additional social and economic benefits from the wider industrialisation and investment that comes from offshore wind development.

[22] IRENA , Renewable Energy Benefits: Leveraging local capacity for Offshore Wind. 2018. Source: Link
[23] Wind Europe, The Netherlands run another successful auction based on non-price criteria. 2022.Source: Link
[24] Ecowende, "Discover our innovations"; Source: Link
[25] Ørsted, "Wilder Humber: Restoring coastal ecosystems"; Source: Link
[26] Blauwind, "Nature enhancement project"; Source: Link
[27] University of Hull, "Propelling the Future of Offshore Wind"; Source: Link
[28] Ørsted, Economic Impact Study of Ørsted Investments in the Humber region, 2022; Source: Link
[29] RWE, "RWE puts UK communities first with £4.5 million funding in 2022"; Source: Link
[30] Ørsted, "Community grants"; Source: Link

OFW ports are key to offshore wind projects by providing a local, cost-effective location for planning, manufacture, installation, and decommissioning capabilities.[31] Designing port infrastructure to support the expected project pipeline is vital to ensure the laydown and quayside is large enough to accommodate the vessels and constructed components. Requirements differ between floating and fixed operations and therefore the associated investment in port upgrades and refurbishment may depend on the local strategy. In the UK, policies such as the 2023 announcement for the Floating Offshore Wind Manufacturing Investment Scheme will provide up to £160 million in grants to upgrade critical infrastructure and help increase the floating offshore wind supply chain.[32]

In many cases brownfield, or existing industrial sites, offer great potential for redevelopment as they are often strategically valuable and well located.[34] The sites can often be a priority site for planners, but the redevelopment is often reliant on funding for regeneration and local policy. As offshore wind is deployed globally, and the size of the industry is increasing, there is a focus on planning and assessment procedures before any consent is granted; this often includes an Environmental Impact Assessment (EIA) to consider the biophysical, socio-economic, and other effects of a development proposal.[33]

There are also opportunities for ports to focus on O&M activities. These ports typically require less investment to upgrade their facilities and their proximity to windfarms is the most significant factor in their selection. The number of jobs and scale of investment in local communities varies, for example, the Port of Tyne in the UK operates the O&M base for the 3.6 GW Dogger Bank Wind Farm which has specifically created 400 long-term O&M jobs and over 50% of the investment to build the base was in local companies.[34] In France, the construction of O&M facilities for the 500 MW Fécamp offshore wind farm will create 100 long-term jobs with EDF Renouvelables utilising the port for the lifespan of the wind farm, having used local companies from the Normandy region for 70% of the construction.[35]

Ports typically form a critical part of offshore wind cluster development and create economic benefits for the local region through the concentration of OFW related companies, suppliers, and supporting institutions. Bringing together manufacturers, service providers, and technology developers in proximity, clusters encourage collaboration and coordination, leading to a more integrated and streamlined supply chain and allow for knowledge sharing and collaboration. Hence, investment and consistent policy support in catalysing a cluster can be effective to stimulate local growth and job creation.

Nevertheless, the associated costs that come with cluster formation and port upgrades are significant and therefore need to be considered carefully by decision-makers to ensure that long-term local stimuli are created. Conducting a thorough analysis to determine where the need, benefit, and impact are likely to be the greatest within any given region is imperative.

[31] QBIS, Sylvest T. Socio-economic impact study of offshore wind, 2020; Source: Link.
[32] UK Government, Floating Offshore Wind Manufacturing Investment Scheme. 2023. Source: Link
[33] Glasson J, Durning B, Olorundami T and Welch K., 2020. Guidance on assessing the socio-economic impacts of offshore wind farms (OWFs). RADAR Institutional repository of Oxford Brookes University. Source: Link.
[34] Dogger Bank, "Dogger Bank Wind Farm welcomes local supply chain to Port of Tyne", 2022; Source: Link
[35] Offshorewindbiz, "EDF opens Fecamp Operations and Maintenance Base in France", 2022; Source: Link

### Status and opportunity for South Korean ports

The ports in South Korea are planned and managed by the Ministry of Oceans and Fisheries (MOF) and categorised into trade ports and coastal ports. As of 2023, of the total 62 ports in South Korea 31 are international trading ports. Among the 31 international trading ports, 14 are constructed and operated by MOF, and the rest are constructed by MOF but operated by municipal governments.[36] In the case of coastal and local ports, there are 12 ports constructed and operated by MOF and 19 ports constructed by MOF and operated by municipal governments. Ports in South Korea are intricately connected to local communities as they often include or are in proximity to the 20 out of 44 total industrial complexes.

According to the 4th National Port Plan for South Korea, the South Korean government aims to prepare ports under the increasing demand for digital technologies for cargo management and sustainable development through co-development with local communities. Major plans include diversifying port functions, establishing smart ports with the latest and sustainable technologies and establishing specialised ports for cargo and services.


**Exhibit 4: Map of National Ports. Source: Operation Authority**

**Table 2: Specifications for International Trading Ports in South Korea (Operated by MOF). Source: MOF (2020)[37]**

| Ports | Quay Length (m) | Capacity (# of ship) | Laydown Area (m²) | Laydown Area Capacity (tonnes) |
|---|---|---|---|---|
| Incheon | 26,736 | 125 | 3,672,346 | 9,694,993 |
| Gyeongin | 2,300 | 20 | 88,330 | 17,183,000 |
| Pyeongtaek-Dangjin | 14,424 | 64 | 2,313,295 | 6,940,645 |
| Daesan | 8,144 | 33 | 98,609 | 579,034 |
| Janghang | 330 | 2 | 1,535 | 124,605 |
| Gunsan | 7,806 | 39 | 1,446,021 | 4,991,310 |
| Mokpo | 5,999 | 28 | 49,422 | 2,931,730 |
| Yeosu | 692 | 2 | - | - |
| Gwangyang | 25,525 | 108 | 1,998,549 | 3,997,097 |
| Masan | 6,824 | 29 | 666,653 | 1,999,959 |
| Busan | 32,561 | 163 | 2,987,697 | 19,243,865 |
| Ulsan | 20,521 | 116 | 1,223,811 | 3,630,856 |
| Pohang | 12,032 | 51 | 1,406,915 | 4,615,964 |
| Donghae-Mukho | 4,477 | 23 | 190,970 | 597,260 |

[36] Song, D.W. and Lee, S.W., 2017. Port governance in South Korea: revisited. Research in Transportation Business & Management, 22, pp.27-37. Source: Link.
[37] MOF. (2020). The 4th National Port Plan (2021-2030); Source: Link

# ECONOMETRIC ANALYSIS

# Econometric Analysis

An Input-Output (I-O) analysis is used in this report to estimate the economic multiplier effect. The underlying assumption of IO analysis states that intermediate goods used in producing final goods are interconnected, creating impacts on production, value-added, and employment. OFW has a sizable economic impact due to a value chain that spans diverse industries such as construction, electrical, machinery, steel making, shipbuilding, etc.

This chapter analyses the value chain of developing OFW projects during the construction and operations and maintenance (O&M) phases, estimates the cost for each phase, and derives and applies coefficients for value-added and employment using the national input-output (IO) table released by the Bank of South Korea.[38] We use the terms "CapEx" for the construction phase (all costs incurred until commercial operations begins) and OpEx for the O&M phase.

The structure for estimating the economic multiplier effect in this study is shown in Exhibit 5 below.

**Cost Break Down of CapEx and OpEx**

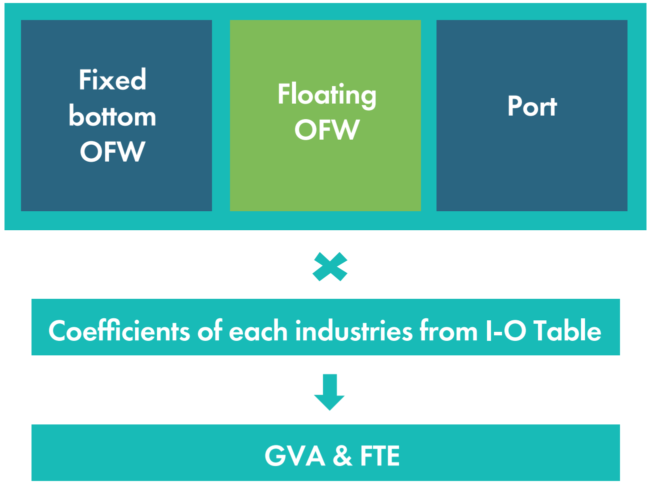



**Exhibit 5: Structure for the Cost break down of CapEx and OpEx**

[38] Bank of South Korea. (2019). Source: Link.

# Capital cost break down

## OFW farm (fixed and floating)

When compared with the fixed bottom offshore wind, floating OFW shows a reduced share of turbines in the CAPEX and, instead, shows an increase in the costs for installing substructures. This results from relatively higher installation costs of floating OFW from affixing floating bodies to the seabed with depths exceeding 60m.

**Table 3. Estimates of total investment required for wind in South Korea (KRW) Source: NREL (2021)**[40]

| Category | Fixed | Floating | Total |
|---|---|---|---|
| Capacity (MW, estimate) | 8,800 | 5,500 | 14,300 |
| Unit cost (/kW) | 6,673,176 | 9,614,891 | - |
| Total investment (KRW million) | 58,723,949 | 52,881,901 | 111,605,849 |
| Total investment (USD)[39] | 45,080.538 | 40,609.371 | 85,735.95 |

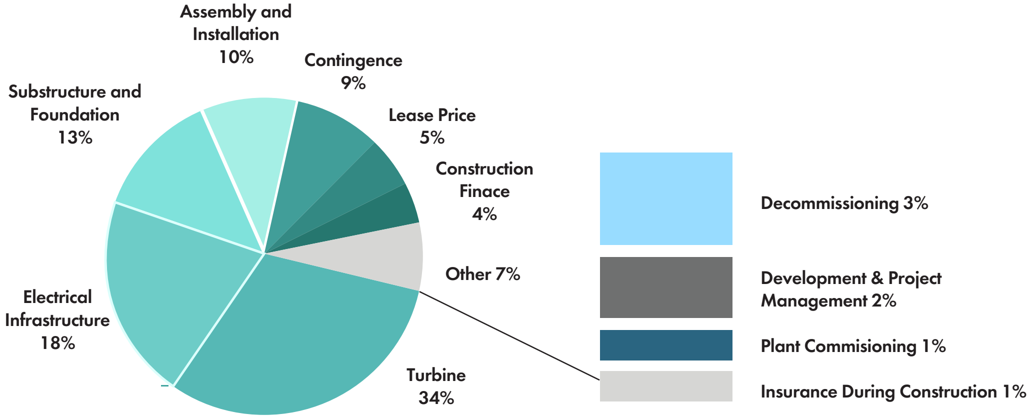



**Exhibit 6: Share of Supply Chain Components in Investment (Fixed Bottom OFW)**

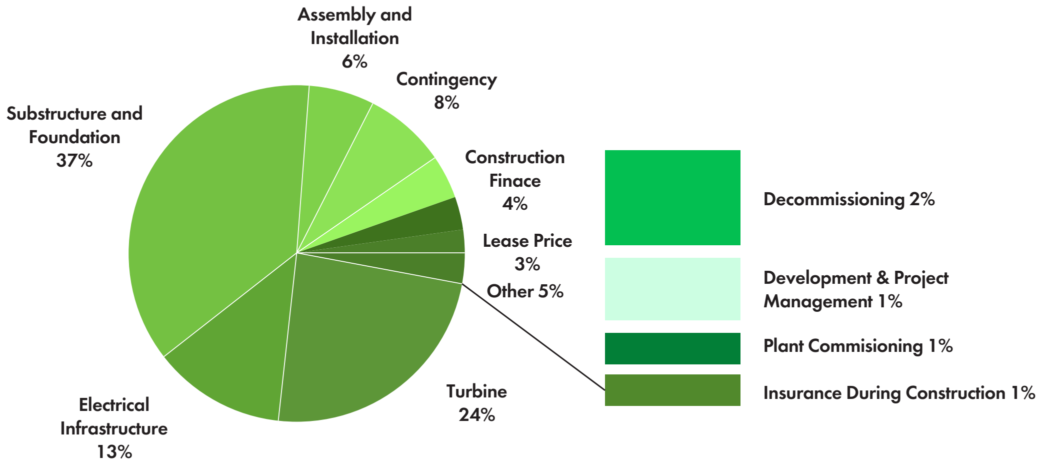



**Exhibit 7: Share of Supply Chain Components in Investment (Floating OFW). Rearranged from NREL (2023)**[41]

Globally, over the past 1-2 years, the investment cost has risen 30% due to the global supply chain bottlenecks resulting from macroeconomic effects. However, these costs will likely decrease with the learning curve.[42] Inflationary pressures in South Korea could also lead to an increase in unit costs of both fixed and floating OFW.

[39] Currency Rate used:1 KRW = 0.000765534 USD / USD = 1,306.28 KRW.
[40] Stehly, T., & Duffy, P. 2021. 2020 cost of wind energy review (No. NREL/TP-5000-81209). National Renewable Energy Lab.(NREL), Golden, CO (United States). Source: Link.
[41] Shields, M., Stefek, J., Oteri, F., Kreider, M., Gill, E., Maniak, S., ... & Hines, E. (2023). A Supply Chain Road Map for Offshore Wind Energy in the United States (No. NRELTP-5000-84710). Source: Link.
[42] DNV. (2022). Floating wind: The power to commercialize. Source: Link.

## Port

The cost of constructing dedicated ports for OFW power generation is challenging to ascertain through project-specific empirical data. In the analysis of port development, we have relied on research findings related to harbour construction in South Korea and the United States, as well as CAPEX in Taiwan, generating assumptions for various scenarios.[43]

Based on these data, the cost range for the construction of dedicated ports for OFW for this research is approximated, and the results are summarised in the table below. As depicted in the table, the cost of constructing dedicated ports for a 14.3 GW offshore wind power complex is anticipated to range between a minimum of USD 1,866.6 million and a maximum of USD 4,548.6 million. For simplicity, the case 2, based on South Korean data, was chosen for the analysis.

| Category | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Total Investment (USD million) | 1,866.62 | 4,372.90 | 3,807.28 | 4,548.57 |

**Case 1.** Constitutes 2. 10% of the total project cost (South Korea)
**Case 2.** Constitutes 5. 20% of the total project cost (South Korea)
**Case 3.** Based on the estimated cose of port construction required for eveloping 30GW of OFW by 2030(US) The ratio for port construction and manufacturing specialized vessels is 70:30(%)
**Case 4**. Based on the cost of the maintenance and expansion of Taichung Port (Taiwan)

Like the OFW cost breakdown, the estimation of the economic multiplier effect from the construction of the port and hinterland for OFW projects was also done by dividing estimates for existing port CAPEX according to the supply chain.[44] In this analysis, costs were estimated based on the estimated share out of the total project budget while referring to known costs and shares out of the total project budget from the US and Taiwan. O&M of ports is marginal at only around 2-4% of the total investment cost for OFW. Therefore, the economic multiplier effect focuses mainly on construction costs.

The composition of the CAPEX for port construction is based on each component's cost structure for port development from KDI (2021) "Preliminary Feasibility Report for Busan New Port 2".[41] However, the sectoral assignment of each constituent cost to industries was based on the research team's independent judgment and independent of the Preliminary Feasibility Study Report.

According to the Preliminary Feasibility Study, the CAPEX in the construction of Busan New Port is estimated to be USD 7.013 billion (KRW 9.1342 trillion). The cost structure is primarily classified into Construction costs, Facility auxiliary costs, Compensations for Fisheries Rights, and contingencies. Construction costs have approximately 72% share of the CAPEX and consist mainly of costs for civil engineering except for a small amount assigned to Electrical constructions. Supply chain analysis, as done for OFW cost breakdown, was not conducted for the analysis of port construction. Therefore, more in-depth cost analysis was not addressed in this study, which poses limitations for the analysis of economic effects.

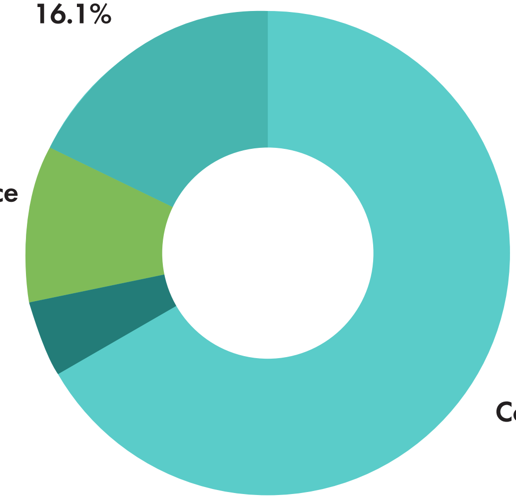


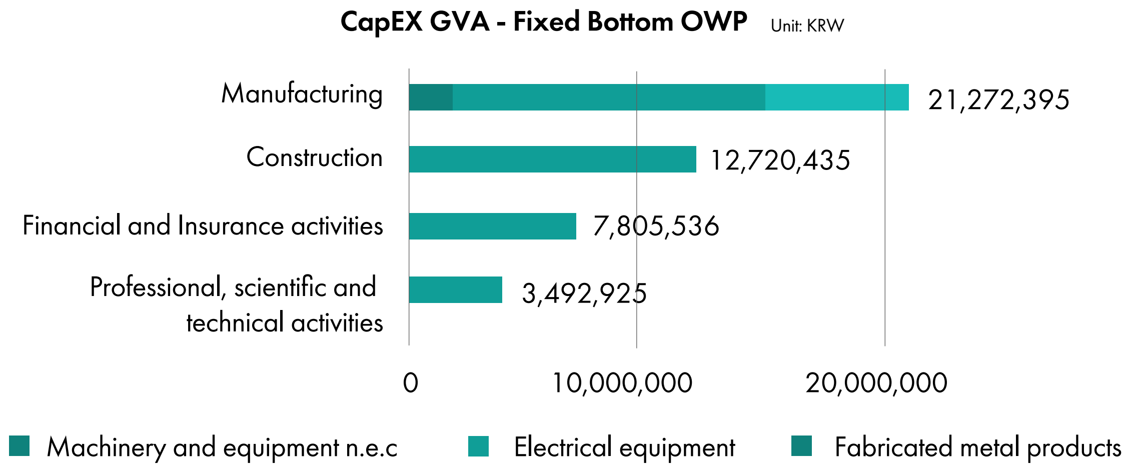

**Exhibit 8: Cost Breakdown of Port Construction Cost (%)**

[41] Shields, M., Stefek, J., Oteri, F., Kreider, M., Gill, E., Maniak, S., ... & Hines, E. (2023). A Supply Chain Road Map for Offshore Wind Energy in the United States (No. NRELTP-5000-84710). Source: Link.
[43] Lee et al. (2019). "Strategy to Utilize Ports and Hinterland Complexes for the Development of OFW Clusters."
[44] KDI. (2021). Preliminary Feasibility Report for Busan New Port 2.

# Results

### OFW farm (fixed and floating)

The following section is split into gross value-added effects and estimated job creation for CapEx and OPEX components in relation to 14.3 GW capacity from 2023 to 2030. It is unlikely that the total 14.3 GW pipeline will be achieved and generating by 2030. However, the analysis is simplified to give an indication of potential economic benefits associated with OFW in South Korea. As there is still uncertainty over the timeline for development and construction, the analysis assumes a 7-year development phase, with the multiplier effect from O&M coming into effect from 2030. In addition, inflation and future discount rates are not considered, and the total 8-year period is treated as a single time frame.



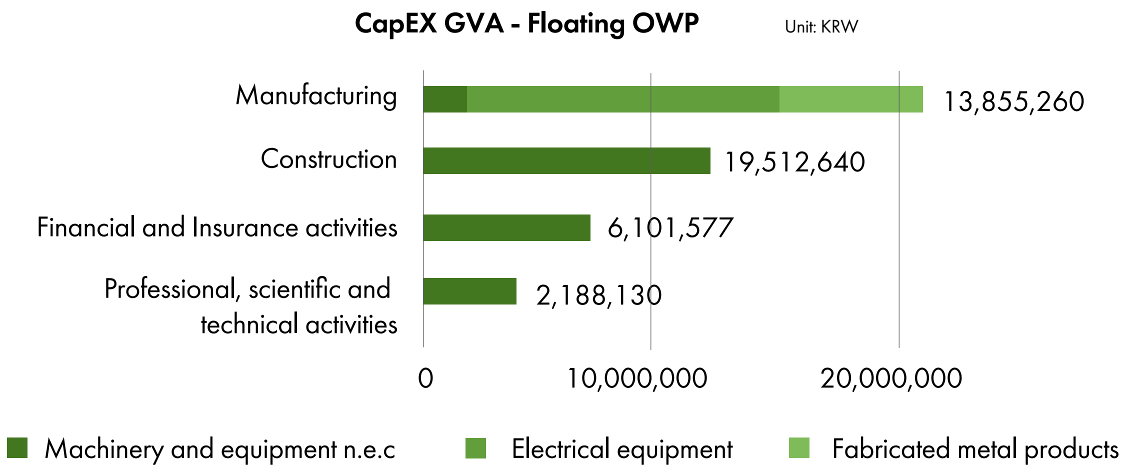




**Exhibit 9: Gross Value-added for CapEx**

Assuming that by 2030, a total of 14.3 GW of OFW farms will be constructed, the gross value-added effect for a fixed OFW is approximately 45.3 trillion won for 7 years, and a floating OFW is around 41.7 trillion won (Exhibit 9). The gross value added during the construction phase is the highest in the manufacturing sector for fixed bottom OFW, followed by construction, financial and insurance, and professional, scientific, and technical activities.

For floating OFW, the construction sector had the most signicant effect, followed by manufacturing, financial and insurance, and professional, scientific, and technical activities. The split among these professions, and thus the GVA, may change as floating technologies become better understood.

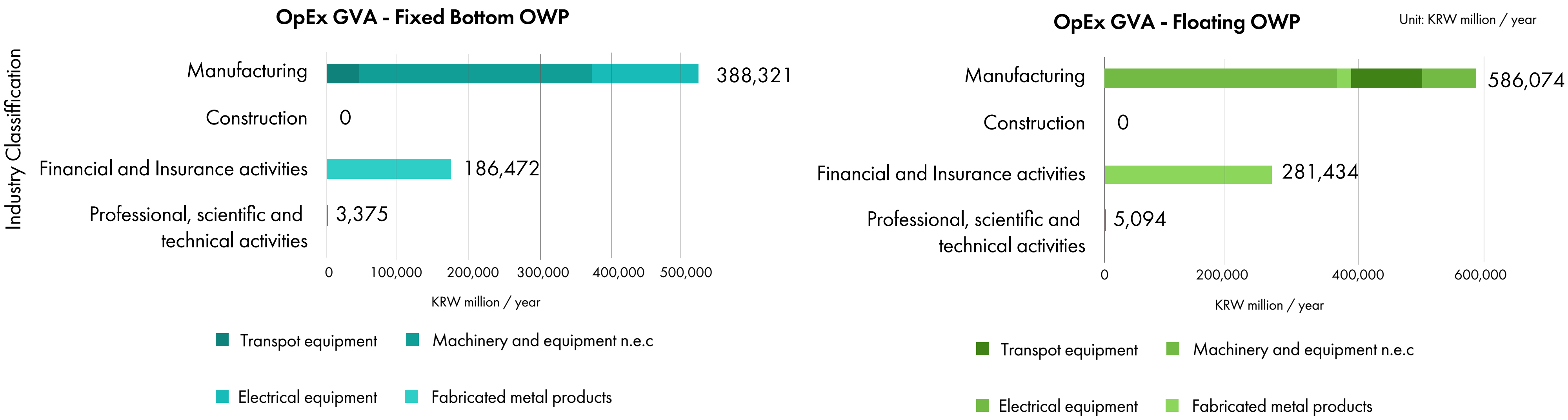



**Exhibit 10: Gross Value-added for OpEx**

During the O&M phase, 87.26 billion won for a fixed bottom for one year and 57.82 billion won worth of gross value-added effect can be estimated (Exhibit 10). In this study, the value-added effect was analysed from 2023 to 2030. The figure above illustrates the value-added effect of the O&M for 2030 alone. The reason for relatively lower value-added effects in the floating OFW case is attributed to the assumed capacities of the commercially operating OFW farms, which are 8.8 GW and 5.5 GW, respectively, with floating OFW being lower in the total capacity.

The gross value added is estimated to mainly come from manufacturing, financial, and insurance activities in both fixed bottom and floating. In other words, constant maintenance during the O&M phase continues to create demands in the manufacturing sector, with constant work demands for financial and insurance-related services.

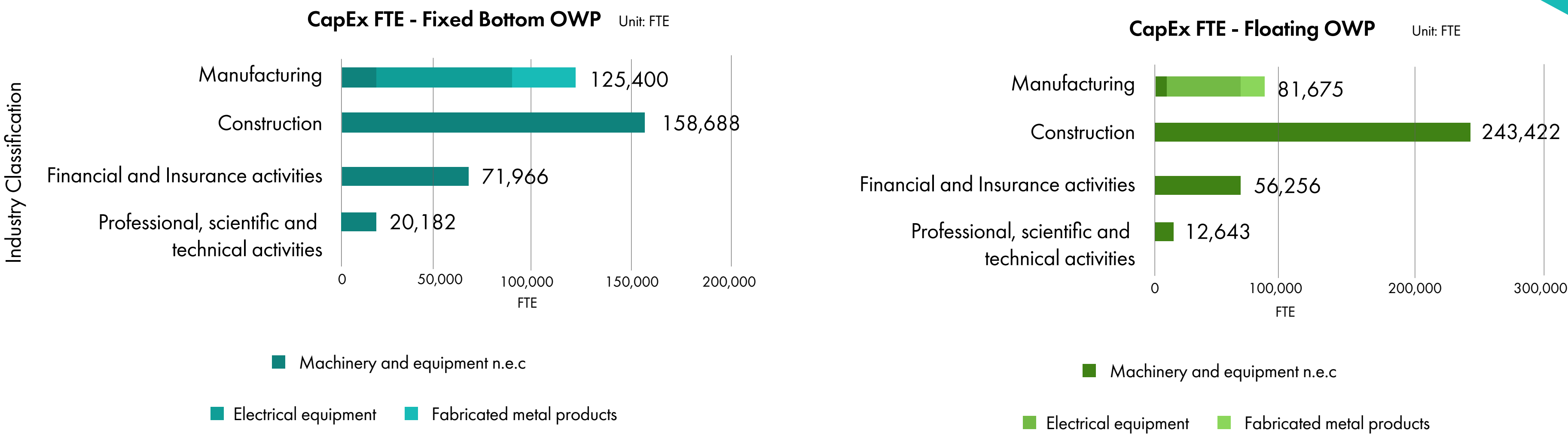



**Exhibit 11: Full-Time Employment for CAPEX**

The full-time equivalent employment effect for the fixed bottom is around 376.2 thousand FTE; for floating, it is around 394 thousand FTE for the entire construction phase (Exhibit 11). According to CAPEX, the job creation effect is expected to be 376,200 jobs in fixed OFW and 394,000 jobs in floating OFW. This is due mainly to the fact that floating OFW creates more employment in the construction sector. By sector, fixed OFW creates approximately 159,000 jobs in the construction sector and 125,000 jobs in the manufacturing sector, while floating OFW creates approximately 243,000 jobs in the construction sector and approximately 82,000 jobs in the manufacturing sector.

On the other hand, significant job creation is also expected in the financial and insurance sectors and professional, scientific, and technical sectors. The main reason for the prominent job creation effect from the construction sector in floating OFW is that while the demand for manufacturing, finance, specialised science, and technology is mainly prop ortional to the capacity of the OFW farm, the overall project cost is more considerable in flowing OFW. Simply put, floating OFW is expected to create more jobs during the construction period compared to the fixed OFW. It is difficult to conclude that these newly created jobs will only be short-term, as constructing OFW requires a higher skill level than low-skill level workers generally employed.

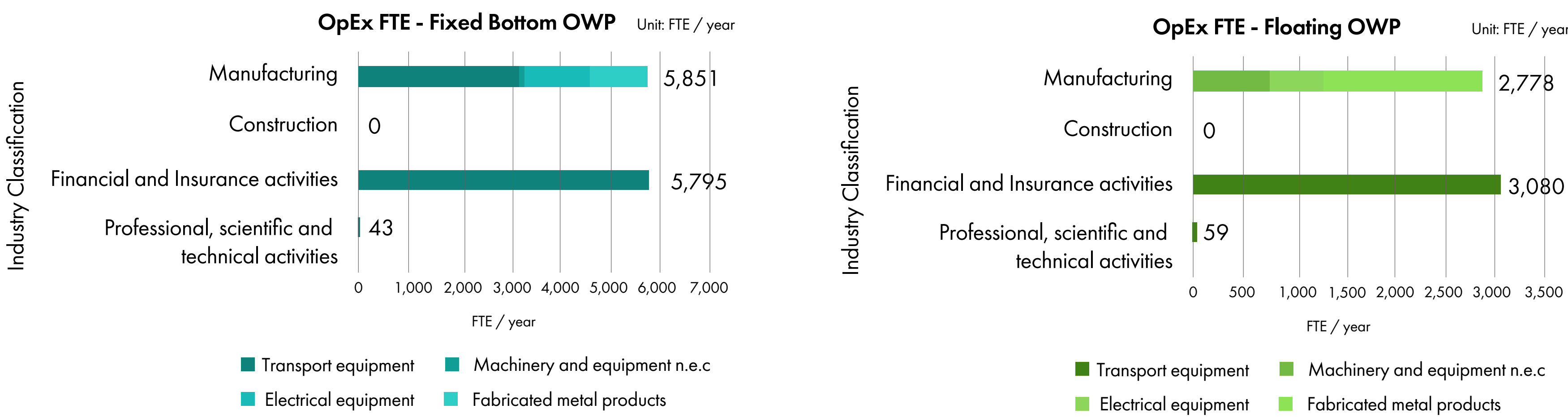



**Exhibit 12: Full-Time Employment for OpEx**

For the O&M phase, for the year of 2030 alone, it is estimated that 11,689 FTEs can be created annually in fixed bottom OFW, while there is estimated to be 5,917 FTEs in floating wind (Exhibit 12). It is expected that there will be demands for key components and materials during operation and maintenance which contribute to around half of the total FTE to the manufacturing sector. Rest of the job creation effect occur in the financial and insurance sectors and professional, scientific, and technical sectors with the former consisting of the majority of jobs created.

**Ports**

The economic multiplier effects that occur through port construction and O&M mainly occur during construction. According to the Busan New Port preliminary feasibility report, the total operating cost constitutes about 3% of the investment cost, with the operational period estimated to be 25 years. Based on these findings, the value-added and job creation effects of operation compared to the investment cost are relatively small. Therefore, this study analysed the economic multiplier effects of port investment and operation with a focus on investment costs. The construction of an OFW port can be diverse, such as renovating or expanding an existing port or creating an entirely new one, but a specific approach is not specified in this study.

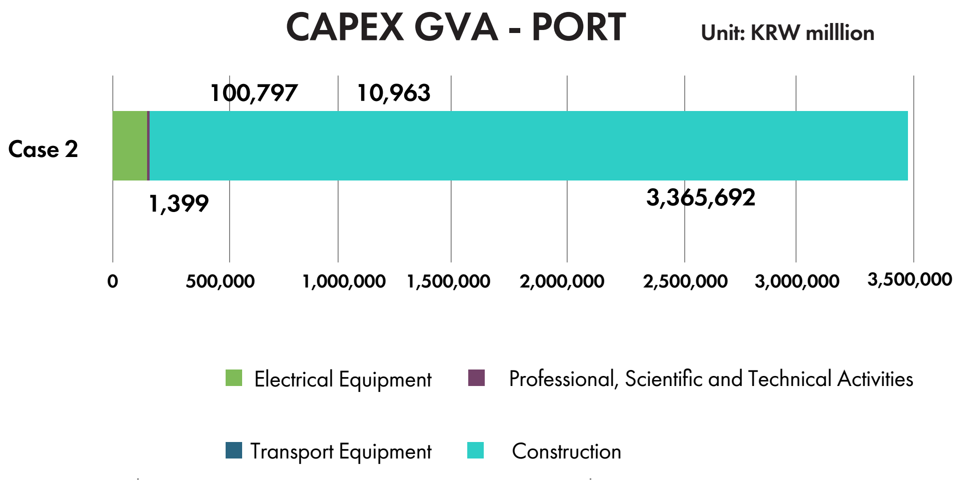



**Exhibit 13: CAPEX GVA – Port**

As seen in Exhibit 13, the total port investment cost for 14.3 GW can be seen as approximately KRW 5,691,89 million (435.7M USD). The value added from port CAPEX is estimated at KRW 3,478,851 (2,663.1M USD).

When linking port construction with industry, the most significant relevance can be found in the construction sector, followed by electrical equipment, professional science and technology, and transport equipment. Depending on the investment cost size, the construction result appears to exceed 95% of the total value-added effect.

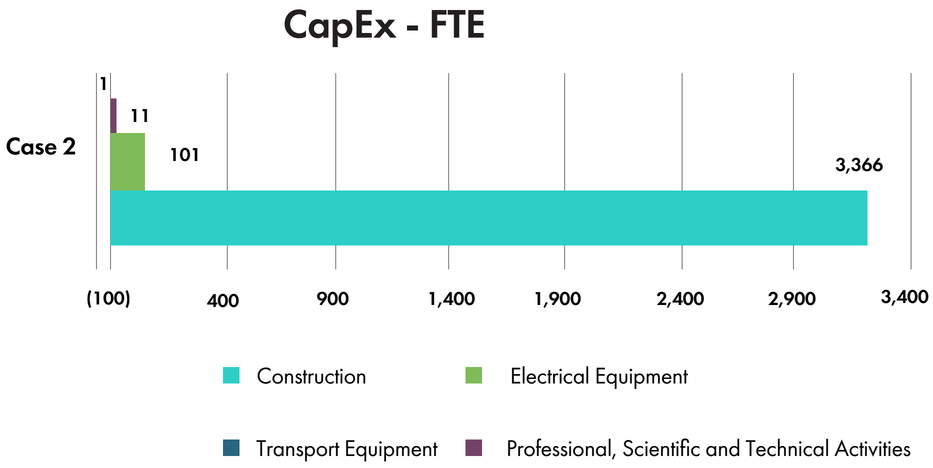



**Exhibit 14: CAPEX - FTE**

The expected job creation effect from port construction is estimated to be 3,479 people during the construction period (Exhibit 14). Most jobs are expected to occur in the construction sector followed by the electrical equipment; professional, scientific and technical activities; and transport equipment sector. Converting this to the annual average of the construction period, it can be seen as approximately 700 people.

# ENSURING OFFSHORE WIND DEVELOPMENT SUPPORTS COASTAL COMMUNITIES: LESSONS LEARNT AND BEST PRACTICES

# Ensuring offshore wind development supports coastal communities: lessons learnt and best practices

While many ports and coastal communities globally are thriving, there are often some communities that have not yet shared in this development. Smaller coastal communities are often defined by slower economic growth than those located either inland or around larger port and marine industries. Many coastal industries, like tourism, are seasonal, which deflates average wages and investment over the course of the year. Declines in traditional industries such as fishing and local shipbuilding, as well as a growth in affordable foreign holidays, have contributed to reduced investment. As a result, many coastal areas can have poor infrastructure and transport links, as well as outward migration of younger people. This geographic isolation and changing population dynamic further contributes to stagnation of the local economy.[45]

Coastal regeneration describes the various efforts that can be taken to restore the economic, social and environmental characteristics of coastal communities. In 2010, the Coastal Community Alliance, a non-profit organisation based in the UK, asserted that coastal regeneration means more than just the creation of new jobs. Instead, the term signifies 'giving a new, fresh lease on life to something that is already there.[46] In this sense, coastal regeneration involves revitalising all of the aspects that make a coastal community unique. For example, coastal regeneration initiatives must not only consider the underlying challenges of economic deprivation, but also explore economic diversification; restore physical assets (for instance, built assets like ports and manufacturing sites, and natural assets like sand dunes); and support aspects that contribute to the social fabric of a particular place, such as social cohesion, historic and culture heritage and quality of life.[47]

The various benefits of offshore wind development, with the right support from government and industry, could help support coastal regeneration efforts. In Europe, coastal economies have benefitted from the positive economic impact of offshore wind in locations where the oil and gas sector previously provided a significant number of jobs. For example, in Denmark, the Port of Esbjerg had already transitioned from a key fishing port to one that serves the oil and gas industry with several major companies based in the area. Since 2000, as the offshore wind sector began to grow, the port has managed to capitalise on the existing infrastructure, provide additional investment and house companies across the entire offshore wind value chain.

Ensuring that local communities benefit from offshore wind development requires a collaborative approach between industry and government. Government policies should provide a supportive framework and pipeline of projects to encourage private investment into large infrastructure projects. These in turn, can support high quality, long-term, and diverse jobs with additional benefits through industry programmes such as community funds and environmental restoration. The long-term success of coastal regeneration activities also depends on the extent to which local industries, such as construction, oil and gas and fishing, can collaborate and adapt to the needs of the offshore wind sector.

There is often a trade-off balance between low-cost development and local investment. The cost of offshore wind development has decreased significantly over the past several years as a result of technological innovation, economies of scale and interaction between the local and global supply chain. In short, some services will be most efficiently delivered locally and in the country of development, and others may be delivered more competitively elsewhere.[48]

Despite this necessary tension between local and global, there are three main mechanisms that government and industry can employ to ensure that offshore wind development leads to economic, social and environmental benefits in local, coastal communities, and supports coastal regeneration overall.

The primary mechanisms for supporting coastal regeneration through offshore wind development discussed in this report are:

- **Revitalisation of existing assets**
- **Development of clusters to support innovation and efficiency**
- **Technical upskilling through dedicated education and training efforts**

[45] House of Commons Library, The future of Coastal Communities, 2022; Source: Link.
[46] Walton, J.K. and Browne, P. eds., 2010. Coastal Regeneration in English Resorts-2010. Coastal Communities Alliance; Source: Link
[47] UN Habitat, "Urban Regeneration"; Source: Link
[48] World Bank, Key Factors for Successful Offshore Wind Development in Emerging Markets, 2021; Source: Link

Revitalising existing infrastructure, and particularly ports, will be essential to support most offshore wind development. The Port of Esbjerg in Denmark is one example of port regeneration; formerly used exclusively to support oil and gas development. Today, it serves as one of the primary ports for offshore wind development in the North Sea. The Port of Taichung, Taiwan was transformed by foreign international investment and today has become similarly crucial for offshore wind development in the Asia-Pacific region. Similar regeneration approaches could be applied to South Korea's Mokpo port, which, given its geographic location, has the potential to service major offshore wind development in South Korea and the wider region.

Developing clusters – place-based collaboration between government, industry and academia – could also support the development of the local offshore wind supply chain in a region with maritime heritage. While there are multiple examples of successful cluster models around the world, the UK's Humber Cluster now supports over one third of the UK's current offshore wind capacity.[49] This report will examine the development of the Humber Cluster to provide recommendations for Icheon city and Gusan City in South Korea, which are similarly well located and connected to support wider industry development regionally and nationally.

Finally, upgrading existing assets and developing clusters both require people with specialist and technical skills. Governments and industry will have to work together to ensure that the local workforce is duly supported to participate in the just transition. This in turn, can lead to less risk and greater confidence in a given offshore wind market.

## Revitalising ports and other existing assets

Commercial-scale deployment of offshore wind, and in particular, floating offshore wind, will require significant port upgrades. Revitalising ports and surrounding brownfield sites requires collaboration between port authorities and industry and governments. Following restoration, ports can support the regional offshore wind supply chain, in turn becoming a hub for development and increased economic productivity.

This section highlights the redevelopment efforts associated with the Port of Esbjerg and the Port of Taichung, and outlines the factors which have contributed to their overall success. In South Korea, Mokpo and Sinan is a region that has been identified as a potential location for a new offshore wind port, which is well placed to service OFW development in South Korea.

[49] Green Port Hull, "Humber Offshore Wind Cluster"; Source: Link

Case study: Port of Esbjerg, Denmark

## CASE STUDY | Port of Esbjerg
### Key information

A market leader with 22 GW of OFW shipped from Esbjerg since 2001, accounting for 80% of Europe's installed capacity.

**Location:** Esbjerg, Denmark

**Size of Port:** 4.5m $sqm^2$

**OFW energy:** Supplies 4.9 GW of OFW energy

**Revenue:** €29.1m in 2022[50]

**Regional strengths:** Well-located along the Danish Coast to service OFW sites in the North Sea

**Supply Chain:** 200+ companies with 10,000 employees across entire wind value chain, e.g., R&D, manufacturing, transport, pre-assembly, installation, and maintenance

**Owner:** Self-governing port owned by Municipality of Esbjerg since 2000

Historically, the port was a fishing port and served the O&G industry from the 1970s. As a first mover in the European offshore wind industry in the early 2000s and its convenient location on the Danish coast, the Port of Esbjerg secured itself a key market position as the leading offshore wind port in Europe serving over 55 offshore wind projects (see Exhibit 15).

To meet the demand of the growing offshore wind industry, the port has expanded and invested 1 billion Danish Krones between 2004 and 2013 (approximately USD 170 million at the time) in new areas and facilities that support the wind value chain.[51] It diversified its service capabilities away from O&G towards renewable energy, resulting in a decline in revenue from O&G related activities which accounted for only 10% of total revenue in 2015 compared to 25% of revenue from OFW related activities.[52]

**Exhibit 15: Port of Esbjerg**

The key competitive advantage of the Port of Esbjerg is its link between production facilities in Northern Europe and offshore wind sites in the North Sea and surrounding waters. Leveraging this potential, its diversification towards OFW had a significant impact on the local supply chain, with more than 200 companies affiliated with the port operations that account for over 10,000 employees across the value chain in R&D, manufacturing, transport, pre-assembly, installation as well as maintenance of the offshore wind farms.[53]

[50] Port of Esbjerg, Annual Report, 2022; Source: Link
[51] Port Esbjerg, "History"; Source: Link
[52] Qbis, Socio-economic impacts of offshore wind, 2020; Source: Link
[53] State of Green, "Port of Esbjerg: World's largest base port for offshore wind activities", 2022; Source: Link

## Impact on local industry and investment

The port continues to attract investment for continuous improvement and upgrades for future technology challenges from both public and private investors. A few notable examples of investment into the Port of Esbjerg:

- In 2023 the Port was chosen as a NATO maritime hub and received a grant of over €28m from the **European Commission and the European Union's (EU) Connecting Europe Facility (CEF)** to make upgrades to its infrastructure and expand by 570.000 sqm². Furthermore, its fairway will be deepened by 12.8m by 2024 to allow for bigger installation vessels to use Esbjerg as a pre-assembly and service port for the new generation of larger offshore wind turbines.[54]

- **PensionDanmark** has made a significant investment of around €940m in 2023 for construction facilities to alleviate the pressure on the supply chain and limit bottlenecks in the North Sea to establish 134 GW by 2034.

- The Swedish investment fund **Infranode** confirmed the gradual investment of up to €145m in port facilities at Esbjerg for storage, re-assembly, and manufacturing of offshore wind components in 2020 to create green jobs in Denmark and the Nordic region.[55]

Both local supply chains and the labour market have benefitted from the transition from traditional O&G services to a focus on renewable energy that has as a result facilitated significant investment in the region. While it is difficult to fully quantify the wider economic impact and regional Gross Value Added (GVA) over the years, a rule of thumb can be applied with an average of £0.1-0.5m of regional GVA per MW of OFW developed.[56] In the scenario of Port of Esbjerg where 22GW have been shipped to the North Sea, this would result in a GVA estimated between the range of £2.2m and £11m over the last two decades.

[54] Project Cargo Journal, "EU awards major grant to Port Esbjerg, 2023"' Source: Link
[55] OE, "Infranode to Invest Up to €145m in Port Esbjerg's Offshore Wind Facilities", 2020; Source: Link
[56] Vattenfall, Guidance on assessing the socio-economic impact of offshore wind farms (OWFs), 2020; Source:Link

## CASE STUDY | Port of Taichung
### Key information

The largest port in Taiwan acting as a free-trade zone and attracting large international companies looking to build-out offshore wind.

**Location:** Wuqi District, Taichung, Taiwan

**Size of Port:** 40 km$^2$

**OFW energy:** Supplies 4.9 GW of OFW energy

**Regional strengths:** The free-trade zone leads to reduced production costs and increase GVA and attract further business to the port. There has been significant investment into the port's infrastructure to accommodate OFW deployment.

**Investment:** NT$458bn by 59 companies (2010)[57]

**Supply Chain:** 100 firms with established operations in the port and free-trade zone (2023)[58]

**Owner:** Taiwan International Ports Corporation, state-owned shipping company

The Port of Taichung was opened in 1976 as part of the Taiwanese Ten Major Construction Projects following the 1973 oil crisis. Upgrading key infrastructure for the future economic modernisation of Taiwan ultimately attracted foreign investment, the government additionally invested NT$300bn (~£8bn) into these projects.[59]

Currently, the Port of Taichung is the largest of Taiwan's four international commercial ports and contains 50 wharves, 16 specialised zones, and three free-trade zones. The introduction of free-trade zones has led to reduced customs intervention, extensive processing capabilities, a bonded system, tax incentives, streamlined administrative requirements, and relaxed labour restrictions. The free-trade zones and their benefits contribute to reductions in transaction and production costs for companies, attracting investment as it enables generation of greater added value and the opportunity to explore more diversified business models. The Port of Taichung is closely working with local authorities to establish collaborations with science-based parks, industrial parks, and value-add services in the region to facilitate innovation to maximise economic benefit.[60]

Its innovation-driven approach reflects the Port of Taichung's commitment to the expansion of renewable energy. Over the last few years, Taiwan International Ports Corporation (TIPC) allocated NT$3.5bn (approximately USD 110 million) to expand the port by two new heavy lift wharves for turbine assembly to support the work on offshore wind farms off Taiwan's coast to meet Taiwan's national goal of generating 5.7 GW of OFW by 2025.[61]

The facilities available at the port to support offshore wind development include turbine manufacturing, OWP backup land, import and export areas for turbine components and assembly areas. The port also has dedicated training centres, including International Windpower Training Corp. Ltd. (TIWTC), which aims to support the development of a critical domestic workforce to ensure value is added to the local economy.

**Exhibit 16: Port of Taichung**

[57] Taipei Times, "Taichung's port passes Jeelung in cargo, MOTC says", 2010; Source: Link
[58] Port of Taichung, Taiwan International Ports Corporation, Ltd., "About Us", 2024; Source: Link
[59] DBpedia, Ten Major Construction Projects; Source: Link
[60] Port of Taichung, Taiwan International Ports Corporation, Ltd., 2023; Source: Link
[61] Port of Taichung, Taiwan International Ports Corporation, Ltd., Completion of First of Several Wharves Tailor-Made to the Needs of Offshore Wind Farm Development Efforts Reflects Port of Taichung's Full Commitment to the Offshore Wind Industry, 2020; Source: Link

### Impact on local industry and investment

The combination of free-trade benefits and excellent infrastructure for OFW development has attracted the investment of several national and international OFW players:

- **Ørsted** signed a wharf lease as well as a 20-year O&M lease for their projects Greater Changhua 1 & 2a and committed to make updates to the leased wharves from 2022 onwards, demonstrating long-term commitment to the region[62]

- **Taipower** signed a 20-year lease, worth roughly NT$3bn, for 13 hectares comprising two wharves and hinterland for the handling, assembling, and storing of components of Changhua County[63]

- **Northland Power** will serve their 1 GW Hai Long project together with Yushan Energy Co. Ltd from the Port of Taichung from 2024 onwards[64]

- **Gamesa Renewable Energy** opened their offshore nacelle plant in 2021 at Port of Taichung with over 90,000 m2, significantly adding value to the local economy by upskilling Taiwanese personnel[65]

- **MHI Vestas** signed a lease with the Port of Taichung to supply Copenhagen Infrastructure Partners' (CIP) Changfang and Xidao project which will feature 62 9.5MW turbines, working closely with local Taiwanese suppliers, such as Yeong Guan Energy Technology Group (YGG), to ensure adding local value[66]

- **Jan de Nul**, a Dutch EPCI contractor, signed a MoU with TIPC to establish a logistics hub and signed a lease for 7.6 hectares of space in the Taichung Port which will be used as the storage, assembly, and load-out area for the Formosa 1 Phase 2's monopile foundations and other underwater infrastructure in 2019[67]

- **Hitachi**, a Japanese cable supplier, set up a Joint Venture Company with Fortune Electric with a capital of NT$1.4bn in 2014 for the manufacturing of transformers in the free-trade zone of Port of Taichung to respond to the increasing international demand for transformers and supply its international markets from the strategic location in Taiwan[68], creating around 200 local jobs

A strong commitment and continuous investment in the expansion of the port infrastructure led to the successful attraction of international companies to settle in the port for their offshore operations and the successful establishment of the Port of Taichung as the major hub for offshore wind development in the Asia-Pacific region.

[62] Ørsted, "Ørsted signs 20-year lease with Port of Taichung for Greater Changhua offshore wind farms", 2020; Source: Link
[63] Taipower, Phase 1 of the Offshore Wind Project - Powering Up Green Energy with Sea Breeze, 2022; Source: Link
[64] Hai Long Offshore Wind, Anchor Project, 2021; Source: Link
[65] Siemens Gamesa Renewable Energy, Tripling in Taiwan: Siemens Gamesa to massively expand offshore nacelle manufacturing activities, 2022; Source: Link
[66] OffshoreWIND.biz, MHI Vestas and CIP Book Assembly Site at Taichung Port, 2020; Source: Link
[67] OffshoreWIND.biz, Jan de Nul Settles in Taichung Port, 2018; Source: Link
[68] Hitachi, Hitachi Announces Establishment of Joint Venture Company for Manufacturing Transformers in Taichung, Taiwan, 2013; Source: Link

## Case study: Mokpo & Sinan, South Korea

**CASE STUDY** | **Mokpo International Trading Port Key information**

Mokpo is an established port city, with plans to develop the existing port to support OFW development. Sinan is a municipality extending across islands with ties to renewable energy.

**Location:** South Jeolla Province, Southwestern coast of South Korea

**Area of administration:** 51,680 $m^2$

**Population:**(M) 218,858 (S) 260,941 (as of June 2023)

**Strengths:** Strategic location and Mokpo is home to multiple industrial complexes. Supporting political setting.

Mokpo International Trading port first opened in 1897 as a traditional fishing port and today is a crucial maritime trade and transportation hub. The Mokpo region has seen a growth in local fisheries, manufacturing, and shipbuilding industries. However, compared to the great development of other regions with the economic development that began in the 1960s, it has relatively shrunk.
As Mokpo Port has limitations in its natural and location conditions as a port, its economy has slowed down significantly as its economic scale has grown. In addition, with the development of land transportation, Wando, Jindo, Jangheung, Gangjin, and Haenam, which were previously commercial lines with Mokpo, were further reduced by being incorporated into the Gwangju area. However, it is still the centre of the coastal route connecting the archipelago of Shinan-gun and Haenam-gun, and passenger ships operate to 165 nearby islands, including Jeju Island.[70] The key industrial complexes in Mokpo are Sanjung, Sapjin, and Daeyang. However, the region may be at risk of the collapse of major industries in recent years.

The provincial government has plans[71][72][73] to develop the New Mokpo Port to support the Southwestern OFW project. This plan has a significant investment of KRE 231 billion (USD 177.425 million) and aims to create a 50,000-tonne capacity steel dock with hinterland and an area of 238,000$m^2$.[74]

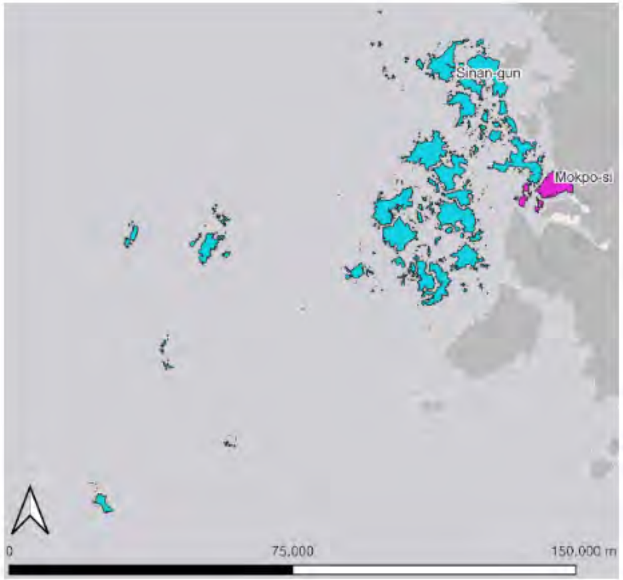



**Exhibit 17: Mokpo and Sinan**

The Sinan municipality would also benefit from Mokpo port development. The municipality extends across islands that historically had fishing and agriculture as their primary industries.[75] Today Sinan has developed its renewable industries and has a 200MW solar PV project.[76] According to a study from 2022, Sinan was found to be one of the four municipalities that has achieved RE100[77]. Moreover, according to the provincial plan, Sinan is in the 1st phase of OFW development, with 4.1GW of the planned OFW project on the southwestern coast of South Korea reaching a total of 8.2 GW.[78]

[69] South Jeolla Province. (Accessed 2024, Feb 1).
[70] Encyclopaedia of South Korean Culture. (Accessed 2024, Feb 1). Source: Link.
[71] InvestJeonnam. (Accessed 2024, February 1): South Jeolla Province. 2024. Major Work Plan. Source: Link.
[72] South Jeolla Province. (2023). Major Work Plan. Source: Link.
[73] Mokpo City. (2023). Major Work Enactment Plan. Source: Link.
[74] Ahn, S. M. (2023). (2023 Wind Energy Society Academic Conference) Suitable sites for offshore wind power-only ports are 'Mokpo Port, Gunsan Port, and Ulsan Port'. Source: Link.
[75] Sinan-gun. (Accessed 2024, February 13). Source: Link.
[76] Song, B. H. Energy Daily (Accessed 2024, February 2) Source: Link.
[77] Energy Transition Forum. (2022). Source: Link.
[78] South Jeolla Province. (Accessed 2024, February 13). Source: Link.

## Recommendations for South Korea

The Port of Esbjerg and Port of Taichung are clear examples of ports and port cities being revived through committing to OFW. The port of Esbjerg is now central to supporting OFW farms in the North Sea and the Port of Taiwan has been attracting foreign investment and like Mokpo port has numerous active industrial complexes and is now a hub in the APAC region. The following factors have led to these ports now being hubs for the offshore wind industry:

**1. Geographic proximity to key offshore wind farms**

**2. Existing infrastructure** can be upgraded and have specific areas designated for OFW development.

**3. Renewable Energy Targets** in both Denmark and Taiwan aiming to reach Net Zero by 2050.[79] Regarding renewable energy, Denmark has a target of 100% electricity and 55% consumption[80] and Taiwan aims to source 20% of electricity from renewables by 2025.[81]

**4. Economic incentives** in the Port of Taichung. The implementation of free-trade benefits has led to international investment.

**Table 4: Industrial Port opportunity for Mokpo and Sinan, South Korea.**

| | Mokpo & Sinan |
|---|---|
| Opportunities | • Opportunity to transition a port into an offshore wind hub<br>• Potential to increase R&D and inward investment into the Mokpo and Sinan region and local supply chains<br>• Increasing local jobs and revitalising local industry<br>• Opportunity to increase logistic coordination and specialisation of ports in the APAC region<br>• Obtain Foreign Direct Investment<br>• Creation of a training centre to upskill local workforce |
| Challenges | • Local workforce may not initially have the skills required for the new industry, upskilling and training programmes will be required to meet workforce demands.<br>• Local industries have no prior experience in supplying products for OFW projects. This can prove to be a challenge as most bidding by major project developers may require prior experience in supplying components. The local firms may not fulfil the requirement for the procurement bidding process without assistance, for example by partnering with international companies in the OFW supply chain. |
| Best practice recommendations | • The Port Esbjerg authority fostered cooperation and system building, acting as an 'innovation system builder'<br>• Taichung Port has attracted FDIs and collaboration between international and local enterprises. |

[79] Barker, A., et al, 2022. Towards net zero emissions in Denmark. OECD Economics Department Working Papers, No. 1705, OECD Publishing, Paris
[80] IEA, Denmark. Source: Link.
[81] Gao et al., 2021. Review of recent offshore wind power strategy in Taiwan: Onshore wind power comparison. Energy Strategy Reviews, 38, p.100747. Source: Link.

# Development of clusters

A cluster is a place-based or regional collaboration between industry, academia and government acting to bolster regional supply chain development, increase economic productivity and support local (typically coastal) communities. Collaborations between government entities, private sector companies and international partners have proved successful in accelerating offshore wind development globally.

There are a number of examples of existing offshore wind clusters, though one of the most successful is the Humber Cluster in the UK. This section outlines the key successes to the Humber Cluster and recognises the factors which have contributed to its success. In South Korea, two regions have been identified as prospective locations for offshore wind clusters; the challenges and opportunities for each are analysed further.

### Case study: Humber Cluster, UK

**CASE STUDY** | **Humber Cluster, UK**
**Key information**

**Location:** Humber, UK

**Size:** The Humber Estuary nears 24.5 thousand km².

**OFW energy:** Supplies 4.9 GW of OSW energy, accounting for nearly a third of the UK's current (2023) offshore wind capacity.[82]

**Supply chain:** Humber Cluster's industries and supply chains together are valued at £52 billion, accounting for 4% of the UK's GVA.[83]

**Exhibit 18: Humber offshore wind industrial cluster**[84]


The Humber Offshore Wind Cluster is one of eight offshore wind clusters in the UK. The region has eight operational offshore wind farms generating 4.9 GW of energy and is expected to deliver a total pipeline of 13.8 GW by 2030.[99] Historically, the region focused on shipping and fishing industries and prior to focusing on the growing OFW farm activities on the east coast, the region had begun to undergo economic decline.[85]

The region is now well-known for its offshore wind capabilities encompassing almost all stages of an offshore wind farm's lifecycle, including innovation and business incubation, testing and demonstration, turbine manufacture, assembly, installation, and O&M using existing servicing facilities. First recognised as an offshore wind cluster in 2011, it has since become a global example of how to regenerate a region by building on its maritime and manufacturing heritage to further develop R&D capabilities, attract investment and develop local skills through education programmes.[114] Currently, the Humber region generates around £18 billion per year in Gross Value Added (GVA) and supports 360,000 jobs across the Humber's industries and associated supply chains (which includes offshore wind).[86]

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[82] Humber Offshore Wind Cluster; Source: Link.
[83] Drax. (2019). Capture For Growth. Source: Link,
[84] Business Live, Humber's key role in seeing off offshore wind's economic headwinds highlighted; Source: Link and Reach PLC
[85] Green Alliance, Growing the UK's coastal economy, 2015; Source: Link
[86] IDRIC, Humber Industrial Cluster; Source: Link.
[99] Green Alliance, Growing the UK's coastal economy Learning from the success of offshore wind in Grimsby, 2015,; Source: Link
[114] Yang, E. J. & Park, S. H.. (2017). Changes of Conservation Plans for a Historic City Center in Gunsan -Based on Content Analyses of Gunsan City Plans. South Korean Journal of Urban Design, Urban Design, 18(5), 5-17.

### Initial government support spurred subsequent private sector investment

Government-funded initiatives focused on strengthening the UK's offshore wind manufacturing base in the Humber region. These included investment for:

- **Enhancing existing facilities –** £160 million of government financial support has been granted to manufacturers like Siemens Gamesa and GRI Renewable Industries, aimed at enhancing manufacturing facilities.[84]

- **Developing new ports and infrastructure –** Up to £95 million has been invested to develop two new ports on the Humber and Teesside, providing the necessary infrastructure that will facilitate the build-out of the next generation of offshore wind projects. Collectively, these ports will accommodate up to 7 manufacturers and create around 3,000 new jobs.[104]

Supportive policies subsequently encouraged private sector investment in developing the local supply chain and strengthening the local economy of the Humber:

- **Local employment and education** - Offshore wind developer Ørsted has collectively invested £9.5 billion into the Humber region, with £45 million estimated to be directly invested in the local community. This local investment is derived from links with local colleges for apprenticeships [88] and the extension of its East Coast Hub O&M facility in Grimsby has secured the long-term employment of over 370 local workers which is thought to increase to 800 staff by 2030.[89] The University of Hull, which has strong engineering capabilities, has supported the development of innovation initiatives like the Aura Innovation Centre, enabling collaboration amongst academia and companies working in the field of Net Zero, including Siemens Gamesa, which apprenticeship schemes.[61]

- **Creating new facilities** - Around £180 million in private sector investment for offshore wind manufacturers SeAH Wind and Smulders Projects UK will be directed towards creating new facilities in the Humber which will create and protect over 1,000 jobs. Siemens Gamesa invested £310 million in the development of a new offshore wind turbine blade manufacturing facility, creating over 1,000 local jobs, to support Ørsted's growing offshore wind pipeline in the Humber region.[90]

- **Local links with research institutions** - Around £2.8 million has been invested to develop a 5G Testbed that will enable the test and demonstration of equipment and new technologies in real-world conditions. The consortium, led by ORE Catapult, expects benefits to a wide range of existing offshore wind technologies including robotics and autonomous systems (RAS), remote sensors, vessels, and ports.[91]

[61] Port of Taichung, Taiwan International Ports Corporation, Ltd., Completion of First of Several Wharves Tailor- Made to the Needs of Offshore Wind Farm Development Efforts Reflects Port of Taichung's Full Commitment to the Offshore Wind Industry, 2020; Source: Link
[88] Ørsted, "Apprenticeships"; Source: Link
[89] Business Live, "Orsted launches record apprenticeship recruitment campaign in Grimsby," 2023; Source: Link
[90] Green Port Hull, "Siemens Gamesa"; Source: Link
[91] ORE Catapult, "The biggest offshore wind 'living lab' in the world to be developed in the Humber," Press release; Source: Link
[104] KOSIS. (2022). National Business Survey.

### The need for national, cohesive industrial strategy

The UK has a less centralised industrial strategy than the EU, which supports long-term manufacturing initiative or the US, which passed the Inflation Reduction Act (IRA) to provide billions of dollars on loans and grants for clean energy.[93] Instead, over the past several years the UK has taken a market-led approach to industrial investment, and the government has launched numerous stand-alone programmes to support new technology development. The government has also supported a range of individual 'sector deals', including those focused on artificial intelligence, clean growth, an ageing society, the future of mobility, and offshore wind.

Despite these efforts, a 2023 report by The Manufacture's Organisation cited that 81% of manufacturers surveyed felt their company was at a competitive disadvantage globally due to an absence of cohesive, UK industrial strategy.[94] The sector deals, pledged in 2017, were followed in quick succession by Boris Johnson's 2021 'Plan for Growth' citing infrastructure, skills and innovation as the country's main investment pillars;[95] Liz Truss's 2022 Growth Plan outlining tax cuts to support private sector growth; and Jeremy Hunt's 2023 announcement as Chancellor to support five new growth sectors in the UK economy: Digital Technology, Green Industry, Advanced Manufacturing, Creative Industries and Life Sciences.[97]

The absence of a cohesive and strategic industrial policy may impact on the success of the Humber Cluster, and other similar clusters, in the long-term.

### Lessons learnt from the Humber Cluster

The Humber Offshore Wind Cluster in the UK is a clear example of how a region can transition from declining industries to offshore wind industry and how that strengthens and revitalises a community. Over the past 13 years, the region has been successful in converting government support into private sector investment, supporting local communities and creating long-term jobs. A number of factors have led to the success of the Humber industrial cluster, which include:

- **Geographical proximity to the market.** The Humber region was strategically located for supplying and servicing the first offshore wind farms in the UK. The North Sea area has favourable conditions for offshore wind development, with sustained wind speeds and shallow waters.[98] The pipeline of early UK wind farm projects were all easily serviceable from the Humber region. The area has benefited from a stable growth of offshore wind developments, matched with stable growth of infrastructure and job opportunities.[99]

- **Existing industrial history and expertise.** The maritime and fishing history formed a good foundation for a just transition in the area. With a strong fishing fleet and understanding of the maritime trade, employees were able to transition to supporting site management and construction, and subsequently other areas.

- **Strong commitment from local authorities.** The local governments have capitalised on government funding to implement policies to attract private investment and ensure economic growth. Programmes such as 'Growing the Humber' delivered by local authorities have maximised investments to build the offshore wind sector in the Humber region.[100]

- **Strong local partnerships.** The local authorities were integral to early collaboration between supply chain, innovation and businesses. Partnerships with the Aura consortium, the University of Hull and other initiatives such as the Offshore Renewable Energy Catapult are further strengthening the Humber offshore wind leader status.

- **The requirement for transition.** The Humber region was facing economic decline due to the weakening fishing and maritime trades. Leveraging government support, local authorities, businesses and investors ensured the Humber successfully avoided economic downturn and could transition to other areas of expertise.

[93] The White House, Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investment in Clean Energy and Climate Action, 2022; Source: Link
[94] MakeUK, Industrial Strategy: A Manufacturing Ambition, 2022; Source: Link
[95] UK Parliament, Securing Britain's industrial future, Research Briefing, 2022; Source: Link
[97] UK Government, "Chancellor sets out long-term vision to grow the economy," News story, 2023; Source: Link
[98] Hjelmeland, M. and Nøland, J.K., 2023. Correlation challenges for North Sea offshore wind power: a Norwegian case study. Scientific Reports, 13(1), p.18670; Source: Link
[99] Green Alliance, Growing the UK's coastal economy Learning from the success of offshore wind in Grimsby, 2015,; Source: Link
[100] The Humber offshore Wind Cluster Prospectus. Source: Link

## Case study: Incheon Metropolitan City, South Korea

**CASE STUDY** | **Incheon Metropolitan City**
**Key information**

**Location:** West coast of South Korea, nr Seoul.

**Population:** 2,987,918 (as of September 2023)[101]

**Size:** The area of administration is 1,067.04 km².[102]

**OFW energy:** Pipeline of 3.5 GW including a 1.6 GW development from international developer Ørsted.

**Employment:** As of 2021, Incheon Metropolitan City incorporates over 300,000 businesses with 1,223,448 employees.

**Type of development scheme:** Government and private

**Exhibit 19: Incheon Region**[105]

The Incheon region made of various islands, 32 of which are currently inhabited. As the fishing trade in these communities diminishes, the local government is supportive of renewable energy deployment to regenerate the area and improve electricity access and transmission.

The Incheon coastal region has been a significant hub for international sea trade and has received regular port upgrades to support major industrial activities in Seoul and its surrounding areas, with easy access transport links. The region hosts diverse industries including heavy equipment, electrical equipment, metal works and automobiles. Incheon Port comprises four distinct ports, namely Inner, South, North, and New. Among these, two ports have been recognised for their capacity and suitable specifications to serve as an offshore wind installation port and an offshore wind operation and maintenance (O&M) port.

The region saw significant growth by government-led economic development plans and establishing numerous industrial complexes as part of the 5-Year Master Plan for Economic Growth and from its designation as a Free Economic Zone in the early 2000s.[106] However, recent years have seen a relative decline in the region, with only an outward appearance of economic growth due to the growth in the service industry. The Incheon branch of the Bank of South Korea suggests focusing on industries with high economic multiplier effects and improving inter-industry associations[107]

The Incheon region has an offshore wind project pipeline of over 3.5 GW, which has attracted international developers. The local government is supportive of offshore wind in the area, capitalising on government support from the Offshore Wind Development Support Programme.[108] The development of these projects has not been without opposition; the region is home to productive fishing grounds and local fishermen are concerned about disturbance to fishing grounds from turbine foundation installation.[109] The local government stepped in to undertake mediation and the Ministry of Industry subsequently set up a working group in four regions to resolve conflicts in offshore wind projects.

**Table 5: Offshore wind farm pipeline in Incheon.**[110]

| Opportunities | Capacity | Investment (USD $) | Construction |
|---|---|---|---|
| **KOEN** | 640 MW | USD 2.457 billion | 2023 - 2026 |
| **Ørsted South Korea** | 1,600 MW | USD 6.142 billion | 2025 - 2027 |
| **C&I Leisure Industry Co., Ltd.** | 233.5 MW | USD 998.088 million | TBC |
| **OW South Korea (South Korean Peninsula Offshore Wind)** | 1,200 MW | USD 4.606 billion | TBC |

[101] KOSIS. (2023). Resident registration population status. Source: Link.
[102] Incheon Metropolitan City. (Accessed 2024, February 1) Link.
[105] Incheon Metropolitan City. (2021). Survey Report for potential hinterland port for Incheon offshore wind power)
[106] Incheon Chamber of Commerce and Industry. (2023). Incheon regional economic status and tasks.
[107] Bank of South Korea Incheon Branch. (2021). Changes in industrial structure and implications in the Incheon region. Source: Link.
[108] Ahn S. M. (Accessed 2024, February 2) Link.
[109] Dong.A.com (2022) Offshore wind fishermen backlash spreads. Source: Link.
[110] Incheon Metropolitan City. (2021). Survey Report for potential hinterland port for Incheon offshore wind power)

## Case study: Gunsan City, South Korea

**CASE STUDY** | **Gunsan City**
**Key information**

**Location:** North Jeolla Province, mid-western coast of South Korea

**Size:** The area of administration is 398.3 km².[111]

**OFW energy:** 2.4 GW pipeline[112]

**Employment:** As of 2021, Gunsan City incorporates over 33,000 business with 116,443 employees.[113]

**Regional strengths:** Geographical proximity to the market; physical infrastructure and ports; pre-existing manufacturing base; supportive political setting.

**Type of development scheme:** Government-led.

The West Coastal development initiative undertaken by the Government in the 1980s and 1990s spurred the expansion of manufacturing, including the establishment of car manufacturing and heavy industries shipyards in Gunsan City[114]. However, more recently, the closure of two critical manufacturing facilities[115], coupled with a decline in the local population, has resulted in economic stagnation for the city. The South Korean government designated the area as a special response area and formulated multiple support programs to revitalise the shipbuilding and car manufacturing industry.[116] Despite these efforts, the region's regeneration has seen limited success.[117]

Gunsan City is well placed to form an offshore wind cluster development, with proximity to proposed western and southern South Korean offshore wind farms. Gunsan port is strategically positioned to provide marshalling operations to not only local OFW farms, but support international developments in Japan, China and Taiwan.

**Exhibit 20: Gunsan City region**

The collaboration between the government, local industry, and academic institutions can facilitate the development of an offshore wind cluster, as demonstrated in the Humber Cluster. This gives a mechanism through which strategic, long-term planning can be enacted to ensure sustained investment and active participation within the cluster. Gunsan City has the opportunity to leverage the expertise of nearby institutions capable of providing education and training for offshore wind skills, to further strengthen the regions' cluster status. The Research Institute for Offshore Wind at Kunsan National University was established in 2009;wind power engineering is within its curriculum.[118]

To successfully develop an offshore wind cluster in Gunsan City, attracting investors and technology providers to the North Jeolla region is key. North Jeolla is already home to a number of manufacturing industries and research and training institutes associated with the offshore wind industry. Existing manufacturing industries include blade manufacturing, turbine tower manufacturing, foundation manufacturing, steel fabricators and service providers for O&M services[119]. The R&D institutions in North Jeolla are well established, including local branches of agencies such as the South Korea Institute of Materials Science, South Korea Institute of Energy Technology Evaluation and Planning, South Korea Energy Agency, and Jeonbuk Technopark (JBTP).

[111] Gunsan, Source: Link.
[112] New Gunsan, Source: Link.
[113] KOSIS, Source: Link.
[114] Yang, E. J. & Park, S. H.. (2017). Changes of Conservation Plans for a Historic City Center in Gunsan -Based on Content Analyses of Gunsan City Plans. South Korean Journal of Urban Design, Urban Design, 18(5), 5-17.
[115] Gunsan City. (2020). Operational performance and evaluation of employment crisis areas in Gunsan City.; KEIS. (2022). Achievements and tasks of support for employment crisis areas in Gunsan region. Source: Link.
[116] KEIS. (2022). Achievements and tasks of support for employment crisis areas in Gunsan region. Source: Link.
[117] KBS, Source: Link.
[118] Kunsan National University, Source: Link.
[119] Bank of South Korea North Jeolla Branch. (2021). Research on development plans for Jeonbuk offshore wind power industry ecosystem. Source: Link.

## Recommendations for South Korea

Two regions in South Korea have been identified to have strong potential to form an offshore wind cluster. The opportunities for each region are outlined in the tables below. The cited regions serve as examples and should not constrain the involvement of other local municipalities or regions in investing in South Korea's offshore wind industry, particularly in regions where there is notable enthusiasm for project development, such as parts of Cheongnam province and Ulsan city.

**Table 6: Industrial cluster opportunity for Incheon Metropolitan City, South Korea.**

| | Incheon Metropolitan City |
|---|---|
| **Opportunities** | • **Geographical proximity to the market.** Incheon Metropolitan City has two existing ports, with specifications capable of supporting OFW activities. There is a pipeline of offshore wind projects in the region, and the ports are well located to service these projects. Existing industrial history and expertise. The Incheon region has expertise in many manufacturing and logistics industries. Existing facilities and workforce can be utilised for OFW development, to revitalise the economy.<br><br>• **Existing industrial history and expertise.** The Incheon region has expertise in many manufacturing and logistics industries. Existing facilities and workforce can be utilised for OFW development, to revitalise the economy.<br><br>• **Strong commitment from local authorities.** The local government is supportive of renewable energy deployment, with an aim to strengthen electricity supply to the many islands and to support the decline of the existing fishing industry. The local authorities were proactive in applying to the government-led Offshore Wind Development Support Programme.<br><br>• **Strong local partnerships.** The pipeline of projects in the Incheon region is attracting international offshore wind developers. There is an opportunity to proactively engage with these international players to ensure education and support schemes are developed to benefit the local economy and community.<br><br>• **The requirement for transition.** Incheon has experienced a decline in the manufacturing and construction industry, and the region is at risk of stagnation without transition. |
| **Challenges** | • **Infrastructure challenges.** The Incheon region experiences a large tidal range of 8-10m, which needs to be considered inside the ports and during vessel movement. To overcome this, many wharves have developed lock gates at their docks, which should be considered if there are large amounts of traffic for offshore wind servicing. The height of the Incheon bridge will limit the air draft available for vessels.[120]<br><br>• **Difficulties in siting.** Incheon coast is heavily crowded with international trading ships.[121] A potential site faced disputes with fishermen as it overlapped with the country's largest swimming crab fishing ground.[122] Large areas are also reserved for military uses.[123] |

[120] Incheon Metropolitan City. (2021). Survey Report for potential hinterland port for Incheon offshore wind power)
[121] Moon, J. K. (Accessed 2024, February 13). "2023 Incheon Port records highest performance ever, including 'Con' cargo volume". Source: Link.
[122] DongA.com Business News (2022, March 21) (Accessed 2023, December 21). Source: Link.
[123] Ahn, S. H., So, Y. M., Ryu, H. J., Han, M. H. & Yun, S. J. (2023). Institutional Solution to Complex Conflicts in the Site Selection Process of Offshore Wind Power - from a Multi-level Governance Perspective.

| Incheon Metropolitan City | |
|---|---|
| **Best practice recommendations** | • **Develop an economic plan with local partnerships.** The local authorities should prioritise forming relationships with regional partners to strategically support local employment opportunities. Conducting an evaluation of potential job opportunities and investment requirements could support this, to shape a long-term vision. Local authorities will need to devise a funding model to facilitate support for investment.<br>• **Establish a framework for engaging with investors.** The arrival of offshore wind developers in the area opens up opportunities to implement direct community benefits through dedicated support schemes. |

**Table 7: Industrial cluster opportunity for Gunsan City, South Korea.**

| Gunsan City | |
|---|---|
| **Opportunities** | • **Geographical proximity to the market.** Gunsan City has close proximity to the southwestern OFW farm pipeline. The port has easy access to major highways near industrial complexes, for ease of component transportation and existing specifications to become a marshalling port.<br>• **Existing industrial history and expertise**. The region has strong manufacturing and heavy industry skills, which can be utilised for offshore wind transition.<br>• **Offshore wind skills.** The wider region of North Jeolla has been steadily growing an offshore wind economy, with a number of manufacturing and R&D facilities.<br>• **Strong commitment from local authorities.** The local authorities have been vocal about the desire to bring the workforce back to the local area. These desires need to be backed up with robust local policy and investment. The local municipality of Gunsan has outlined a plan to invest and build a specialised port.[124][125][126][127]<br>• **Strong local partnerships.** There are a number of OFW focused R&D institutes and manufacturing training institutes in the North Jeolla province, which could be utilised for OFW training and education.<br>• **The requirement for transition.** Gunsan City has faced economic stagnation in recent years.There is an opportunity to transition to cement the area as a leader in offshore wind. |

[124] IKBN news Source: Link.
[125] Gunsan Port Master Plan Article. Source: Link.
[126] Gunsan Port Article. Source: Link.
[127] Domin, Source: Link.

| | |
|---|---|
| **Challenges** | • **Labour shortages in the manufacturing sector.** Despite the recent improvement in both employment and population indicators, declining younger population and employment in the manufacturing sector can pose a challenger in: securing a workforce in the region[128]<br><br>• **Closing down two manufacturing facilities; shipbuilding and car manufacturer.** The closure of two critical manufacturing facilities – Hyundai Heavy Industries' Gunsan Shipyard in 2017 and GM South Korea's Gunsan Plant in 2018 led to many worker migration to other regions. |
| **Best practice recommendations** | • **Capitalise on education and training partnership opportunities across South Korea.** Gunsan City has expertise in manufacturing, which could offer job opportunities in OFW manufacturing should the facilities restructure to support on OFW. However, Gunsan City may not be best placed to conduct all OFW services. Educational institutes should collaborate with other regions to form agreements for job opportunities or apprenticeships in other aspects (for example, conducting surveys).<br><br>• **Establish a policy framework to revitalise the existing manufacturing industry.** The existing manufacturing facilities in Gunsan Region support some small-medium sized OFW manufacturing, but will need support to scale up to service the pipeline of OFW projects in the region. Demonstration of local authority support through long-term planning will help to attract private sector investment.<br><br>• **Establish a framework for local partnerships.** The local authorities should prioritise forming relationships with local partners to establish an OFW specific consortium. In the North Jeolla region, where a number of OFW focused R&D institutes exist, broader government support for establishing relationships with supply chain and investors could enhance the influence of the R&D institutions. |

# Technical upskilling through education and training

Offshore wind development can lead to the creation of local employment opportunities, either through a cluster model where multiple opportunities are created within a district, or in more of a standalone approach reflected by port revitalisation. It is predicted that the number of jobs in the offshore wind sector could triple by 2040 in the EU.[129] The roles in construction, installation, operation and maintenance of wind projects will require unique skill sets, encompassing safety protocols for working at elevated heights and survival at sea.[130] While there are employment opportunities within the sector that do not require any specific qualifications, to address jobs and skills bottlenecks, investment is required in training centres, partnerships with colleges and further education institutes and apprenticeships with developers and contractors.

[128] Kim, K. H. (Accessed 2024, February 13). Overcoming the employment recession in Gunsan City, a graduation after 4-years of being designated an employment crisis area. Source: Link.
[129] European Commission. (2021). Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions on a new approach for a sustainable blue economy in the EU Transforming the EU's Blue Economy for a Sustainable Future. Source: Link.
[130] Global Wind Energy Council (GWEC), Global Offshore Wind Report 2023, 2023; Source: link

An example of a training centre within the cluster model is in the Humber region, Maersk has established a training centre that offers the Global Wind Organization (GWO) Basic Safety Training (BST), GWO Basic Technical Training (BTT), GWO Enhanced First Aid with additional course on GWO Blade Repair and GWO Advanced Rescue Training due soon.[131] These types of centres partner with the installation contractors and developers to employ local people by allowing them to access the required training. Additionally, offshore wind developers, such as Ørsted and RWE, launched safety training programmes[132] and apprenticeship schemes[133] in the Humber region to adequately develop a skilled workforce.

Universities also have an important role to play in regional development of offshore wind. Partnerships with technical universities support the link between industry and academia and provide opportunities for appropriate skills development and a pathway into the industry. For example, universities such as TU Delft (NL), DTU (DK) and Strathclyde (UK) all have strong relationships with developers and local supply chains.

## Equitable employment in offshore wind

As the number of employment opportunities within offshore wind increases to meet the energy targets, it is important to consider how those within the local population will have access to these opportunities. The UK government has set an ambitious target in its Offshore Wind Sector Deal of 40% women employed in the sector by 2030 compared to the 16% that have been employed by 2018 and committed to investing significant sums into STEM education both on higher and lower education level.[134]

An International Renewable Energy Agency (IRENA) survey highlighted that women make up 21% of the wind energy workforce and 32% of the total renewable energy workforce,[135] with the lowest amount of representation in non-administrative (technical) functions. Industry wide initiatives such as the Women in Wind Global Leadership programme and the Global Women's Network for the Energy Transition (GWNET) are aiming to address these inequalities through networking, mentoring and training.[136][137] Companies can also set targets for recruitment such as Ørsted's 40% by 2030 goal, or improve retention and address gender pay gaps. Additionally, for existing employees a diverse workplace can be supported through flexible working, family friendly working, career development following parental leave and creating internal networks.

131 Maresk Training in Humber; Source: link
132 Ørsted (2020), Ørsted launches immersive safety programme in a first for the Humber, Source: link
133 The Hull Story, Green energy: Wind turbine apprenticeship scheme opens at RWE, 2023; Source: link
134 Gov.uk, Offshore Wind Sector Deal, 2020; Source: link
135 Wind energy: A gender perspective (irena.org)
136 GWEC, Women in Wind; Source: link
137 GWNET, Global Women's Network for the Energy Transition; Source: link

# CONCLUSION AND POLICY SUGGESTIONS

# Conclusion and Policy Suggestions

Offshore wind has an integral role to play in South South Korea's energy transition and can offer a wide range of opportunities for the regeneration of coastal communities. OFW development is likely to generate large-scale investment, connect to a wide range of supply chains, and have strong industrial linkages, making it a major contributor to the regeneration of coastal cities. However, the potential economic benefits will only be fully realised once development takes place, hence there is a level of urgency to accelerate policies that could support OFW.

Due to the nature of OFW development, which involves global and local supply chains, industries, institutions, and many other actors at international, national, and sub-national levels, policies that look to fulfil the goal of rapidly expanding OFW deployment often involve multiple institutions and political stakeholders from the local to national level. This is complicated and takes guidance from all levels of government, but in particular at the national level.

As such, GWEC encourages the national government to **establish a comprehensive and visionary industrial policy** to support the sector, helping a sector that is critical to the country's net zero targets and that will also rebuild many coastal communities that have seen economic decline.

The following highlights details of our recommendations, split into local, both local and national, and national.

## Local governments

**Build a local regeneration vision with the citizens**

The industry encourages early and increased engagement by local municipalities with all local stakeholders in developing the long-term vision of a region's regeneration. The current ''renewable cluster complexes'' scheme incentivizes proactive roles from local municipalities and provides an opportunity for residents' engagement. However, it is limited in the sense that only the stakeholders directly associated with the physical scope of the project are engaged in site selection. Creating the long-term blueprint of a region's development with the broader local community will help build social acceptance and long-term political support for OFW development.

One of the main causes for delays in private-led projects in South Korea is strong opposition due to concerns by local communities - there has often been limited engagement and understanding between them and the developers. Local municipalities and the local councils can better represent the local citizens by including them in devising long-term strategies for the region early on. This process can greatly be enhanced by continuous efforts in informing, consulting, involving, collaborating, and empowering citizens through forming a public committee or a task force within a city council led by offshore wind departments in local governments.

**Build the workforce capacity with local research institutions and other knowledge partners**

Local municipalities may collaborate with key industrial actors to provide education and training programs. As in the case of Port Hull in the Humber cluster, education and training programs led by local universities and research institutions, privately and publicly co-funded, provide optimal environments to secure skilled labour in the region.

As South Korea's student population is rapidly decreasing, many local universities, national and private, in shrinking cities, are closing due to financial circumstances. Increasing industry-academia collaboration is one among various policy measures to revitalise dwindling local universities. Local municipalities can act as a bridge between the industry sector and provide necessary public financing and support.

**Establish inclusive governance on industrial clusters with stakeholders**
As key stakeholders, the private sector can play a more direct role in the planning and implementation of the OFW industrial cluster in the region. In 2023, the Ministry of the Interior and Safety (MOIS) of South Korea announced that it will relax the requirements for establishing a council between resident firms in small industrial complexes. However, there is a growing need for more efficient ways to engage with public councils in determining the future of industrial clusters. This is especially true for the industrial sector such as OFW which is expected to grow faster.

There are also varying governance models for industrial clusters with goals to achieve net-zero targets. Industrial clusters face many challenges working with a variety of stakeholders to deliver net-zero targets. Therefore, a governance structure tailored to each industrial cluster's characteristics is required. Local governments may assess the current governance model, level of collaboration, range of actors and decision makers involved to determine their unique governance structure for the industrial cluster.

**Strengthen international networks**
Local governments oversee multiple roles as decision makers, planning authorities, managers of municipal infrastructure and central figures in public-private collaboration, which make them ideal drivers of change.

An existing global network between local governments can be utilised to enhance the capacity to plan and implement effective climate action at the local level.

For example, in 2023, Seoul Metropolitan City hosted the biennial World Cities Summit Mayors Forum in 2023 and centred its discussions on the theme of "Liveable and Sustainable Cities: Forging an Inclusive and Resilient Future". This forum exemplifies a local government-level network serving as a dynamic platform. It not only facilitates the exchange of information but also cultivates fresh partnerships between industry experts and public authorities. The Global Covenant of Mayors for Climate & Energy (GCoM), founded in 2016 comprises more than 12,500 cities and local governments spanning six continents and 144 countries. This alliance includes 25 South Korean cities, such as Seoul, Busan, and Sinan, all of which have enthusiastically embraced the commitment to climate action.

## National government

As noted above, GWEC encourages that government to establish a comprehensive and visionary industrial policy to support the sector, including the following:

**Expand the number of free economic zones to enhance offshore wind industry cluster**

As South Korea plans to develop offshore wind on a large scale in a relatively short period of time, the government should create opportunities for foreign and domestic investment, including technology development collaboration with international companies.

It is advisable for the national government to expand the number of free economic zones to provide a level playing field for FDI. Free trade zones offer a wide range of tax breaks and support. To illustrate, one of the reasons for the success of the Humber Industrial Cluster in the UK is that it was selected as an Enterprise Zone in 2011.

In South Korea, there are currently free zones in Incheon, Pyeongtaek, Gwangyang, and Busan etc. Gunsan was selected as a free economic zone, but with the enactment of the Saemangeum Special Law, it was changed to receive various deregulatory benefits within the special law.

By significantly increasing investment opportunities from international firms, local municipalities may align their policies to facilitate more collaboration between global and local firms to create synergistic growth in the OFW industry. From the perspective of local municipalities, new inward investment can assist in job creation and regional economic growth.

**Working with government, industry and local stakeholder communities, develop standardised guidelines for engagement, consider existing practices in community engagement.**

Currently there is limited guidance from the national government regarding best practices in community engagement during OFW development. This situation results in ambiguity for developers, and varying levels of successful engagement with communities. The new Special Bills will place the responsibility for engagement with the government, but until those projects advance, the EBL projects require guidance on best practice community engagement.

**Introduction of a production tax credit system, or a similar incentive, for the wind power supply chain**

If South Korea introduces a production tax credit for companies in the offshore wind supply chain, it is expected to be a strong incentive for companies to invest. As a pilot case, if the governments designate an offshore wind industry cluster and offer production tax credits to companies, we will see how much the community regeneration effects. The tax credit system is under the jurisdiction of the Ministry of Economy and Finance (MOEF); MOTIE and MOEF should work together.

**Prepare long-term plans on port and grid infrastructure for offshore wind to help developers make informed investment decisions**

**Since the expansion of port infrastructure led to successful attraction of international companies to settle in the port for their offshore operations, it is important to strengthen developer's confidence in entering and developing offshore wind in the country by providing long-term port and grid infrastructure plans. Meanwhile, a long-term vision for these crucial elements can strengthen the supply chain, creating ripple effects that will continue for years.**

## Both local and national governments

**Carry out an assessment of coastal communities at a local and national level**
Local governments and communities should be consulted to understand the baseline status of economic, social and environmental factors in specific coastal communities. Baseline assessments could include evaluation of existing jobs and GVA in specific regions, analysis of demographic trends, and cost-benefit analysis to determine the areas which would benefit most from strategic investment.

**Develop a national plan for coastal community regeneration, coordinating with local authorities, communities, and industry for shared understanding of impacts of different stages of offshore wind projects to local communities**
A long-term commitment from the government, in support of growing the offshore wind industry, can provide a stable environment to attract investors and ensure growth. A long-term vision for energy policy and industrial strategy will build confidence in the market, and ultimately attract infrastructure investment. Therefore, the local and central governments, as well as across different ministries (i.e Ministry of Trade, Industry and Energy and Ministry of Oceans and Fisheries), should develop clear and cohesive plans for coastal regeneration and offshore wind development that are informed by engagement with stakeholders. The input of the plan should focus on three pillars:

- Engaging with local residents to communicate the potential benefits of offshore wind development and to create a framework for information sharing, as well as to hear their views and concerns
- Working with the industry and the academia through partnership programmes
- Incorporating views of local environmental stakeholders to understand conservation risks

Through this input, coastal regeneration can be supported through the following routes:

- **Economic investment:** The government can allocate funds and collaborate on an inter-ministerial level to implement clear policies to upgrade infrastructure or increase support for the support the development of industrial clusters through financial or other incentives, both of which could generate downstream effects of employment opportunities. The government can help ensure that the local workforce can benefit from these employment opportunities by supporting reskilling and retraining programmes. While South Korea has a strong maritime and fisheries industry, there is currently a lack of apprenticeship schemes supporting maritime and marine skills. The government should work with the offshore wind industry and existing research institutions to explore potential avenues for reskilling.
- **Social investment:** Sectorial policies should consider quality and diversity in the offshore wind sector. This could include an encouragement of setting and requirements for employers across all stages of wind farm development. These policies should inform apprenticeship and training programmes. Partnerships with local diversity organisations will ensure that the specific barriers faced by underrepresented groups are specific to each region. To fully ensure that the benefits of offshore wind development are distributed equitably among South Korea's population, the government should carry out continued monitoring of progress.
- **Environmental investment:** The government should work with industry to develop programmes to monitor and restore South Korea's natural heritage, whilst ensuring that offshore wind development meets environmental standards.

# APPENDIX

## Methodology

- Estimation for port and hinterland construction cost is also based on this target
• Unit investment costs and supply chain structures for Fixed bottom & Floating OFW is estimated separately.
• Analysis method of NREL (2022)[139] presented in the Exhibit 14 and Exhibit 15 was adopted for analysis, due to following reasons,
  • The data on investment costs for completed OFW projects in South Korea is not readily available.
  • Ongoing projects demand a 15 MW class of turbines that are not yet domestically manufactured.
  • Therefore, international prices were deemed a more valid assumption for this study.
• Current inflated construction costs were used in the analysis, but the prices are expected to gradually decrease by the mid-2020s when construction begins at full speed.
- The price reduction projections used are in line with the findings from DNV (2022).[140]
  • There has been a significant increase in the construction cost of OFW farms globally due to the recent supply chain bottlenecks.
  • However, renewable energy has successfully demonstrated the economies of scale and a learning curve from market expansion, consistently lowering costs.
- One standard price was set for both investment and O&M without applying discount rates according to time.
  • This is due to limitations of IO analysis as a static analytical model using a static input-output model.
  • Dynamic analysis that tracks changes over time requires more information.
• Following assumptions were made for estimation of job creation and gross value add the construction and operation of a 14.3GW capacity OFW farm from 2023 to 2030.
- The economic effect for O&M is assumed to be in 2030 only, considering the time it takes for an OFW farm to be planned and commercially operated.
- OFW development for 14.3GW is in its initial stages and development phase is expected to last 7 years, estimated to be completed in years between 2023 and 2029.
- Construction is assumed to continue until 2029, considering the duration and the uncertainty of the permitting process, with commercial operation only starting in 2030.
- For analytical convenience, factors such as inflation and future discount rates were not considered in the analysis, and the 7 years of construction and one year of operation were treated as a single time frame.
• Estimation of investment and cost inputs for port development

| Category | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Total Investment (USD million) | 1,866.62 | 1,866.62 | 3,807.28 | 4,548.57 |

Case 1: Constitutes 2.10% of the total project cost (South Korea)
Case 2: Constitutes 5.20% of the total project cost (South Korea)
Case 3: Based on the estimated cost of port construction required for developing 30GW of OFW by 2030(US)
The ratio for port construction and manufacturing specialised vessels is 70:30 (%)
Case 4: Based on the cost of the maintenance and expansion of Taichung Port

- Research findings related to port construction in South South Korea, the United States, and Taiwan were used to determine suitable estimates.
  • Case 1 & 2 (South South Korea) - estimated cost for creating ports and hinterland complexes ranged from approximately 2.2% (at minimum, represented by Case 1) to 5.1% (at maximum, represented by Case 2) of the total project cost.[141]
  • Case 3 (United States) - approximately USD 1.1 billion (KRW 14.85 trillion) is necessary to develop ports and associated vessels to facilitate the timely establishment of a 30GW OFW farm by 2030.[142] It was assumed for the analysis that approximately 70% of this cost is allocated for port construction.
  • Case 4 (Taiwan) - based on available data, the Taiwanese government has invested USD 0.92 billion (KRW 1.24 trillion) in upgrades to Taichung Port to fulfil Taiwan's plans to construct a 3GW OFW power complex by 2030.
- Various factors (e.g., water depth, sea level, and seabed topography) may affect the cost for port construction.
- Final cost for port construction is also determined by whether the specific type of port for OFW utilises or expands the existing infrastructure or is newly developed.
- For the analysis, five years was assumed as the maximum time required to build berthing facilities and containers in South Korea.
  • This is based on the Article 7 of the Harbor Act which states that the amendment to port development plans may take place every 5 years.
  • In the case of Busan New Port, the construction period is planned to be 18 years, from the breakwater construction to the completion of the berthing facilities. However, the construction period can be shortened if the construction involves expanding the existing port facilities.
• Average output capacity of an installation port was assumed to be 2GW per year to fulfil the target capacity planned for 2030. The cost of creating and maintaining the installation port and O&M ports were estimated accordingly.

[139] Stehly, T., & Duffy, P. (2022). 2021 cost of wind energy review (No. NREL/TP-5000-81209). National Renewable Energy Lab.(NREL), Golden, CO (United States).
[140] DNV. (2022). Floating wind: The power to commercialise.
[141] Lee et al. (2019). "Strategy to Utilize Ports and Hinterland Complexes for the Development of OFW Clusters."
[142] Shields, M., Cooperman, A., Kreider, M., Oteri, F., Hemez, Z., Gill, L., ... & Lim, J. (2023). The Impacts of Developing a Port Network for Floating Offshore Wind Energy on the West Coast of the United States (No. NREL/TP-5000-86864). National Renewable Energy Laboratory (NREL), Golden, CO (United States).

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